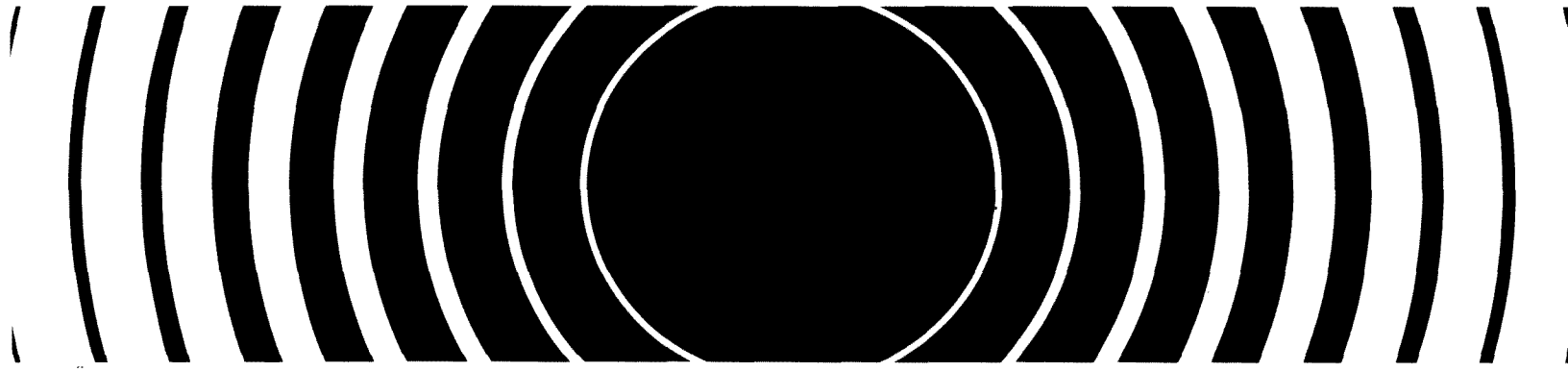
United States
Environmental Protection
Agency

Air and
Radiation
(ANR 461)

EPA 520/1-90-009
March 1990

EPA

EPA Workshop on Radioactively Contaminated Sites



TECHNICAL REPORT DATA *(Please read Instructions on the reverse before completing)*		
1. REPORT NO. EPA 520/1/-90-009	2.	3. RECIPIENT'S ACCESSION NO. PB 90 227950/AS
4. TITLE AND SUBTITLE EPA Workshop on Radioactively Contaminated Sites		5. REPORT DATE March 1990 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Office of Radiation Programs		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Environmental Protection Agency Office of Radiation Programs 401 M Street, SW Washington, DC 20460		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS U.S. EPA ORP/OSWER 401 M Street, SW Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED 14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

This report is a compilation of reports presented at a workshop that was sponsored jointly by the Environmental Protection Agency's Office of Radiation Programs and Office of Emergency and Remedial Response. They include status reports from DOE, DOD, and private industry, EPA case studies, and summaries of applicable technology and research.

17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Radionuclides Radiation Contamination Sites Waste Exposure Workshop Disposal		
18. DISTRIBUTION STATEMENT Release unlimited	19. SECURITY CLASS *(This Report)* Unclassified 20. SECURITY CLASS *(This page)*	21. NO. OF PAGES 180 22. PRICE

EPA WORKSHOP ON RADIOACTIVELY CONTAMINATED SITES

May 3-5, 1989
Albuquerque, New Mexico

Sponsored by:

ORP/OSWER

under

Contract No. 68D90170
Work Assignment No. 1-8

Prepared for:

U.S. Environmental Protection Agency
Office of Radiation Programs
Washington, D.C. 20460

March 1990

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

ABSTRACT

A 3-day workshop was held to share information on the investigation, management, and remediation of radioactively contaminated Superfund sites and other similar Federal facility sites. These sites can pose a significant threat to the public health and safety and have been found to present particular problems because of difficulties in cleanup and disposal of the radioactive wastes. Currently, 25 sites are on or proposed for the National Priorities List. These sites have been identified as having significant radioactive contamination, and it is estimated that there may be more than 100 additional Superfund and Federal facility sites in this category. Most of the Federal facility sites occur on lands managed by the Department of Energy (DOE) and the Department of Defense (DOD); both Agencies have developed comprehensive programs to address these problems.

The workshop was sponsored jointly by the Environmental Protection Agency's Office of Radiation Programs and Office of Emergency and Remedial Response. The more than 130 attendees represented a wide spectrum of EPA offices and DOE and other Federal agencies, as well as government contractors and state agencies. Presentations included status reports from DOE, DOD, and private industry, EPA case studies, and summaries of applicable technology and research. Unresolved issues and problem areas were explored in panel discussions. Ongoing research examining various aspects of soil cover designs were visited at the Los Alamos National Laboratory.

The DOE and DOD have by far the largest share of the Federal Facility Hazardous Waste Sites and have developed extensive programs for addressing these. DOE, in particular, has a legacy of radioactively contaminated sites dating from the Manhattan Project in the early 1940s, including isolated buildings, uranium mill tailings and vicinity properties, research complexes, and waste storage/disposal sites. These are being addressed under the Formerly Utilized Sites Remedial Action Program (FUSRAP), Surplus Facility Management Program (SFMP), and Uranium Mill Tailings Remedial Action Program (UMTRAP). In the nuclear industry, several major corporations, led by Babcock & Wilcox, have formed a decontamination and decommissioning consortium to address generic concerns and problems.

The EPA staff, particularly personnel in Regional Offices, is gaining extensive site-specific experience in investigating, characterizing, and remediating radioactively contaminated sites. Sites discussed at the workshop included buildings with radium contamination dating from the early 1900s, private landfills and improperly operated disposal sites, and uranium processing sites. Major problems have been tracking historical records and identifying potentially responsible parties (PRPs), lack of applicable remediation standards, and costs for disposing of the contaminated wastes. Because of transportation and disposal costs for the large volumes of radioactively contaminated waste involved, EPA is sponsoring research in soil treatment to reduce the volume of contaminated material. Work at the radioactively contaminated sites has required extensive adaptation of existing equipment and technologies to address the unique problems found at these sites. Laboratory radiometric measuring instruments and protocols have been adapted to field surveys, and verification and aerial surveys are used to

identify the presence and extent of contamination. Various soil treatment technologies are being examined in an effort to reduce the volume of contaminated material requiring disposal at a licensed facility. In situ vitrification is being tested as a method of isolating the radioactive contaminants.

Problems and issues peculiar to these sites were the subject of four panel discussions: Listing and Ranking of Radioactive Sites, Problems in Investigation and Characterization, Are Standards Adequate?, and Technologies - Being Developed Fast Enough?

1. WELCOMING REMARKS: INTRODUCTION TO EPA OVERSIGHT OF FEDERAL AGENCY CLEANUPS

Nick Morgan
Environmental Protection Agency

I work in EPA's Federal Facilities Hazardous Waste Compliance Office, a special office, established in 1987, to ensure a nationally consistent compliance program for all Federal installations. Our primary areas of responsibility are the Resource Conservation Recovery Act, RCRA, and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Superfund law. Not only do we assist the regions in negotiating compliance agreements, but we also develop relevant RCRA and CERCLA guidance and policy. We also support general enforcement actions taken by the regional offices and handle any issues that are elevated for headquarters resolution.

To explain a little bit more about where this Federal Facilities Hazardous Waste Compliance Office fits within EPA, there are several larger offices underneath the Administrator. For example, the Office of Air and Radiation, the Office of Pesticides and Toxic Substances, and the Office of Solid Waste and Emergency Response (OSWER) which handles both Superfund and RCRA. We are a special office that reports to the director of the Office of Waste Programs Enforcement within OSWER. Unlike most offices, we handle several environmental statutes; RCRA and Superfund.

At this point, we have defined the universe of facilities that we are interested in. These include all major Federal installations, as well as any small Federal facility that may have had a release. We have identified about 1200 major Federal facilities nationwide with which we are concerned. These range in size from just a few acres to tens of thousands of acres, such as the Bureau of Land Management units. Most of these 1200 facilities are owned by the Department of Defense, Department of Energy, or Department of Interior, but we handle everything from Treasury buildings to DEA storage facilities. We cover the full range of contaminant types from explosives, to solvents, to radioactive materials. Additionally, we address any release, whether related to weapons manufacturing and testing or the production, processing and recovery of nuclear materials. We are especially interested in the releases of these hazardous substances if they pose threats to human health or the environment. These releases generally happen as a result of past disposal practices which were either indiscriminate or even best management practices of the time. Common disposal practice included the use of unlined pits, drainage ditches, discharge on the ground, as were as direct injection underground.

As I mentioned our office covers two environmental statutes -- RCRA and Superfund--and over the years, especially during the last two amendments of these two statutes, it became obvious that there's quite a bit of jurisdictional overlap between RCRA, which includes the HSWA amendments to deal with corrective action for past releases, and the Superfund law, which was amended by SARA and had a special section dealing with Federal facilities. Both of these statutes now deal with the same kind of issues; that is cleaning

up past contamination. We have spent a lot of time wondering about how to manage this jurisdictional overlap and I'll talk about that in just a moment.

First I'll mention something about RCRA. Section 6001 of RCRA requires that Federal facilities comply with the act, including permitting requirements, to the same extent as any private party. That sets the framework of how Federal agencies deal with RCRA. The act also requires that EPA conduct annual inspections at Federal facilities. We can't delegate that to the states, as we have with most of our other inspection authorities. EPA currently inspects 80 Federal land disposal facilities and 256 Federal treatment and storage facilities each year.

CERCLA Section 120 contains several requirements unique to Federal facilities. The first one is that EPA establish a docket of all Federal installations that need to go through the Superfund process. We established the first docket in February 1988, it was updated in November 1988 and again in December 1989.

At this point, the universe of Federal facilities on the docket is about 1200. For these Federal installations, a preliminary assessment, and, if required, a site inspection, must be conducted within 18 months of listing. The information is provided to EPA and we'll work with you to establish a Hazard Ranking Scoring (HRS) score for your facility. Where appropriate, EPA will list these facilities on the National Priorities List. In March of this year, we finally published a listing policy for Federal facilities. Under this listing policy we stated that we would include Federal facilities on the National Priorities List regardless of the status of RCRA permit or RCRA corrective action activities at that facility. That is different from private facilities where we do not list them on the NPL if they have a RCRA permit and are pursuing corrective action or will pursue corrective action in a responsible manner. This policy is the result of the SARA requirement that we list all Federal facilities on the NPL where appropriate.

Currently there are 41 Federal facilities on the NPL and 22 more proposed for listing. We expect that another 50 or 60 will be proposed within a month or two. That will be part of a special Federal facilities update, the last one to be conducted using the old Hazard Ranking System scoring model. The new model is out for comment under the NCP. If you have not submitted PA/SI data and a draft HRS score using the old model to EPA, your future requirements are to submit a draft HRS package using the new model. Ultimately we expect about 200 Federal facilities to be listed on the NPL and I expect that almost every major DOE operating facility will someday be on the NPL because most have significant enough releases to warrant inclusion on the NPL.

Another important component of CERCLA is the requirement that you begin a remedial investigation/feasibility study within 6 months of listing on the NPL. This means that you must have an approved work plan from EPA or you must have entered into an Interagency Agreement which contains the schedule for submitting your work plan within that 6-month time frame. That's different than the actual field work which most facilities have already initiated. Because we are interested in ensuring that any field work is consistent with EPA guidelines, we have determined that you must have a work plan approved by

the EPA office within 6 months of listing in order to meet this statutory requirement.

Furthermore, EPA and the states must publish enforceable time-tables and deadlines for the expeditious completion of your remedial investigation and feasibility study. EPA and the State are also required to be involved in the development and selection of the remedy at your site.

CERCLA further mandates that Federal installations on the NPL enter into an Interagency Agreement with EPA for any necessary remedial actions at your site. This is the real cornerstone of EPA's involvement at Federal facilities. These Interagency Agreements are the vehicles for selecting your remedy at the site. They are three-party agreements in almost every instance. We will work with you and the State to ensure that we have an agreement that covers all three parties' interest. We'll integrate RCRA requirements and CERCLA requirements into this one document so you have one frame-work for conducting the response. We're also going to enter these agreements as early as possible. We plan to start negotiations at the time of proposal to the NPL, where possible. We certainly intend to have executed the IAG by the time you've begun your remedial investigation/feasibility study. It's important to note that these agreements are then enforceable by citizens and the State.

To help in developing these Interagency Agreements, we developed model language with DOE and DOD headquarters in 1988. The model agreements have nine sections. They deal with the most confrontational and difficult to negotiate sections, so the folks in the field will not have to renegotiate these sections. They deal with issues such as enforceability, RCRA-CERCLA integration, dispute resolution, inspections, and funding. We have 10 agreements to date. Three are for DOE facilities: Lawrence Livermore - the first in the country to get signed, Monticello Properties, Utah, and the third, Hanford, is in draft right now and is out for public comment. We expect to be signing it on the 15th of this month.

Any site that does get on the NPL, or is proposed for inclusion on the NPL, as I mentioned, will be a candidate for negotiation of one of these agreements. We view these as really helpful agreements to the facilities; facility people will know where the state and EPA are coming from, what their requirements are going to be; useful for the states so they will know what their role and involvement in the process is; and for EPA so that we can have a defined role in commenting on documents. Furthermore, a time schedule is set so all parties can meet their review/comment and deliverable time frames.

CERCLA also mandates that cleanup activities begin 15 months after completion of the remedial investigation/feasibility study. The completion is defined as the signature of a Record of Decision (ROD). Once you complete the RI/FS, and sign the ROD with the EPA office, you must, within 15 months, begin substantial continuous physical onsite remedial action activity. Finally, CERCLA requires that annual reports be prepared and sent to Congress describing compliance with all these activities for all Federal facilities in the nation.

Now to look at your authorities, Executive Order 12580, which implements Superfund, clearly assigns to all Federal agencies the responsibility to perform all necessary response actions. You are designated the lead agencies, as defined in the National Contingency Plan, and it's your responsibility to actually perform the work in compliance with the NCP. It's your program and we are here to ensure that you do it properly. DOD is meetings its requirements through the Installation Restoration Program, which was started in 1975. They're spending about $500 million a year. DOE doesn't have as centralized a program set up yet but they're also spending about that much each year. Other agencies do not appear to have established as unified a program as the DOD's.

As we have jointly administered RCRA and CERCLA at Federal facilities over the last few years, we have become aware of several significant differences. For example, there is a very different enforcement process. Because of an incomplete waiver of sovereign immunity in RCRA 6001, and a lack of waiver in CERCLA, EPA may not issue unilateral orders under CERCLA against Federal installations. However, RCRA 3004U and provisions have been viewed as requirements. Hence, EPA can unilaterally issue such permit provisions. Cercla section 106 orders are certainly available, but only with Department of Justice concurrence.

It's also important to note that RCRA does not regulate the radioactive portions of mixed waste. It only regulates the chemical fractions of mixed waste, whereas CERCLA does regulate the radioactive portions of mixed waste, as well as any radioactive substance which may be released to the environment. RCRA does not regulate pure radioactive waste streams. Also, if the waste stream was permitted by the AEC or DOE and is a special nuclear byproduct, as defined by the AEC, or some special source material, RCRA will not regulate that substance either. Superfund, on the other hand, can address any radioactive substance since such materials, when released, may cause harm to human health and the environment.

At many installations we have listed the entire facility on the NPL, including all releases contained therein. RCRA, when you obtain your permit, requires that you do a facility assessment for the entire facility and look for all possible source areas. RCRA then regulates all the releases from those source areas. RCRA requires you to get a corrective action permit to address the releases from any possible source area that handles or handled a RCRA hazardous waste. Accordingly, at a NPL site, Superfund may be regulating the entire facility and RCRA will also be regulating all the releases from all the solid waste management units. Hence, two statutes will be regulating all of the same releases. This is where an Interagency Agreement will really help a facility sort out its requirements.

As you know, RCRA is a program which we ultimately delegate to the state. By law, they are allowed to implement a more stringent RCRA program than the federal RCRA program. When a state is operating its RCRA program in lieu of the Federal RCRA program, you will often have far stricter state requirements for corrective action. State corrective action requirements may, in fact, conflict with the Federal Superfund process even when both are regulating the exact same units. This additional complication can also be resolved through

the IAG. They are excellent vehicles for carving up responsibilities and resolving the regulatory overlaps.

We think the Hanford agreement is an excellent IAG model. Hanford is the first of its kind and is a working document, subject to change in future agreements. At Hanford the state has been given the authority to control the response at about half the units under its RCRA authority while EPA will maintain the lead for other sites under Superfund. The facility will sometimes be meeting State RCRA requirements while using the Superfund process for other sites. When there's a conflict, the two agencies will get together and discuss which of the two authorities will be used to clean up the particular sites.

During the scoping process in the Interagency Agreement, we carved up responsibilities at the site so we would know what was under which Agency's control. Accordingly, these interagency agreements allow you to investigate and cleanup a site following just one set of procedures, and not performing both State RCRA requirements and Federal Superfund requirements.

The real goal of all this is getting to cleanups. We're really interested in conferences like this because they will help transfer knowledge on cleanup technologies, as well as data on health and safety requirements. While this is a difficult task, for the Agencies who must actually do the work as well as the regulators who must do the oversight, it is an exciting challenge. I know that all of us at EPA look forward to working with you as we move towards sound, protective cleanups.

2. DEPARTMENT OF ENERGY
DEFENSE ENVIRONMENTAL RESTORATION REMEDIAL ACTIONS PROGRAM

Anthony Kluk
Department of Energy

The DOE Environmental Waste Cleanup 5-year Plan encompasses waste management operations, inactive site cleanup, and corrective actions needed at all DOE operating facilities to bring air, water, and solid waste discharges within acceptable limits. Through this plan DOE coordinates and consolidates all of its waste and cleanup activities. The plan provides a focus for management as well as a basis for FY 1991 programs. It accesses current technology development activities and also provides a basis for future research, development, and demonstration of new and innovative technologies. Finally, the plan places highest priority on facilities where there are known releases with the potential to affect public health and the environment.

The Environmental Restoration Remedial (ER) Actions Program (AP), created at the request of the House Armed Services Committee and assigned to the Office of Defense Waste and Transportation Management (DWTM) for management and execution, includes all phases of remediation of inactive radioactive, hazardous, and mixed waste sites at Defense Program installations. The program includes preliminary assessments and site inspections, remedial investigations and feasibility studies, and remedial actions at radioactively and nonradioactively contaminated sites that primarily meet the criteria of RCRA 3004(u), CERCLA, or SARA. Remediation associated with pre-1970 buried transuranic wastes is also included in the program. The decontamination and decommissioning of inactive defense facilities is a related activity under the ER Program which does a small number of soil cleanup activities.

The ER Program does NOT include the following:

- -RCRA compliance for currently generated waste streams
- -emergency spill response
- -waste management facilities not part of remediation
- -routine environmental monitoring
- -remediation of land units opened after March 1, 1987.

The budget for the ER Program for FY 1988, 1989, and 1990 is summarized below.

	Appropriation FY 1988	Appropriation FY 1989	Request FY 1990
	(thousands of dollars)		
Total Operations Offices	75,116	125,750	335,411
All Sites, Technology & Demonstrations	5,734	15,920	36,993
Total Decontamination & Decommissioning	16,988	17,655	28,889
Total-base program	97,838	159,325	401,293

The funding prioritization of tasks is based on the Program Optimization System (POS). The POS is based on multi-attribute decision analysis system, a quantitative approach for analyzing decisions with multiple objectives. It evaluates alternative funding levels, not specific projects, and recommends funding programs whose benefits exceed costs if funds are not constrained. If funds ARE constrained the POS selects programs with highest benefit-to-cost ratio. The system allows field offices to propose alternative programs and funding levels. The alternative programs are scored against quantitative performance measures representing health and safety, regulatory responsiveness, public concern, mission impact, and costs. The field office scores are then reviewed and revised, if appropriate, at workshops involving representatives from the field offices and headquarters (three such workshops have been held to date). To assist in the allocation of the total ER budget among the field offices, DOE uses a computer program that maximizes net value or benefit.

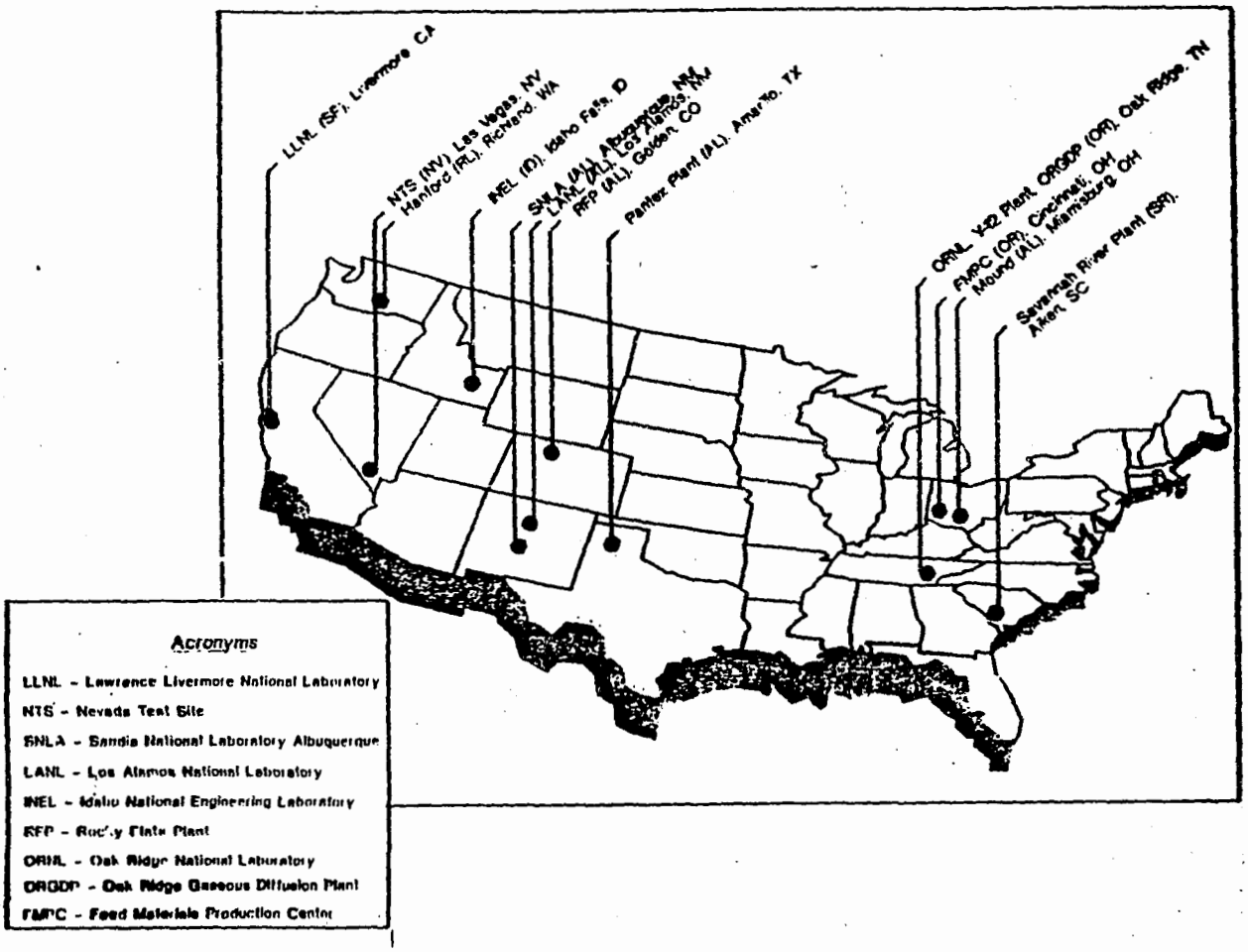


Figure 1. Environmental Restoration Program DOE/DP Locations

Table 1. Environmental Restoration Remedial Actions Program
Radioactive Mixed Waste Summary
Albuquerque Operations Office

INSTALLATION	NO. OF POTENTIAL RELEASE SITES[a]	RELEASE SITE TYPES
KANSAS CITY PLANT	NONE IDENTIFIED	NOT APPLICABLE
LOS ALAMOS NATIONAL LABORATORY (51 WAGS)	470	CONTAMINATED AREAS, OPERATIONAL RELEASES, SEPTIC SYSTEMS, DISPOSAL AREAS, FIRING SITES, BURNING PITS, LANDFILLS, OUTFALLS, SURFACE IMPOUNDMENTS, DRUM STORAGE, STORAGE TANKS, DRAIN LINES, INCINERATORS, WASTE WELLS, WASTE LINES, SUMPS, SHAFTS, STABILI-ZATION PITS, BUILDING DEBRIS
MOUND PLANT (2 WAGS)	19+	CONTAMINATED SOIL LANDFILLS, BUILDINGS UNIDENTIFIED SOURCES
PANTEX PLANT (2 WAGS)	10	LANDFILL, SURFACE DEPOSITS, TRENCHES, SHAFTS
PINELLAS PLANT	NONE IDENTIFIED	NOT APPLICABLE
ROCKY FLATS PLANT (1 WAG)	17	SURFACE SPILLS, LANDFILL, TRENCHES
SANDIA NATIONAL LABORATORIES ALBUQUERQUE (10 WAGS)	68+	SURFACE IMPOUNDMENTS, SPILLS, DRAINFIELDS, LANDFILLS, SEPTIC SYSTEMS, SURFACE CONTAMINATION, SCRAP YARDS, TEST HOLES, BURN SITES, BURIAL MOUNDS, BUNKERS, DISPOSAL PITS, TRENCHES, OUTFALLS
SANDIA NATIONAL LABORATORY LIVERMORE	NONE IDENTIFIED	NOT APPLICABLE

[a] Total number of release sites in WAGs. Specific radioactive and mixed waste release site information has not been reported.

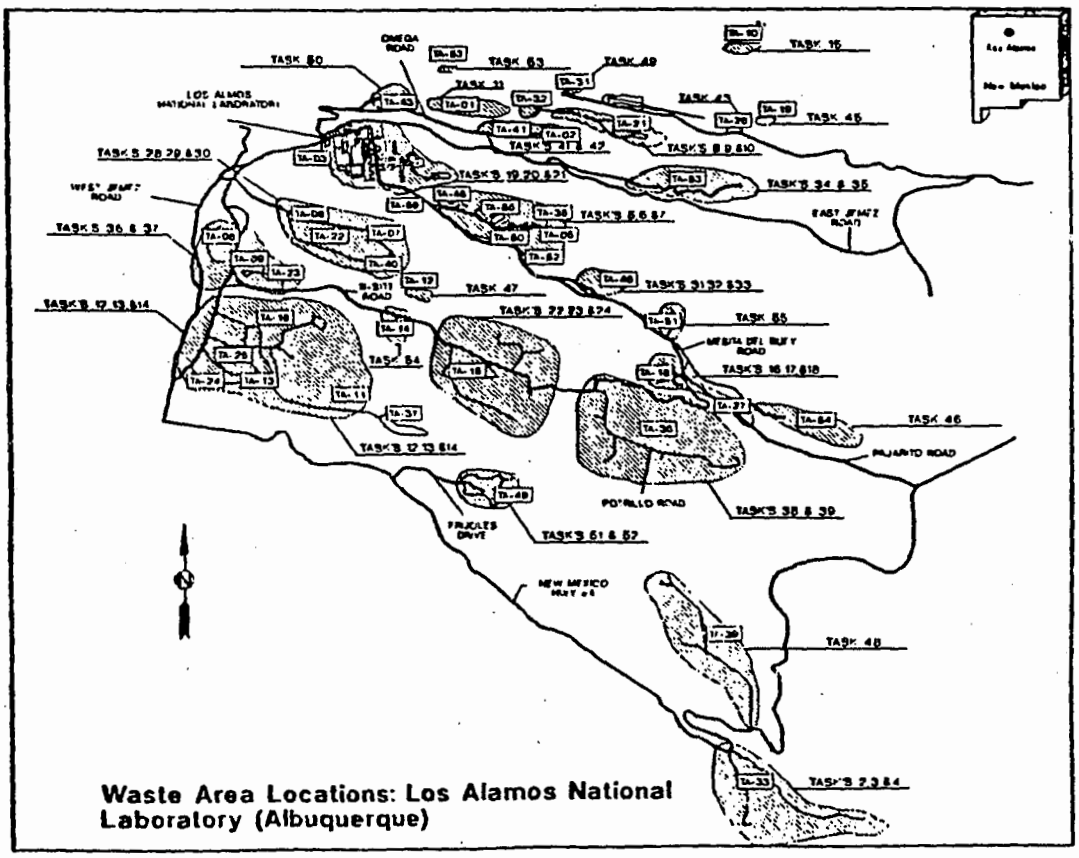


Figure 2. LANL

Table 2. Environmental Restoration Remedial Actions Program Radioactive Mixed Waste Summary Albuquerque Field Office, Los Alamos National Laboratory

WAG ID NO.	WAG TITLE	NO. OF POTENTIAL SITES [a]	RAD/MIX CONTAMINANTS	RELEASE SITE TYPES
AL-LA-1	TA[b]-CANYONS	NA	RADIONUCLIDES	CONTAMINATED AREAS
AL-LA-2	TA-33	8	RADIONUCLIDES	CONTAMINATED AREAS/OPERATIONAL RELEASES/SEPTIC SYSTEMS/ MATERIAL DISPOSAL AREAS D, E, AND K
AL-LA-3	TA-33	24	RADIONUCLIDES	CONTAMINATED AREAS/FIRING SITES/BURNING PITS LANDFILLS/OUTFALLS
AL-LA-4	TA-33	1	URANIUM	FIRING SITES
AL-LA-5	TA-4,5,35,42, 48,50,52,55	20	RADIONUCLIDES	CONTAMINATED AREAS/SEPTIC SYSTEMS/OPERATIONAL RELEASES/SURFACE IMPOUNDMENTS/MATERIAL DISPOSAL AREAS C,R,W
AL-LA-6	TA-4,5,35,42, 48,50,52,55 48,50,52,55	14	URANIUM/ RADIONUCLIDES	CONTAMINATED AREAS/ UNDERGROUND STORAGE TANKS/SEPTIC SYSTEMS/ OPERATIONAL RELEASES/ FIRING POINTS
AL-LA-7	TA-4,5,35,42, 48,50,52,55	11	RADIONUCLIDES	CONTAMINATED AREAS/SEPTIC SYSTEMS/OUTFALLS/DRUM STORAGE/UNDERGROUND STORAGE TANKS
AL-LA-8	TA-21	11	RADIONUCLIDES	OPERATIONAL RELEASES/ OUTFALLS/DRAIN LINES/ MATERIAL U AND V
AL-LA-9	TA-21	17	RADIONUCLIDES	LANDFILLS/SEEPAGE PITS/SUMPS/UNDERGROUND STORAGE TANKS
AL-LA-10	TA-21	12	RADIONUCLIDES	CONTAMINATED AREAS/ LANDFILLS/LIQUID WASTE WELLS/INCINERATORS/ SURFACE DISPOSAL
AL-LA-11	TA-1	11	RADIONUCLIDES	CONTAMINATED AREAS/ACID WASTE LINES/SEPTIC SYSTEMS/DISPOSAL AREAS
AL-LA-13	TA-11,13,16, 24,25	65	RADIONUCLIDES	CONTAMINATED AREAS/SEPTIC SYSTEMS/OPERATIONAL RELEASES/SURFACE IMPOUNDMENTS/OUTFALLS/ FIRING SITES/LANDFILLS/ DRY WELLS/SUMPS/STORAGE TANKS
AL-LA-14	TA-11,13,16, 24,25	8	RADIONUCLIDES	CONTAMINATED AREAS/SEPTIC SYSTEMS/LANDFILLS/BURNING PITS
AL-LA-15	TA-10	8	RADIONUCLIDES	CONTAMINATED AREAS/ LANDFILLS/SEPTIC SYSTEMS
AL-LA-16	TA-18,27	2	RADIONUCLIDES	CONTAMINATED AREAS/ LANDFILLS/OPERATIONAL RELEASES
AL-LA-17	TA-18,27	12	RADIONUCLIDES	CONTAMINATED AREAS/ FIRING PITS/SEPTIC SYSTEMS/OPERATIONAL RELEASES
AL-LA-18	TA-18, 27	16	RADIONUCLIDES	CONTAMINATED AREAS/ FIRING SITES/UNDERGROUND STORAGE TANKS/SEPTIC TANKS
AL-LA-19	TA-2, 59	9	RADIONUCLIDES	CONTAMINATED AREAS/ SEPTIC SYSTEMS/ UNDERGROUND STORAGE TANKS/SUMPS/OUTFALLS/ LANDFILLS
AL-LA-20	TA-3, 59	14	RADIONUCLIDES	CONTAMINATED AREAS/ OUTFALLS/LAGOONS/PITS/ SEPTIC SYSTEMS/LANDFILLS
AL-LA-21	TA-3, 59	14	RADIONUCLIDES	CONTAMINATED AREAS/ OPERATIONAL RELEASES/ UNDERGROUND STORAGE TANKS/SUMPS/SEPTIC SYSTEMS
AL-LA-22	TA-15	8	RADIONUCLIDES	CONTAMINATED AREAS/ BURNING PITS/SHAFTS/ PITS/SHAFTS/SEPTIC SYSTEMS/SUMPS/MATERIAL DISPOSAL AREAS N AND Z
AL-LA-23	TA-15	13	RADIONUCLIDES	CONTAMINATED AREAS/FIRING SITES/LANDFILLS
AL-LA-24	TA-15	15	RADIONUCLIDES	CONTAMINATED AREAS/SUMPS/ SEPTIC SYSTEMS/OUTFALLS/ OPERATIONAL RELEASES
AL-LA-25	TA-0	13	URANIUM	CONTAMINATED AREAS/ LANDFILLS/INCINERATORS/ FIRING RANGES
AL-LA-26	TA-0	2	RADIONUCLIDES	CONTAMINATED AREAS/ LANDFILLS
AL-LA-27	TA-0	7	RADIONUCLIDES	CONTAMINATED AREAS/ INCINERATORS/UNDERGROUND STORAGE TANKS
AL-LA-28	TA-6,7,22,40	11	RADIONUCLIDES	CONTAMINATED AREAS/ DISPOSAL PITS/FIRING SITES/SEPTIC SYSTEMS/ OPERATIONAL RELEASES/ SUMPS/MATERIAL DISPOSAL AREA F
AL-LA-29	TA-6,7,22,40	14	RADIONUCLIDES	CONTAMINATED AREAS/SEPTIC SYSTEMS/SUMPS/UNDERGROUND STORAGE TANKS/FIRING PITS/LANDFILLS
AL-LA-31	TA-46	5	RADIONUCLIDES	CONTAMINATED AREAS/ OUTFALLS/SPILLS/ OPERATIONAL RELEASES/ SEPTIC SYSTEMS
AL-LA-32	TA-46	10	RADIONUCLIDES	CONTAMINATED AREAS/SEPTIC SYSTEMS/SUMPS/LANDFILLS
AL-LA-34	TA-20,53	3	RADIONUCLIDES	CONTAMINATED AREAS/ DISPOSAL PITS/FIRING SITES/LAGOONS/OUTFALLS
AL-LA-35	TA-20	8	RADIONUCLIDES	CONTAMINATED AREAS/ DISPOSAL PITS/OUTFALLS
AL-LA-36	TA-8,9,23	10	RADIONUCLIDES	CONTAMINATED AREAS/SEPTIC SYSTEMS/FIRING SITES/ LANDFILLS/OUTFALLS/SUMPS/ PITS/MATERIAL DISPOSAL AREAS M AND Q
AL-LA-37	TA-8,9,23	8	RADIONUCLIDES	CONTAMINATED AREAS/ FIRING SITES/LANDFILLS/ BURNING PITS/LIQUID WASTE HOLDING/MATERIAL DISPOSAL AREA M
AL-LA-38	TA-36	8	RADIONUCLIDES	CONTAMINATED AREAS/ FIRING SITES/LANDFILLS/ BURNING PITS/LIQUID WASTE HOLDING/MATERIAL DISPOSAL AREA M
AL-LA-39	TA-36	6	RADIONUCLIDES	CONTAMINATED AREAS/FIRING SITES/LANDFILLS/DROP TOWERS
AL-LA-40	TA-32	8	RADIONUCLIDES	CONTAMINATED AREAS/SEPTIC SYSTEMS/INCINERATORS
AL-LA-41	TA-2,41	8	RADIONUCLIDES	CONTAMINATED AREAS/ OPERATIONAL RELEASES/ OUTFALLS/SEPTIC SYSTEMS/ SUMPS AND LINES
AL-LA-42	TA-2,41	4	RADIONUCLIDES	CONTAMINATED AREAS/ OPERATIONAL RELEASES/BURN PITS/OIL STORAGE AREAS
AL-LA-43	TA-26	3	RADIONUCLIDES	CONTAMINATED AREAS/SEPTIC SYSTEMS/OUTFALLS/LANDFILLS
AL-LA-44	TA-26	2	RADIONUCLIDES	CONTAMINATED AREAS/ SEPTIC SYSTEMS/OUTFALLS
AL-LA-45	TA-19	2	RADIONUCLIDES	CONTAMINATED AREAS/SEPTIC SYSTEMS/BUILDING DEBRIS
AL-LA-46	TASK 54	4	RADIONUCLIDES	MATERIAL DISPOSAL AREAS G, H, J, AND L
AL-LA-47	TA-12	5	RADIONUCLIDES	CONTAMINATED AREAS/ FIRING SITES/PITS/ OPERATIONAL RELEASES
AL-LA-48	TA-39	5	RADIONUCLIDES	CONTAMINATED AREAS/FIRING SITES/LANDFILLS/SEPTIC SYSTEMS/MATERIAL DISPOSAL AREA T
AL-LA-50	TA-43	2	RADIONUCLIDES	CONTAMINATED AREAS/ OUTFALLS
AL-LA-51	TA-49	2	RADIONUCLIDES	CONTAMINATED AREAS/SEPTIC SYSTEM LEACH FIELDS/ MATERIAL DISPOSAL AREA AB
AL-LA-52	TA-49	1	RADIONUCLIDES	CONTAMINATED AREAS/ BURNING AREAS/MATERIAL DISPOSAL AREA AB
AL-LA-53	TA-45	1	RADIONUCLIDES	CONTAMINATED AREAS/ OUTFALLS/DRAINS
AL-LA-54	TA-34	3	RADIONUCLIDES	CONTAMINATED AREAS/FIRING SITES/BURNING AREAS/ LANDFILLS
AL-LA-56	TA-57	1	RADIONUCLIDES	CONTAMINATED AREAS/ DISPOSAL AREAS
TOTAL	51	470		

[a] Total number of release sites in WAG. Specific radioactive and mixed waste site information has not been reported.

[b] Technical Area.

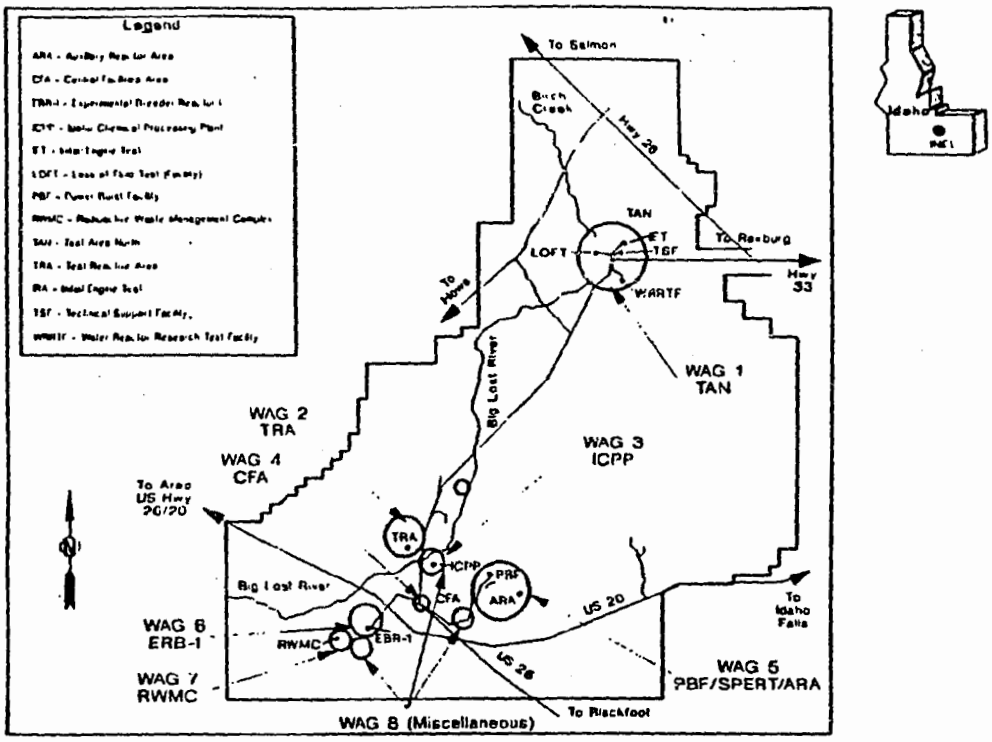


Figure 3. Waste Area Locations: Idaho National Engineering Laboratory (Idaho)

Table 3. Environmental Restoration Remedial Actions Program Radioactive/Mixed Waste Summary Idaho Operations Office, Idaho National Enginneering Lab.

WAG ID NO.	WAG TITLE	NO. OF POTENTIAL SITES [a]	RAD/MIX CONTAMINANTS	RELEASE SITE TYPES
1	TEST AREA NORTH	61	RADIONUCLIDES	TANKS/PITS/SPILLS/WELLS/ PONDS/LEACH FIELDS
2	TEST REACTIVE AREA	39	RADIONUCLIDES	PITS/DITCHES/PONDS/WELLS TANKS/PILES/SPILLS
3	CHEMICAL PROCESSING	78	RADIONUCLIDES	SPILLS/TANKS
5	PBF/SPERT/ ARA	47	RADIONUCLIDES	TANKS/PITS/PONDS/LEACH FIELDS/DITCHES/WELLS/ LANDFILLS
6	EBR/BORAX	19	RADIONUCLIDES	TANKS/POND/LANDFILLS/ SEEPAGE PITS
7	RWMC	5	RADIONUCLIDES	BURIAL GROUNDS AND EARTH COVERED STORAGE
8	MISCELLANEOUS	10	RADIONUCLIDES	PITS/PONDS/WELLS/TANKS
TOTAL	7	259		

[a] Total number of release sites in WAG. Specific radioactive and mixed waste site information has not been reported.

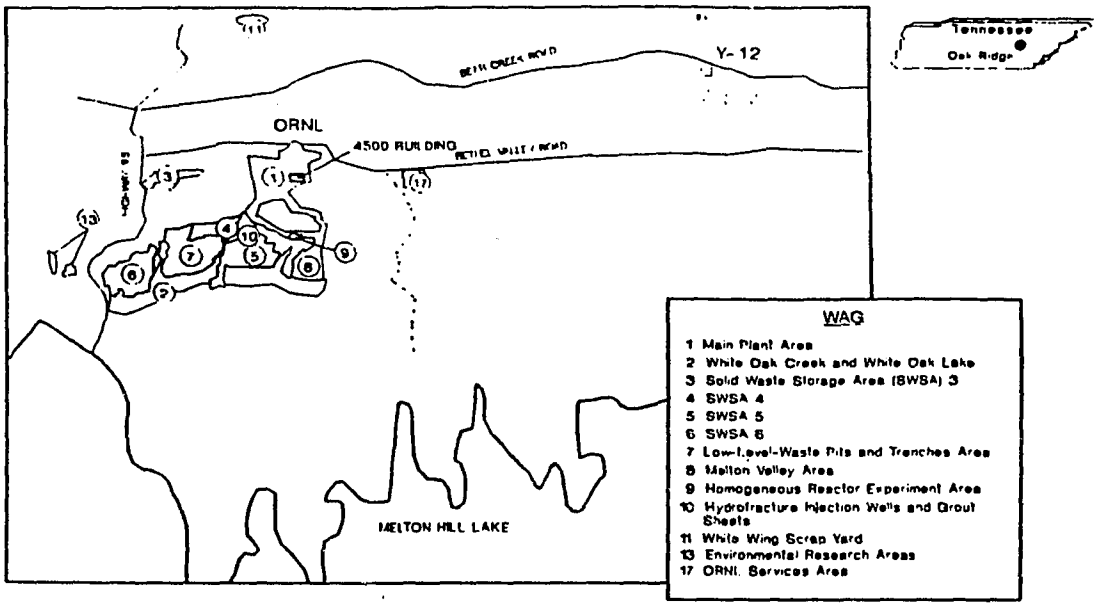


Figure 4. Waste Area Locations: Oak Ridge National Laboratory (Oak Ridge)

Table 4. Environmental Restoration Remedial Actions Program Radioactive/Mixed Waste Release Site Summary Oak Ridge Operations Office, Oak Ridge National Laboratory

WAG ID NO.	WAG TITLE	NO. OF RELEASE SITES[a]	PRINCIPAL CONTAMINANTS	RELEASE SITE TYPE
1	MAIN PLANT AREA	99	RADIONUCLIDES	SPILLS/LEAKS/ SURFACE IMPOUNDMENTS/BURIAL GROUNDS/UNDERGROUND STORAGE TANKS WASTE TRANSFER
			LINES	
2	WHITE OAK CREEK AND WHITE OAK LAKE	2	RADIONUCLIDES	WHITE OAK CREEK WATERSHED
3	SOLID WASTE STORAGE AREA (SWSA) 3	3	RADIONUCLIDES	BURIAL GROUNDS
4	SWSA 4	3	RADIONUCLIDES	LEAKS/BURIAL GROUNDS
5	SWSA 5	13	RADIONUCLIDES	SPILLS/LEAKS/BURIAL GROUNDS
6	SWSA 6	3	RADIONUCLIDES	BURIAL GROUNDS/DETONATION TRENCHS
7	LOW-LEVEL PITS AND TRENCHES	12	RADIONUCLIDES	SPILLS/LEAKS/PITS/ TRENCHES
8	MELTON VALLEY AREA	11	RADIONUCLIDES	SPILLS/LEAKS
9	HOMOGENEOUS REACTOR EXPERIMENT AREA	3	RADIONUCLIDES	SURFACE IMPOUNDMENTS/ LEAKS
10	HYDROFRACTURE INJECTION WELLS AND GROUT SHEETS	4	RADIONUCLIDES INJECTION POINTS	UNDERGROUND
11	WHITE WING SCRAP YARD	1	RADIONUCLIDES	SURFACE CONTAMINATION
13	ENVIRONMENTAL RESEARCH AREAS	2	RADIONUCLIDES	SURFACE CONTAMINATION
14	TOWER SHIELLDING FACILITY	2	RADIONUCLIDES	SURFACE CONTAMINATION
15	FACILITIES AT Y-12	2	RADIONUCLIDES	SURFACE CONTAMINATION
16	HEALTH PHYSICS RESEARCH REACTOR	8	RADIONUCLIDES	SURFACE CONTAMINATION/ IMPOUNDMENT
17	OAK RIDGE LAND FARM	1	RADIONUCLIDES	SURFACE DISPOSAL
TOTAL	16	169		

[a] Total number of release sites in WAG. Specific radioactive and mixed waste site information has not been reported.

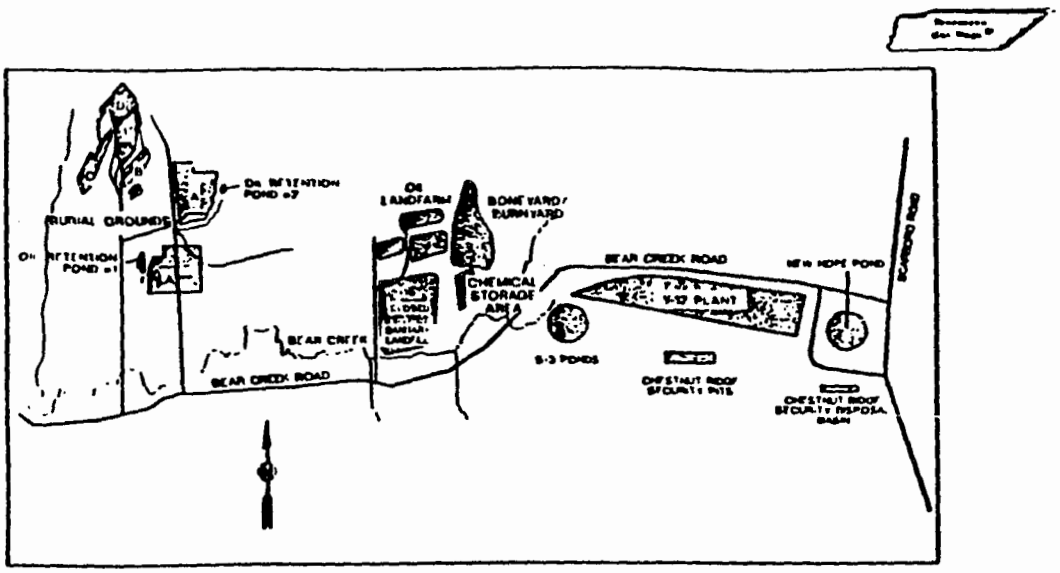
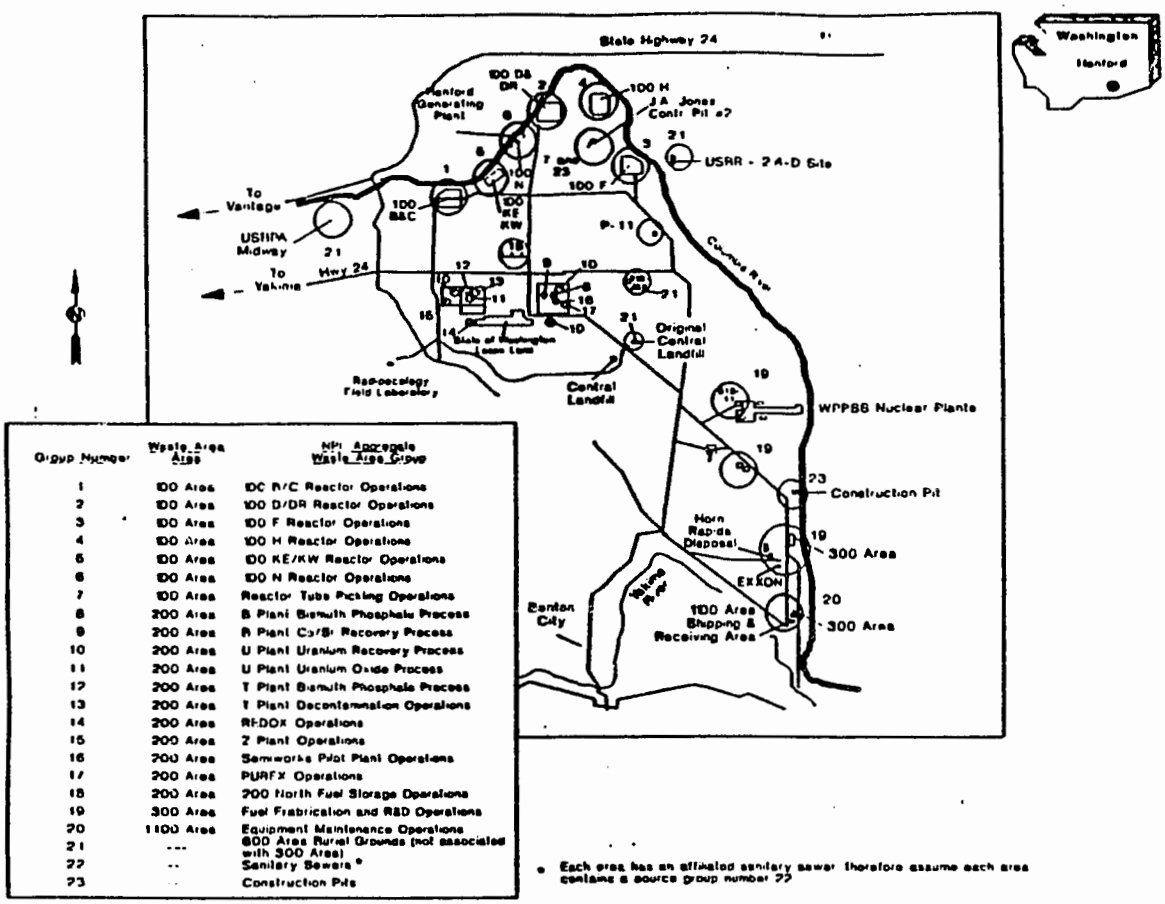


Figure 5. Waste Area Location: Y-12 Plant, Oak Ridge

Table 5. Environmental Restoration Remedial Actions Program
Radioactive/Mixed Waste Release Site Summary
Oak Ridge Operations Office
Y-12 Plant

WAG ID NO.	WAG TITLE	NO. OF RELEASE SITES[a]	PRINCIPAL CONTAMINANTS	RELEASE SITE TYPE
Y-003	WASTE MACHINE COOLANT BIODEGRADATION FACILITY	1	URANIUM	CONCRETE BASIN/ EFFLUENT BRAIN FIELD
Y-004	S-3 PONDS	1	RADIONUCLIDES	SURFACE IMPOUNDMENT
Y-010	NEW HOPE POND	1	URANIUM	SURFACE IMPOUNDMENT
S-020	SALVAGE YARD & OIL SOLVENT DRUM STORAGE AREA	2	URANIUM	DRUM STORAGE UNIT
O-023	CHESTNUT RIDGE SECURITY PITS	2	URANIUM	LANDFILL
O-024	BEAR CREEK BURIAL GROUNDS	12	RADIONUCLIDES	LANDFILL
S-030	INTERIM DRUM STORAGE YARD	1	URANIUM	DRUM STORAGE UNIT
S-017	9409-5 STORAGE FACILITY	1	URANIUM	BULK STORAGE-ABOVE GROUND TANKS
Y-038	WASTE COOLANT PROCESSING FACILITY	1	URANIUM	TREATMENT
O-104	COAL PILE TRENCH	1	URANIUM	DISPOSAL
Y-109	SALVAGE YARD DRUM DEHEADER	1	URANIUM	TREATMENT
S-111	SALVAGE YARD SCRAP METAL STORAGE AREA	1	URANIUM	STORAGE
O-115	9418-3 URANIUM VAULT	1	URANIUM	DISPOSAL
S-203	TANK 0690-U TRANSFER STA.	1	URANIUM	STORAGE
S-217	TANK	1	URANIUM	STORAGE
S-218	TANK	1	URANIUM	STORAGE
S-227	TANK	1	URANIUM	STORAGE
S-228	TANK	1	URANIUM	STORAGE
S-313	DOCK 164	1	URANIUM	STORAGE
S-321	9201-1 WEST YARD	1	URANIUM	CONTAINER ACCUMULATION
S-335	9401-3 EAST YARD	1	URANIUM	CONTAINER ACCUMULATION
Y-1	NITRIC ACID PIPELINE	TBD	URANIUM	WASTE TRANSFER LINE
Y-2	UPPER EAST FORK POPLAR CREEK	TBD	URANIUM	SURFACE WATER STREAM
Y-3	EAST FORK POPLAR CREEK	TBD	URANIUM	SURFACE WATER STREAM
Y-4	BEAR CREEK	TBD	URANIUM	SURFACE WATER STREAM
TOTAL		25	34+	

[a] Total number of release sites in WAGs. Specific radioactive and mixed waste site information has not been reported.



Group Number	Waste Area Area	NPL Aggregate Waste Area Group
1	100 Area	100 B/C Reactor Operations
2	100 Area	100 D/DR Reactor Operations
3	100 Area	100 F Reactor Operations
4	100 Area	100 H Reactor Operations
5	100 Area	100 KE/KW Reactor Operations
6	100 Area	100 N Reactor Operations
7	100 Area	Reactor Tube Pickling Operations
8	200 Area	B Plant Bismuth Phosphate Process
9	200 Area	B Plant Cs/Sr Recovery Process
10	200 Area	U Plant Uranium Recovery Process
11	200 Area	U Plant Uranium Oxide Process
12	200 Area	T Plant Bismuth Phosphate Process
13	200 Area	T Plant Decontamination Operations
14	200 Area	REDOX Operations
15	200 Area	Z Plant Operations
16	200 Area	Semiworks Pilot Plant Operations
17	200 Area	PUREX Operations
18	200 Area	200 North Fuel Storage Operations
19	300 Area	Fuel Fabrication and R&D Operations
20	1100 Area	Equipment Maintenance Operations
21	---	600 Area Rural Grounds (not associated with 300 Area)
22	--	Sanitary Sewers *
23	-	Construction Pits

* Each area has an affiliated sanitary sewer therefore assume each area contains a source group number 22

Figure 6. Waste Area Locations: Hanford (Richland)

Table 6. Environmental Restoration Remedial Action Program Radioactive/Mixed Waste Release Site Summary Richland Operations Office, Hanford Site

WAG ID NO.	WAG TITLE	NO. OF RELEASE SITES[a]	PRINCIPAL CONTAMINANTS	RELEASE SITE TYPE
1	100 B/C REACTOR OPERATIONS	37	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
2	100D/DR REACTOR	32	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
3	100 F REACTOR OPERATIONS	28	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
4	100 H REACTOR OPERATIONS	18	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
5	100 KE/W REACTOR OPERATIONS	35	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
6	100 N REACTOR OPERATIONS	22	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
7	B PLANT OPERATIONS	70	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
8	U PLANT OPERATIONS	97	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
9	T PLANT OPERATIONS	71	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
10	REDOX OPERATIONS	67	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
11	Z PLANT OPERATIONS	36	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
12	SEMIWORKS PILOT PLANT OPERATIONS	17	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
13	PUREX OPERATIONS	90	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
14	200 N FUEL STORAGE OPERATIONS	8	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
15	FUEL FABRICATIONS AND R & D OPERATIONS	66	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
16	EQUIPMENT MAINTENANCE OPERATIONS	12	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
17	600 AREA ISOLATED UNITS	15	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
18	SUPPORT SERVICES OPERATIONS	TBD	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
18A	SINGLE SHELL TANKS	161	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
18B	OTHER (NOT YET ASSIGNED TO WAGS	518	RADIONUCLIDES	LIQUID/SOLID/UNPLANNED
TOTAL	20	1,390		

[a] Total number of release sites in WAG. Specific radioactive and mixed waste site information has not been reported.

Table 7. DOE Operations Offices Environmental Restoration Remedial Actions Program, Comparison of Radioactive/Mixed vs. Total Release Sites

OPERATIONS OFFICE	INSTALLATION	TOTAL NUMBER OF RELEASE SITES[a]	NUMBER OF RADIOACTIVE/MIXED WASTE RELEASE SITES[b]
ALBUQUERQUE	KANSAS CITY PLANT	27	0
	LOS ALAMOS NATIONAL LABORATORY	508	470
	MOUND PLANT	20+	19+
	PANTEX PLANT	46	18
	PINELLAS PLANT	13	0
	ROCKY FLATS PLANT	104	17
	SANDIA NATIONAL LABORATORIES ALBUQUERQUE	81+	68+
	SANDIA NATIONAL LABORATORIES LIVERMORE	4	0
IDAHO	IDAHO NATIONAL ENGINEERING LABORATORY	301	259
NEVADA	NEVADA TEST SITE AND OFF-SITE AREAS	726	725
OAK RIDGE	FEED MATERIALS PRODUCTION CENTER	27	14
	OAK RIDGE NATIONAL LABORATORY	387	169
	Y-12 PLANT	APPROXIMATELY 165	34+
RICHLAND	HANFORD	1,390	1,390
SAN FRANCISCO	LAWRENCE LIVERMORE NATIONAL LABORATORY	TBD	TBD
SAVANNAH	SAVANNAH RIVER PLANT	320	84
	TOTAL:	3,719+	3,259+

[a] Total number of release sites in all WAGs.

[b] Total number of release sites in WAGs known or suspected to contain radionuclides. Specific radioactive and mixed waste release site data has not been reported.

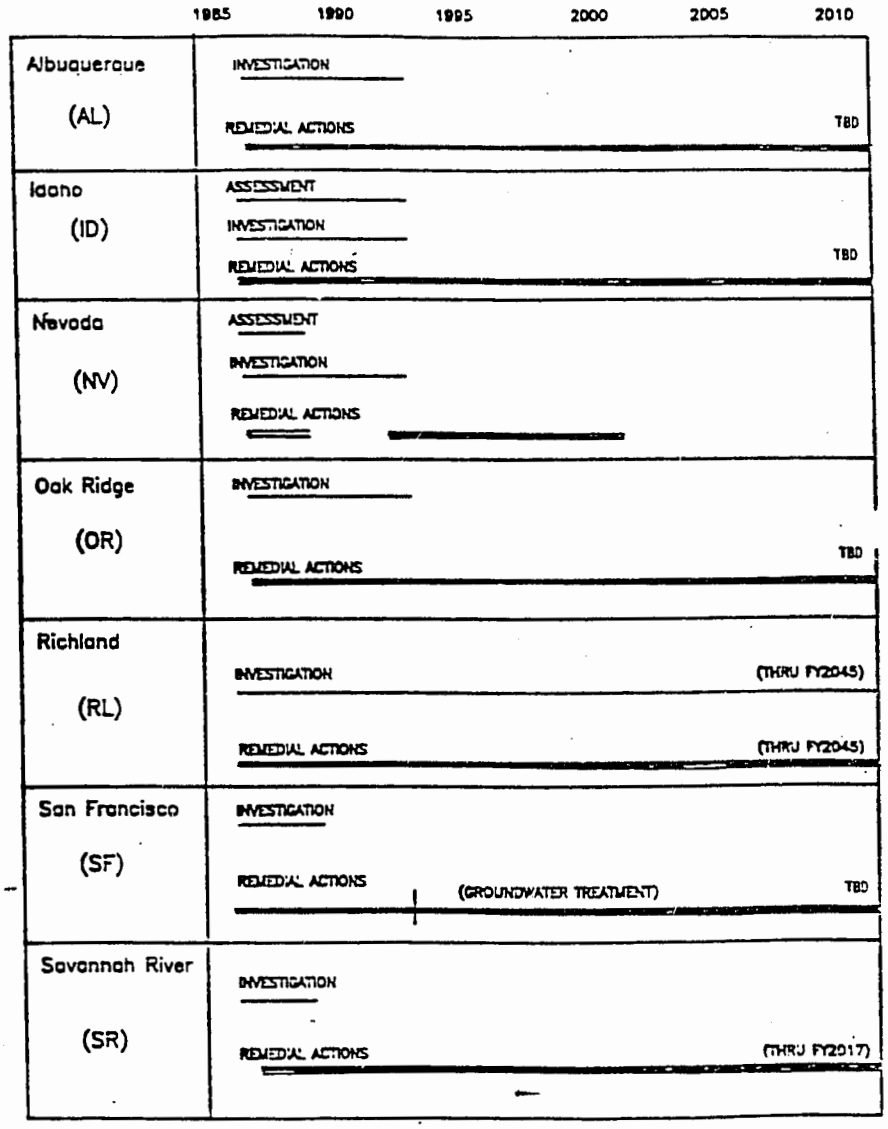
Table 8. DOE DP Operations Offices Environmental Restoration Remeidal Actions Program, Rough Comparison of Estimated Waste Volumes, Total Program vs. Radioactive/Mixed/Other[a,b,c]

INSTALLATION	ESTIMATED VOLUME OF WASTE (CUBIC YARDS) ALL WAGS	WAGS WITH RAD/ MIXED/OTHER WASTE
IDAHO NATIONAL ENGINEERING LABORATORY	2,411,360	2,201,360
NEVADA TEST SITE & OFF-SITE FACILITIES	TBD	TBD
FEED MATERIALS PRODUCTION CENTER	875,500+	EST. 861,500
OAK RIDGE NATIONAL LABORATORY	TBD	TBD
Y-12 PLANT	TBD	TBD
OAK RIDGE GASEOUS DIFFUSION PLANT	TBD	TBD
HANFORD	1,892,494,919	1,892,494,919
LAWRENCE LIVERMORE NATIONAL LABORATORY	TBD	TBD
SAVANNAH RIVER PLANT	76,345,800	75,997,800
TOTAL:	1,981,269,432	1,980,158,649

[a] Volume reported for radioactive/mixed waste is actually the total for all release sites in WAGS with radioactive/mixed waste and may include nonradioactive/mixed waste volumes.

[b] All volumes are very rough approximations. Future RI activity will provide more accurate data.

[c] Data take from the Environmental Restoration Program and Implementation Plan, October 31, 1988.



Reference: Environmental Restoration Program and Implementation Plan, October 31, 1988

Figure 7. Environmental Restoration Remedial Actions Long-Range Schedule Summary

3. OVERVIEW OF FUSRAP AND SFMP

James W. Wagoner II
Department of Energy

The Formerly Utilized Sites Remedial Action Program (FUSRAP) and the Surplus Facilities Management Program (SFMP) are two of DOE's major hazardous waste management programs. FUSRAP currently includes 30 sites, 25 sites formerly used by the Manhattan Engineering District or its successor, the Atomic Energy Commission, and 5 sites assigned by Congress. SFMP includes 41 projects involving decontamination and disposal of surplus DOE nuclear-contaminated facilities and sites.

FUSRAP

This program addresses the safe management, decontamination, and disposal of all formerly utilized sites, and any other sites assigned by Congress. This will include a complete comprehensive site search and screening process; assurance of public health and safety through effective surveillance and maintenance and cost-effective, safely planned remedial action; and the development of new permanent disposal sites and transport of wastes to those sites.

Under this program, 350 sites will be reviewed to determine the potential for contamination and authority for remediation; remedial actions based on potential health effects, Congressional priorities, and other factors; and a means to store waste on an interim basis until permanent disposal sites are available. The program also encompasses working with the state of waste origin to locate candidate disposal sites and coordinating activities with EPA (for sites on the National Priorities List) and states.

SFMP

This program addresses the safe management, decontamination, and disposal of surplus DOE nuclear-contaminated facilities and sites. This program will assure public health and safety through effective surveillance and maintenance, cost-effective and safely planned remedial actions, proper disposal of radioactive waste, and full compliance with all applicable Federal and state environmental regulations. DOE will seek to maximize re-use of facilities or sites, provide D&D technology transfer of experience to the nuclear industry, and participate in and benefit from the exchange of experiences through international collaboration.

This program currently includes 41 projects: 30 remaining at 15 different sites, including 6 at non-DOE laboratory locations. Completion of the current inventory is targeted for about 2015. Decommissioning activities will be assigned priorities on the basis of potential environmental and public impacts, legal/regulatory requirements, optimization of government expenditures, and maximizing manpower resources. Additional facilities will be added to the program as appropriate.

SFMP projects cover the full range of the nuclear fuel cycle and nuclear research facilities, including uranium extraction and refining facilities, waste storage/disposal sites, uranium and thorium metal fabricating facilities, research and power reactors, research facilities (hot cells, glove boxes, etc.), and spent fuel storage. Materials include contaminated structures and building rubble, equipment, process residue, soil, and ground water. Wind and surface water erosion and the movement of residues by individuals have resulted in contamination of properties in the vicinity of several of the major FUSRAP and SFMP sites. Approximately 100 vicinity properties require remedial action, and surveys to identify additional properties are continuing.

Wastes and residues consist of low-level wastes, including some greater than class C and by-product materials, uranium and thorium tailings or process residues (AEA 11e(2)) by-product material, TRU wastes, and mixed chemical and radioactive wastes. The major contaminants include radium, uranium, and thorium and their decay products and transuranics including plutonium, induced radiation (i.e., Co-60), and fission products. Contaminated soil and residue containing uranium, thorium, and radium account for the greatest volume of wastes, presently estimated to exceed 2 million yd^3. These will require establishment of several special disposal sites; other wastes will be disposed of at existing DOE disposal sites.

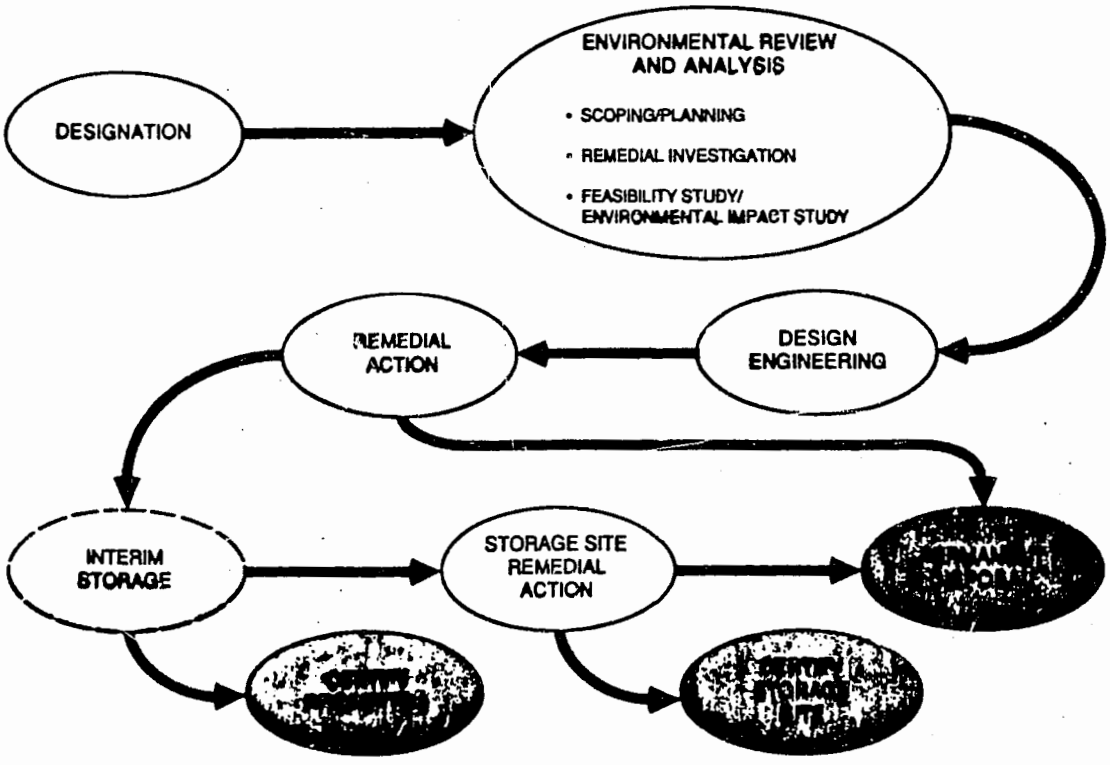
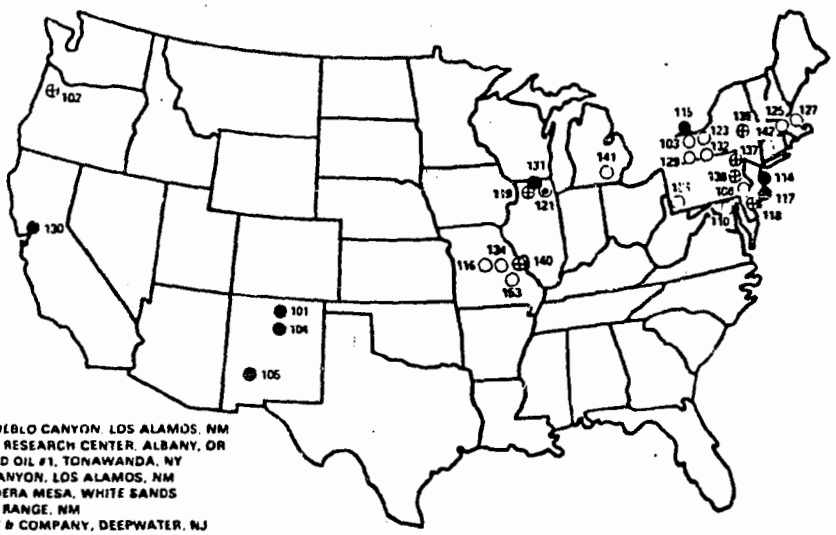


Figure 1. Basic Steps in the Remedial Actions Program



101 ACID/PUEBLO CANYON, LOS ALAMOS, NM
102 ALBANY RESEARCH CENTER, ALBANY, OR
103 ASHLAND OIL #1, TONAWANDA, NY
104 BAYO CANYON, LOS ALAMOS, NM
105 CHUPADERA MESA, WHITE SANDS MISSILE RANGE, NM
108 DUPONT & COMPANY, DEEPWATER, NJ
110 W.R. GRACE & COMPANY, CURTIS BAY, MD
114 KELLEX/PIERPONT, JERSEY CITY, NJ
115 NIAGARA FALLS STORAGE SITE (VICINITY PROP.) LEWISTON, NY
116 MALLINCKRODT, INC., ST. LOUIS, MO
117 MIDDLESEX LANDFILL, MIDDLESEX, NJ
118 MIDDLESEX SAMPLING PLANT, MIDDLESEX, NJ
119 NATIONAL GUARD ARMORY, CHICAGO, IL
121 PALOS PARK FOREST PRESERVE, COOK COUNTY, IL
123 SEAWAY INDUSTRIAL PARK, TONAWANDA, NY
125 SHPACK LANDFILL, NORTON, MA
126 UNIVERSAL CYCLOPS, ALIQUIPPA, PA
127 VENTRON, BEVERLY, MA
129 LINDE AIR PRODUCTS, TONAWANDA, NY
130 UNIVERSITY OF CALIFORNIA, BERKELEY, CA
131 UNIVERSITY OF CHICAGO, CHICAGO, IL
132 ASHLAND OIL CO #2, TONAWANDA, NY
134 ST LOUIS AIRPORT SITE (VICINITY PROP.), ST. LOUIS, MO
137 WAYNE/PEQUANNOCK, NJ
138 MAYWOOD, NJ
139 COLONIE, NY
140 HAZELWOOD (LATTY AVENUE), MO
141 GENERAL MOTORS, ADRIAN, MI
142 SEYMOUR SPECIALTY WIRE, SEYMOUR, CT
163 ST. LOUIS AIRPORT SITE, ST. LOUIS, MO

○ REMEDIAL ACTION PLANNED
⊕ REMEDIAL ACTION PARTIALLY COMPLETED
● REMEDIAL ACTION COMPLETED
◉ RADIOLOGICAL MONITORING ONLY

Figure 2. Location of FUSRAP Sites

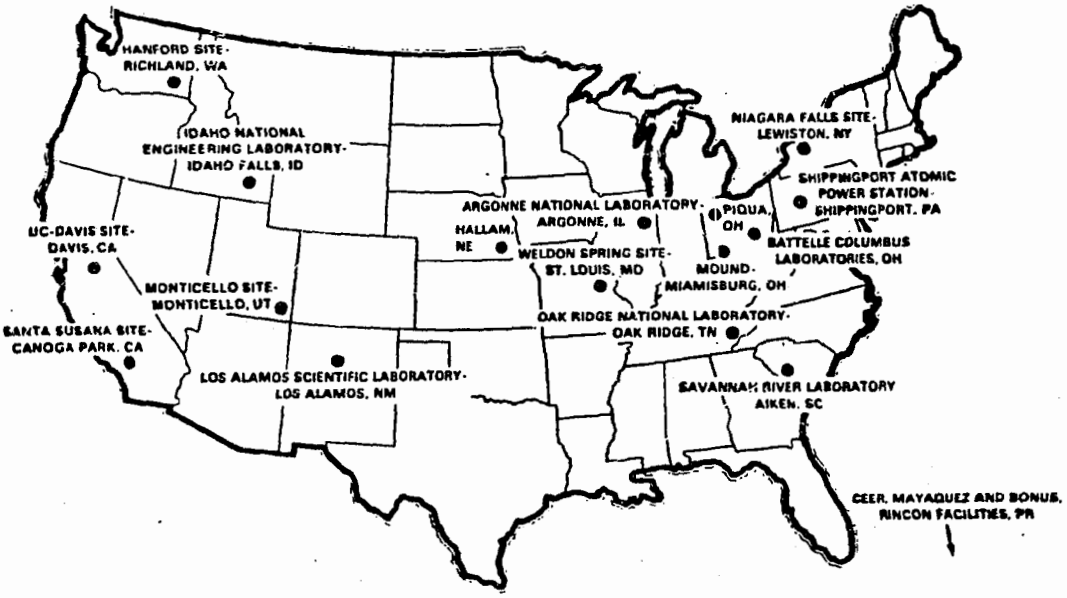


Figure 3. Surplus Facilities Management Program Facilities and Site Locations

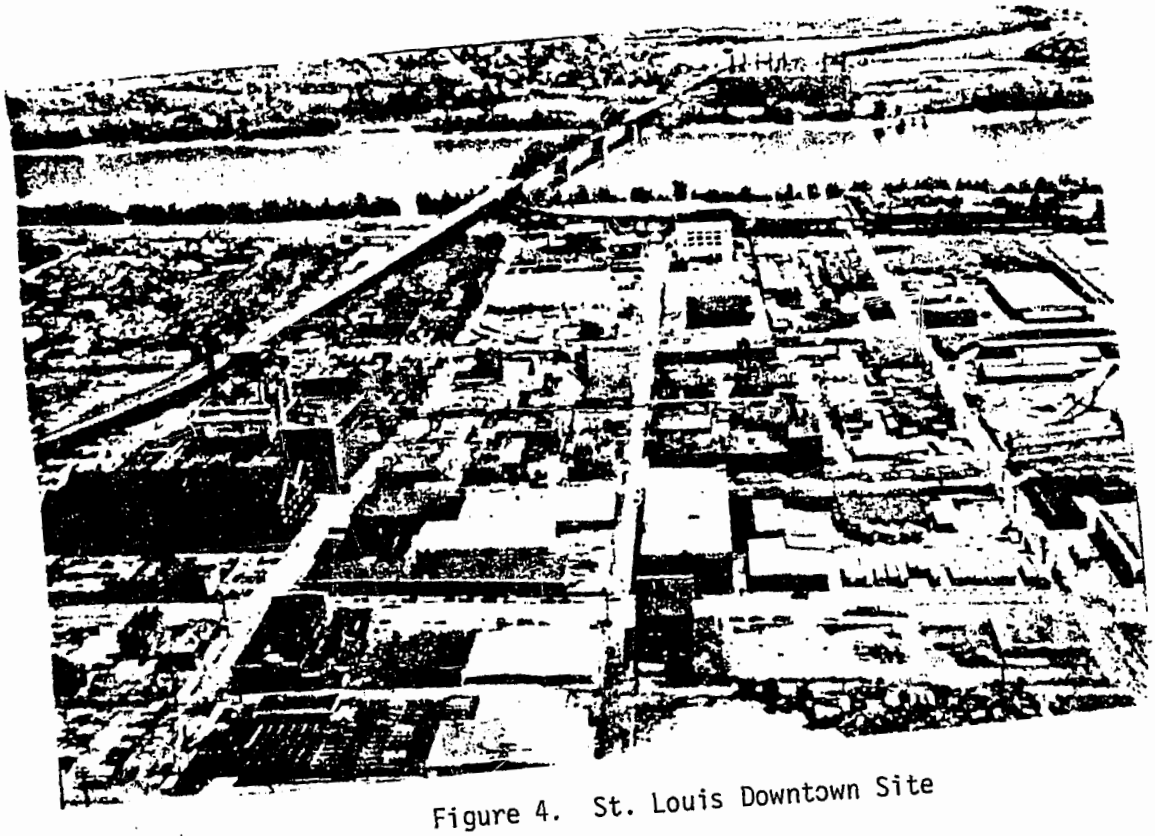


Figure 4. St. Louis Downtown Site

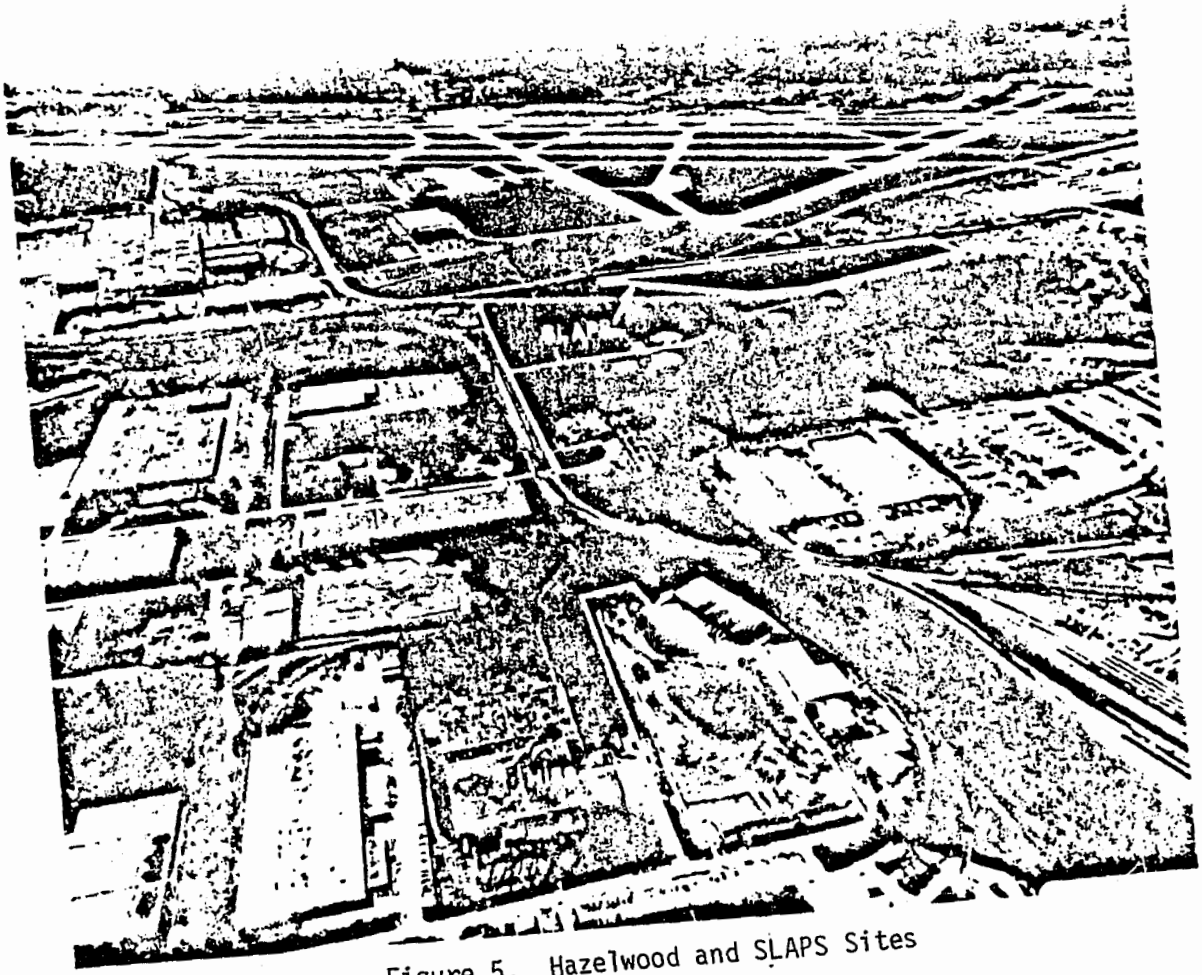


Figure 5. Hazelwood and SLAPS Sites

Figure 6. National Guard Armory, IL

Figure 7. Scabbling Concrete at National Guard Armory, IL

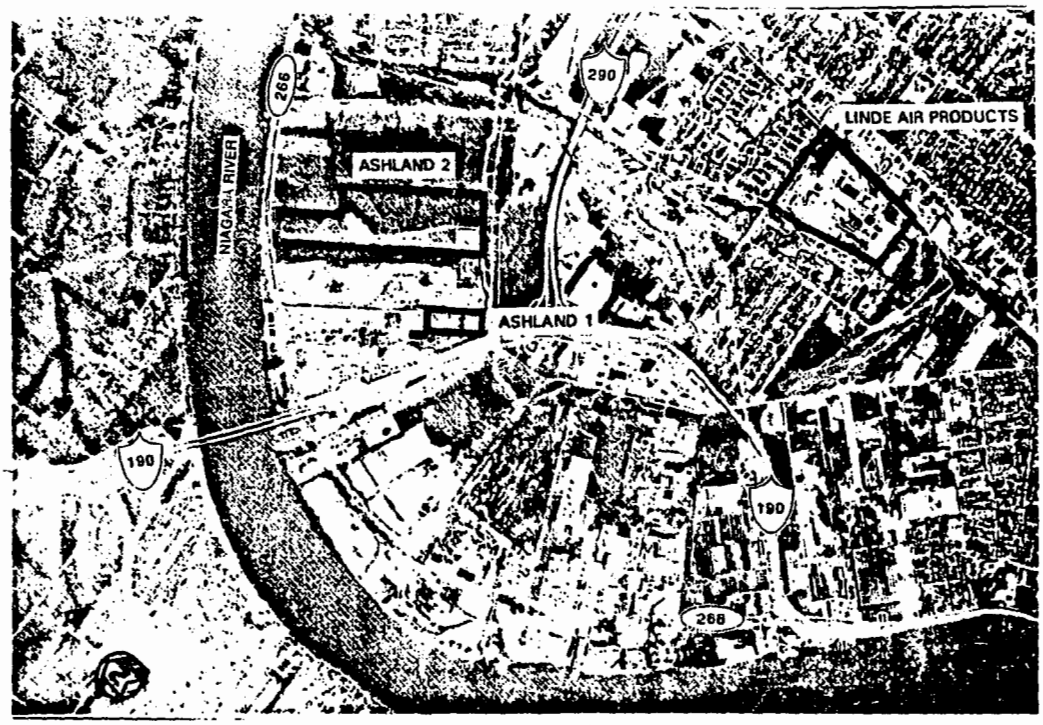


Figure 8. Aerial View of the Tonawanda Sites

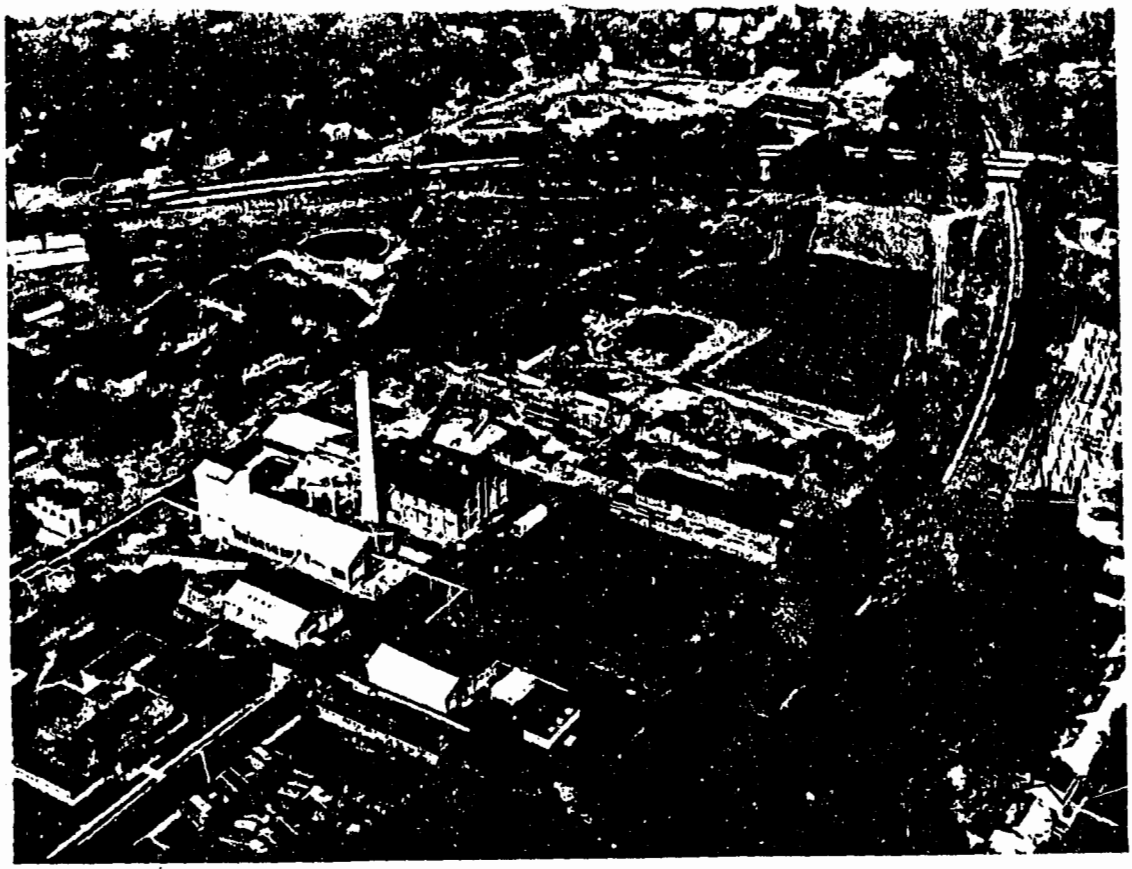


Figure 9. Maywood Interim Storage Site Nursing Home Under Construction on Ballod Property

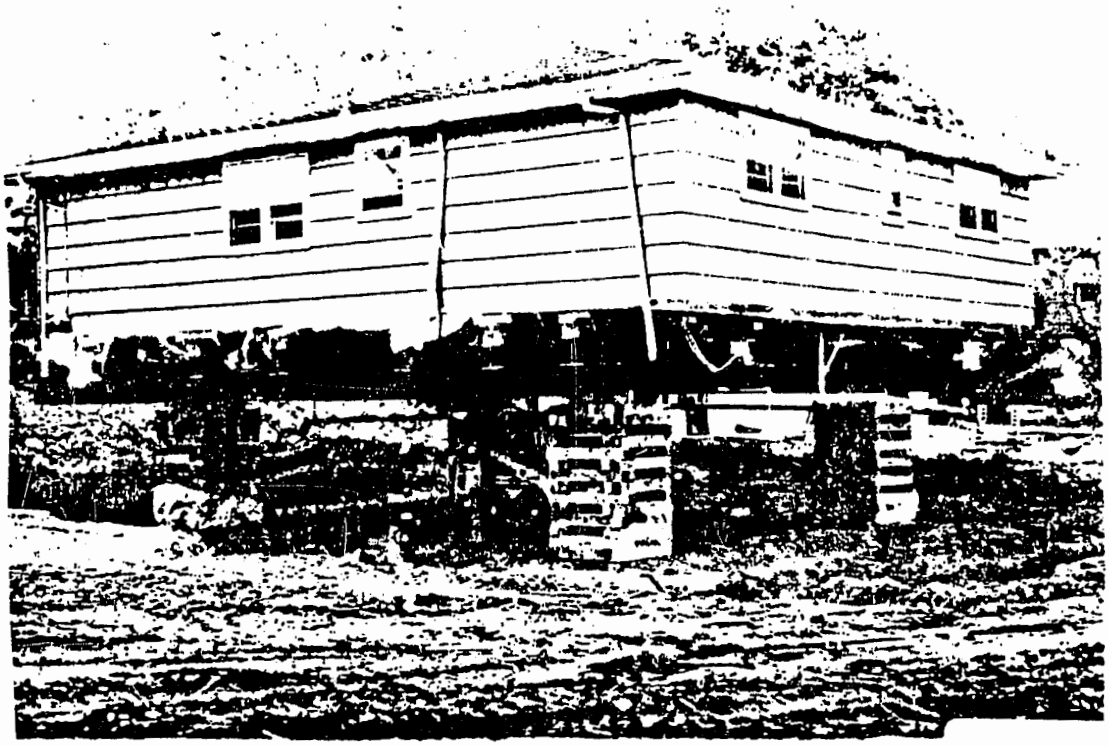


Figure 10. Vicinity Property with Foundation Removed

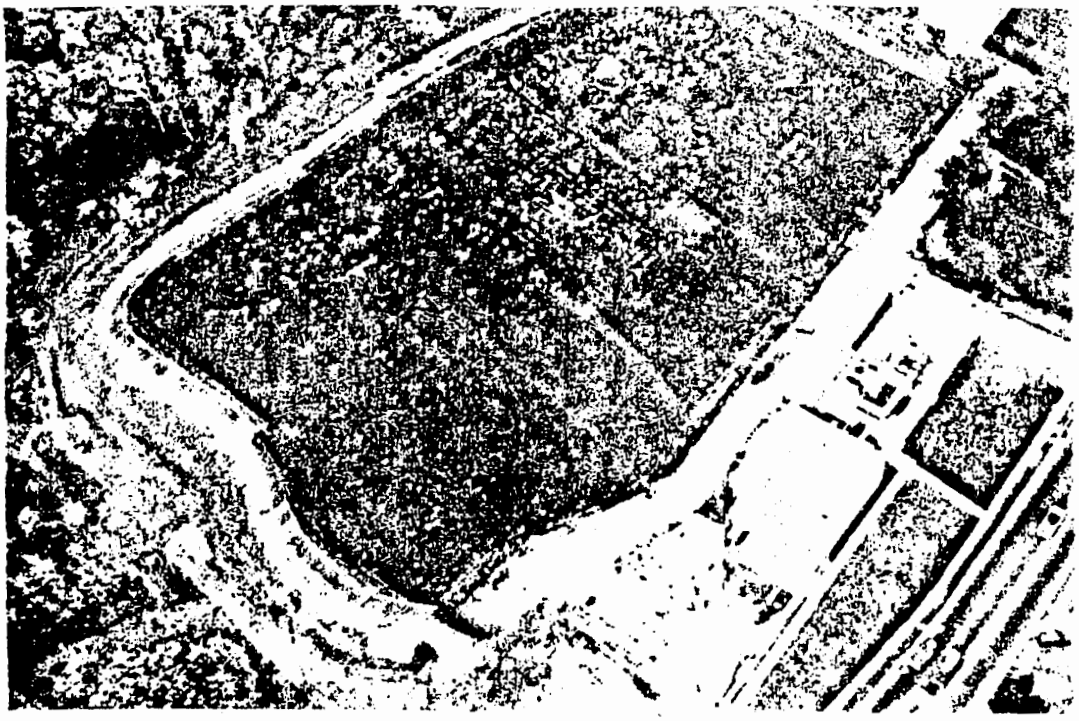


Figure 11. Wayne, NJ

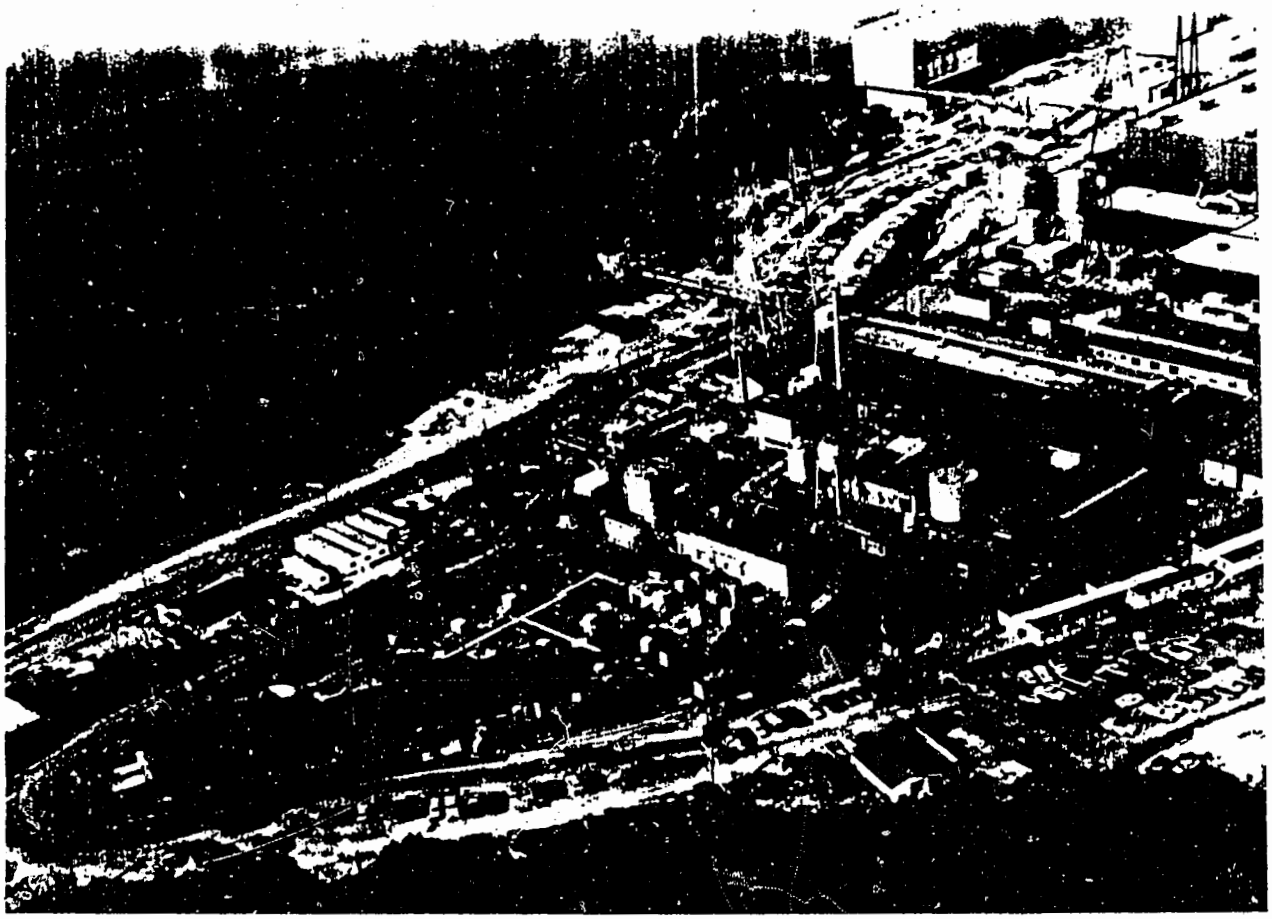


Figure 12. Shippingport Atomic Power Station

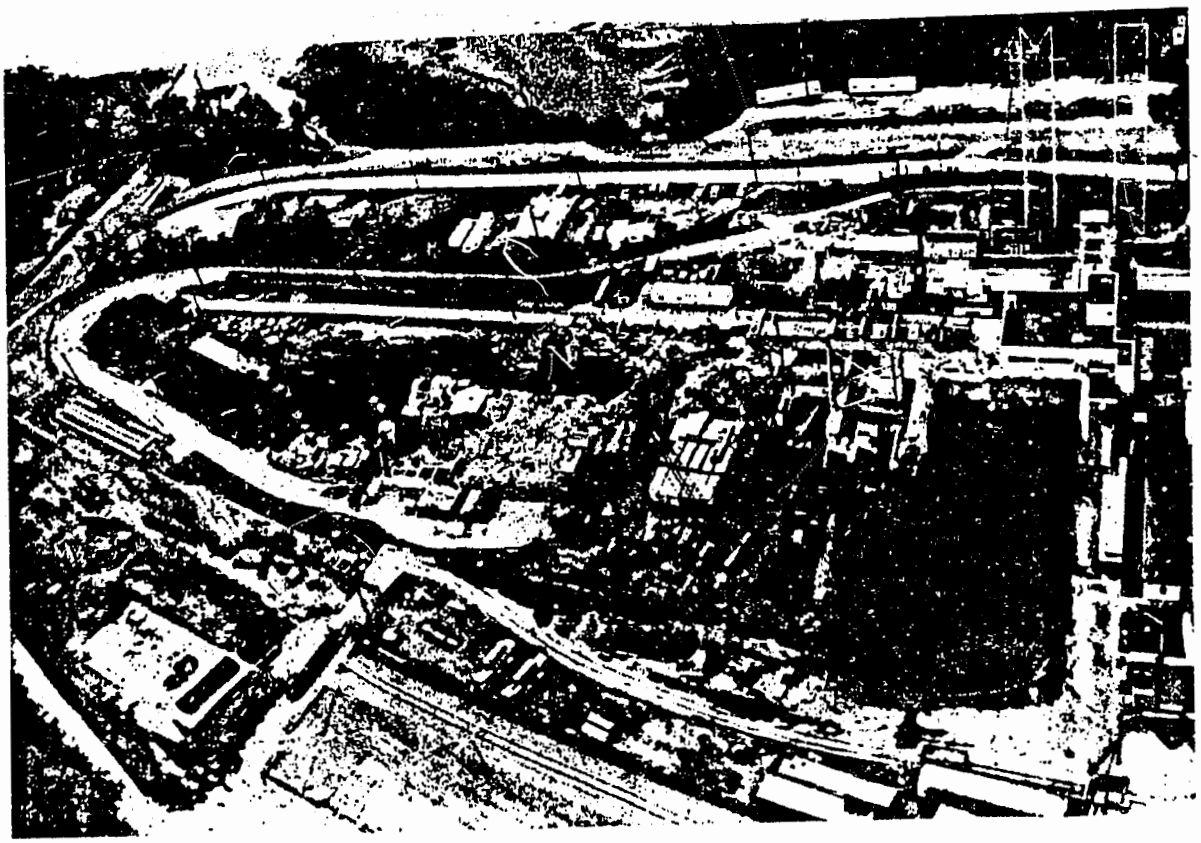


Figure 13. Shippingport Atomic Power Station During Decommissioning

Figure 14. The RPV is Emerging from the Below-Grade Portion of the Reactor Enclosure and Canal by Late Morning

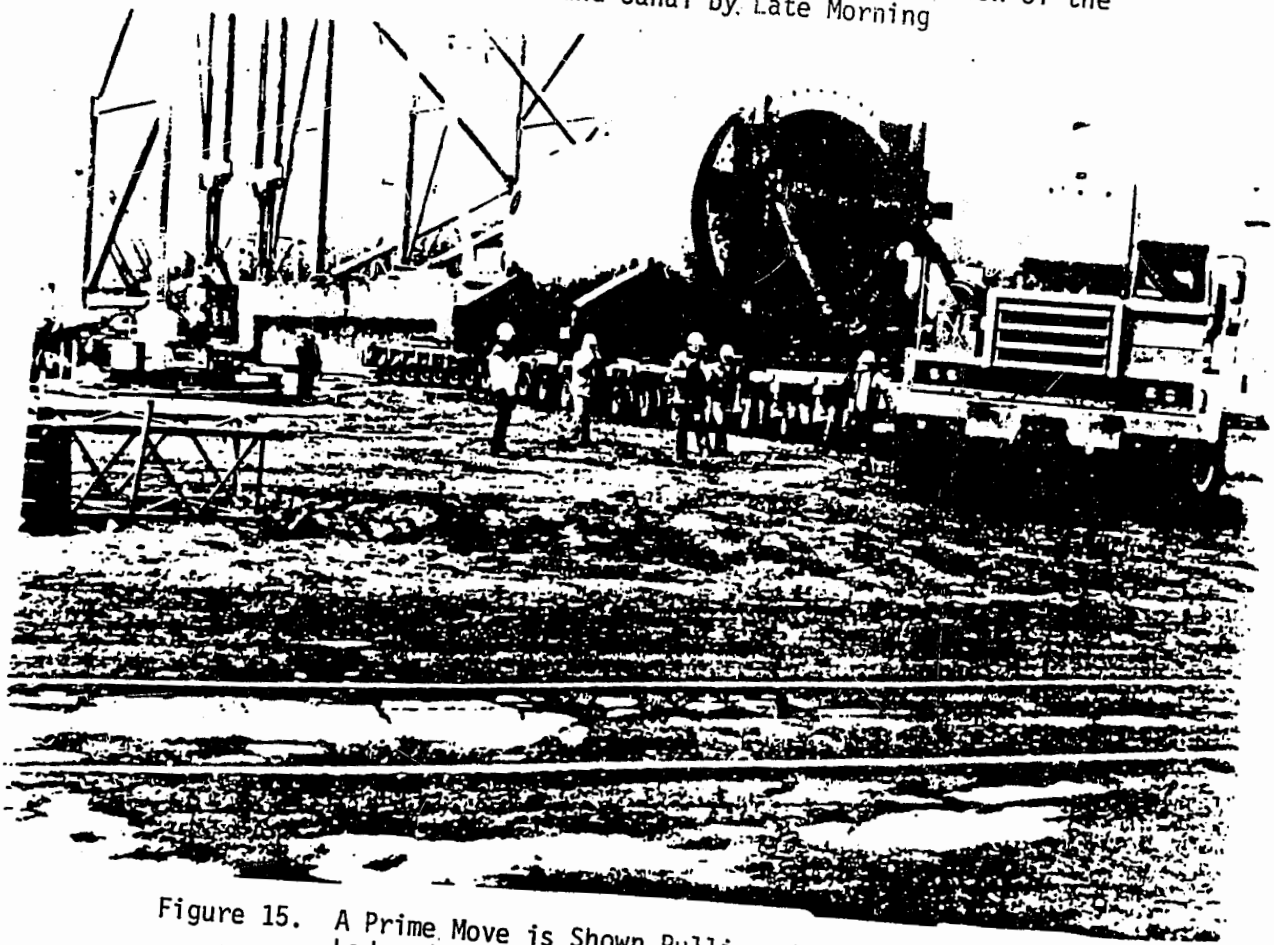


Figure 15. A Prime Move is Shown Pulling the Transporter Ladened with the RPV Package

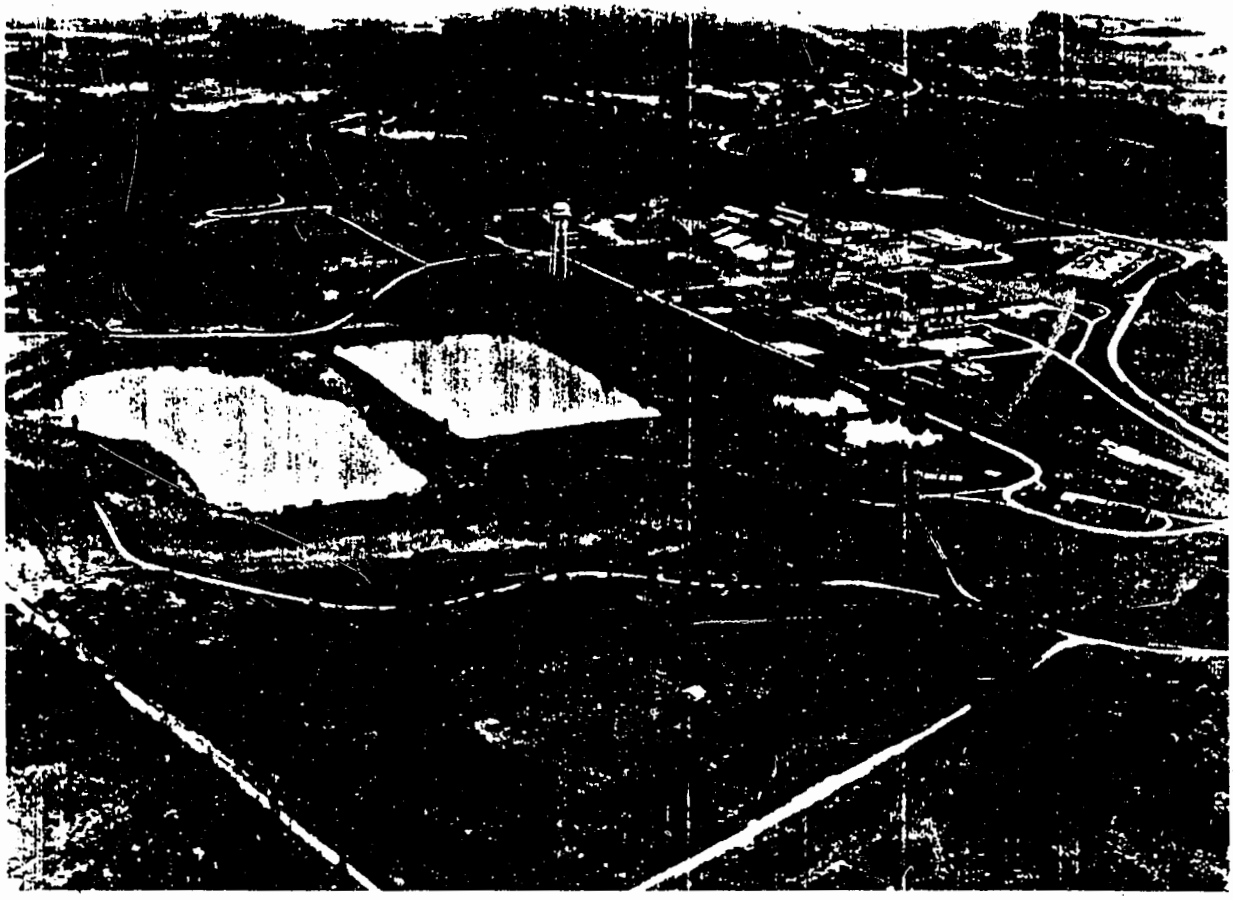


Figure 16. Raffinate Pits and Chemical Plant

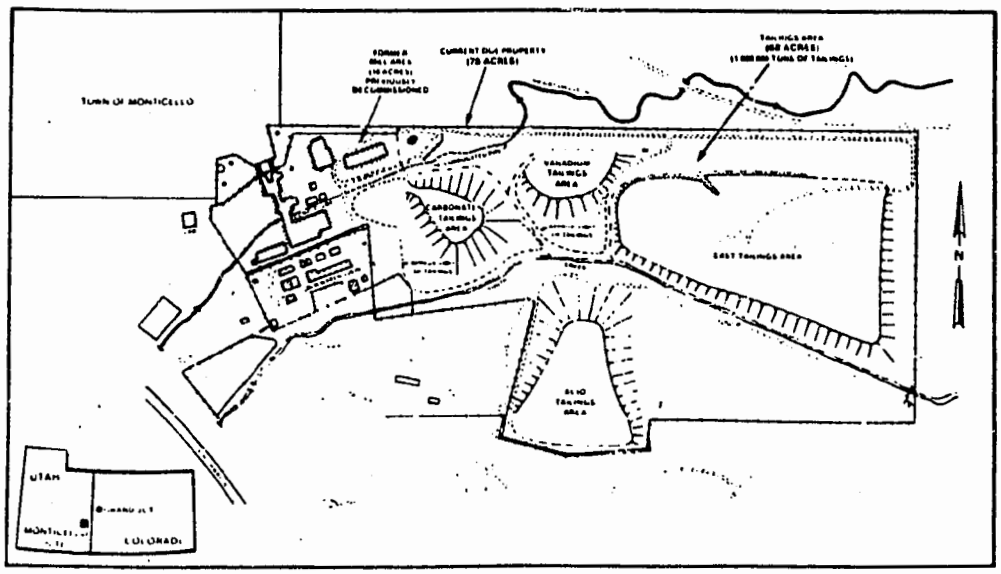


Figure 17. Monticello Mill Site

4. REGION 6 INVOLVEMENT IN NEW MEXICO: URANIUM MILLS AND MINES

William Rowe
Environmental Protection Agency

UNITED NUCLEAR CORPORATION - CHURCHROCK SITE

The United Nuclear Corporation (UNC) site is located in McKinley County, New Mexico, approximately 17 miles northeast of Gallup. The site includes a uranium mill complex and tailings impoundment, both located approximately 1 mile south of the Navajo Indian Reservation. The mill and associated tailings impoundment, situated in the Pipeline Canyon, cover approximately 125 acres.

The UNC mill was granted a radioactive materials license pursuant to the Atomic Energy Act by the State of New Mexico in 1977 and operated from 1977 to 1982. The mill used an acid leach, solvent extraction method to remove uranium from the ore. The acid leach process produced an estimated 3.5 million tons of tailings which were disposed of in three cells adjacent to the mill.

Before licensing of the uranium mill, uranium mining was conducted in the area north of the mill site. In 1968, the northeast Churchrock mine began operating and discharged mine water into Pipeline Canyon Arroyo which is located between the uranium mill and the tailings impoundment. Two other mines, the Old Churchrock and Quivira Mines, also operated in the area and produced uranium ore for milling at the UNC site. All uranium ore was mined from the Westwater Canyon Member of the Morrison Formation.

In July 1979, a dam at the south end of the tailings impoundment broke, releasing more than 90 million gallons of tailings liquids into Pipeline Canyon Arroyo and the Rio Puerco. The dam was repaired shortly after the release, and the spill was cleaned up according to criteria imposed by State and Federal agencies, including EPA.

In 1983, EPA formally placed the UNC site on the National Priorities List (NPL) of Superfund sites, primarily because of ground-water contamination. At the time of the listing, New Mexico, under "agreement state" status with the Nuclear Regulatory Commission, regulated the site.

EPA conducted a Remedial Investigation at the site after the NPL listing focusing on impacts to ground water resulting from seepage from the tailings impoundment. (The geology, geohydrology, and proposed ground-water remedy for the site are illustrated by several slides shown during the presentation. See Figures 1 through 6.)

NRC resumed licensing authority for uranium mills in New Mexico in June 1986, and as a result, EPA and NRC are coordinating their respective requirements at the site. EPA signed a Record of Decision for groundwater in September 1988 and established clean-up standards. NRC also approved UNC's reclamation plan in 1988. Groundwater corrective action and reclamation activities are scheduled to begin this summer (1989).

HOMESTAKE MINING COMPANY

The Homestake Mining Company (HMC) site is in the northern portion of Cibola County, New Mexico, about 5.5 mi north of Milan (figures 7 and 8). The site is located in the San Mateo drainage basin at an elevation of 6,600 ft.

The HMC mill has been a major producer of uranium concentrate since 1958. The mill employs an alkaline leach-caustic precipitation process for concentrating uranium oxide. The mill has a design throughput capacity of about 3,500 tons per day of ore.

Tailings are disposed of in an embankment that covers approximately 200 acres and is 95 to 100 ft high. Total tailings received to date are on the order of 25 million tons.

HMC operated under a license issued by the State of New Mexico prior to June 1986, at which time NRC resumed licensing authority. In 1983, EPA placed the HMC site on the National Priorities List, primarily because of ground-water contamination that had migrated offsite and into private wells in surrounding subdivisions. As a result of tailings seepage migration offsite, EPA required HMC to provide an alternate water supply to the neighboring subdivisions. Alternate water was fully installed in 1985. In addition to EPA requirements, an aquifer restoration program was planned and implemented by HMC, pursuant to a Ground-water Discharge Plan approved by the New Mexico Environmental Improvement Division.

In 1987, HMC entered into a Consent Agreement with EPA under which the company would conduct an offsite indoor/outdoor radon monitoring program in subdivisions surrounding the operation. Results of this effort are expected to be final this summer, and a Record of Decision signed in September 1989.

Other environmental work performed by HMC includes the implementation of an interim stabilization program for all tailings not covered by standing water, and the removal of windblown tailings in areas delineated during radiological surveying outside the tailings impoundment.

Both the EPA and the NRC will continue to coordinate their respective requirements at the site.

COORDINATION WITH OTHER AGENCIES ON URANIUM MILLS

The EPA is working closely with the Nuclear Regulatory Commission and New Mexico Environmental Improvement Division in order to achieve timely reclamation and remediation of the UNC-Churchrock site and Homestake Mining Company site.

Three other NRC-licensed mills are located in New Mexico, namely Anaconda-Bluewater, BP America, and Quivira.

HMC has an approved Ground-water Discharge Plan, whereas UNC-Churchrock does not.

URNAIUM MINES - POTENTIAL CERCLA INVOLVEMENT

EPA has been giving attention to abandoned uranium mine wastes, and mine wastes in general, as concern over possible environmental and human health impacts from tailings and waste rock has increased. The primary concerns about uranium mine wastes are:

1. Radon emanation from mine vents, mine headworks, and other workings

2. Dispersion of wastes by gravity-driven and wind-driven processes

3. Fluvial dispersions of wastes and related drainage impacts.

Issues regarding environmental assessments of uranium mine wastes have been reported on both Federal and Tribal Lands in EPA Region 6.

Sites on Federal Land

The State of New Mexico has reported two uranium mine waste sites located on Federal land to EPA Superfund. One is located on land controlled by the Bureau of Land Management; the other is on Forest Service land. Both sites may not be eligible for funding by the Abandoned Mines Program under the Surface Mining Control and Reclamation Act.

Sites on Tribal Lands

EPA Region 6 has assisted the Navajo Nation in establishing a Navajo Superfund Office in Window Rock, Arizona. Navajo Superfund is in the process of submitting preliminary assessment reports to Region 6, which include a number of areas west of Shiprock previously mined for uranium. Mining took place in the Jurassic Morrison Formation along the border of New Mexico and Arizona. The preliminary assessment reports are focusing on waste piles and areas worked on the surface during prospecting for and mining of uranium.

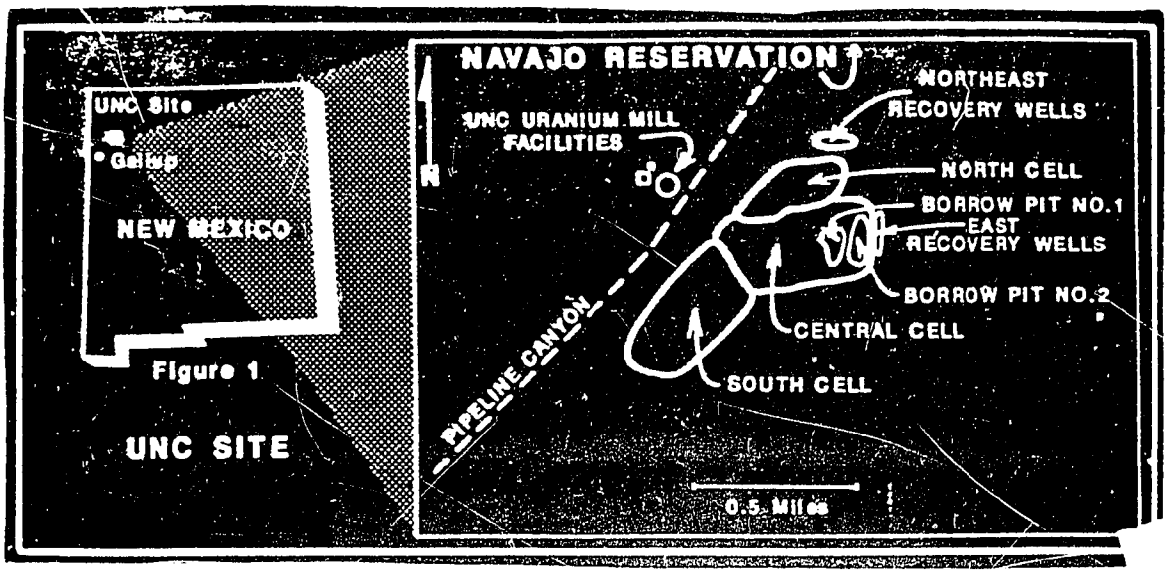


Figure 1. Map showing location of UNC Uranium Mill facilities and tailings area.

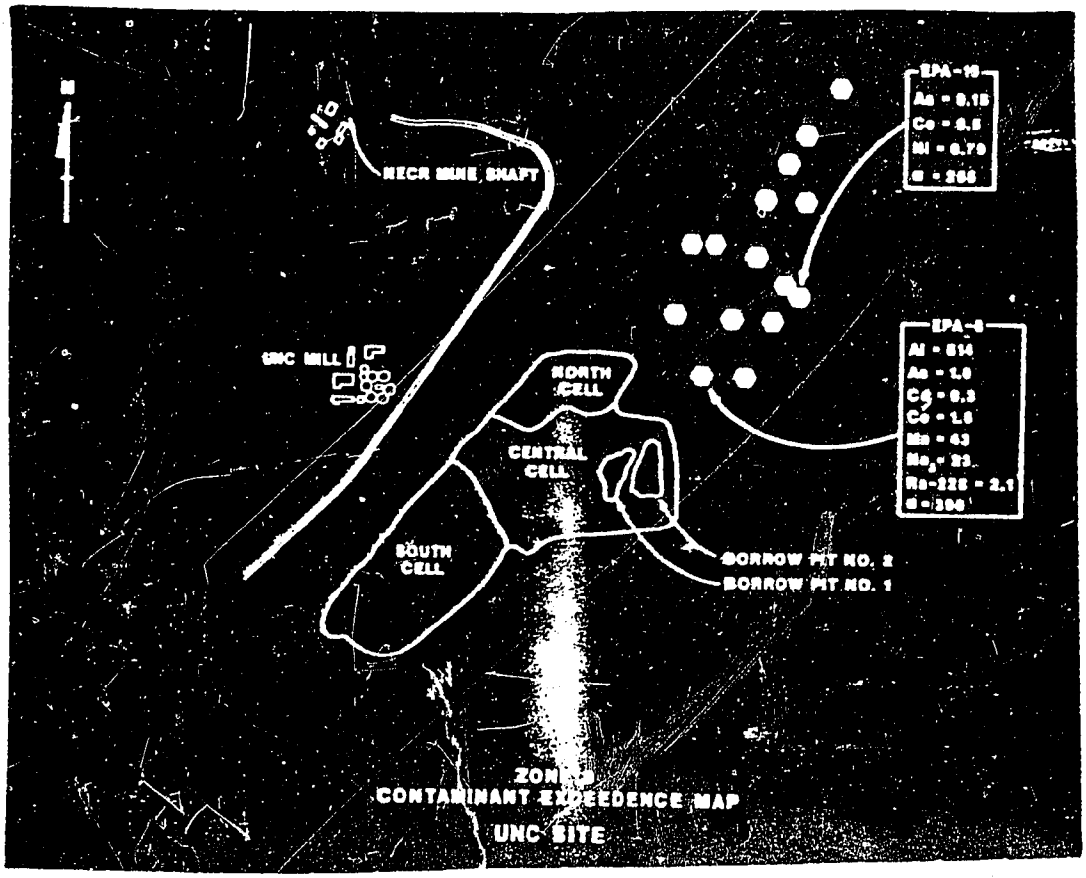


Figure 2. Map of UNC tailings area, showing drill holes for sampling and monitoring of contaminated zones.

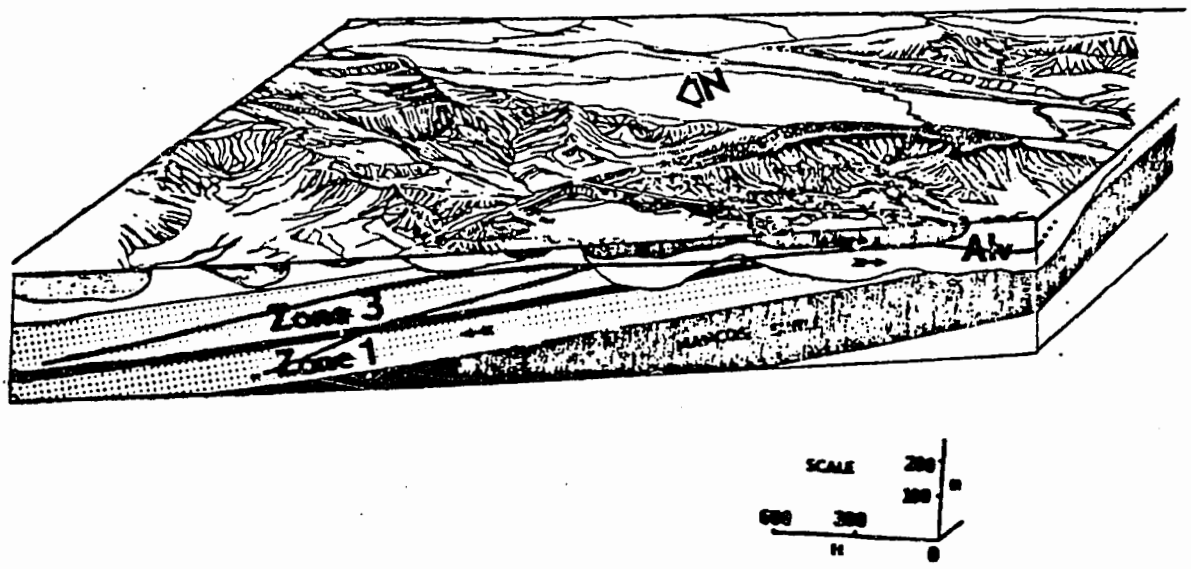


Figure 5. Schematic through UNC tailings showing sandstone aquifers, and base of the tailings.

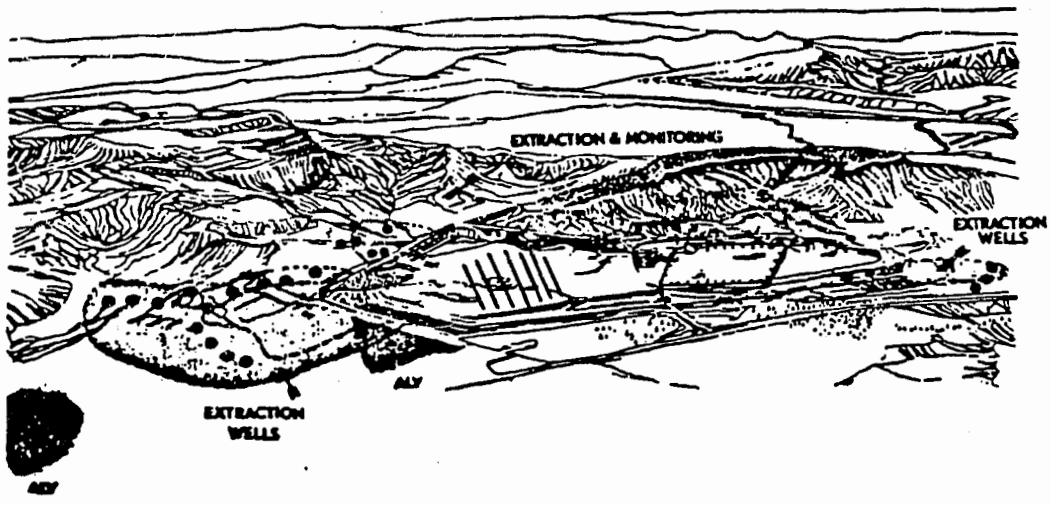


Figure 6. Schematic showing groundwater contamination, and proposed extraction wells at UNC tailings area. An evaporation disposal system will be constructed within the tailings area to handle extracted groundwater.

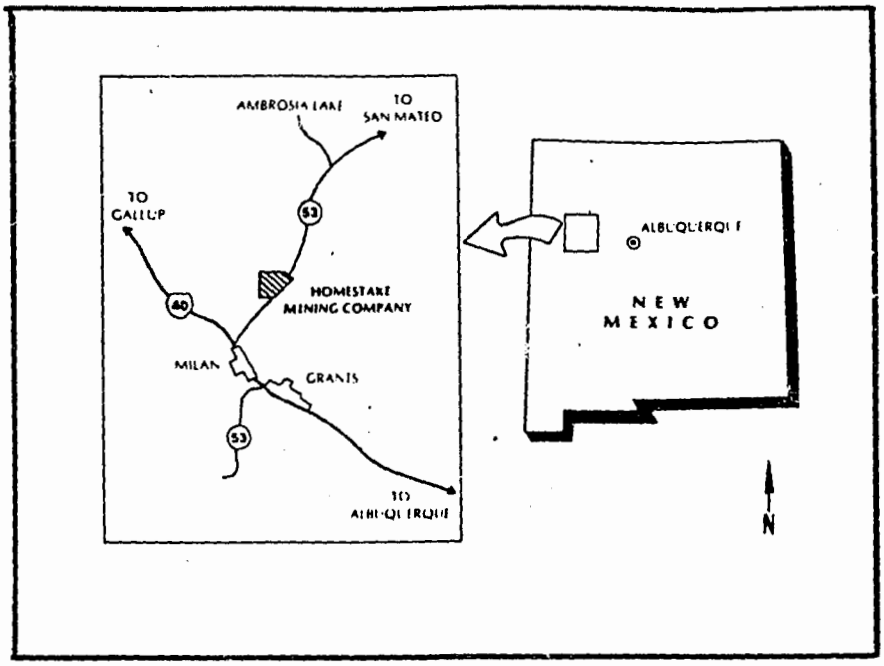


Figure 7. Homestake Mining Company Site Location

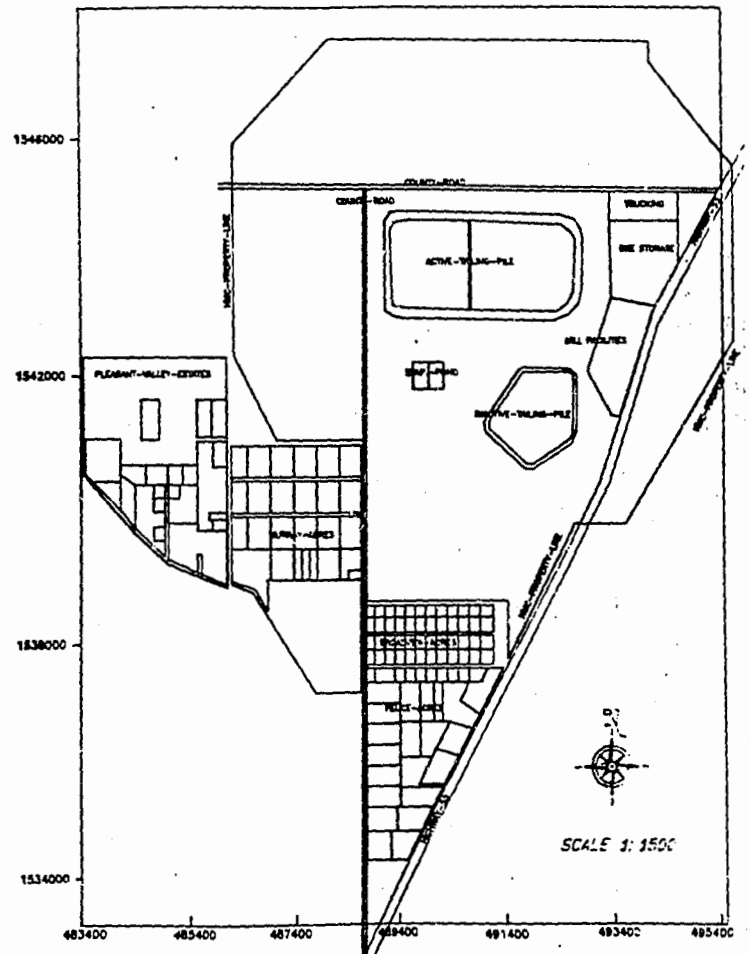


Figure 8. HMC Mill and Subdivisions Locations

5. COMMERCIAL URANIUM INDUSTRY DECONTAMINATION AND DECOMMISSIONING CONSORTIUM

David G. Culberson, Chairman

Good morning. My name is Dave Culberson. I am the Manager of the Technical Control Department at Babcock & Wilcox's Nuclear Service Operations in Apollo, PA. I am very pleased to be here today as chairman of a newly formed decontamination and decommissioning consortium representing the commercial uranium processing industry, and this morning I will be sharing with you some information on the background to the formation of this group, an overview of our goals and objectives, a summary of recent accomplishments, and our plans for the next few months.

BACKGROUND

The events leading to the formation of the decontamination and decommissioning consortium began in May of 1988 when Babcock & Wilcox began to look closely at the cleanup requirements at its two former fuel processing facilities in Apollo and Parks Township, PA. This internal review was prompted, in part, by the then "proposed" decommissioning regulations introducing new requirements on licensees relative to decommissioning plans and decommissioning funding commitments.

As early as 1980, B&W began to phase out production operations at both of its Pennsylvania facilities, and in 1984 efforts were underway to remove all production equipment from the Apollo facility. The removal of production equipment was followed by a general cleanup and radiological characterization of the facility.

In early 1986, radiological surveys conducted by B&W and Oak Ridge Associated Universities revealed surface contamination and radiation "hot spots" slightly above background in the parking lot of the Apollo facility. This area had been an unrestricted area for many years. The identification of soil contamination led to extensive characterization of the parking lot and other areas adjacent to the facility, including some offsite areas. This characterization effort included direct radiation surveys and a soil sampling program which has thus far resulted in isotopic analysis of over 4800 soil samples. To date, B&W has identified approximately 500,000 ft^3 of uranium contaminated soil which is above the NRC guideline level of 30 pCi/g.

INITIAL INDUSTRY CONTACTS

Early in 1988, B&W took a much closer look at the growing problem of disposing of very large quantities of contaminated soil. Even the earliest estimates indicated that disposal costs could soar over the 100 million dollar mark. These early cost estimates, along with other influencing factors, led to a corporate decision to pursue remedial action alternatives which would preclude having to bury this material at a commercial LLW disposal facility.

As a result, in an effort to identify alternatives for dealing with contaminated soil, B&W made contact with decommissioning coordinators at the following commercial facilities involved in similar cleanup efforts:

- Kerr-McGee Corporation's Cimarron site, where they were exhuming onsite burial trenches and decommissioning former uranium and plutonium processing facilities,

- Nuclear Fuel Services' Erwin, TN, site, where they were cleaning up settling ponds and a former plutonium processing facility,

- Westinghouse's Cheswick, PA, site where they had previously decommissioned a uranium and plutonium facility and exhumed an onsite burial trench, and

- United Nuclear's site at Wood River Junction, RI, where they had decommissioned a former uranium scrap recovery facility.

We discovered an overwhelming interest in pooling resources and experience to solve some of the generic problems and issues facing the industry. Although each of the companies initially contacted had completed some decommissioning work, each had other licensed facilities to be addressed at some future date.

INITIAL CONSORTIUM MEETING

In response to this overwhelming interest, particularly in cleanup of contaminated soil, a planning meeting was held on November 1-2, 1988, at B&W's Apollo, PA, facility. This first meeting served as the springboard for the consortium and was attended by 17 technical and management representatives of 9 NRC-licensed facilities including: B&W Pennsylvania Nuclear Service Operations (Apollo, PA), B&W Commercial Nuclear Fuel Division and B&W Naval Nuclear Fuel Division (Lynchburg, VA), Westinghouse Electro-Mechanical Division (Cheswick, PA), Westinghouse CNFD (Columbia, SC), Kerr-McGee Corporation-Cimarron Site (Cimarron, OK), Nuclear Fuel Services (Erwin, TN), United Nuclear Corporation (Wood River Junction, RI), and General Electric, Nuclear Fuel and Components Manufacturing Division (Wilmington, NC).

In addition, an invitation was extended to Mr. Robert Alexander, President of the Health Physics Society and who at that time was on the NRC staff for the Office of Governmental and Public Affairs (Washington, DC). Mr. Alexander provided a detailed update on the NRC's efforts to establish a Below Regulatory Concern (BRC) Policy Statement, and was instrumental in the consortium's early efforts to address the issue of BRC. Messrs. Henry Morton and Tom Potter, environmental and criticality consultants from Washington, DC, were also included in this initial meeting principally because of their professional association with several of the companies in the consortium and their key role in addressing similar issues in the past.

The principal objectives at this first meeting were to discuss generic decontamination and decommissioning issues, and to consider establishment of a formal industry consortium which would provide a mechanism for:

1. Sharing operational and decontamination and decommissioning experience on an informal and regular basis

2. Identifying generic decontamination and decommissioning issues

3. Jointly funding activities in the hopes of finding solutions to these generic issues

4. Becoming involved in related regulatory affairs on a unified industry basis

The response was overwhelmingly positive, and even before the first meeting had ended we had initiated our first joint effort, that being to develop, with the assistance of Morton & Potter, an industry position on the proposed NRC Policy Statement on Below Regulatory Concern. This industry position was presented to the NRC at a public meeting in Bethesda, MD, on January 12, 1989.

CHARTER

Since that first meeting last November, the initial group of six companies has grown to include Nuclear Metals Inc. (Concord, MA), Advanced Nuclear Fuels (Richland, WA), Sequoyah Fuels (Oklahoma City, OK), and Combustion Engineering (Windsor, CT). We have developed a draft charter which embodies the objectives of the consortium. The five key points of this draft charter are:

1. To provide a forum where representatives can discuss and share operational, technical, regulatory, and other problems and experience.

2. To provide a means for establishing industry-wide positions on technical, regulatory, and other matters.

3. To provide a forum for initiating, reviewing, or critiquing and influencing regulatory issues related to, or impacting on, facility and site decontamination and decommissioning.

4. To provide a forum for discussing and evaluating emerging or existing technologies pertaining to decontamination and decommissioning.

5. To provide a mechanism for joint funding of projects and activities for the benefit of the entire industry.

The consortium meets on a quarterly basis and is involved in other activities related to these objectives.

A number of key generic issues have been identified as topics for future discussion and consideration and we anticipate action on these over the next several months. These topics include:

- Ultimate disposition of onsite buried materials, formerly authorized under 10 CFR 20.302

- Potential mixed waste issues

- Investigation of the applicability of the Backfit Rule (10 CFR 50.109) as a protection against future liabilities resulting from changing regulations

- Initiation of federal rulemaking to replace existing non-binding "guidelines" (i.e., Branch Technical Position)

- Development of "fact sheets" to quantify and describe the decontamination and decommissioning issues which may be affected by changes in the acceptance criteria

- Investigation of institutional and technological alternatives (those which have been proven and those which are under development)

- Possibilities for generic exemption under current regulations

- Development of generic pathway analysis for applications under 10 CFR 20.302, "Methods for Obtaining Approval of Proposed Disposal Procedures."

CURRENT AND PLANNED ACTIVITIES

The consortium has chosen as its first major undertaking, the generic issues associated with cleanup of soil contaminated with low levels of uranium, thorium, and depleted uranium. Two working groups have been formed to evaluate alternatives for soil contaminated slightly above those levels determined to be acceptable for unrestricted release (this represents the largest portion of the total volume of soil which must be dealt with), and to develop rulemaking options for the establishment of consistent and practical federal acceptance criteria. (Currently the industry is operating under "guidelines" set by the NRC which are considered nonbinding and which may be subject to change.)

We expect these efforts to lead to additional jointly funded tasks over the next several months.

We continue to follow the NRC and EPA's activities in the areas of BRC, Policy-setting and rulemaking, and intend to remain involved to the extent possible. We believe that by not being involved, the industry leaves itself open to the possibility of unnecessary and unrealistic cleanup requirements.

SUMMARY

In summary and conclusion, this commercial uranium industry decontamination and decommissioning consortium has proven to be an effective mechanism for (1) identification of generic decontamination and decommissioning issues, (2) exchange of information on available technological and institutional alternatives, (3) coordination of industry involvement in regulatory matters having a direct bearing on decontamination and decommissioning activities, and (4) joint funding of specific decontamination and decommissioning projects and

efforts which will benefit the industry as a whole. We continue to seek new ideas, additional input and alternatives, and welcome opportunities to participate in programs such as this EPA MRCS workshop which promote the exchange of useful information which will be beneficial to the nuclear industry as a whole.

6. NEW JERSEY RADIUM SITES
MONTCLAIR/WEST ORANGE AND GLEN RIDGE

Raimo Liias
Environmental Protection Agency

The Montclair/West Orange and Glen Ridge radium sites are located in three residential communities of suburban Essex County, NJ (figure 1). These sites were identified as a result of a New Jersey Department of Environmental Protection (NJDEP) program to investigate former radium-processing facilities within the State. In 1981, NJDEP requested that EPA conduct an aerial gamma radiation survey of a 12-mi^2 area in Essex County; this survey identified a number of areas with elevated levels of gamma radiation.

Soil at the sites is contaminated with radioactive waste materials suspected to have originated from radium-processing or utilization facilities located nearby in the early 1900s. The material, similar to uranium mill tailings, was disposed of in then-rural areas of the communities. It is thought that some of the radium-contaminated material was moved from original disposal areas and used as fill material in low-lying areas. Houses were later constructed on or near the waste disposal sites, and, in a few instances, it appears that some of the waste material was used in concrete for sidewalks and foundations. This has resulted in local residents being exposed to elevated indoor concentrations of radon and radon decay products and, in some cases, excessive levels of gamma radiation.

EPA began preliminary investigations in late 1983 to assess the extent of contamination at the sites. Since then, temporary radon ventilation systems and gamma radiation shielding have been installed and maintained by EPA and NJDEP, and a program was established to monitor the levels of radon decay products in affected houses on a quarterly basis. The West Orange area was added to the ongoing investigation in April 1984, and the Montclair/West Orange and Glen Ridge radium sites were added to the NPL in 1985.

NJDEP secured a disposal site in Nevada and began excavating the contaminated soil in June 1985. Four properties in Glen Ridge had been completely remediated when Nevada revoked the disposal permit and NJDEP was forced to leave containerized soil at a transloading facility in Kearny, NJ, and at partially excavated properties in Montclair. By the summer of 1988, NJDEP was able to dispose of the material from Montclair and Kearny.

More than 300,000 yd^3 of soil on public and private properties within portions of the 3 communities are contaminated with varying degrees of radium. EPA proposes to excavate the contaminated soil from the 23 most contaminated properties and install engineering controls (e.g., radon control systems and gamma radiation shielding) at a number of less contaminated properties.

The proposed plan would require excavation and removal of approximately 50,000 yd^3 of radium-contaminated soil at a cost of $53 million.

Excavation of the radium-contaminated soil is the EPA-preferred solution, but it has proved very difficult to find a disposal facility for this volume of low-level radioactive wastes. Because of this, EPA is evaluating other solutions to the problem, including possible soil treatment technologies to reduce the volume of contaminated material requiring offsite disposal.

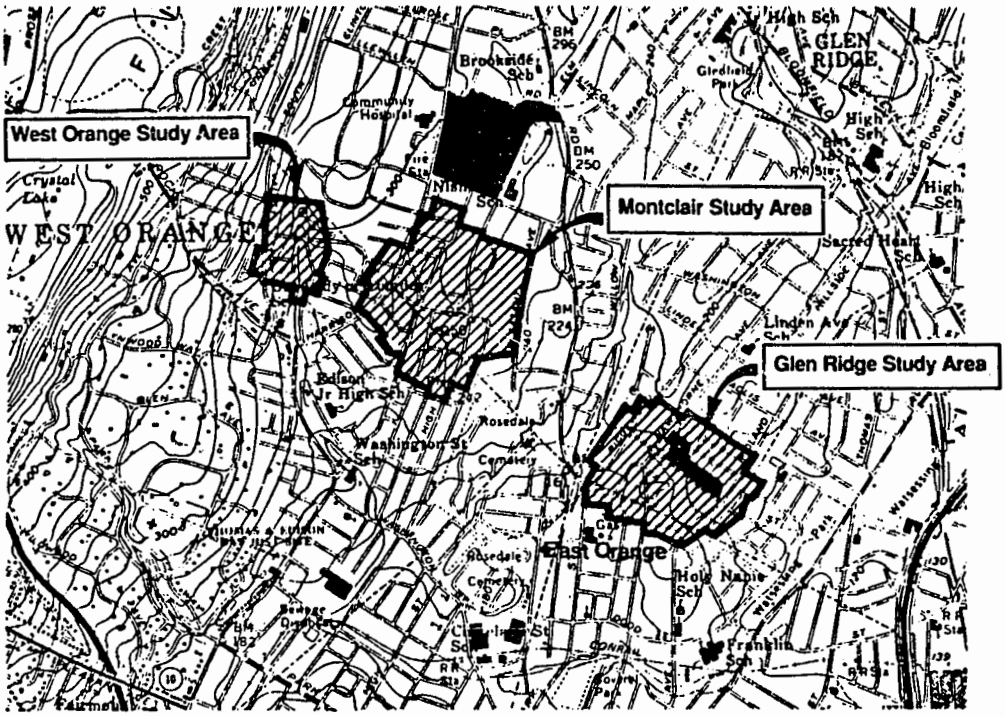


Figure 1. Study Area Location Map

Figure 2. Montclair Study Area

Figure 3. Glen Ridge Study Area

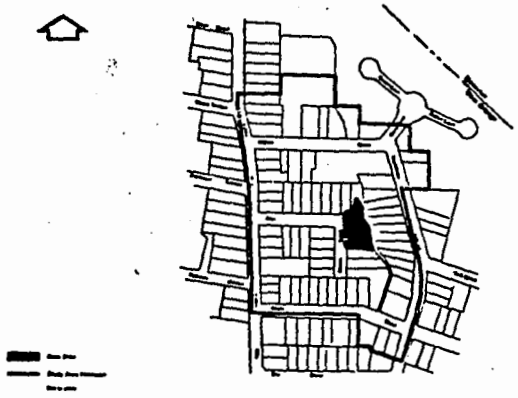


Figure 4. West Orange Study Area

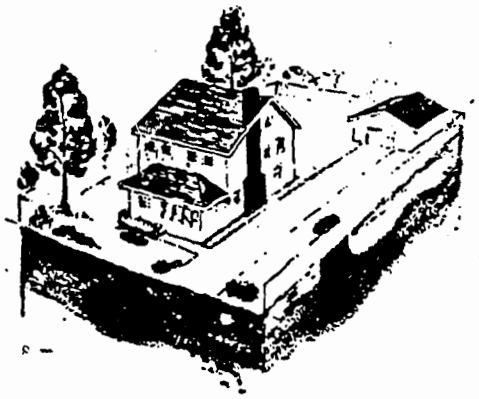


Figure 5. Typical Contamination Distribution Beneath Hot Spots

Table 1. PRAP Criteria

Category I	Properties with Radon ≥ 0.02 WL, elevated Gamma Radiation Levels and House Situated over Core Area
Category II:	Properties with Outdoor Gamma Radiation Levels ≥ 50 μR/Hr or Basement Wall Gamma Radiation Levels ≥ 50 μR/Hr
Category III:	Properties with Radon or Gamma Radiation Levels above Health Guidelines* which are not included in Categories I and II
Category IV:	Properties with Soil Contamination above Cleanup Standards but with Radon and Gamma Radiation Levels below Health Guidelines*
Category V:	Properties with No Soil Contamination above Cleanup Standards

* Health Guidelines = Radon ≥ 0.02 WL or Gamma Radiation Levels ≥ 30 μR/Hr

Table 2. Proposed Plan

		Number of Properties
Category I	Full Excavation	23*
Category II	Partial Excavation and Engineering Controls	75
Category III	Engineering Controls and Hot Spot Removal	65
Category IV	Radon and Gamma Radiation Monitoring	286
Category V	No Further Action	298
		747

Institutional controls for Categories II, III and IV.

* Includes 4 NJDEP Phase I properties.

Table 3. Impacted Properties

	Montclair	West Orange	Glen Ridge*	Total
Properties in study area	239	202	306	747
Properties with radium contamination above soil cleanup standards	172	132	145	449
Properties exceeding health guidelines	75	39	49	163

* Includes properties in East Orange

Table 4. Impacted Properties by Category

	Montclair	West Orange	Glen Ridge**	Total
Category I	16*	2	5	23*
Category II	37	17	21	75
Category III	22	20	23	65
Category IV	97	93	96	286
Category V	67	70	161	298

* Includes 4 NJDEP Phase I properties
** Includes properties in East Orange

7. CHARACTERIZATION OF SOIL CONTAMINANTS FOR REMEDIAL MEASURES

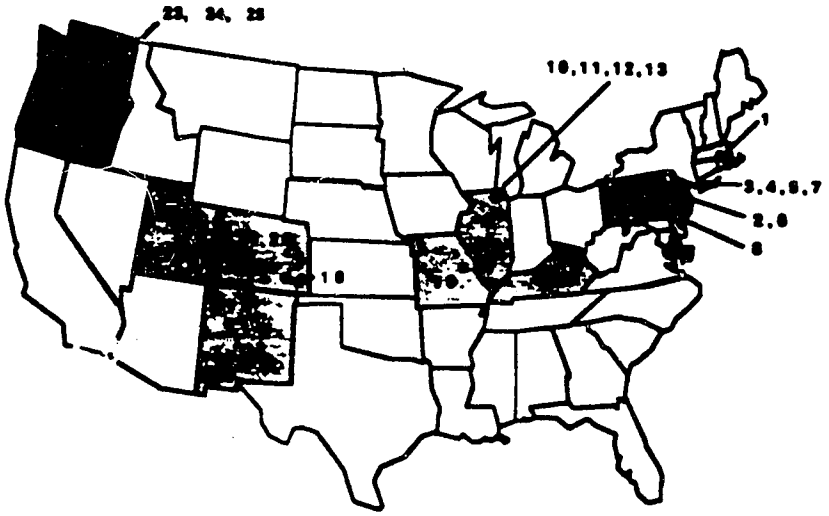
James Neiheisel
Environmental Protection Agency

The radioactively contaminated soils at Superfund sites differ in the materials constituting the native soil and the nature of the offending contaminants. Native soils may range from homogenous to complex heterogeneous admixtures with varying adsorptive properties, and radioactive materials may encompass complex ore and tailing assemblages to magnetic furnace-fired radium paint residues. Methods for contaminant characterization may differ for the various sites.

The characterization plan for the Montclair and Glen Ridge, New Jersey, sites utilized physical sizing, radiochemical and chemical analysis, mineralogical testing, magnetic separations, and heavy liquid and linear density gradient separation techniques which enabled identification of percentage of radium contamination to specific materials of contrasting particle size, physical properties, and solubility. Radium contamination was found to be highest in the fine grain-size materials; radiobarite and amorphous silica from radium mill tailings comprise more than half of the contamination. The rest of the radium contaminants were uranium ore minerals, uraninite in coal ash, furnace-fired radium paint residue, and adsorbed radium on mineral surfaces.

Limited analysis of radium contamination associated with the Ottawa, IL, site suggests radium contamination mainly associated with radium paint on objects and in magnetic furnace-fired materials.

It is clearly evident that characterization of contaminants in radioactive sites is an important first step in remedial actions. Prediction of the nature and distribution of radioactive contaminants will be facilitated by a characterization site data base.



	Site Name	Site Location	
1	Shpack Landfill	Norton/Attleboro	MA
2	Maywood Chemical Co.	Maywood/Roch. Pk	NJ
3	U.S. Radium Corporation	Orange	NJ
4	W.R. Grace & Co. Inc.	Wayne Township	NJ
5	Glen Ridge Radium Site	Glen Ridge	NJ
6	Lodi Municipal Well	Lodi	NJ*
7	Montclair Radium Site	Montclair/W. Orge.	NJ
8	Lansdowne Radiation Site	Lansdowne	PA
9	Maxey Flats Nuclear Dispos.	Hillsboro	KY
10	Kerr-McGee (Kress Creek)	DuPage County	IL*
11	Kerr-McGee (Reed Keppler)	West Chicago	IL*
12	Kerr-McGee (Residential)	W. Chicago/DuPage	IL*
13	Kerr-McGee (Sewage)	West Chicago	IL*
14	Homestake Mining Company	Milan	NM
15	United Nuclear Corporation	Church Rock	NM
16	Weldon Spring Quarry	St. Charl. Co.	MO
17	Denver Radium Site	Denver	CO
18	Lincoln Park	Canon City	CO
19	Uravan Uranium	Uravan	CO
20	Rocky Flats Plant (USDOE)	Golden	CO*
21	Monticello Rad. Con. Props.	Monticello	UT
22	Teledyne Wah Chang	Albany	OR
23	Hanford 200-Area (USDOE)	Benton Co.	WA*
24	Hanford 300-Area (USDOE)	Benton Co.	WA*
25	Hanford 100-Area (USDOE)	Benton Co.	WA*

* Proposed, not final as of June 1988

Figure 1. Locations of the 25 Radioactively Contaminated Superfund Sites

There are 25 radioactively contaminated Superfund sites in the United States and there will probably be more added in the future. Each site has a characteristic geologic host media and a unique assemblage of radioactive contaminants. The geologic host media or native soil at each site has a mineral assemblage that adsorbs some of the contaminants.

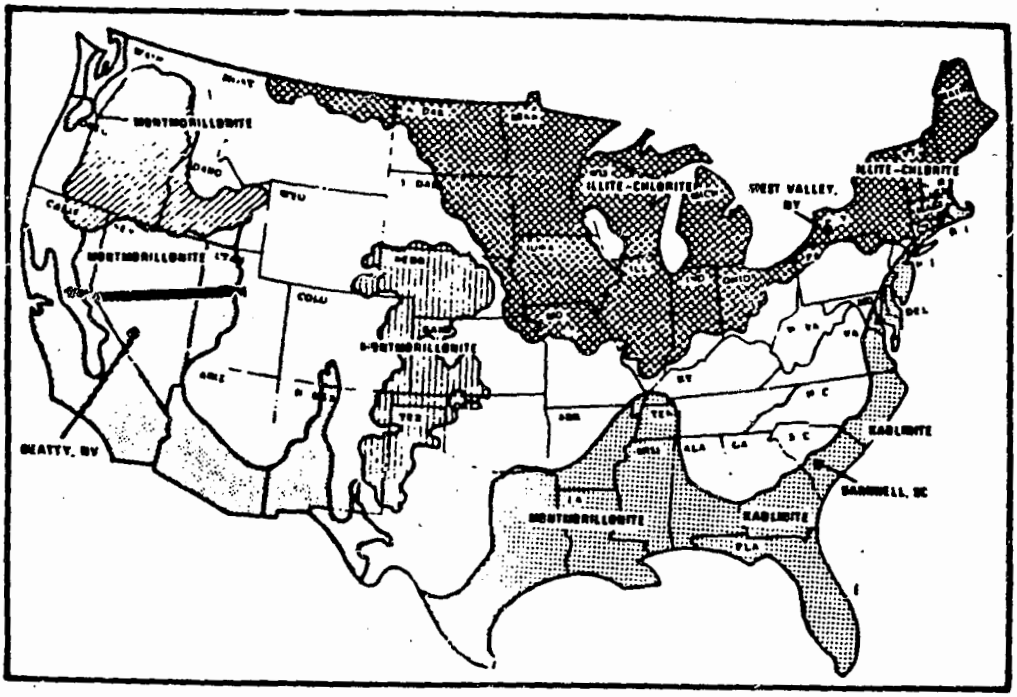


Figure 2. Surficial Map

One can gain a general idea of the degree of adsorption of radionuclides at a site from surficial maps, such as depicted here, and from adsorption distribution coefficient measurements of the radionuclides at the site. Approximately half of the Superfund sites occur in the glaciated central region depicted as the checkered pattern in the diagram. Illite and chlorite are the most abundant clay minerals (most adsorbent) in this region. Kaolinite tends to be the most typical clay mineral in the Atlantic coastal plain and montmorillonite the most abundant in the western States. In some places of the mid-west, e.g., Chicago, wind deposited montmorillonite from the west sits as a thin surficial deposit over the glacial illite and chlorite like "icing" on a cake.

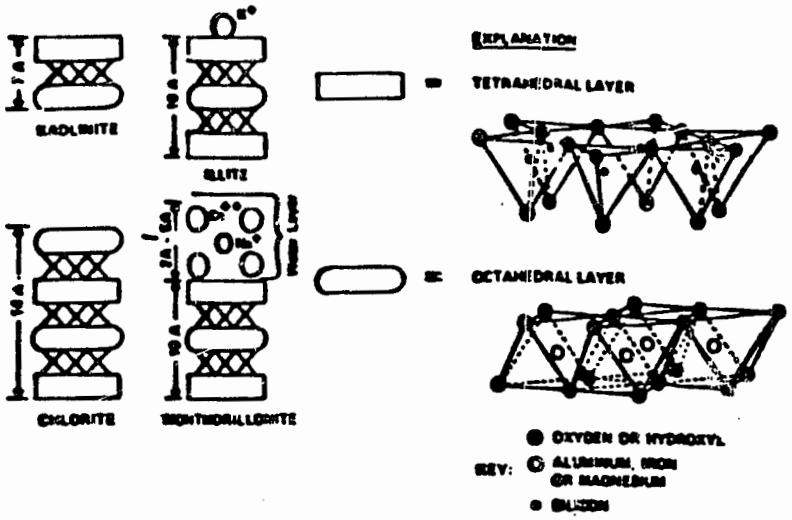


Figure 3. Clay Minerals

This sketch diagram of some of the clay minerals shows their sheet-like structure made of tetrahedral layers (silicia tetrahedrons) and octahedral layers (alumina sheets). The clay minerals are highly adsorbent because of their (a) small size (less than 2 microns) and hence large surface areas (b) negative charge, and (c) exchangeable cations. The clay mineral illite, for example, has k ions in the space between silica tetradrons. Radium of 1.43 A ionic radius can substitute for the potassium (k) ion of 1.33 A ionic radius in this structure.

Adsorbent	Kd (ml/g)
Montmorillonite	6,500
Kaolinite	1,900
Albite	20,000
Muscovite	20,000
Quartz	1,700
Ferric Hydroxide	-28,000

Figure 4. Radium Kds for Various Mineral Adsorbents

The adsorption distribution coefficient or kd is the chemical measure of the ability of a cation to adsorb to mineral surfaces. The higher the kd number, the greater the retention. In the above list of kd numbers for radium, muscovite has a kd of 20,000. The clay mineral illite has a similar chemical composition and structure as muscovite and would have a similar or higher kd number considering its smaller size. Radium is the radionuclide of concern at the Montclair and Glen Ridge Superfund Site.

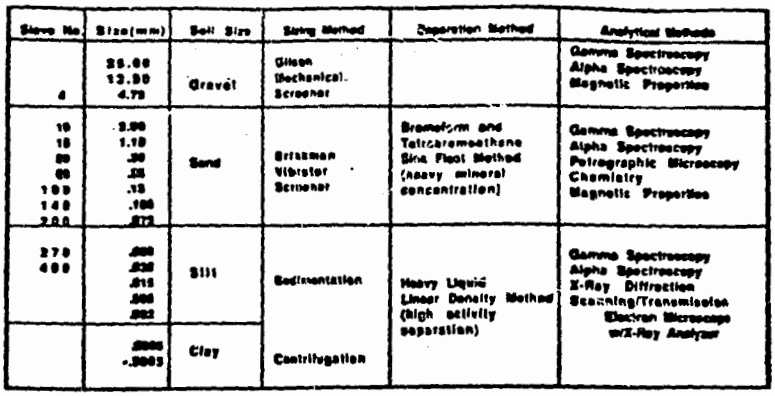


Figure 5. Laboratory Methods for Characterization of Radium Contaminated Soils

The characterization plan for the Montclair and Glen Ridge sites included construction of a grain size distribution curve and physical separation of 18 size fractions (listed above) for complete radioassay in mineral analysis. Special chemical tests were conducted for chemical signature and other correlation purposes. Magnetic, heavy liquid, and linear density gradient separations were made of selected size fractions to concentrate sufficient amounts of these minute quantities of high radium activity materials for identification and quantification. This characterization plan may serve as an example for other Superfund sites.

- Radium in Secular Equilibrium
  - -Uranium Minerals (carnotite, uraninite, etc)
  - -Uraninite in Coal Ash/Slag
  - -Background Minerals (zircon, monazite, etc)
- Acid Leach Radium Materials
  - -Radiobarite (BaRaSo4)
  - -Amorphous Silica
  - -etc
- Radium Concentrates
  - -Radium Paint in Furnace Fired Material (magnetic slag, etc)
  - -Radium Paint on Objects
- Adsorbed Radium
  - -Geologic Host Minerals
  - -etc

Figure 6. Types of Radium Contaminants at Superfund Sites

These are the radium contaminants found at the Montclair and Glen Ridge sites. The most abundant radium materials were acid leach materials (62%), uranium and background materials (16%), radium concentrates (10%), and adsorbed radium on host minerals (12%). Some radium-contaminated sites will contain less varieties. Ottawa, Illinois sites are void of acid leach radium materials or uranium ore minerals but contain building materials and incinerated or furnace-fired slag with radium paint residues.

Sieve	Size Microns	White Sands		Glen Ridge		Montclair		
		pCi/g	Wgt %	pCi/g	%Ra	Wgt %	pCi/g	%Ra
-3 1/2/+4	4750	-	35	345	16	26	44	8
-6/+10	2000	296	10	357		4	85	
-10/+16	1180	641	3	2,1		3	39	
-16/+50	300	993	17	500	27	20	140	33
-50/+100	150	980	4	472		14	113	
-100/+140	106	1,035	3	498		7	139	
140/+200	75	1,913	3	677		3	178	
	50	8,456	4	1,867		6	598	
	38	14,490	3	953		3	248	
	15	9,525	4	1,164		6	369	
	5	15,170	5	3,034		4	438	
	2	17,620	2	3,039		1	444	
					57			59
	0.5	21,800	1	576		0.5	1,113	
	-0.5	3,725	1	3,301		0.5	264	

Table 1.

This table shows the highest concentration of radium in the Montclair and Glen Ridge sites occurring in the fine materials (silt/clay). The fines with approximately one fifth of the volume contains 57-59 percent of the radium.

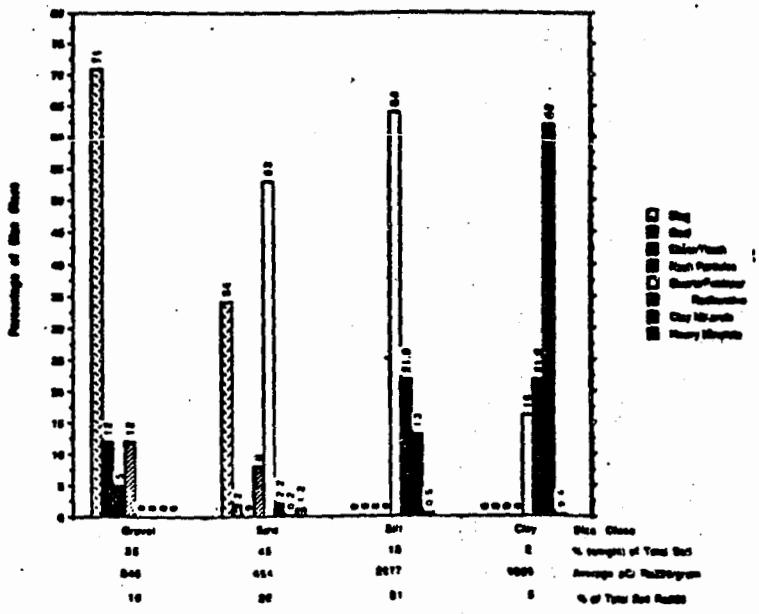


Figure 7. Mineral and Material Composition of Glen Ridge Soil

This figure depicts the mineral and material composition of the gravel, sand, silt, and clay-sized fractions of the Glen Ridge contaminated soil. The average radium concentration and percent radium contained in each site is also listed.

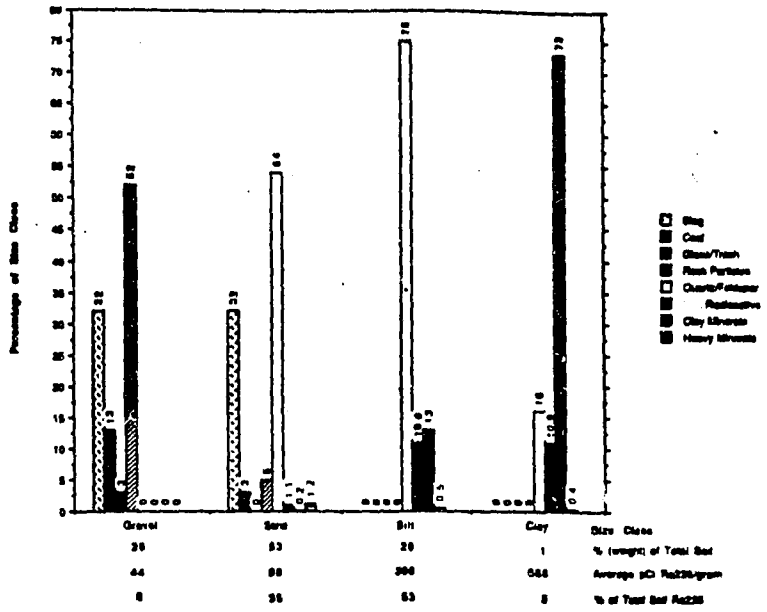


Figure 8. Mineral and Material Composition of Montclair Soil

This figure depicts the mineral and material composition of the gravel, sand, silt, and clay-sized fractions of the Montclair contaminated soil. The average radium concentration and percent radium in each site is also listed.

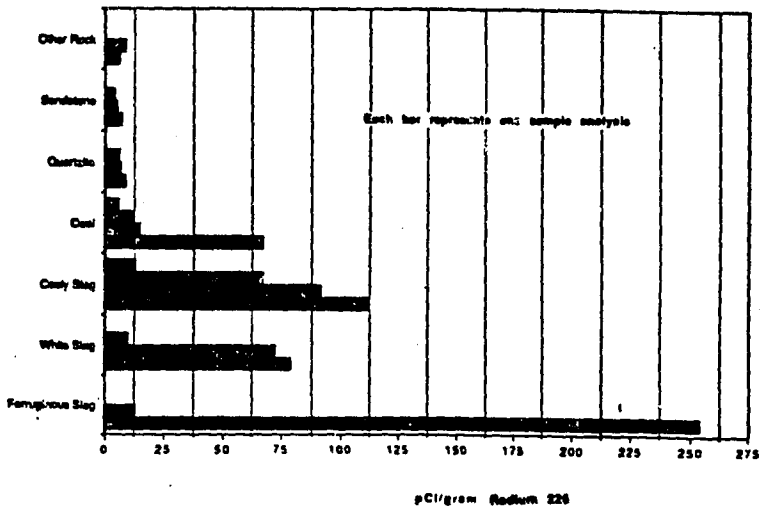


Figure 9. Ra226 on Washed Gravel-Size Particles

The ferruginous slag particles are the incinerated or furnace-fired materials containing the highest radium activity. The ferruginous slag is also magnetic and further studies have shown that this material averages 300 pCi/g Radium 226 and constitutes the major radium content of the gravel-size materials. Magnetic separations may remove much of this material from the soil.

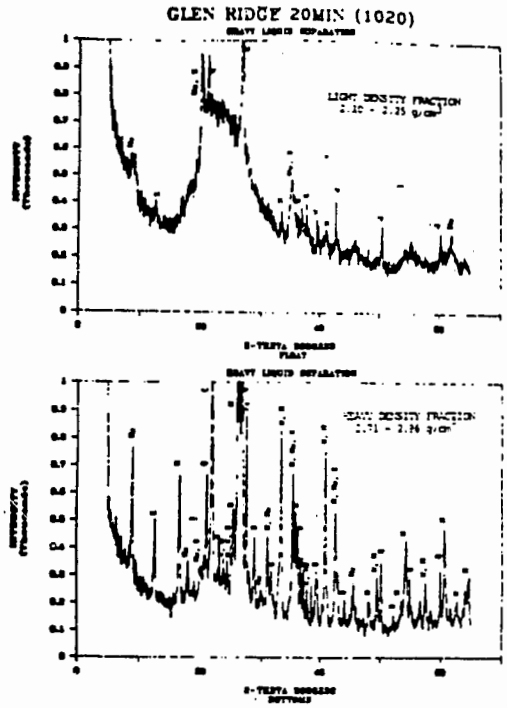


Figure 10. X-Ray Diffractograms of Glen Ridge 10 to 20 Micron-size Light and Heavy Density Fractions

X-ray diffractograms of linear density gradient bands of Glen Ridge soil fraction showing amorphous welt on the light density scan (top). The amorphous welt was verified as amorhpous silica by SEM and EDX probe of the material.

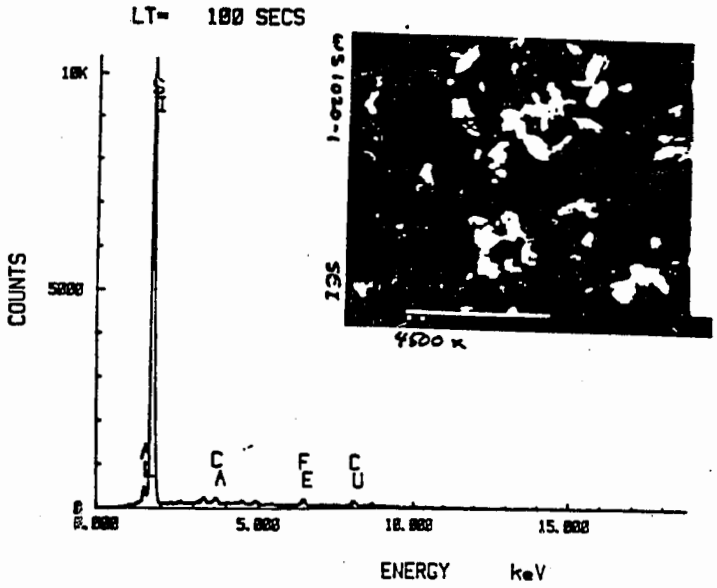


Figure 11. SEM and Energy Scan of Amorphous Silica

The scanning electric micrograph (SEM) and energy scan of amorhpous silica from the 2.10 to 2.35 Specific gravity linear density gradient band of the 10-20 micron size fraction of Glen Ridge soil validates that the amorphous silica is the carrier of the 30 percent radium activity associated with this fraction.

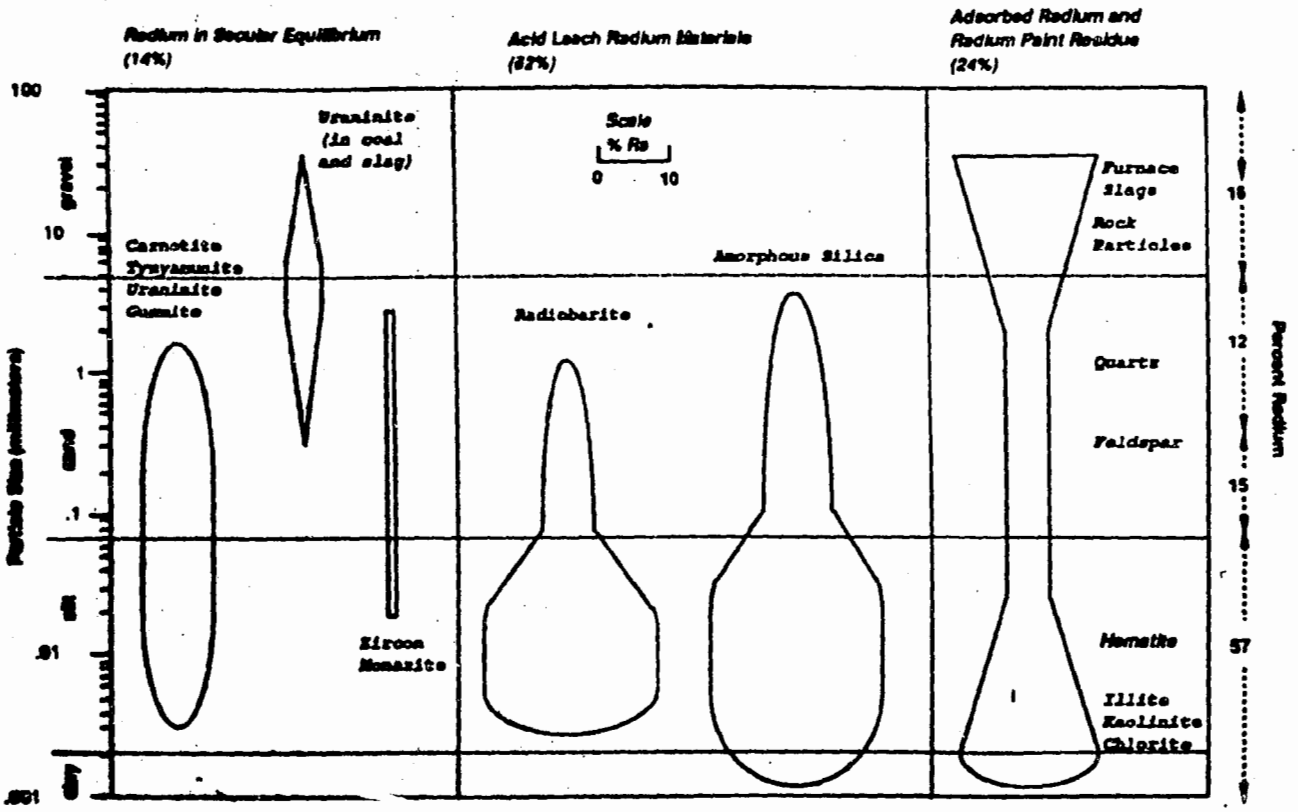


Figure 12. Relationship of Particle Size and Mineral Composition to Percent Radium Distribution in Glen Ridge Soil

This summary diagram shows the spatial relation of specific contaminants and the percent of the radium they contain for the Glen Ridge contaminated soil.

Gravel size 16% Ra	Radium activity predominantly in magnetic ferruginous slag ferruginous slag containing uraninite (coal ash), adsorbed radium, and radium residue from incinerated paint and materials.
Sand-sized 27% Ra	Uranium ore minerals, radiobarite, amorphous silica on quartz, and minor adsorbed radium.
Silt clay 57% Ra	Uranium ore minerals, radiobarite, amorphous silica and adsorbed radium on clay and hematite.

8. CHARACTERIZATION AND WASHING OF RADIONUCLIDE-CONTAMINATED SOILS FROM NEW JERSEY

W. S. Richardson
Tonya B. Hudson
Auburn University at Montgomery
S. Cohen & Associates, Inc.

Joseph G. Wood
Charles R. Phillips
U.S. EPA
Montgomery, Alabama

INTRODUCTION

Soils from residential and business communities in Montclair and Glen Ridge, NJ, are contaminated with Ra-226 and Th-230. The contamination allegedly was produced by a radium extraction mill that operated nearby in the early part of the century. As a result of the subsequent use of this radium residue as landfill during construction, approximately 300,000 yd^3 of soil over 95 acres are contaminated; almost 1,700 people in more than 500 homes are affected to one degree or another by elevated levels of gamma radiation as well as Rn-222 gas. The most significant contaminants producing the gamma radiation and radon gas are Ra-226, ranging from about 40 to 1,000 pCi/g of soil, and thorium, ranging from over 100 to almost 900 pCi/g (CDM85a and b).

The contamination is the result of the presence of process residue containing barium-radium sulfate precipitates, partially extracted ores, and other radiominerals that are mixed to varying degrees with the native soils (Ne88). Earlier studies on uranium mill tailings indicated that volume reduction by physical separation and chemical extraction might be feasible as a means of remediation of the Montclair and Glen Ridge sites (Ri87).

PROCEDURES

Determination of Particle Size and Size Distribution

Wet sieving was performed on two soil samples from the Montclair site and one from the Glen Ridge site, using a vibrating siever. One of the Montclair samples labeled "Montclair" while the other was labeled "Representative," since, as reported in CDM Report (CDM83a and b), the specific activity of Ra-226 contamination in the latter represented an average value for the overall sites. Each soil had been previously mixed to provide a uniform Ra-226 activity. The soils were dried at 60 °C before separation.

Radiochemical Analysis

All soil samples and soil fractions were analyzed for Ra-226 by gamma-ray spectroscopy (Li84). Soils and selected wet-sieved fractions and samples were also analyzed for Th-230 (Li84) and, in some cases, for uranium isotopes (Li84).

Wash Studies

Four soil fractions were identified for wash studies: +4 (+4 designates material retained by a number 4 sieve); -4/+16 (-4/+16 designates material that passes through a number 4 sieve but is retained by a number 16 sieve); -16/+30; and -30/+50. Based on the literature survey (Ri87), water and several salt or salt/acid solutions were selected as wash reagents.

One-Step Wash Studies. Samples of the selected soil fraction prepared by dry screening, were analyzed for Ra-226. The samples were then mixed with water or the selected wash solution in a Nalgene container and shaken at room temperature for 1 hr. At the end of that time, they were rinsed with water, and the solid residue (R1) was collected over the appropriate sieve - number 4 for a +4 soil fraction or number 16 for a -4/+16 fraction, for example. The residue was dried, weighed, and analyzed for Ra-226 and/or Th-230 and uranium isotopes. The filtrate was subsequently filtered through a filter paper and then a micropore filter. These residues were dried and weighed. The volume of the filtrate was measured and, along with the residues, analyzed for Ra-226.

Two-Step Wash Studies. The first step of the two-cycle wash studies was performed as described above for a one-step study using water exclusively, but shaking the mixture for a period of only 5 min. The first residue was treated again for 1 hr with water or one of the wash reagents selected for the study.

Three-Step Wash Studies. The three-step wash studies were performed as described above for a two-step study except that the residue from the second step was washed again with water for 1 hour.

Soaking studies. Soaking studies were performed on selected soil fractions as described for the one-step wash studies, except that the sample was gently mixed with water and allowed to stand for 18 hr before shaking.

Recycle Studies. Samples of soil fractions were washed using the procedure described for one-step wash studies; the micropore filtrate was collected for the second step of the study. In the second step, a new soil fraction was washed with the filtrate from the first step. The filtrate from the second step was, in turn, used to wash a third new soil fraction.

Combined Washing and Wet-Sieving of Total Soils

Soil samples were weighed for Ra-226 analysis. After analysis, the samples were mixed with tap water in a Nalgene container and shaken vigorously at room temperature for 30 min. The soil mixtures were then sieved under vacuum using appropriate sieves.

RESULTS AND DISCUSSION

Particle Size and Radiochemical Distribution

Table 1 gives the average concentration of Ra-226 and Th-230 in the Montclair, Glen Ridge, and Representative soil samples, based on their dry weights. The concentration of Ra-226 is approximately 4 times higher in the Glen Ridge soil than in the Montclair soil, while the Representative soils contain less than 1/3 that of the Montclair soil. Th-230 concentration in the Glen Ridge soil is 3.5 times higher than in the Montclair soil; the isotope concentration in the Representative soil is considerably less than the concentration in the Montclair soil.

The distributions of Ra-226 and Th-230 by particle size are indicated in Tables 2, 3, and 4 for the Montclair, Glen Ridge, and Representative soil fractions, respectively. Note in Table 2 that the Ra-226 activity is moderate, less than 100 pCi/g, in the Montclair fractions larger than 600 u (30 mesh size), but it generally increases as the particle size decreases. There is a noticeable increase between the -10/+16 and the -16/+30 fractions and between the -200/+400 and the -400 fractions and an unexpectedly high value for the -16/+30 fraction -- more than twice the value of the preceding fraction. The Th-230 values are, with the exception of one fraction (-16/+30), less than that of Ra-226.

Table 3 shows that the Ra-226 concentration is distributed in a similar manner in the Glen Ridge soil, but the increase in concentration is not as uniform with decreasing particle size. There is, again, a noticeable increase from the number 16 to 30 mesh size and from 400 to -400 mesh, a doubling in activity, with a very high activity in the -400 fraction. Th-230 concentration is also inversely related to the particle size, doubling between the 16 and 30 mesh size and between the 400 and -400 fractions. In each fraction, however, the Th-230 concentration is less than Ra-226.

Table 4 indicates that the Ra-226 concentration is more evenly distributed in the Representative soil, but an increase in concentration is observed with relatively significant increases from the -30/+50 fraction to the -50/+100 fraction and from the -100/+140 to the -140/+200 fraction. Each fraction contains less Th-230 than Ra-226.

The elevated concentrations of radioactivity in the fine material are clearly demonstrated by these data. Thus, partial remediation of the soils by wet sieving techniques appears to be feasible.

Tables 2 through 4 also summarize the particle size distributions, in percentage by weight, of the material and sieved. In the Montclair soil, Table 2, approximately 30 percent of the soil was retained by the number 16 sieve; 34 percent was retained up to the number 30 sieve (600 u).

Table 3 indicates a similar trend for the Glen Ridge soil. At least 45 percent of the sample was retained up to the number 16 sieve during wet sieving, 50 percent was retained up to the number 30 sieve.

Table 4 indicates that the Representative soil is similar to the Montclair in distribution of particles by weight. However, it contains approximately 10 percent more fine material (-400 mesh); unlike the Montclair soil, no large rocks (> 2 inches) are present in the soil.

Soil Wash Studies

Examination of the distributions of Ra-226 concentrations in the Montclair and Glen Ridge soils before and after wet sieving, along with preliminary evidence from the geological characterization by James Neiheisel (Ne88), indicated that preliminary wash studies should be performed on +30 soil fractions. These fractions had been separated, by the methods described above, from Montclair and Glen Ridge soils obtained from the New Jersey site in October 1987.

Table 5 is a summary of the initial results of single-step wash studies with water and gentle shaking. With one wash, water removed approximately 50 percent of the Ra-226 activity from the +4 fraction and about 85 percent of that in the -4/+16 fraction. In each case, the filtrate contained little to no activity (data not shown in Table 5). The final average specific activity of the Montclair samples ranged from 10 to 71 pCi/g. Although the Glen Ridge samples followed the same trend, the final activity was well above 71 pCi/g (121 to 330 pCi/g) since the activity of the samples was high initially.

The final specific activity of the Montclair +4 and -4/+16 fractions indicate a promising trend for remediation by washing and screening since their average values after washing are 10 pCi/g and 33 pCi/g, respectively. Th-230 values are lower than those of Ra-226, indicating that ingrowth of Ra-226 would not be a long-term problem.

In most instances the salt solutions produced similar, and in several cases slightly better, results (see Table 6). The data generally indicate, however, that, relative to water, salt solutions increased the activity of Ra-226 in the filtrate.

Pre-soaking the soil samples before washing was examined to deter-mine its effect on one-step washing with water. For these studies, the intermediate-size fraction, -4/+16, of both soils was selected for the study. The results of the study and comparison of the data to those without preliminary soaking indicate that soaking the fraction before shaking does not increase the effectiveness of the water-wash procedure.

An important consideration in a large-scale remediation process using water is the amount of water required. If the wash water could be recycled, an appreciable amount would be conserved during volume reduction. Further, recycling would avoid the necessity of disposal or decontamination of large volumes of radioactive liquids. In a study designed to examine the feasibility of water recycling, a -4/+16 soil fraction was first washed with deionized water; the filtrate was collected after filtering through a micropore filter and used to wash a new -4/+16 fraction. The filtrate from the second wash was used, in turn, to wash another new fraction. In each step of the wash process, the same percentage of activity was removed leaving samples with comparable specific activities. The activity of the filtrate in

each case was less than 25 pCi/L. Thus, the study indicates that wash water filtered through a micropore filter to remove suspended particles may be recycled at least twice with no significant decrease in removal efficiency.

The effect of two- and three-step washing was also examined. With each fraction, the study indicates that the two-step process, compared to the one-step process removed a greater percentage of Ra-226 activity. Like the single-step procedure, each step of the process removed some mass from the sample. The first step removed the majority of the associated fines, but visual examination of the sample after two wash steps indicated that the material had less fine particles associated with it than did a comparable sample washed only once. The loss of material during the second wash step was approximately 5 percent of the initial sample weight. In every experiment, the specific activity of the filtrate was less than 25 pCi/L. The results of the three-step wash study with water indicate that only a very small amount of additional sample is removed by the third wash step. Examination of the residues from the two- and three-step studies support this observation, since there is no visual physical difference in comparable residues. There is no significant increase in the loss of total activity of the samples after the third wash and the specific activity is essentially the same.

A preliminary study of washing rocks with water was also initiated. Similar to the +4 soil fractions, the geometry of the rock sample presents a problem for Ra-226 analysis by gamma-ray spectroscopy than those of smaller fractions. The Montclair rocks, however, indicated a specific activity of less than 15 pCi/g and were not washed. On the other hand, the Glen Ridge rocks with more coal-like and coaly-slag character have a specific activity of 260 + 217 pCi/g, but the wash study was not conclusive.

Combined Washing and Wet Sieving Studies of Total Soils

The results of the wet sieving and water-wash studies indicated that the examination of a combination of the two processes applied to a total soil sample would be appropriate. Table 7 indicates that by combining vigorous shaking with vacuum sieving up to 35 percent of the Montclair soil can be separated with an average Ra-226 specific activity of 15 pCi/g, a specific activity very similar to that obtained in the preliminary studies. With the inclusion of the -50/+100 fraction, however, almost 43 percent of the Representative soil can be recovered with a Ra-226 specific activity of 15 pCi/g. It is important to note that 56 percent of this soil sample can be recovered with a specific activity of 16 pCi/g and 67 percent can be recovered at 19 pCi/g.

Although vigorous shaking and wet sieving with vacuum was not effective in producing a sufficiently remediated Glen Ridge soil, the process did separate approximately 55 percent of the soil (+30) with less than half the specific activity of a sample that had been shaken gently, 120 pCi/g compared to 290 pCi/g.

In light of the proposal from ORP to develop a simple, safe, economical, onsite method of treatment that would produce a significant volume of remediated soil that would remain onsite, the results of the initial wash

studies indicate that water washing is a prime candidate for onsite remediation.

Using water exclusively would eliminate the necessity for removal of salt and/or acids by processes that would require one or more steps, possibly including, among others, ion-exchange, neutralization, or precipitation. Since the data indicate that little radium-226 is present in the filtrate after washing the soil fraction either once or twice with water, it is likely that the water could be disposed directly with dilution or, more importantly, be recycled several times during the washing process. Thus, a wash process that would include wet screening of the soil to separate the +100 fraction would be followed by filtration of the -100 fraction to remove wash water that in turn would be recycled in the process. The -100 fraction could be collected for disposal or additional treatment.

REFERENCES

CDM85a "Remedial Investigation Study for the Montclair/West Orange and Glen Ridge, New Jersey Radium Sites," Vol. I. Camp Dresser and McKee, Inc.; Roy F. Weston, Inc.; Clement Associates, Inc.; ICF, Inc.. EPA Contract No. 68-01-6939. U.S. Environmental Protection Agency, New York, September 13, 1985.

CDM85b "Appendices for Remedial Investigation Study for the Montclair/West Orange and Glen Ridge, New Jersey Radium Sites," Vol. II. Camp Dresser and McKee, Inc.; Roy F. Weston, Inc.; Clement Associates, Inc.; ICF, Inc.; EPA Contract No. 68-01-6939. U.S. Environmental Protection Agency, New York, September 13, 1985.

Li84 Lieberman, R., ed.. "Eastern Environmental Radiation Facility Radiochemistry Procedures Manual." Report 520/5-84-006, U.S. Environmental Protection Agency, June 1984.

Ne88 Nieheisel, J., "Characterization of Contaminated Soil from the Montclair/Glen Ridge, New Jersey Superfund Sites." EPA Inhouse Report. Office of Radiation Programs, EPA, Washington, DC, 1988.

Ri87 Richardson, III., R.S., Snodgrass, G.B., and Neiheisel, J.. "Review of Chemical Extraction and Volume Reduction Methods for Removing Radionuclides from Contaminated Tailings and Soils for Remedial Action." EPA Office of Radiation Programs, Analysis and Support Division, Washington, DC and Eastern Environmental Radiation Facility, Montgomery, AL, July 24, 1987.

Table 1. Total Soil

Radiochemical Analysis

Soil	Ra-226 (pCi/g)	Th-230 (pCi/g)
Montclair	182 ± 5%	126 ± 4%
Glen Ridge	813 ± 2%	881 ± 4%
Representative	53 ± 3%	18 ± 5%

Dried at 60°C.

Percentage error for concentration represents ± 2 sigma error.

Table 2. Montclair Soil

Wet Sieving

Size	Weight Percent *	Ra-226 (pCi/g)	Th-230 (pCi/g)
+4	18.25	44 ± 20%	7 ± 6%
-4/+10	7.94	26 ± 24%	12 ± 9%
-10/+16	3.23	39 ± 31%	15 ± 8%
-16/+30	4.54	84 ± 15%	175 ± 4%
-30/+50	7.46	117 ± 12%	71 ± 5%
-50/+100	14.16	113 ± 12%	62 ± 5%
-100/+140	6.74	138 ± 11%	68 ± 5%
-140/+200	5.55	170 ± 8%	115 ± 4%
-200/+400	10.85	194 ± 11%	132 ± 4%
-400	21.28	382 ± 8%	283 ± 5%
	100.00		

Dried at 60°C.

*Percentage of sieved material; 3.34% of soil is large rocks and 1.46% is trash.

Percentage error for concentration represents ± 2 sigma error.

Table 3. Representative Soil

Wet Sieving

Size	Weight Percent *	Ra-226 (pCi/g)	Th-230 (pCi/g)
+4	15.79	14 ± 9%	5 ± 9%
-4/+10	6.70	22 ± 9%	8 ± 6%
-10/+16	2.65	27 ± 10%	8 ± 6%
-16/+30	4.74	25 ± 9%	9 ± 5%
-30/+50	7.73	25 ± 7%	16 ± 5%
-50/+100	12.29	33 ± 5%	23 ± 5%
-100/+140	5.55	33 ± 25%	23 ± 5%
-140/+200	4.56	52 ± 16%	39 ± 5%
-200/+400	10.48	58 ± 10%	55 ± 4%
-400	29.51	105*	**
	100.00		

Dried at 60°C.

*Calculated from total activity of the sample sieved and percentage of the fraction.

**Not measured.

Percentage error for concentration represents ± 2 sigma error.

Table 4. Glen Ridge Soil

Wet Sieving

Size	Weight Percent *	Ra-226 (pCi/g)	Th-230 (pCi/g)
+4	31.78	346 ± 9%	76 ± 6%
-4/+10	9.74	307 ± 7%	154 ± 4%
-10/+16	3.61	268 ± 10%	108 ± 5%
-16/+30	4.93	535 ± 8%	211 ± 4%
-30/+50	5.85	492 ± 5%	289 ± 4%
-50/+100	11.09	472 ± 5%	302 ± 4%
-100/+140	5.64	498 ± 5%	365 ± 3%
-140/+200	4.02	677 ± 5%	500 ± 3%
-200/+400	7.62	1,006 ± 4%	987 ± 4%
-400	15.70	2,855 ± 3%	2801 ± 5%
	99.98		

Dried at 60°C.

*Percentage of material sieved; 0.65% of soil is large rocks and 0.30% is trash.

Percentage error for concentration represents ± 2 sigma error.

Table 5. Summary of Results from One-Step Wash Study with Water

Soil	Size	Initial Sp. Act. Ra-226 (pCi/g)	Final Sp. Act. Ra-226 (pCi/g)	Percent of Total Activity Removed	Weight Percent of Sample Recovered	Int./Final Sp. Act. Th-230 (pCi/g)
M	+4(a)	19 ± 7.0	10 ± 3.7	52 ± 7.0	86 ± 5.6	27/3
	-4/+16(b)	104 ± 14	33 ± 8.3	86 ± 3.4	45 ± 2.0	104/15
	-16/+30(c)	168 ± 15	71 ± 9.7	86 ± 3.8	34 ± 1.9	158/55
G	+4(a)	193 ± 57	121 ± 28	40 ± 14	92 ± 4.3	1,057/68
	-4/+16(b)	850 ± 54	238 ± 53	82 ± 3.5	66 ± 2.5	611/108
	-16/+30(c)	1,092 ± 67	330 ± 44	87 ± 2.2	44 ± 1.3	794/167

(a) Represents the average and standard deviation of seven runs.
(b) Represents the average and standard deviation of eight runs.
(c) Represents the average and standard deviation of four runs.

Table 6. Summary of Results from One-Step Wash Study with Salts

Soil	Size	Reagent	Initial Sp. Act. Ra-226 (pCi/g)	Final Sp. Act. Ra-226 (pCi/g)	Filtrate Sp. Act. (pCi/L)	Percent of Total Activity Removed	Weight Percent of Sample Recovered
M	+4	NaCl	35	28	104	46	68
M	+4	KCl	28	10	72	70	84
M	+4	$CaCl_2$/HCl	28	14	538	56	85
M	+4	EDTA	26	11	*	64	85
M	-4/+16	NaCl	82	41	106	76	49
M	-4/+16	KCl	92	19	287	91	44
M	-4/+16	$CaCl_2$/HCl	101	26	1,890	89	42
M	-4/+16	EDTA	147	32	*	90	44
G	+4	NaCl	331	186	352	51	88
G	+4	KCl	276	142	765	55	88
G	+4	$CaCl_2$/HCl	202	122	4,588	44	92
G	+4	EDTA	174	108	*	40	97
G	-4/+16	NaCl	945	520	0	62	70
G	-4/+16	KCl	822	196	1,493	84	65
G	-4/+16	$CaCl_2$/HCl	898	135	5,120	91	62
G	-4/+16	EDTA	813	244	*	81	64

* Not measured.

Table 7. Final Studies of Vigorous Shaking and Subsequent Sieving of Soils on the Wet-Vac Siever

Size	R Weight Percent	R Ra-226 (pCi/g)	M Weight Percent	M Ra-226 (pCi/g)	G Weight Percent	G Ra-226 (pCi/g)
+4	11.06	12	21.94	15	18.68	102
-4/+16	5.59	21	5.69	15	11.73	151
-16/+30	4.10	14	2.67	16	2.91	175
-30/+50	7.99	14	4.49	18	5.52	182
			34.79*	15**	38.84*	134**
-50/+100	13.89	15	10.46	42	11.63	174
	42.63*	15**				
-100/+200	13.46	22	13.61	59	11.41	246
-200/+400	11.40	34	13.12	92	8.23	484
	67.49	19**				
-400	32.51	180	28.02	427	29.89	3,581
	100.00		100.00		100.00	

Th-230 specific activity for each fraction was less than the specific activity of Ra-226.
*Cumulative weight percent.
**Weighted average of specific activities of above fractions.

9. THE WELDON SPRING SITE, MISSOURI

Daniel R. Wall
Environmental Protection Agency

The Weldon Spring Site is in the greater St. Louis metropolitan area, situated between the Missouri and Mississippi Rivers (figure 1). The Department of the Army acquired the property in the early 1940s, during World War II, for construction of an explosives production facility, the Weldon Springs Ordnance Works, which would manufacture trinitrotoluene (TNT) and dinitrotoluene (DNT). During operations, there was considerable spillover of red waste waters from production lines and catchments, contaminating both surface waters and ground water.

The facility was shut down at the end of the war, and later, in the mid-1950s, the Atomic Energy Commission (AEC) acquired the property and built the Weldon Springs Uranium Feed Materials Plan. This operated from 1957 until abandoned in 1966. The plant processed uranium concentrates to uranium salts; it was similar to the Fernald Plant in Ohio, which it predates. During operations, the immediate terrain, buildings, sewer system, and drainage easement were contaminated.

Four miles to the south, in bluffs along the Missouri River, a 9-acre limestone quarry was used for over 25 years by the Army and AEC for disposal of wastes (figures 1 and 2). The Army disposed of contaminated debris, soils, and rubble from the explosives production, and the AEC disposed of drums, equipment, soils, and rubble contaminated with uranium, radium, and thorium. The quarry was the first portion of this 220-acre DOE surplus facility to be placed on the NPL. Investigations show that it has about 95,000 yd^3 of chemically and radiologically contaminated wastes and is hydraulically connected through fractured limestone to the Missouri River alluvium. The county has a well field in alluvium about 3/4-mi distant. Though uranium, radium, and nitro-aromatics contamination has been detected outside the quarry boundaries, none has been found in the well field.

The chemical plant and raffinate pits were recently added to the definition of the quarry, and now the entire facility is on the NPL as one site. An estimated 220,000 yd^3 of contaminated sludges are in the raffinate pits; the contaminant of primary concern is thorium. The chemical plant includes about 40 buildings, many of which are contaminated with uranium. Remedial action is complicated by proximity to the local high school; thus, the site has a high public profile. Also, the bulk of the contaminants are radionuclides, but there are also nitro-aromatics, heavy metals, and organics. The ground water is contaminated with nitrates and nitro-aromatics, most of the buildings had PCB transformers (which have been removed), and many of the buildings have asbestos insulation.

DOE, under an agreement with the EPA, is now conducting an RI/FS for the site. These studies have been underway for 5 years and will take another 2 years to complete. Complete remediation is likely to taken another 10 years. For purposes of the RI/FS, the site has been divided into two sections - the chemical plant area (including the raffinate pits) and the quarry area. Each

contains several distinct components which will require separate RI/FS documentation.

However, pending completion of the RI/FSs, there is an immediate need to stabilize the site and stop migration of contaminants off-site, so an extensive interim response action program is underway. Actions have included removal of containerized chemicals, removal of PCB transformers and incineration offsite, demolition of the less contaminated buildings, installation of a diversion dike system for stormwater control, and construction of a waste water treatment plant at the quarry. These actions will enable further remedial actions; once the contaminated water is treated, the bulk sludges can be removed from the quarry. There are over 20 separate environmental compliance components underway. An extensive and dynamic public relations program has been developed, and a Superfund technical grant has been awarded to a community group.

Looking ahead, the most feasible alternative appears to be onsite disposal in the chemical plant area if investigations show that site to be appropriate. All of the nonradioactive contaminated wastes will go off site; this includes most of the chemical wastes, so the bulk of the contamination to be dealt with onsite will be radiological wastes. Up to 10 percent of the waste may fall into the mixed waste category; if these wastes must remain on-site and cannot be effectively treated, they may influence the design of the disposal cell. Because of the large quantity of contaminated wastes involved, DOE and EPA are looking at all possible volume reduction technologies.

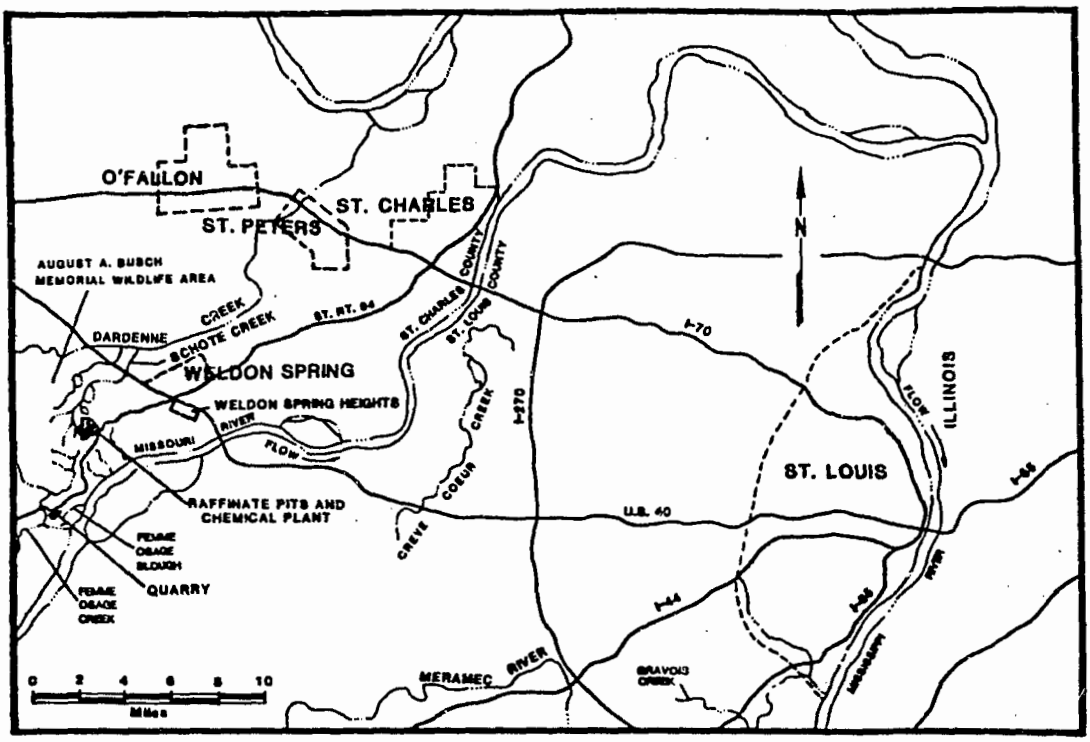


Figure 1. Area and Vicinity Map of the Weldon Spring Site, Weldon Spring, Missouri

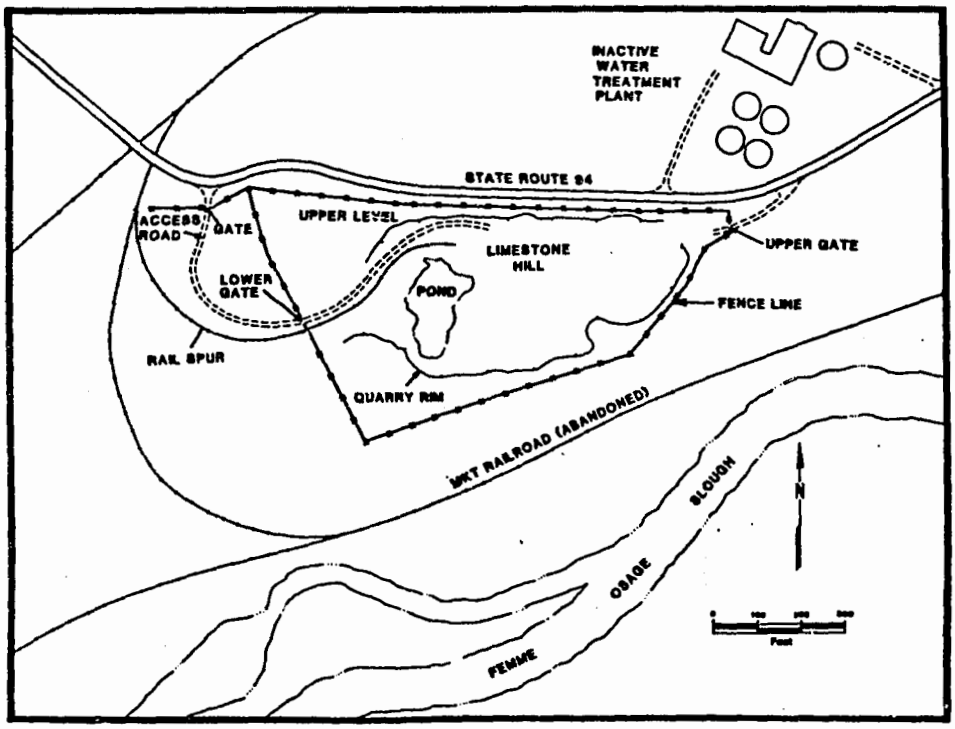


Figure 2. Layout of the Weldon Spring Quarry

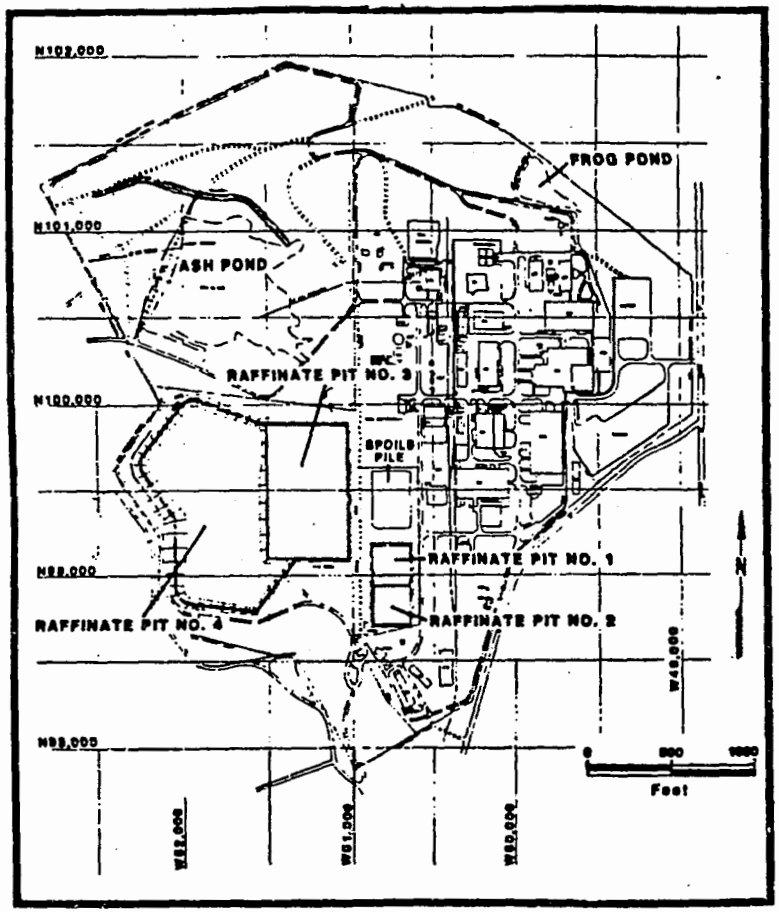


Figure 3. Layout of the Weldon Spring Raffinate Pits and Chemical Plant Area

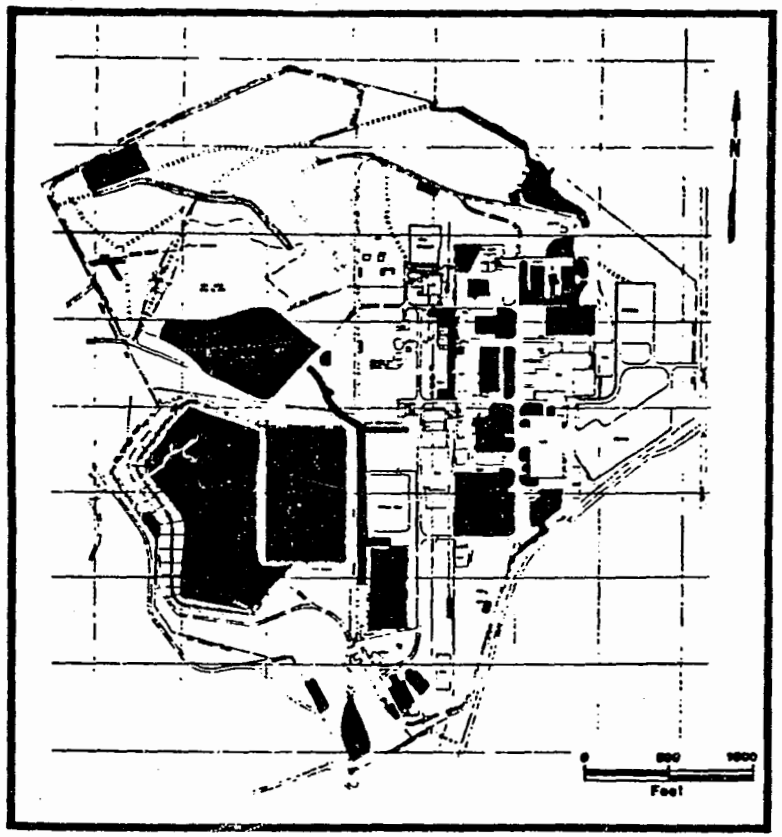


Figure 4. Areas in the Raffinate Pits and Chemical Plant Area that have Exposure Rates Above Background

10. OTTAWA RADIATION SITES

Verneta Simon
Environmental Protection Agency

Ottawa Radiation Sites consists of 17 areas in Ottawa, IL, where anomalous levels of Ra-226 were identified by a Department of Energy (DOE) aerial survey and by an EPA gamma mobile survey. Ottawa, a city with a population of 18,000, is about 80 mi south-west of Chicago.

From 1920 to 1978, Ottawa was the location of two radium watch-dial painting facilities, Radium Dial and Luminous Processes Incorporated (LPI). Radium Dial opened in 1920 and was razed in 1968; the current location of the debris is unknown. LPI was in operation from 1932 to 1978; during 1985 and 1986, the Illinois Department of Nuclear Safety (IDNS) dismantled the vacant factory. The Department disposed of the contaminated soil, building materials, and sewer lines at the nuclear waste landfill in Hanford, WA.

While the IDNS was decommissioning the LPI site, it learned that waste material from the site was used for landfill in and around Ottawa. This was substantiated when EG&G, a DOE contractor, performed an aerial radiological survey of the area in May 1986 and identified 13 areas with varying degrees of radium contamination. This State survey also led to the identification of 5 structures with high indoor radon levels - that is, in excess of 100 pCi/L of air. EPA's action guideline is 4 pCi/L.

In December 1986, the IDNS requested EPA assistance in dealing with Ottawa's radium and radon problems. After several discussions, a three-phased approach was decided upon.

Phase 1 was to determine if the contamination was natural or of industrial origin. Soil samples collected from several locations in December 1987 proved the contamination was industrial.

Phase 2 was to determine if there were other contaminated areas. During December 1987, EPA conducted an extensive street-by-street inspection of Ottawa with a gamma survey van. The gamma survey van was provided by EPA's Las Vegas Facility. It houses a 4x16 sodium iodide detector that measures radiation counts per minute and a pressurized ion chamber that measures exposure per hour, making it easy to relate counts-per-second to exposures-per-hour.

Survey results confirmed the presence of radioactive materials at 13 sites identified by the aerial survey and found 4 additional sites. The 17 contaminated sites range in size from 10 ft^2 to approximately 10 acres.

A convincing piece of evidence that the contamination was industrial in origin is a radium paint vial found at one site. Dry paint residue in the vial measured 100 uR/hr on contact.

During this phase, radon testing was conducted in 62 buildings, both homes and commercial structures. EPA found 3 residences and 1 commercial building with

elevated indoor radon levels, between 20 and 378 pCi/L, that required reduction. With confirmed radon levels between 20 and 200 pCi, EPA recommends taking remedial action within several months; at confirmed levels over 200 pCi, immediate action should be taken to reduce levels.

Superfund's Emergency Removal Program provided $193,500 to mitigate radon in four buildings. The primary reduction method selected was subslab suction or ventilation. This method requires boring a hole in the building foundation. PVC piping is inserted into the hole and sealed tightly at all connections. The pipe is vented to the outside and fitted with an exhaust fan to suck the radon from under the building and vent it to the outside where there will be no impact. This reduces the indoor radon buildup.

Subslab ventilation systems were offered at no cost to the owners of the four buildings with the highest levels; three owners accepted and these systems are installed and operating. The owner of the house with the highest level, 378 pCi/L, refused EPA's offer of a subslab ventilation system and also refused temporary relocation. The owner opens basement and upper level windows at night to ventilate the radon. Initially, the owner would not let EPA back on the property for further assessment of radium contamination but finally relented.

Phase 3 called for remediation of the contaminated properties. This involved evaluation of the extent of contamination and options for removal, conducted under an interagency agreement with the DOE's Argonne National Laboratory.

Five of the largest of the 17 contaminated sites were identified. Tubes 1 inch in diameter were driven into the ground with a jack-hammer, and radiation measurements were taken at 6-in increments below the surface. The volume of contaminated soil was estimated by multiplying the square footage of the contaminated area by the depth of contamination.

Currently, four options are being considered:

1. Excavation and disposal of contaminated soil at S. K. Hart in Clive, UT. An estimated 20,000 to 40,000 yd^3 of soil would have to be removed. Removal and shipping costs are estimated to be $20 million to $40 million.

2. In situ vitrification, a thermal process that converts soil into a glassy rock. The procedure involves placing metal rods in the soil to the depth of contamination. Applying a high voltage to the rods converts the soil between the rods to a liquid, which later solidifies. This technology was developed for the DOE to prevent migration of transuranic wastes; it now is being applied to other types of waste. The estimated cost of using this method at the Ottawa site is $15 million to $25 million.

3. Soil washing, which entails washing the contaminated soil with a chemical solution or water. Radioactive materials are transferred to the liquid in the process. Pilot tests of this technology are under way for a similar project.

4. Consolidating and capping contaminated soil at a single site. The estimated cost is $7 million to $9 million.

A combination of options may be used if EPA determines that it would be more efficient and effective. A decision is expected shortly, following the results of the in situ vitrification pilot test.

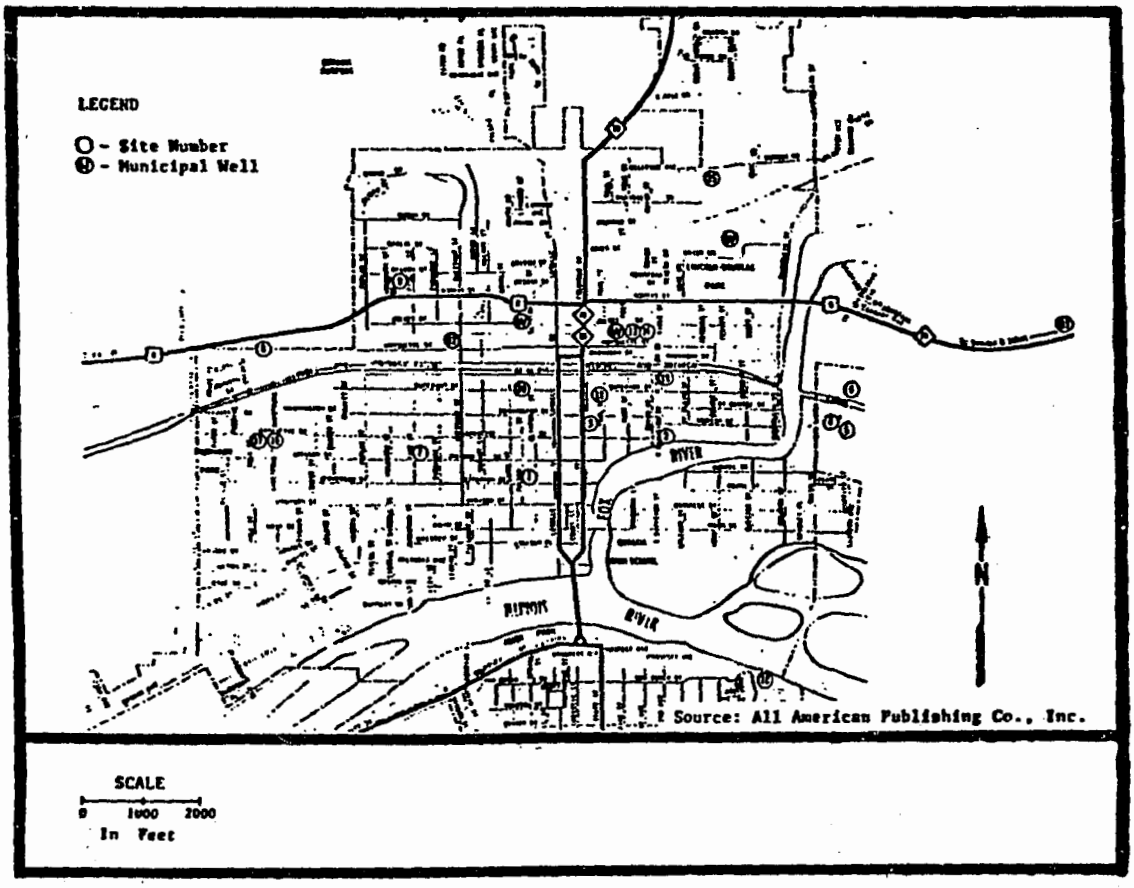


Figure 1. Sites Map, Ottawa Radiation Sites, Ottawa, Illinois

11. SHPACK LANDFILL, MASSACHUSETTS

David Leqerer
Environmental Protection Agency

The Shpack Landfill is located in Norton, Massachusetts, on the town line between Norton and Attleboro. The Attleboro Municipal Landfill lies on the other side of the line (figures 1 and 2). The privately owned, 6-acre Shpack Landfill was closed by court order and has been abandoned for the past 15 years; the publicly owned, 40-acre Attleboro Landfill is still in operation. The Attleboro area has been the center of jewelry manufacturing for many years; the Balfour Ring Company, long-time maker of school rings, is one of the area's best-known manufacturers.

Wastes from the local heavy industry and jewelry manufacturing include spent plating solutions and sludges, organic solvents, and various mixed wastes. Before RCRA, disposal was not always done in the best fashion. Locally, it was reported that the Shpack dump, started in 1946 by a retired municipal employee on his farmland, would take any wastes refused at the Attleboro site.

The Shpack residence is right beside the landfill area; the well has been tested many times and shows no contamination. In fact, monitoring to date has revealed no offsite radiological contamination and very little chemical contamination. This is explained by the very shallow or flat hydraulic gradient of the swampy area. It is believed that the contaminants have been adsorbed by or adhered to soil particles; monitoring wells to the north and permitted wells around the Attleboro site have shown no radiological contamination of the ground water.

The Attleboro Landfill is permitted by the State and still operating, generating large quantities of leachate which are now regulated by the State. The ground-water contour map (figure 3) shows some gradients but there is no general direction of movement; contaminant migration offsite is not evident.

Several radiological surveys have been performed. In the late 1970s, the NRC received a complaint from a citizen who had tested the area with a geiger counter and found anomalous spots. Subsequent investigations included local interviews with local companies and a complete radiological site survey (figure 4). The DOE radiological survey showed no clear pattern; the radioactive contamination is unevenly or spottily distributed both vertically and horizontally from the surface to a depth of several feet. The radioactive waste appears to be just scattered debris, no drums or disposal pits. Readings at the site boundaries and surface water in the swamp are background. Air quality monitoring has indicated no problems.

Investigations at the site are still in the early stages. The Shpack Landfill is on the National Priority List and some potentially responsible parties have been identified. EPA is the lead agency; DOE is providing some funding for addressing the radioactive contamination under the Formerly Utilized Sites Remedial Action Program. The question now is how to get all of the PRPs together; the list could include most of the industries in the town and probably many from elsewhere in the state.

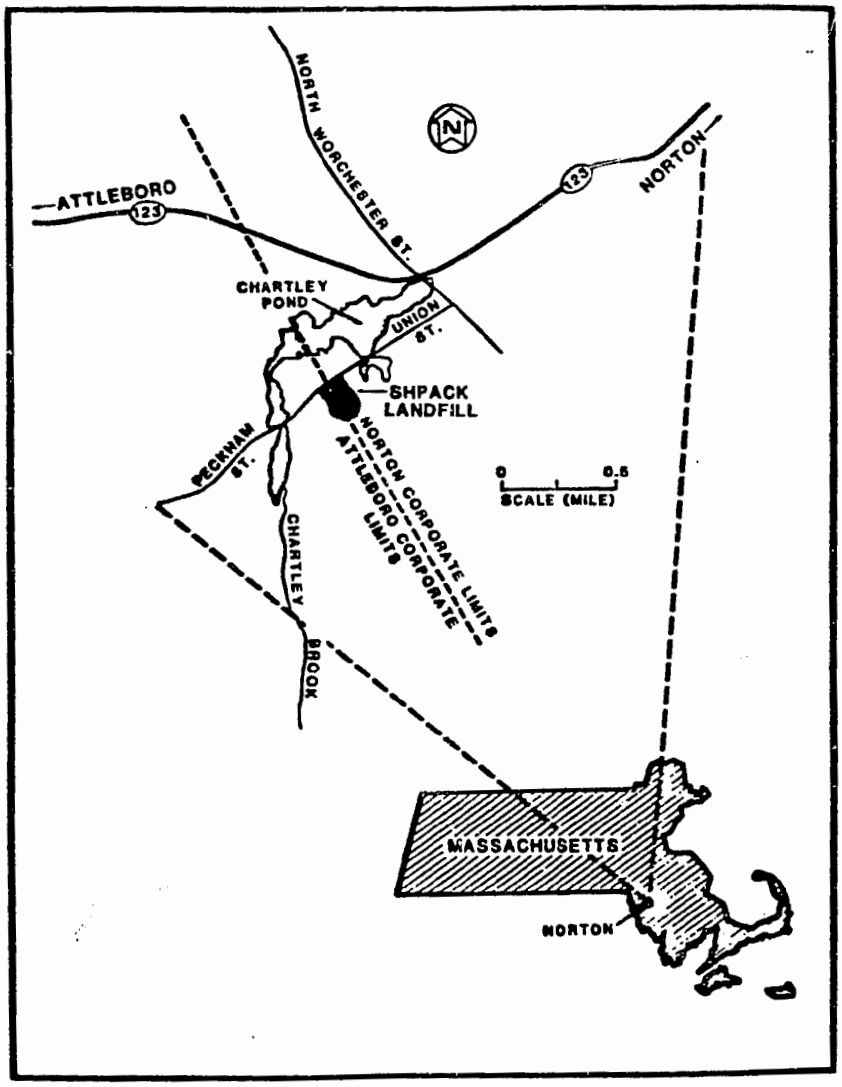


Figure 1. Location of Shpack Landfill Site

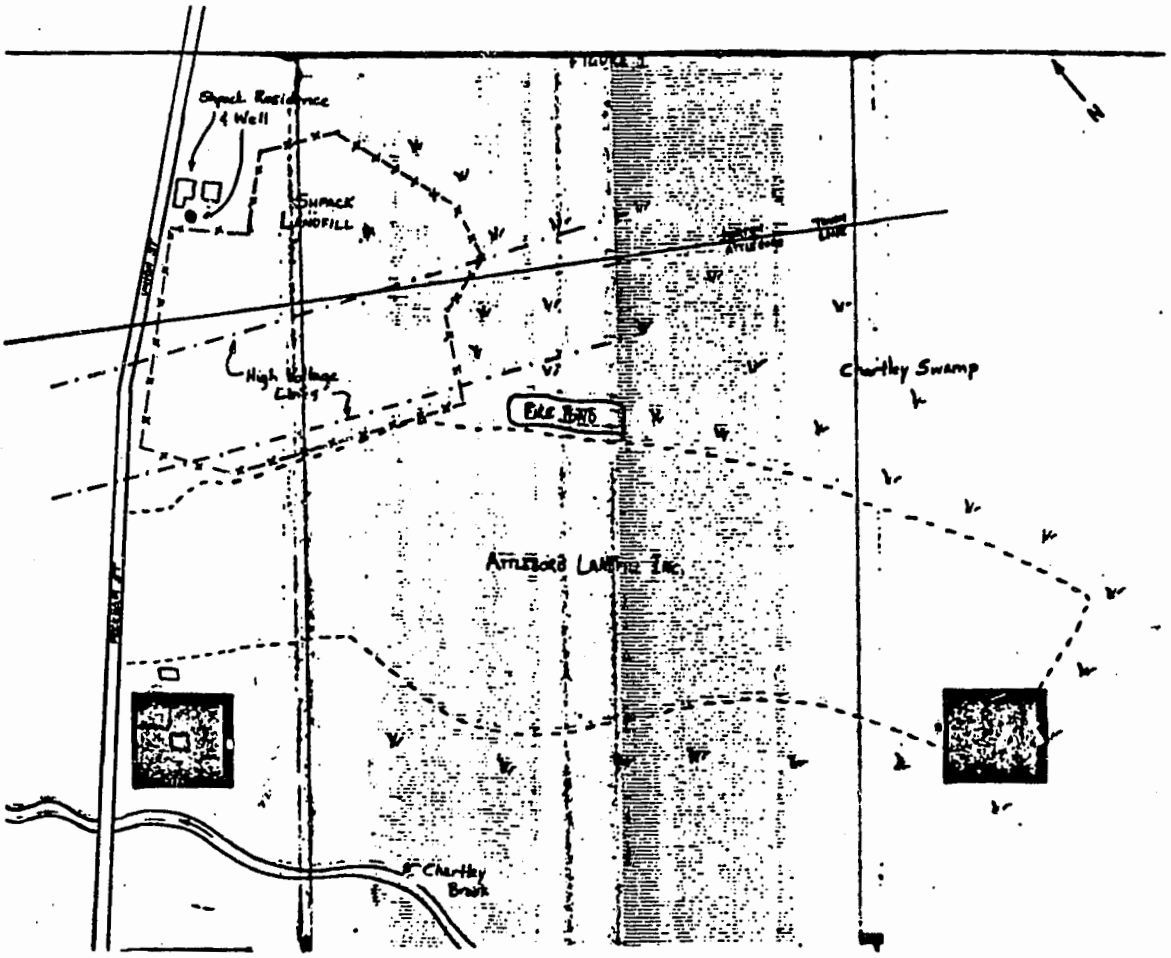


Figure 2. Shpack Superfund Site

Figure 3. Water Table Map Constructed from Table 4 Data with possible directions of Groundwater movement (dashed arrows)

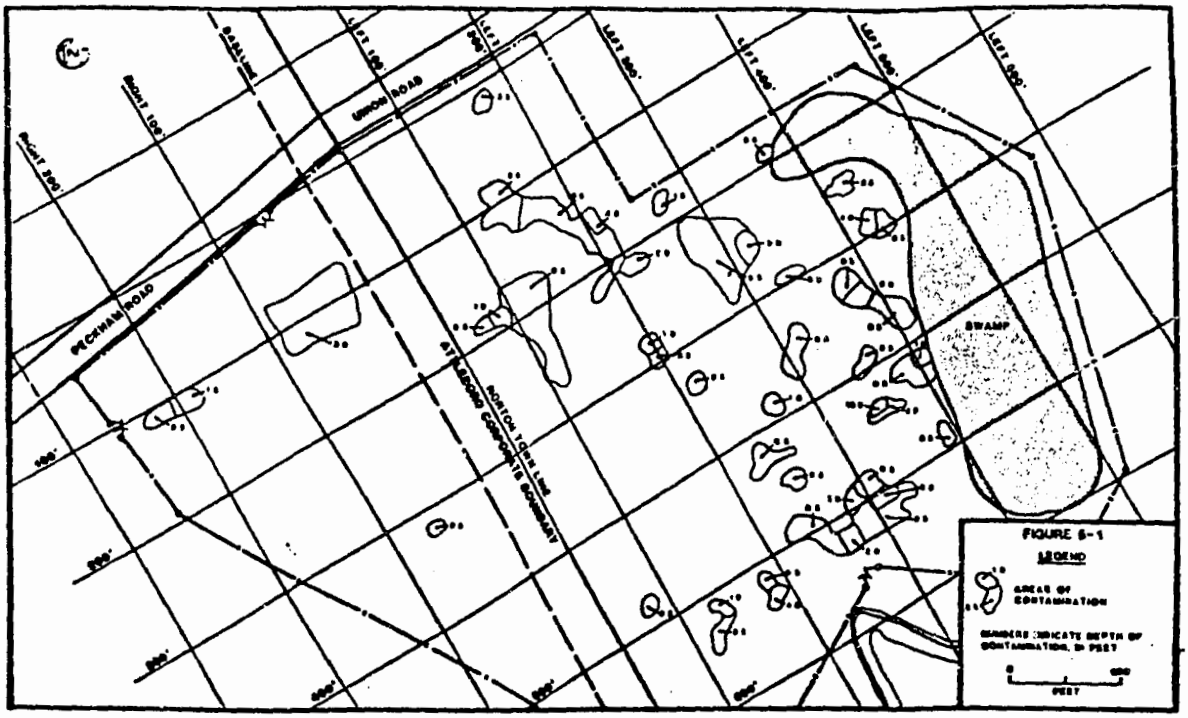


Figure 4. Shpack Landfill Areas of Contamination

	Parameter	Max. Concentration
Soil	Lead	3,055 ppb
	Arsenic	18 "
	Chromium	3,060 "
	Copper	36,170 "
	Cadmium	54 "
	Nickel	301,318 "
	Zinc	56,497 "
	Ra-226	1,571 pCi/g
	U-234	4,200 "
	U-235	200 "
	U-238	16,460 "
Groudwater	trans 1,2-dichloro-ethylene	32,000 ppb
	trichloropethene	13,000 "
	tetrachloroethene	19,000 "
	vinyl chloride	73 "
	bis (2-ethylhexyl) phthalate	136 "
	acetone	47 "
	2-buthanone	29 "
	methylene chloride	13 "
	Ra-226	270 pCi/l
	U-234	3,900 "
	U-235	380 "
	U-238	6,300 "
Surface Water	U-234	16 pCi/l
	U-235	1 "
	U-238	21 "
	gamma exposure	53 uR/h
	beta dose rate	1.5 mrad/hr
	Ra-226	7.1 E-04 pCi/m^3
	U-234	3.9 E-04 "
	U-235	1.1 E-04 "
	U-238	1.7 E-04 "

Table 1. Summary of Contamination at Shpack Landfill

12. THE LANSDOWNE RADIATION SITE

William Belanger
Victor Janosik
Environmental Protection Agency

During the early 1900s, Ra-226 was utilized for medical and industrial purposes with few or no health precautions. Production, purification, and packaging of this radionuclide were conducted at small industrial sites, laboratories, and even private homes.

In 1910, Dr. Dicran Kabakjian, a physics professor at the University of Pennsylvania, developed a process for the purification of radium. This process was used by a local company from 1913 to 1922 when the company closed down. The professor then continued a similar business from his house at 105 East Stratford Avenue in Lansdowne, Pennsylvania, for 20 years, producing and repairing radium implant needles and working with other medical devices.

The Kabakjian side of the twin house (105 E. Stratford Avenue) was owned successively by the Tallant family and the Kizirian family. The property currently belongs to the Kizirian estate.

In 1963, the Pennsylvania Department of Health (PDH) inspected the house and found extremely high levels of radiation. The U.S. Public Health Service (PHS) and the PDH decontaminated the 105 E. Stratford portion of the twin house as a "demonstration" project in 1964. The U.S. Air Force supplied a mobile radiation laboratory to monitor the cleanup.

Decontamination consisted of removing as much radium as practical by sanding, scraping, vacuuming, and washing the house walls, floors, and ceilings. Some wooden floorboards and portions of the concrete basement floor were also removed. It is postulated that the acid fumes from the radium-purification procedure that Dr. Kabakjian used, as well as spills, burning of contaminated newspapers, and tracking of the radium on the bottoms of the residents' shoes carried the radium throughout the home and resulted in its penetration deep into the wood and plaster of the house. After the cleanup, epoxy-based paint was applied to limit the outward migration of the remaining radium. It is estimated that approximately 90 percent of the radium in the house was removed in the 1964 cleanup action.

The Kizirian family was allowed to move back into the unit. The PHS estimated that the radiation dose rate received by the occupants was just above the then-existing guideline of 0.5 rem/yr and that further decontamination of the house would be impractical.

EPA'S EMERGENCY RESPONSE ACTION

In 1983, the Pennsylvania Department of Environmental Resources (PDER) notified EPA of the Lansdowne site and its previous contamination. EPA and PDER's sampling and monitoring of the structure showed high radon and gamma radiation levels in #105 (the Kizirians') and high radon levels but with lower gamma levels in #107 (the Bashores'). Additionally, very high levels o.

radiation were measured in the soil around the properties. In March 1984, the Chronic Disease Division of the Centers for Disease Control (CDC) wrote that based on the measured levels, "...the entire duplex structure should be considered to pose a significant health risk to long-term occupants." Gamma radiation levels were found to be about 100 uR/hr throughout most of 105 E. Stratford and ranged to 300 uR/hr in the dining room. Radon daughters were found to be about 0.3 WL. (This was before the discovery of the Watras House in the Reading Prong area of Pennsylvania and these radon levels were considered very high.)

EPA's emergency response actions in 1984 included installation of burglar alarm and fire alarm systems and a full sprinkler system throughout the structure. A 1,000-gal water bladder was installed in the basement of each house as a back-up for the municipal water supply. The insides of all windows were sealed with plastic to minimize radon and radon daughter dispersion, and security arrangements were made with the Lansdowne Police Department. The owners were allowed to remove any uncontaminated furniture, but contaminated furniture and other household items were left in the houses pending the remedial action. A number of contaminated pieces of heirloom mahogany furniture could not be satisfactorily decontaminated and had to be left.

To alleviate public concern about possible contamination of other homes, EPA offered to survey other houses in the neighborhood. The offer was extended to people who possessed articles that were taken from 105 or 107 E. Stratford Avenue in years past and that might be contaminated with radium. While none of the nearby houses were found to be contaminated, elevated gamma levels were found in the back yards of the adjoining properties. It was not clear at the time whether this was due to shine from the 105/107 property or to actual contamination.

Three metal cabinets, removed from 105 E. Stratford by Dr. Kabakjian's son, were found in the basement of the son's home, near the E. Stratford Avenue site. These cabinets contaminated the son's home and required a subsequent emergency response action (called "Son of Lansdowne") by EPA.

RECORDS OF DECISION

A Record of Decision (ROD), signed on August 2, 1985, by the EPA Region III Administrator, provided for permanent relocation of the site residents. A second ROD called for the removal of the contaminated structures and the contaminated soil to an approved offsite disposal facility and removal and replacement of the contaminated sewer line on E. Stratford Avenue. The site would then be back-filled with clean soil and revegetated. At the time, the project was expected to cost approximately $4,500,000.

REMEDIAL DESIGN

EPA Region III developed an Interagency Agreement (IAG) with the U.S. Army Corps of Engineers (COE), Omaha District, to develop cleanup specifications and select a contractor. Of major concern were the protection of area residents from radioactive aerosols, and the level to which contaminated soil would be cleaned up. It was decided that the UMTRACA standard of 5 pCi/g

(above background) for surface soil at uranium mill tailing sites was an appropriate cleanup criterion for the soil in this densely populated area.

It was conservatively estimated at the time of the design process that approximately 1,000 tons of contaminated soil would have to be excavated. It was assumed that the house was of frame and stucco construction and that approximately half of the rubble from the house would be disposed of as contaminated waste while the other half would become ordinary demolition debris. Revised estimates brought the remedial action budget to $6 million.

On April 26, 1988, the COE's Omaha Division awarded the construction contract to Chem-Nuclear Systems, Inc., of Columbia, South Carolina, and the project was transferred to the COE's Baltimore District Office.

SITE ACCESS

The Commonwealth of Pennsylvania legislated money to pay the owners of 105 and 107 E. Stratford Avenue for their properties. The owners were paid the full value of their properties. They retained the ownership of the building lots and will take possession of those lots following the remedial action.

Access was obtained from the six property owners surrounding the 105/107 E. Stratford Avenue property because it was suspected that the soil of the back yards of those residences would be contaminated with radium and would require excavation. One home owner, in the process of attempting to sell his house, resisted allowing EPA access, but this impasse was resolved with the assistance of a Department of Justice attorney. Home owners were encouraged to allow access by a contract provision requiring replacement of all fencing, walkways, buildings, trees, shrubbery, etc., damaged or destroyed as part of the cleanup of any "offsite" properties.

REMEDIAL ACTION

Chem-Nuclear began activities onsite at the beginning of August. These included fencing of the 105/107 property, installation of electric and telephone service, construction of a small building to separate contaminated from uncontaminated wastes, and placement of four trailers to house the site personnel.

The structure was removed from the inside out. The house shell was used as containment to prevent migration of the radium off the site; the structure was kept at a negative pressure with a fan and HEPA filter to prevent leakage. Material removed from the house was classified as either rad waste or as demolition waste. This process required some simplifying assumptions for cost control. All materials with inaccessible interior surfaces, porous surfaces, or painted surfaces were classified as rad waste. Materials noticeably above background on a G-M survey meter received similar treatment. Only two items from the structure, a half brick and three quarters of a brick, were classified as uncontaminated waste. Whereas it had been originally assumed that the houses were of frame and stucco construction, it was discovered during the dismantlement that the exterior walls were of solid stone, ranging from 18 inches to 24 inches thick, from the foundation to the roof line.

Worker protection onsite consisted of cotton coveralls, booties, and respiratory protection. Two forms of respiratory protection were used: negative pressure HEPA filter respirators and Racal AH-3 Air Stream helmets. Level C protection was selected based on site conditions, prior cleanup, and survey data; this selection was confirmed by the air measurements taken during the interior work. The cumulative average airborne contamination for the entire job was 1.2 MPC-hr. This is far below the MPC for radium. The maximum level measured was 7.5 MPC-hr for one 2-hr period.

The initial survey indicated that the soil contamination in the yard around the house was more or less uniformly distributed and had been washed into the soil by rainfall. Soil core samples appeared to confirm this assumption. However, upon excavation the pattern of contamination was found to be quite different. The hottest spots (1-2 mR/hr gamma) were associated with broken test tubes apparently buried 6 inches to 1 ft below the ground. A hot spot was discovered immediately to the right of the front porch door. It appears that the professor occasionally discarded solutions by dumping them on the ground beside the door and even had buried some materials in his yard.

It was found that soil contamination was more extensive than had previously been estimated. Radium contamination was found to a depth of 9 ft in the 105/107 E. Stratford backyards and to 11 ft on 2 adjoining properties. The contamination had migrated onto all six of the adjoining properties and required excavation. An additional $4 million was added to the project in January 1989, bringing the budget to $10 million. In April 1989, another $1.6 million was added to bring the budget to $11.6 million. Cleanup activities continue. The sewer line on East Stratford Avenue has been excavated and replaced, and two nearby garages were dismantled to permit removal of contaminated soil. Site restoration activities will include backfilling soil, revegetating lawns, replacing trees and shrubs, rebuilding fences, and building new garages for those neighbors whose garages were destroyed during the remedial action. The onsite cleanup and restoration activities are expected to be completed in late June or July 1989.

13. DENVER RADIUM SITE

Holly Fliniau
Environmental Protection Agency Region VIII

The Denver Radium Site consists of 44 properties stretching along roughly 6 miles of the South Platte River within the Denver, CO, metropolitan area (figure 1). The properties were contaminated by residues from about 10 radium-processing operations which were in business from 1914 to the mid-1920s. The 44 properties are divided into 11 groups, or operable units, for study and cleanup purposes. The groupings are based on location or similarity of site characteristics.

Following several years of study, EPA decided that the best cleanup remedy for all but two of the operable units was to excavate the radium-contaminated material and transport it to a facility licensed to accept such waste for permanent disposal. In 1988, cleanup began at 2 of the 11 operable units, Operable Units IV/V and X. Material removed from these two locations is scheduled to be transported for disposal beginning in spring of 1989. Other locations are scheduled to be cleaned up through the 1992 construction season.

OPERABLE UNIT IV/V

Unit IV is the Robinson Brick Company (ROBCO) located at 500 S. Santa Fe Drive. Unit V is the adjacent Denver and Rio Grande Western Railroad (D&RGWRR) property. The site includes approximately 17 acres. The contaminated buildings used by the National Radium Institute have been torn down and the debris buried in the stockpile at the site. To date, over 60,000 tons of contaminated soil have been excavated from this location and stockpiled for disposal this spring. This stockpile is larger than originally expected because of the discovery of a very large buried deposit of contaminated material. Evidence of contamination by heavy metals, primarily lead and cadmium, also has been discovered. Investigations are under way to determine the extent and significance of the metal contamination. In the meantime, air monitoring and security continue to be provided on a 24-hr basis to ensure that the health and safety of both workers and the public are protected.

During the 1989 construction season, EPA plans to excavate the remaining contaminated soil and load stockpiled material for transportation and disposal.

OPERABLE UNIT X

This unit is the property at 1314 W. Evans. Most of the outdoor contamination has been cleaned up and stockpiled for shipment beginning next spring. Work continued through the winter to remove radium-contaminated material inside and under several structures at the site.

OPERABLE UNITS I, II, III AND VI/IX/XI

Operable Unit I in the 12th and Quivas area consists of five separate properties. It covers about 8.1 acres along the Platte River Valley above the floodplain. Erickson Monument, the Materials Handling Equipment Company, Rudd Investments, B&C Metals, and an alley are located on the site.

Operable Unit II includes approximately 24 acres at 11th and Umatilla Streets. The 11 individual properties in the unit are DuWald Steel, Jerome Park/Highway Department property, Flame Spray, Inc., Burlington Northern Railroad, G&K Services, the Jenkins Building, the Staab Building, Air Conditioning, Inc., Rocky Mountain Research, Capital Management Realty, and Alpha Omega.

Operable Unit III is located in the 1000 W. Louisiana area. It consists of the following properties: a vacant lot at 1000 W. Louisiana, Creative Illumination, Titan Labels, Packaging Corporation of America, and the Burlington Northern property.

Operable Units VI, IX, and XI comprise the "Open Space" properties of the Denver Radium Site. Unit VI consists of the Allied Chemical & Dye Corporation, Brannan Sand & Gravel Company, Burlington Northern Railroad property, Denver Water Department land, Public Service Company property, Ruby Hill Park, and an alley between Mariposa and Lipan Streets. Unit IX includes the International House of Pancakes, Larry's Trading Post and East Side Amusement Center. Unit XI is the Thomas Real Estate Company property.

Cleanup plans for Units I, II, III, and VI/IX/XI are currently in the design phase. Because greater volumes of contaminated material than expected were found at Unit IV/V, EPA ordered additional site assessment work to better identify the extent of contamination at the remaining operable units scheduled for cleanup. Supplemental data-gathering activities have been concluded, and the new data will be incorporated into the detailed construction drawings that are being prepared in anticipation of cleanup activities. The remedial design for these properties will be completed in phases, with the first phases to be finished by spring of 1989, at which time construction contracts for various property units will go out for bid. Cleanup at these locations is scheduled to begin during the construction season of 1989. Work will continue through 1992 as the later phases of design construction are completed.

The vacant lot at 1000 W. Louisiana Avenue, part of Unit III, has been fenced. Dirt removed during fence construction is contaminated with radium and is being stored in barrels onsite to be disposed of as part of cleanup activities. Cleanup activities are scheduled to begin at that location in the summer of 1990, after work has been completed at one of the properties across the street.

OPERABLE UNIT VII

This unit includes sections of nine Denver streets. Radium wastes are contained in a layer of asphalt and aggregate several inches below street level. Residues from radium processing probably were used in paving materials during street construction in the 1920s. EPA has decided to leave these

contaminated materials in place because they pose only a limited threat to public health and the environment. The City and County of Denver and the State Health Department will carefully monitor routine street maintenance, repair, and construction using funds supplied by EPA, these agencies are developing an excavation control plan for the streets. The plan may include provisions to remove contamination found during street work to an approved disposal facility.

OPERABLE UNIT VIII

This unit consists of Shattuck Chemical Company and the adjacent railroad property. This 6-acre site is located at 1805 S. Bannock Street.

The Colorado Department of Health is assisting EPA in the enforcement action by performing a study to identify the nature and extent of contamination at Operable Unit VIII. This study also will propose cleanup alternatives. The study is scheduled to be completed in the fall of 1989.

TRANSPORTATION AND DISPOSAL

Because of the nature of the health hazard represented by the radium processing residues and contaminated soils at the Denver Radium Site, EPA has determined that the best remedy is to remove these materials to an appropriate disposal site. The health hazard from these materials is not so much from direct contact as from the radon gas that they generate.

Radium processing wastes and contaminated soils like those found at the Denver Radium Site are referred to as Naturally Occurring Radioactive Materials (NORM). As a class of radioactive waste, they "fall through the cracks" of the Federal regulatory framework because no Federal regulations apply to their disposal. Until very recently, there was no disposal facility in the United States licensed to accept such radium wastes. Inability to locate a disposal facility delayed EPA's cleanup of the Denver Radium Site. However, last year a facility licensed to receive NORM waste opened, and licensing procedures have begun at one other site. The availability of one or more licensed disposal sites makes it possible for EPA to proceed with cleanup.

To remove the contaminated material from the properties in a timely fashion, EPA must be able to begin transporting the Denver Radium Site material to a licensed disposal site in the spring or summer of 1989. To reach this objective, EPA has obtained the assistance of another Federal agency, the Bureau of Reclamation, to handle contracting for waste transportation and disposal. A Request for Proposals has been prepared, and the process for accepting and evaluating bids for the work is under way. The contract for this work is scheduled to be awarded by the end of April 1989.

COMMUNITY INVOLVEMENT ACTIVITIES

EPA continues to maintain contact with interested citizens, neighborhood groups, local officials, and media representatives to keep the community informed on progress at the Denver Radium Site and involved in the decision process.

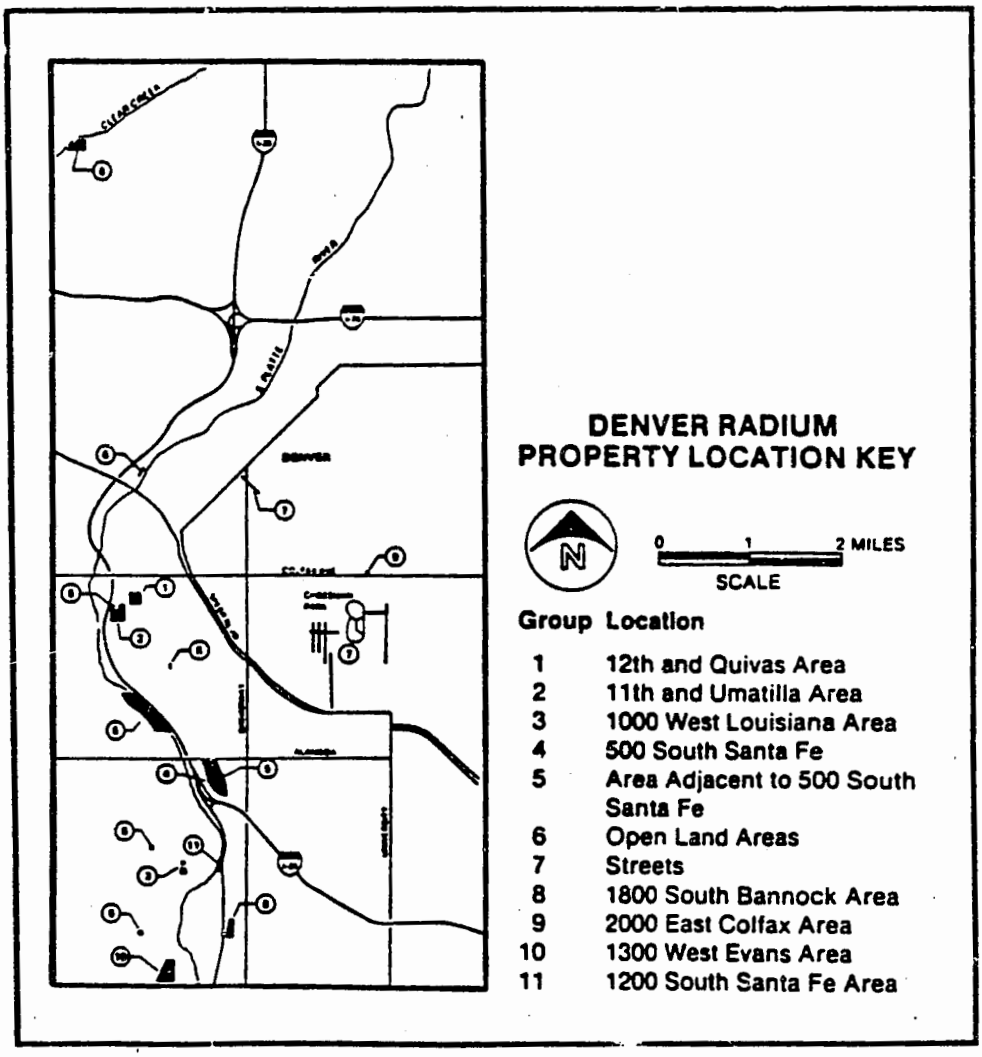


Figure 1. Denver Radium Site

14. ROBINSON BRICK CO. TRACT AT THE DENVER RADIUM SITE

William N. Fitch
Frederick K. Algaier
Bureau of Mines, Department of the Interior

The Bureau of Mines (BM) has been identified as a principal responsible party for the uranium contamination at what EPA has designated as Operable Units IV and V of the Denver Radium Site. The BM's involvement at this site dates back to 1913 when the newly created Bureau entered into an agreement with two medical doctors to form a private corporation, the National Radium Institute, to produce radium for research and cancer treatment. The doctors, Dr. Howard Kelly, a Johns Hopkins University cancer specialist, and Dr. James Douglas, at New York's General Memorial Hospital, supplied the financing, and the BM provided the technical expertise to develop a process for extracting radium from uranium ores.

Operations began immediately. Mining claims in the Paradox Valley of southwestern Colorado were leased from the Crucible Steel Company, and carnotite ore was produced and concentrated at a facility built in Long Park. Meanwhile, the Institute leased a 1-acre tract in Denver between the Denver and Rio Grande Western Railroad tracks and the South Platte River, just north of what is now Alameda Avenue, and constructed a radium processing facility. Bureau personnel quickly developed the nitric acid leach process which recovered over 90 percent of the radium contained in the carnotite, and the plant reached full capacity by June 1914. An additional processing plant was added on the tract and, by 1917, a total of 8.5 g of radium had been produced from 960 tons of ore and 298 tons of concentrate.

The two doctors received 8 g of the radium; the BM kept 0.5 g. The 8 grams, after minor losses, are still held by the Kelly Cancer Institute in Baltimore and the Sloan Kettering Cancer Institute in New York City. The Bureau radium was transferred to the Manhattan Project during World War II and is now held by the Oak Ridge National Laboratory.

In the course of EPA investigations of the Denver Radium Sites, radioactive contamination was found on the 17-acre tract owned by Robinson Brick Co. and the contiguous Denver and Rio Grande Western Railroad lands, designated as Operating Units IV and V respectively. At this time, the BM is the only identified PRP for these two units, although, in view of recently discovered, apparently unrelated metals contamination at these sites, PRP investigations continue.

CLEANUP

UNC Geotech, through agreement with DOE, is the site manager and has conducted the most recent site investigations and planned the cleanup under EPA direction. The BM provides technical input through review of cleanup plans. UNC conducts radiological sampling and laboratory testing; the actual cleanup is subcontracted. Excavated contaminated material is temporarily stockpiled on site, pending location of a suitable disposal site. At the start of cleanup, the total quantity of contaminated material was estimated at

16,000 yd^3 for a cleanup cost of $3 million. As cleanup progressed, it was found that additional contaminated material underlaid clean soil, and by the fall of 1988, about 60,000 yd^3 of contaminated material had been excavated and stockpiled for disposal.

Cleanup objectives are to reduce the Ra-226 concentrations so that they do not exceed background level by more than 5 pCi/g averaged over the first 15 cm of soil and by more than 15 pCi/g averaged over 15-cm-thick soil layers below surface. Background levels in the area have been determined to be 2.1 pCi/g for surface areas and 4 pCi/g for subsurface.

METALS CONTAMINATION

In August 1988, after rain at the site, a green, blue, and white crystalline residue or precipitate was noted on the side of the deepest excavation. Five separate sampling and analysis programs were undertaken in an effort to determine the nature and origin of this contamination. Two samples of the precipitate were analyzed using the EP Toxicity method, and the results revealed cadmium exceeding the 1.0 mg/L standard. This was followed by analysis of 17 samples of precipitate and soil for total concentrations of 23 elements, Th-230, and EP Toxicity; the results showed elevated concentrations of lead, cadmium, and zinc. In three subsequent sampling programs, the area of investigation was extended to the nearby RTD parking lot. Concentrations of silver, arsenic, cadmium, copper, iron, manganese, lead, and zinc are high in the fill material, exceeding typical values by 2 to 4 orders of magnitude. However, only cadmium and lead exceeded the standards. Borehole analyses for Ra-226, Th-230, and total uranium showed background levels except in an area south of the excavated area where Th-230 levels ranged from 25 to 60 pCi/g with one high of 160 pCi/g.

Three boreholes were completed as ground-water monitoring wells. Analyses of water samples from two of these and the excavation indicated the possibility of extensive metals contamination in addition to and perhaps mixed with the radioactively contaminated material. Construction activities were halted pending recharacterization of the site to determine source and extent of the metals contamination in both the soil and ground water.

Site recharacterization is addressing three areas of concern: history of activities at the site, soil contamination, and groundwater contamination. Additional holes are being drilled on 100- and 200-foot grids to determine the extent of contamination; 14 of these will be completed as monitoring wells. All boreholes will be logged with a down-hole gamma Compulogger system and, based on results, soil samples selected for Ra-226 analysis. Th-230 analyses will be made of samples based on proximity to known elevated Th-230 levels and presence of iron-stained alluvial sand. Results of the recharacterization are expected in August 1989.

SITE STATUS

When cleanup activities ceased in the fall of 1988 there were about 60,000 yd^3 of radiologically contaminated material stockpiled on-site. The stockpiled and excavated areas have been stabilized and groomed for drainage control, and

all exposed contaminated areas sprayed with an elastomeric coating. When cleanup operations resume, it is expected that further excavation will be required in the area under the stockpile and the area south of the present pit. There are no accepted cleanup levels or standards for thorium or uranium at present; it is expected that DOE guidelines will be used.

Verification drilling to confirm cleanup is being done in the RTD parking lot area based on a 10-ft x 10-ft grid. In each 30-ft x 30-ft area of 9 squares, holes are drilled to bedrock at the center of 3 randomly selected squares and gamma-logged to determine Ra-226 concentrations. Soil samples are taken at the top of the bore-holes, ground-water interface, and bottom of the hole. If radium levels are found to exceed the criteria, additional holes would be drilled in the other 10-ft squares as needed to determine extent and level of radon contamination.

15. INSTRUMENTATION FOR DEMONSTRATING COMPLIANCE WITH FUSRAP GUIDELINES

Cathy R. Hickey
Bechtel Environmental Inc.

The Formerly Utilized Sites Remedial Action Program (FUSRAP) is funded by DOE for remediation of sites containing natural radio-activity from operations of the Manhattan Engineering District. Radioactive materials on these sites consist primarily of U-238, Th-232, and their daughter products. DOE has developed guidelines for direct radiation, surface contamination, and environmental concentrations of radioactivity under this program. Sites include open land, buildings, and subsurface areas, including drainage courses.

A variety of field measurement techniques and instrumentation have been adapted or developed to identify and characterize areas of contamination, guide remediation efforts and demonstrate or verify decontamination. An accompanying paper describes the instruments used, measurement and verification techniques, and capabilities and limitations of the instruments and procedures.

The presentation focused on actual field experiences with discussion of adaptations for surveys under various field conditions such as winter weather, subsurface measurements, and survey of drainage pipes.

Table 1. Radiological Guidelines for FUSRAP Sites

BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 100 mrem/yr.

SOIL (LAND) GUIDELINES (MAXIMUM LIMITS FOR UNRESTRICTED USE)

Radionuclide	Soil Concentration (pCi/g) above background[a,b,c]
Radium-226 Radium-228 Thorium-230 Thorium-232	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer.
Other radionuclides	Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use.

STRUCTURE GUIDELINES (MAXIMUM LIMITS FOR UNRESTRICTED USE)

Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.[d] In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site to be released for unrestricted use shall not exceed the background level by more than 20 uR/h.

Indoor/Outdoor Structure Surface Contamination

Radionuclide[f]	Allowable Residual Surface Contamination[e] (dpm/100 cm²) Average[g,h]	Maximum[h,i]	Removable[h,j]
Transuranics, Ra-226, Ra-228, Th-230, Th-228 Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224 U-232, I-126, I-131, I-133	1,000	3,000	200

Indoor/Outdoor Structure Surface Contamination (continued)

Radionuclide[f]	Allowable Residual Surface Contamination[e] (dpm/100 cm²) Average[g,h]	Maximum[h,i]	Removable[h,j]
U-Natural, U-235, U-238, and associated decay products	5,000 α	15,000 α	1,000 α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 β-γ	15,000 β-γ	1,000 β-γ

[a] These guidelines take into account ingrowth of radium-226 from thorium-230 and of radium-228 from thorium-232, and assume secular equilibrium. If either thorium-230 and radium-226 or thorium-232 and radium-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that the dose for the mixtures will not exceed the basic dose limit.

[b] These guidelines represent unrestricted-use residual concentrations above background averaged across any 15-cm-thick layer to any depth and over any contiguous 100-m² surface area.

[c] Localized concentrations in excess of these limits are allowable provided that the average concentration over a 100-m² area does not exceed these limits.

[d] A working level (WL) is any combination of short-lived radon decay products in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

[e] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[f] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[g] Measurements of average contamination should not be averaged over more than 1 m². For objects of less surface area, the average shall be derived for each such object.

[h] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

[i] The maximum contamination level applies to an area of not more than 100 cm².

[j] The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm² is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

Table 2. Instrumentation for Gamma Exposure Rate Measurements

INSTRUMENT	UPPER MEASUREMENT LIMIT	REMARKS
PRESSURIZED IONIZATION CHAMBER		
• REUTER-STOKES RS-111	500 UR/H	HEAVY AND CUMBERSOME FOR FIELD USE; USED AS CALIBRATION STANDARD FOR FIELD INSTRUMENTS
NAI WITH RATEMETER		
• VICTOREEN 489-55/EBERLINE PRM-6 • VICTOREEN 489-55/VICTOREEN THYAC III • EBERLINE SPA-3/EBERLINE PRS-1	0.5-1.0 MR/H	FOR ACCURATE RESULTS MUST PERFORM ON-SITE CALIBRATION
COMPENSATED GM WITH RATEMETER		
• EBERLINE HP-270/EBERLINE PRS-1	>100 MR/H	USED TO MEASURE RADIATION LEVELS ASSOCIATED WITH HOT SPOTS

Table 3. Instrumentation for Surface Contamination Surveys

RADIATION DETECTED	INSTRUMENTATION		APPLICATION			APPROXIMATE* SENSITIVITY (dpm/100cm²)
	DETECTOR(S)	RATE METER/ SCALER	SCANNING	DIRECT MEASUREMENTS	SMEAR COUNTING	
ALPHA	EBERLINE, AC3-7 EBERLINE, AC3-8 LUDLUM, 43-5 BICRON, A-50	EBERLINE, PRS-1 EBERLINE, ESP-2 BICRON, ANALYST LUDLUM, 2220	•	•	•	<50
		EBERLINE, PRM-6	•			
BETA/ GAMMA	EBERLINE, HP-260 EBERLINE, HP-210 VICTOREEN, 489-110 BICRON, PGM	EBERLINE, PRS-1 EBERLINE, ESP-2 BICRON ANALYST LUDLUM, 2220	•	•	•	<400
		EBERLINE, PRM-6	•			
ALPHA/ BETA	LUDLUM, 239-1	LUDLUM, 2220	•	•		<20 ALPHA
	EBERLINE, SAC-4				•	<100, BETA
GAMMA	BICRON, FIDLER EBERLINE, SPA-3 EBERLINE, PG-2	BICRON ANALYST LUDLUM, 2220 EBERLINE, PRS-1 EBERLINE, ESP-2	•	•		DEPENDENT ON BACKGROUND
	VICTOREEN, 489-55	EBERLINE, PRM-6	•	•		

BASED ON ONE MINUTE INTEGRATED COUNT WITH NOMINAL EFFICIENCY, PROBE AREA, AND BACKGROUND LEVELS

16. AERIAL RADIATION SURVEYS FOR RADIOMETRIC CONTAMINATION

Joel E. Jobst
Harvey W. Clark
EG&G Energy Measurements, Inc.

For the U.S. Department of Energy (DOE) a fleet of 12 twin-engine aircraft is operated by EG&G Energy Measurements, Inc. (EG&G/EM) from operations bases in Las Vegas, NV, and Washington, DC. Ten aircraft are operated as aerial platforms for remote sensing of the environment by 260 personnel. EG&G/EM employs aerial cameras, multispectral scanners, video systems, nuclear radiation detectors, and an array of gas and particulate sampling instruments.

For radiological measurements of ground contamination an array of thallium-activated sodium iodide detectors is mounted externally on a helicopter, shown in Figure 1, a twin-turbine Messerschmitt-Bolkow-Blohm (MBB) BO-105. To achieve maximum instrument sensitivity, the aircraft is flown in a low-altitude survey pattern at altitudes as low as 100 feet above terrain in unobstructed areas. Gamma ray photons generate electronic pulses in eight 4 x 4 x 16-in. extruded log detectors which are coupled to photomultiplier tubes. Gamma pulses are counted by REDAR IV, the Radiation and Environmental Data Acquisition and Recording System.

The helicopter flies a precise survey pattern, as shown in Figure 2. Parallel lines are typically spaced 250 ft apart. The pilot navigates with aid of an Instrument Landing System (ILS) course indicator. This display is derived by one of the REDAR micro-processors from a precision positioning system and the radio altimeter. Position data are obtained from a UHF transponder system consisting of two ground-mounted transceivers and a master unit aboard the helicopter. The REDAR records gamma radiation spectra; aircraft position and altitude; and other important environmental data, such as temperature and barometric pressure. The data are recorded each second for later analysis. Aircraft position can also be determined with an inertial navigation system or LORAN C. Global Positioning System (GPS) navigation will be implemented when enough satellites have been orbited to provide full coverage during daylight hours.

In an aerial radiological survey one generates a map of the spatial distribution and concentration of gamma-emitting radionuclides present in the ground. One can not only map the radiation but also identify the radionuclides which generated it. Aerial surveys can be valuable tools for either emergency response or environmental monitoring programs. The DOE routinely employs aerial surveys for four special purposes:

1. To locate radiation anomalies. For example, a survey was conducted over a 176-mi^2 area of Houston, TX, to locate fragments of contaminated concrete that were improperly disposed of after a Cs-137 spill. A survey with hand-held instruments would have been impossible to conduct.

2. To provide an overview of the radiological character of an environment. An aerial radiological survey of uraniferous lignite mines in Belfield, ND, lead to a reassessment of state and EPA

cleanup criteria. It was found that radioactivity from natural ore outcroppings in the greater area often equaled or exceeded that found in the mined areas. This resulted in a relaxation of the cleanup criteria, at great cost savings to those responsible. A ground-based survey, covering sufficient real estate to discover this phenomenon, would have been expensive to conduct.

3. To guide planning for ground-based measurements. Aerial survey contours, laid directly on a site photography, indicate where detailed sampling is required and, more importantly, where it is not. Focused effort can result in considerable reduction in the time and cost of ground-based measurements. The EPA commissioned an aerial survey of Pocatello, ID, for precisely this reason. "Negative" data are also very useful, especially in dealing with public perceptions after an accidental spill of radioactive materials.

4. To provide cost effective change detection. Detecting and defining changes in the radiological character of a large area with ground-based measurements is a difficult and expensive procedure. Repetitive aerial radiological surveys are a very sensitive and relatively inexpensive means to detect and map such changes. Over the past 15 years many surveys have been conducted at the 300-mi^2 Savannah River Plant to document critical changes in radiation levels.

The REDAR system obtains a total gamma radiation spectrum. Figure 3 shows natural background radiation contributions at the Susquehanna Nuclear Power Plant in Berwick, PA. Two spectra are obtained each second, one a high and one at low sensitivity, to cover a broad dynamic range in radiation activity. The energy range shown here covers a broad range of gamma emitters. The data enable our analysts to clearly identify major contributors to the exposure rate in a give area.

In many cases the natural background tends to obscure man-made contaminants. Hence, we have developed computer algorithms to strip away the natural background. Figure 4 is a net spectrum, which clearly reveals man-made activity, in this case due to Co-58. The technique allows us to locate, quantify and identify anomalous radiation in every portion of a survey area.

The typical products of our data processing are isopleth contour plots. They can be used to show the total exposure rate due to both natural and man-made radionuclides in the soil. Or they can show only the natural exposure rate or the man-made gross count, by selectively removing various spectral contributions. For special situations one may want to show specific radionuclide concentrations, displayed in nCi/m^2 or pCi/g. Isopleth contour plots are frequently provided for Cs-137, Co-60, I-131, I-133, U-235, U-238, Bi-214, K-40, Tl-208, Am-241, and other radionuclides. Aerial surveys can also be used to plot airborne plumes of these and other radionuclides. At Savannah River Plant we successfully measured and plotted airborne concentrations of sulphur hexafluoride, which was released to simulate an accidental release of fission products from the Plant's production reactors.

The data were used to validate plume dispersion models developed at the Plant.

Aerial radiation surveys are sensitive enough to detect very small changes from natural background activity levels, often as low as 5 percent departures from background. For radionuclides such as Cs-137 or Co-60, this implies that concentrations as low as 30 to 50 nCi/m^2 can be consistently detected. For most of the radionuclides customarily associated with a nuclear power plant accident, the aerial detection limits are more than adequate to implement the Protective Action Guides (PAGs) published by the Environmental Protection Agency (EPA). To achieve this sensitivity the radiation detectors are carefully calibrated, at least on a daily basis. As the data are plotted, line-by-line corrections are made for variations in airborne radon concentration, survey aircraft altitude, and temperature. The latter 2 parameters change the effective air-mass attenuation of the gamma ray signal strength at the detectors.

It is difficult to quote a single value for the absolute accuracy of exposure rates measured by an airborne measurement system. There are many variables which must be considered simultaneously. EG&G/EM maintains "test lines" for absolute calibration of aerial systems. Calibration flights have shown, however, that EG&G/EM exposure rates are accurate to + 15 percent over these test regions which have been very accurately measured by other means. That is, many discrete points are measured with calibrated ion chambers, directly below and on both sides of the aircraft flight path. The results are averaged, as the aircraft system effectively does in flying over distributed radiation sources, then compared to the aerial measurements.

The precision of the aerial survey results is much better, i.e., the results are highly reproducible. For typical background areas, successive surveys will show an exposure rate reproducible to + 2 percent. To achieve such precision the detectors are subjected to preflight calibration. And for every survey, an on-site test line is identified; it is flown prior to each survey flight and, when possible, flown again before the aircraft lands on the same mission. Before the final isopleth map is plotted, each line of data is corrected for the variations is air mass thickness and airborne radon concentration which are inevitable during a survey. Detailed quality assurance procedures are followed to maximize the precision and accuracy of the aerial survey results.

Since the inception of the DOE survey program, in the mid 1960s, approximately 300 aerial surveys have been flown. Most of these have been for environmental monitoring purposes. Nineteen separate DOE facilities have been flown. Twenty-two aerial surveys have been flown over the Nevada Test Site, the Northern Marshall Islands, and Johnston Island. Nineteen FUSRAP (Formerly Utilized Sites Remedial Action Program) sites have been surveyed, as well as 24 UMTRAP (Uranium Mine Tailings Remedial Action Program) sites. Twenty naval reactor sites have been surveyed and all of the Kennedy Space Center (KSC). The latter survey was recently done to determine the natural radiation background at KSC.

Several foreign governments have requested DOE to survey within their boundaries for various reasons. Surveys have been conducted in:

-Northwest Territories, Canada
-Maturin, Venezuela
-Chihuahua and Juarez, Mexico
-Maralinga, Australia

The first three surveys were in response to accidental dispersions of radioactivity. Maralinga is a former nuclear weapons test site.

The DOE has cooperative programs with other Federal agencies. For the Nuclear Regulatory Commission (NRC), the DOE objective is to survey the site of each commercial nuclear reactor before power generation begins and then every 5 years thereafter. To date all U.S. commercial reactors have been surveyed at least once. The repeat survey effort, however, has been considerably delayed and reduced in frequency because of NRC funding limitations.

DOE has also surveyed several NRC licensee waste management sites to monitor their impact on the environment. These include:

-Chem-Nuclear Systems, Inc., Barnwell, SC
-U.S. Ecology, Maxey Flats, KY
-U.S. Ecology, Beatty, NV
-U.S. Ecology, Sheffield, IL
-U.S. Ecology, Richland, WA

DOE has also conducted a number of surveys for the Environmental Protection Agency (EPA). These sites include:

-Pocatello and Soda Springs, ID
-Port Henry, NY
-Newark, NJ
-Camden, NJ
-Orange, NJ
-Gloucester, NJ

At most of these sites industrial operations, unrelated to the uranium fuel cycle, were conducted. Such operations included the manufacture of gas lantern mantles and thoriated aluminum castings for aircraft engines. At some sites phosphate ore, rich in radioisotopes from the uranium and thorium decay chains, were processed into fertilizer or elemental phosphorus.

The Pocatello, ID, survey is an excellent example of the use of a specific radioisotope to map a contamination problem. Figure 5 shows net gross counts above background in the energy window from 1.58 to 1.93 HeV at Pocatello. Phosphate slag is rich in Bi-214; hence, a window was centered on the 1.76 HeV photopeak of bismuth. Figure 6 is an enlargement of the previous isopleth plot, which shows the details at the Pocatello airport. Impacted roads, runways and railroad rights-of-way stand out clearly on a map of excess bismuth. Phosphate slag was used as ballast for railroad tracks and as aggregate in

asphalt and concrete for various construction projects: roads, airport runways, building slabs, etc.

The aerial survey technique in this case provided a rapid assessment of the scale and severity of the problem. It was used to plan and guide the ground-based measurements which followed. The aerial survey was quite cost beneficial; it provided excellent focus for soil sampling and air monitoring.

Perhaps the best example of long-term environmental monitoring using aerial remote sensing is the Savannah River Plant. For the past 15 years EG&G/EM has conducted there a program called CIRS: Comprehensive Integrated Remote Sensing. Three different technologies are carefully integrated: aerial photography, multispectral scanning, and gamma radiation surveys. The purpose of the program is to map the site and document the impact on the environment of the nuclear production reactors. In a 15-yr period, 9 nuclear surveys have been conducted, 6 of the same impacted areas. These were closely coupled with the photographic and infrared surveys. For the Savannah River Plant we always provide 4 specific gamma contour plots: total exposure rate, natural exposure rate, a Cs-137 count rate and a Co-60 count rate.

Figure 7 is a sample of the total count rate isopleth plot. Shown here is a portion of Steel Creek, which flows into the Savannah River. The data were obtained in 1985, prior to the restart of L Reactor. The primary concern was that the resumption of high coolant flow in Steel Creek would enhance Cs-137 contamination due to resuspension of this isotope, which was known to be bedded in the silt and clay of Steel Creek and surrounding marshlands.

Figure 8 shows the same area in 1986, after L reactor was restarted. Close comparison indicates that there are considerable changes in both the distribution and the intensity of the total activity map. The large changes are easily recognized. We needed a method to compare the small, subtle changes, as well as the large ones.

Hence, we developed a technique which enables us to obtain the dose difference between two surveys. Both data sets were carefully normalized over background regions not affected by Plant operations. The 1985 data were then subtracted, point-by-point, from the 1986 data to show the changes in total activity. Figure 9 shows the dose differences between 1985 and 1986. The white contours indicate a decrease in activity from 1986 to 1985. The yellow contours indicate regions where activity increased. The changes here reflect differences in distribution due to flooding and changes in soil moisture. Changes as small as 10 percent can be shown.

Similar techniques were used to illustrate the changes in the environment surrounding the Rancho Seco Nuclear Generating Station in central California. Two gamma surveys were made, in 1980 and 1984. Figure 10 shows the distribution of exposure rates, extra-polated to the 1-meter level, over the area surrounding the reactor. The blue contours here show an increase in exposure rate levels between the 1980 and 1984 surveys. Greater concentrations of man-made contamination were found in 4 of the river areas enclosed in blue contours. Ground-based exposure rate measurements in these areas, made by personnel from Oak Ridge National Laboratory, were 3 to 4 times

higher than those inferred from the aerial measured count rate data. These sources were highly localized. Background-subtracted net spectra over these areas showed prominent contamination from Cs-137, Cs-134, and Co-60.

Figure 11 shows the area surrounding the Rancho Seco Plant. The data were obtained in 1980. A stripping technique was used to process the data, called man-made gross count. It effectively removes the contribution from all naturally occurring radionuclides in the soil and sums all the man-made nuclides. The exposure rate conversion factor here is approximately 1000 counts per second equals 1 uR/hr. In aerial surveys the apparent physical size of a strong source is enlarged due to a phenomenon called shine. The activity here is due to the reactor itself and radioactive materials stored at the site.

The same computer algorithm, applied to data from the 1984 survey, shows a dramatic change in Figure 12. There is considerable downstream contamination in the Clay, Hadselville and Laguna Creeks which drain the Rancho Seco site. Irrigation practices have also transported the contamination into neighboring vineyards. The differences between 1980 and 1984 are clear and measurable. An estimated inventory of radionuclides transported downstream has been computed from the data.

From these examples we can conclude that aerial radiological surveys are a valuable technique for environmental monitoring and for planning further monitoring in greater detail. It enables us to search efficiently for radiation anomalies, such as the cesium-contaminated concrete in Houston, TX. It enables us to obtain, very quickly, an overview of a large area, such as the ore outcroppings in Belfield. It enables the user to plan ground-based measurements to focus resources in areas where they are useful, such as the EPA survey in Pocatello. Finally, it provides a precise, readily implemented method of detecting environmental changes; it is used very extensively for this purpose at the Savannah River Plant.

Aerial radiological surveys have several powerful advantages:

1. Fast coverage - more than 8 mi^2 per day can be surveyed;

2. Maps inaccessible areas - such as the swamps and dense forests of the Savannah River Plant;

3. High sensitivity - better than most protective action guides;

4. Excellent reproducibility - repeat surveys of areas not impacted by human activity show changes of +2 percent;

5. Reliable area averages - equal to hundreds or even thousands of measurements obtained from ground-based surveys;

6. Computer compatible data - all of the survey tapes are archived and are readily available for reprocessing or comparison with later surveys. Some users such as the Savannah River Plant, use the tapes directly in their own environmental monitoring programs;

7. Cost effective - a typical field survey is completed in 2 weeks. Preliminary results and data plots are available to the user onsite at the completion of the survey.

There are, of course, some disadvantages to aerial survey:

1. Special equipment is required. The DOE has maintained and operated this capability for the user community since the late 1950s;

2. Compromised spatial resolution. Aerial detectors measure background activity surrounding a finite source and effectively average it over the detector field of view;

3. May require ground-based measurements to corroborate anomalies detected from the air.

As shown in several of the previous examples, the most effective program is one that uses the aerial data to identify anomalies or problems areas, which are then subjected to appropriate ground monitoring and sampling.

To complete this overview of DOE capability one should briefly consider two other technologies being developed by EG&G/EM: in situ gamma spectroscopy and airborne sampling.

Figure 13 shows a high-purity germanium detector being used for in situ gamma spectroscopy with a portable multichannel analyzer. The system is easily portable; it is usually used for cleanups and to corroborate aerial measurements. It is best used for surface distributions of radioactive contamination. Excellent data were obtained at Gore, OK, where uranium hexafluoride was distributed over the landscape surrounding the Sequoyah Production Facility of Kerr-McGee.

The DOE has three aircraft equipped for gas and airborne particulate sampling: a Convair 580 and two identical Beechcraft B-200s. Figure 14 shows one of the DOE B-200 aircraft. They can be used for a wide variety of aerial sampling tasks, including the tracking of sulfur hexafluoride, which has been released at various times to verify plume dispersion models.

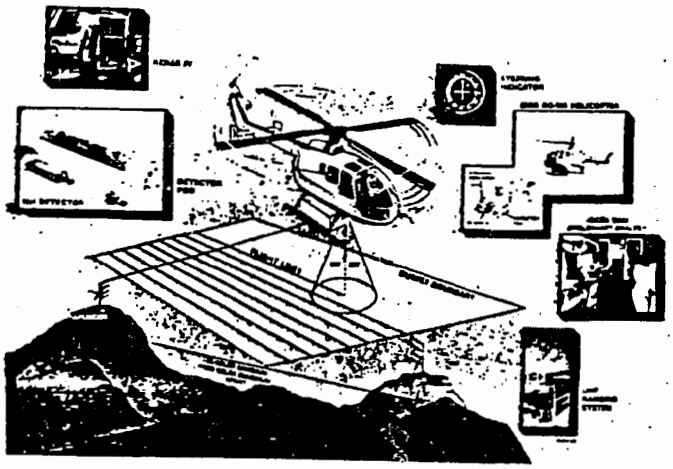


Figure 1. The helicopter flies a precise, low-level survey pattern.

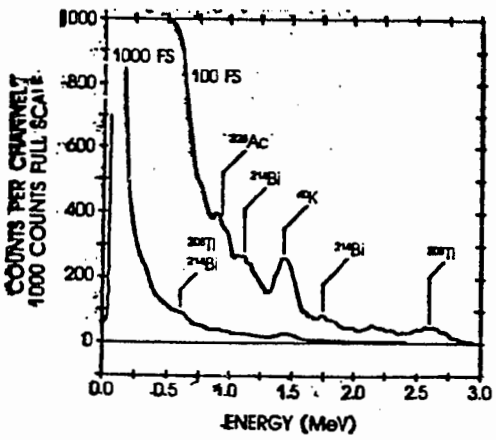


Figure 2. A typical background radiation spectrum.

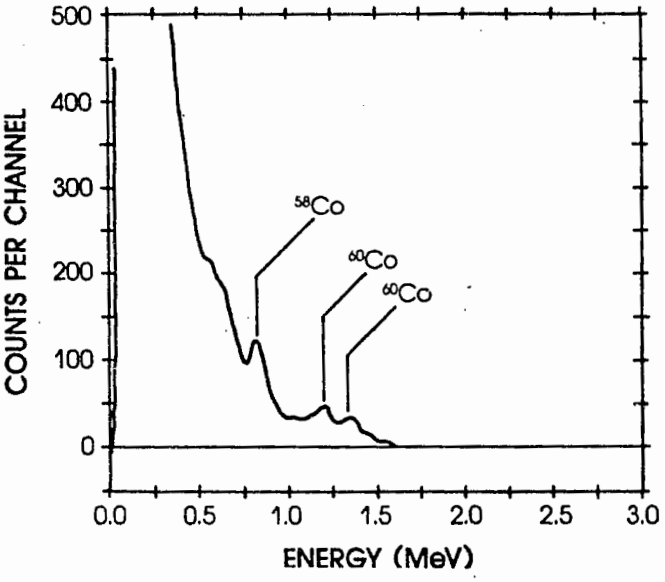


Figure 3. The net spectrum shows man-made activity.

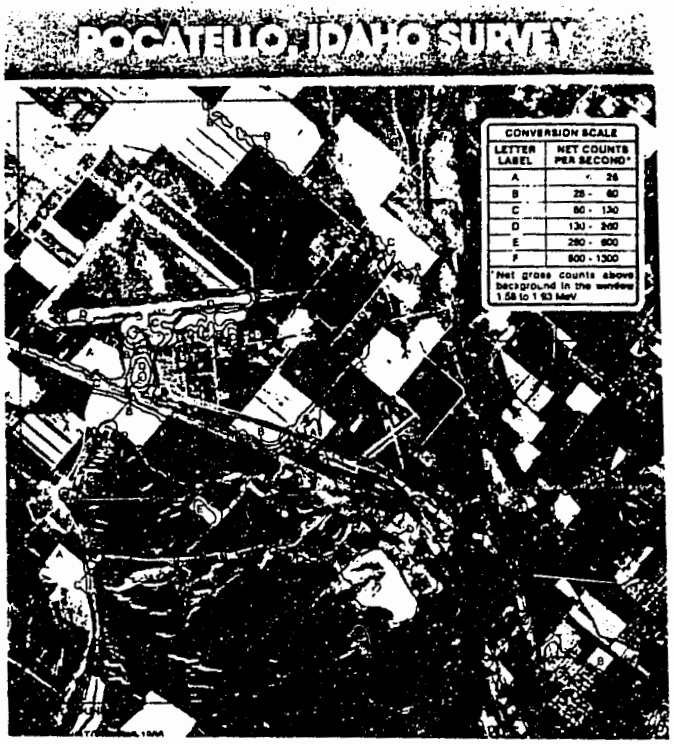


Figure 4. Excess bismuth-214 at Pocattello, Idaho

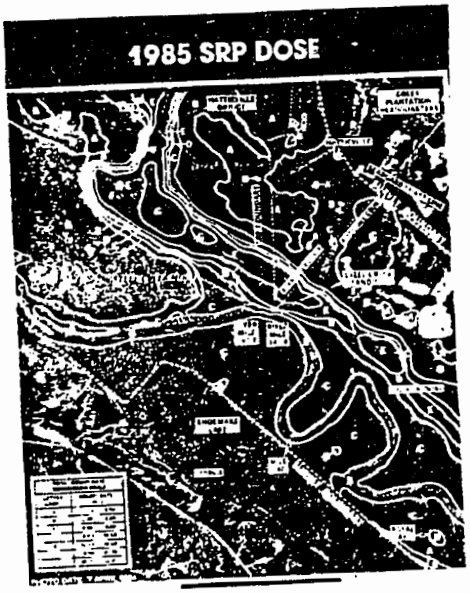


Figure 5. Total count isopleth at Savannah River

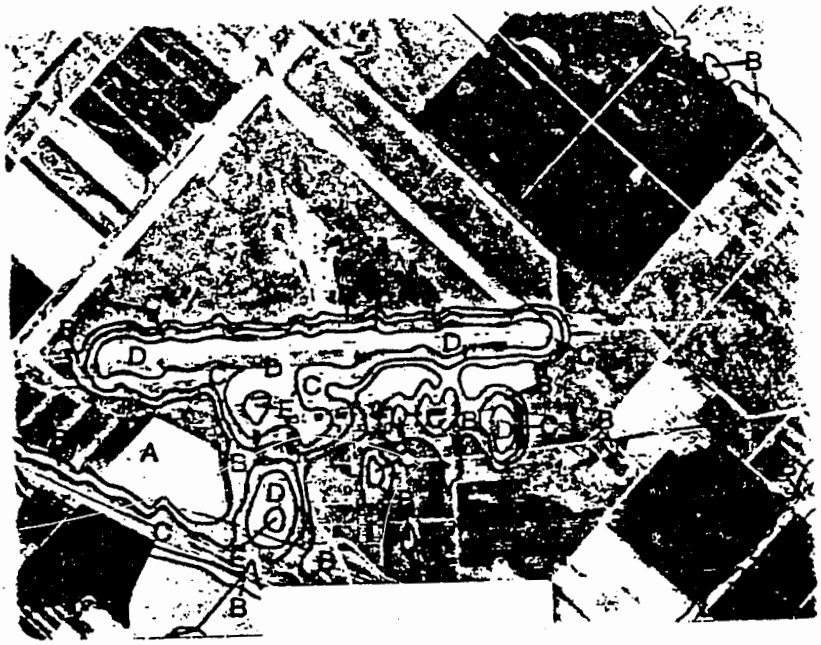


Figure 6. An enlargement of the Pocatello isopleth plot.

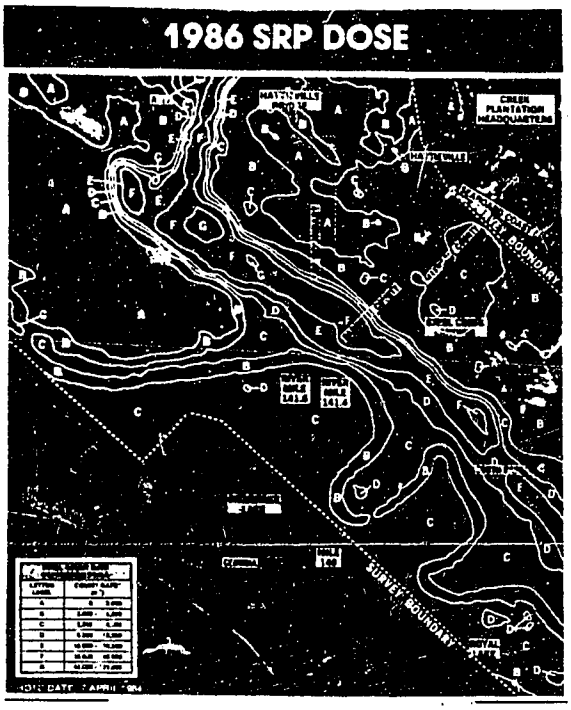


Figure 7. Same area, after L Reactor restart.

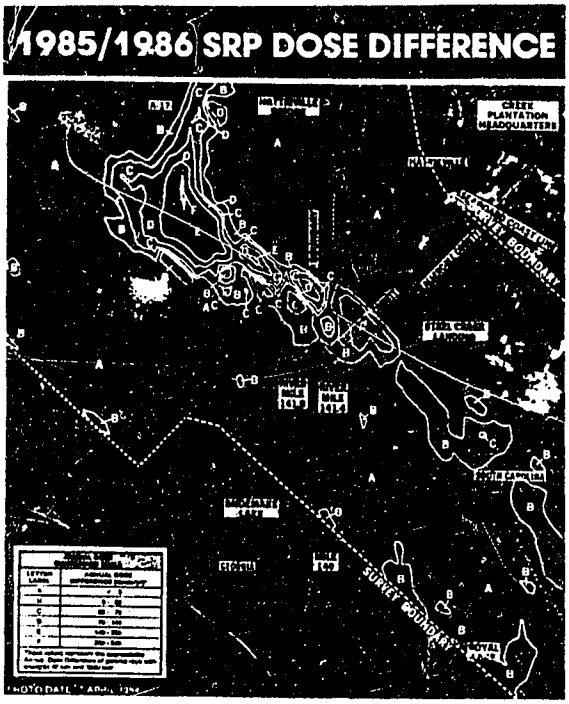


Figure 8. Differences between the 1985 and 1986 surveys.

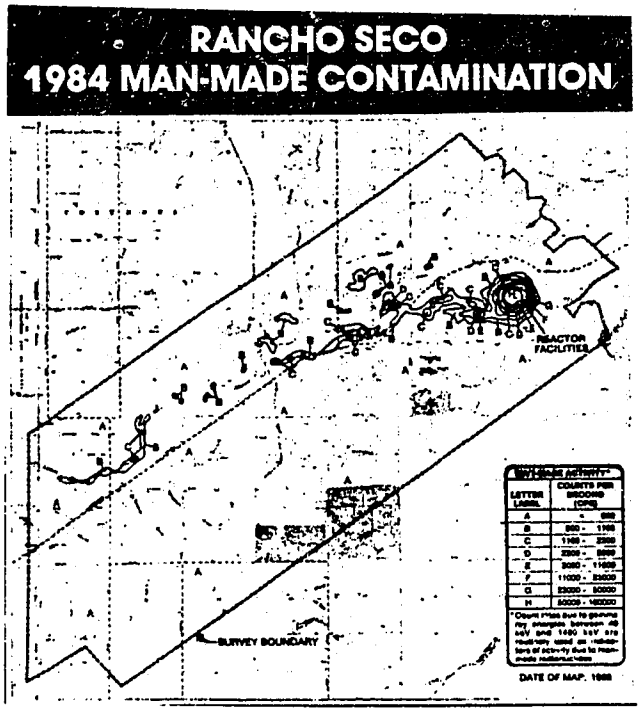


Figure 9. Man-made contamination at Rancho Seco (1984).

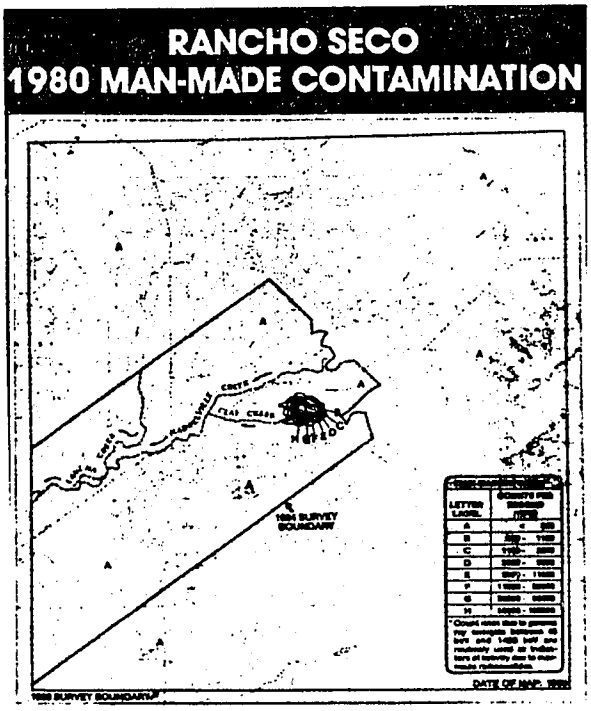


Figure 10. Man-made contamination at Rancho Seco (1980).

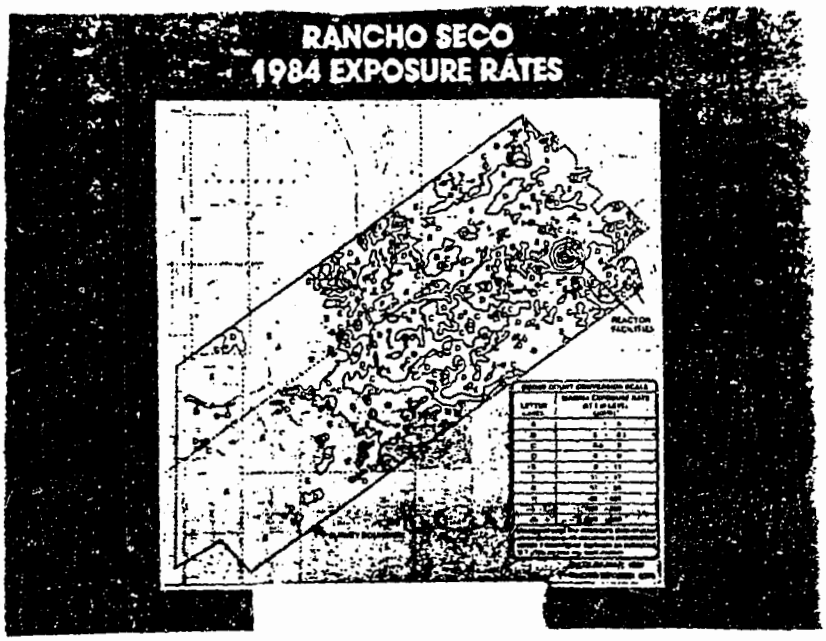


Figure 11. Differences between 1980 and 1984 surveys.

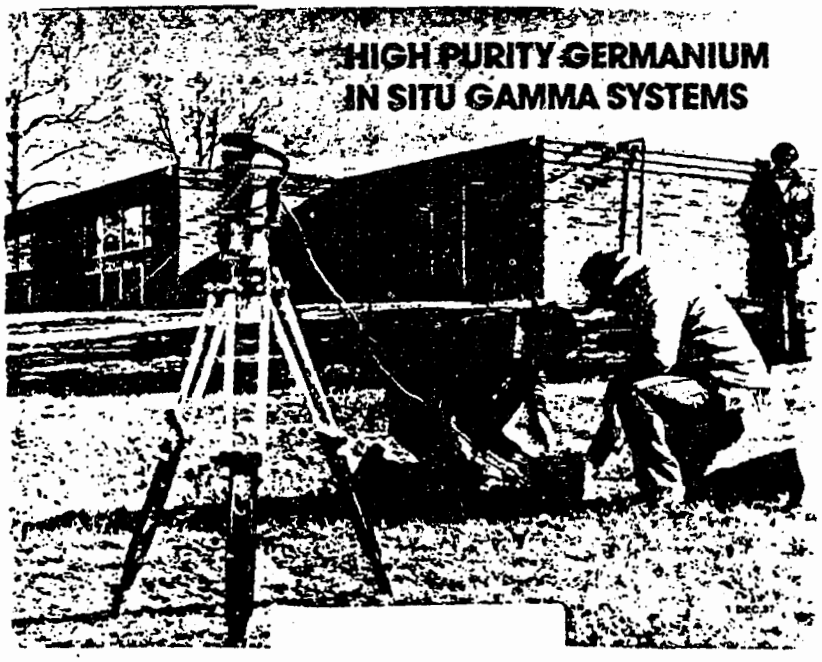


Figure 12. In situ survey at Gore, OK

17. IN SITU VITRIFICATION

Craig Timmerman
Battelle Pacific Northwest Laboratory

Pacific Northwest Laboratory (PNL) is developing in situ vitrification (ISV), a remedial action process for treating contaminated soils. The ISV process is being developed for the U.S. Department of Energy (DOE), primarily for treating transuranic-contaminated soils. It is expected, however, that the process can also be applied to a wide variety of chemical waste sites.

In situ vitrification is a thermal treatment process that converts contaminated soil into a chemically inert and stable glass and crystalline product. Figure 1 depicts the process. A square array of four molybdenum/graphite electrodes is inserted into the ground to the desired treatment depth. Because soil is not electrically conductive when the moisture has been driven off, a conductive mixture of flaked graphite and glass frit is placed between the pairs of electrodes as a starter path. An electrical potential is applied to the electrodes to establish an electric current in the starter path. The resultant power heats the starter path and surrounding soil to 2000°C, well above the initial soil-melting temperature of 1100 to 1400°C. The graphite starter path is eventually consumed by oxidation, and the current is transferred to the molten soil, which is electrically conductive. As the molten or vitrified zone grows, it incorporates radionuclides and nonvolatile hazardous elements, such as heavy metals, and destroys organic components by pyrolysis. The pyrolyzed byproducts migrate to the surface of the vitrified zone, where they burn in the presence of oxygen. A hood placed over the area being vitrified directs the gaseous effluents to an off-gas treatment system.

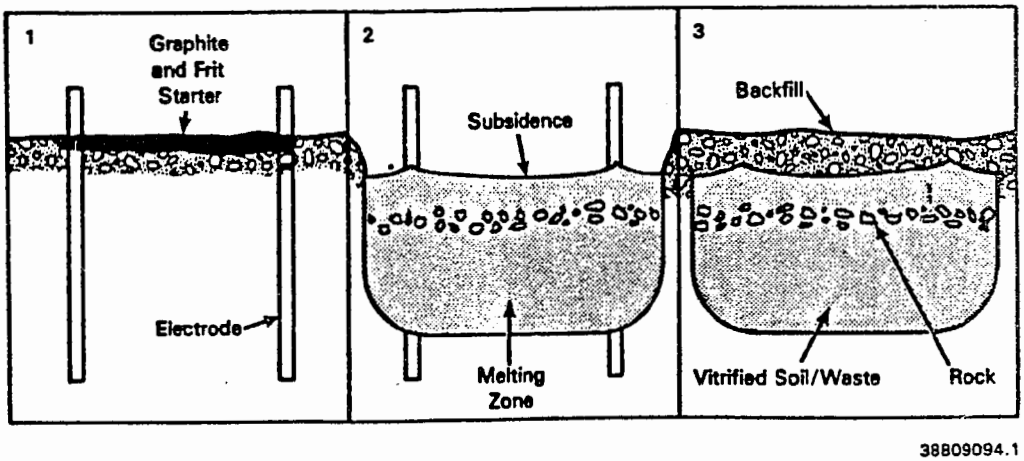


Figure 1. In situ vitrification process

Pacific Northwest Laboratory began developing ISV technology in 1980 under contract to the DOE. Since then, 65 separate experimental tests with a variety of conditions and waste types have been conducted (1, 2). These include 17 pilot-scale tests, each processing 10-50 metric tonnes (t) of contaminated soil, and 5 large-scale tests, processing 400-800 t each.

The first large-scale test of ISV at an actual contaminated soils site was performed at the 216-Z-12 Crib on the Hanford Site near Richland, Washington. The Z-12 site contains primarily transuranic materials that have been previously disposed. The objective of the large-scale radioactive test was to confirm, under actual site conditions, that the process conforms to its functional criteria as predicted by numerous nonradioactive tests (3, 1).

Complete evaluation of the system's performance will require that the core samples from the 700-t block produced during the test be completely analyzed. However, results available now, together with data from previous tests, are summarized in this report.

LARGE-SCALE RADIOACTIVE TEST RESULTS

This document reports the preliminary results of the large-scale radioactive test (LSRT) for the following parameters:

- electrode performance
- equipment performance
- process depth
- element retention in the vitreous block
- scrubber and filter removal efficiencies
- water removal.

Electrode Performance

The reference electrode design used in the radioactive test is composed of a 5-cm-diameter molybdenum core inside a 30-cm-diameter graphite collar (1). This electrode design was developed to promote cold-cap subsidence and to obtain reliable electrode performance during an entire single setting (up to 400 hr). Cold cap subsidence refers to the suppression of the porous glass layer that forms on the surface of the vitrified zone. The radioactive test successfully achieved cold-cap subsidence without an electrode failure. Measurements show that 0.3 to 1.3 m of subsidence was achieved, which simplifies backfilling operations with clean soil over the vitrified zone. On only one electrode was any (10 cm) of the molybdenum core exposed by oxidation of the graphite collar. This did not, however, cause any oxidation or breakage of the core, and thus the flow of current to the molten soil was maintained. Molybdenum oxidation was prevented by a layer of 88 wt% ZrB_2/12% $MoSi_2$ ceramic powder in the annulus between the molybdenum core and the graphite collar. Previous tests with other protection techniques had resulted in electrode failures due to oxidation or breakage, so that the electrodes had to be replaced. Even though electrodes can be replaced during processing, this need was completely avoided in the radioactive test because of the improved electrode design's performance.

Several key features are responsible for the success of the reference electrode design. First is its ability to promote cold-cap subsidence. The graphite collars around the 5-cm-diameter molybdenum rods are employed for that purpose. Graphite provides a relatively inexpensive, large diameter (30 cm) cross-section that promotes conduction of heat to the surface of the vitreous zone, keeping it molten near the electrodes. The molten glass surface aids the release of gases--primarily H_2O, N_2, O_2, and CO_2--generated during the process (1). Throughout the radioactive test, visual observations verified that the only molten regions were at the electrodes. In previous tests, without graphite collars, this molten surface was not observed, and a porous cold cap built up. In addition to heat conduction, graphite also promotes gas release because molten soil does not wet graphite as it does molybdenum. This property maintains an open pathway for gaseous release between the graphite/glass interface, thus reducing the tendency to form a foamy glass layer.

The second significant attribute of the electrode design is the lower current densities on the surface of the electrodes due to the large diameter of the graphite collar (30 cm). Previous large-scale tests with 15 cm-diameter collars had resulted in hot spots at the interface between the graphite and molten glass (1). Stanek (4) reports that the maximum current density of graphite should be limited to 0.3 A/cm^2, compared to 3 A/cm^2 for molybdenum. When this current limit was exceeded in previous large-scale tests, the interfacial resistance created excessive power densities on the electrode surface. This behavior can create excessive physical forces that break electrodes. The condition was eliminated in the LSRT.

Finally, the graphite collar provides mechanical support to prevent breakage of the molybdenum core during soil subsidence events. During processing, the molten soil is consolidated at the surface. Occasionally, the soil around the edges of the subsidence region above the molten soil collapses into the subsidence region. This collapse can create lateral forces on the electrodes. For a 3-m-thick melt with 1.3 m of subsidence, the graphite collars can withstand 1300 newtons (300 lbf) of lateral force with only a 0.64-cm deflection, whereas molybdenum electrodes alone could withstand only 210 newtons (48 lbf) before breaking. These calculations are based on published shear strengths of graphite and molybdenum materials. Since the spacing between the molybdenum core and graphite collar is 0.64 cm, the graphite collars can withstand more than six times the lateral force before exerting any force on the molybdenum core. Breakage of the molybdenum cores was eliminated during the LSRT.

Equipment Performance

Aside from two temporary transformer malfunctions during the test, all processing equipment operated as intended within the function criteria. The process equipment and functional criteria are described by Buelt and Carter (3). The process control system's batch logic, which automatically responds to over 20 potential equipment failures, performed as required. For example, when the 480-V power transformer experienced a primary winding fault to ground, the backup diesel generator automatically restored power, and the process control system restarted all the off-gas equipment in sequential

order without operator influence. The pumps maintained flow and pressure to the wet scrubbing system without interruption. The hood blower and filters provided continuous filtration of residual process off gases when the main power was temporarily down for repairs. The off-gas treatment system, as a whole, was completely successful in containing process effluents during and after the test.

Despite the temporary loss of the two main transformers during the run, downtime for repairs was limited to 68 hr, 23 wt% of the total run time of 295 hr. The malfunctions occurred independently of each other and were caused by internal faults on the transformers. Total operating efficiency during the test was maintained at 46 wt%, counting downtime for repairs.

The lower than normal operating efficiency achieved during the LSRT did not affect the energy-to-mass ratio. Historically, the large-scale process has vitrified 1.3 kg of soil for every kWh of energy consumed (0.75 kWh/kg). Core-drilling of the vitrified block indicated that a 700-t block was produced with 460,000 kWh of electrical energy, for an energy-to-mass ratio of 0.66 kWh/kg. The large-scale test thus confirms the operating efficiency previously measured for this process.

Process Depth

The success of the LSRT was limited by its achieved process depth. The goal of the test was to vitrify the transuranic contamination which existed down to a depth of nearly 7 m. However, recent core-sampling of the vitrified soil revealed that the downward progression of the melt was impeded at 5 m, preventing vitrification of a significant concentrations of radionuclides. The 5-m depth coincides with an artificial rock layer placed in the crib during construction. Because ISV has always processed rocks mixed with soil in previous tests without affecting its downward progression, PNL assembled a task force to investigate the causes of the unusual melting behavior during the radioactive test. After evaluating numerous possible causes, the task force concluded that the larger particle sizes in the artificial rock layer are sufficient to significantly decrease the rate of downward melting. Layers of varying soil compositions can also affect the downward melting rate. However, soils containing rocks throughout the soil depth would not inhibit the downward rate, thus previously predicted depths of as much as 10 m could be achieved.

ISV seeks its own equilibrium melting temperature depending on the fusion temperature of the soil and the particle sizes encountered. When a higher fusion temperature layer or a large particle size (greater than 2 cm) layer is encountered, a higher equilibrium temperature is needed to achieve the same downward progression rate. Otherwise, the molten zone will grow preferentially outward into the soil that allows a lower equilibrium melting temperature. This effect caused the lateral growth observed during the LSRT. Now that this effect is recognized, engineering approaches, such as injecting fluxants (e.g., soda ash, lime, and glass frit) into the voids of rock layers, are being tested and used to enhance the downward melting rate when necessary. The use of these engineering approaches combined with the low

energy-to-mass ratio observed during the LSRT supports past projections that ISV can vitrify at least 10 m deep.

Retention of Radionuclides and Chemicals

The efficiency of retaining or destroying radionuclides and hazardous chemicals during vitrification of contaminated soils can be expressed as the decontamination factor (DF). The DF is defined as follows:

$$DF = \frac{\dot{m}_1}{\dot{m}_e}$$

where $\dot{m}_1$ = the initial or input mass of contaminant in the control volume per unit time.

$\dot{m}_e$ = the exit mass of contaminant from the control volume per unit time.

Table 1 shows the soil-to-off gas DFs calculated from the data. Decontamination factors for the major soil components are typical of DFs observed for nonvolatile species in previous ISV tests (1). The data show extremely high efficiency in retaining particulates during the process. Generally, less than 0.001 wt% (DF = 10^5) of the particulates is evolved with the off gas. Since these data are consistent with particulate and radionuclide retention data from previous tests, losses of transuranic elements are expected to be less than 0.001 wt% as well. The data in Table 1 also supports previous large-scale results of greater than 98 wt% destruction of nitrates. (A DF of 53 is equivalent to 98 wt% destruction.) Phosphates are retained in the ISV product, but sulfates and chlorides are removed, to be captured efficiently by the off-gas treatment system.

Scrubber and Filter Efficiencies

Radionuclides and chemical contaminants not retained in the vitrified soil must be removed from the gaseous effluents before the gases are exhausted to the atmosphere. To assess the efficiency of the scrubbers, scrub solution samples taken during the test and high-efficiency particulate air (HEPA) filter samples taken after the test were chemically analyzed. Scrubber DFs calculated from these data are also shown in Table 1. Accounting for an additional DF of 1000 for particulates due to the presence of HEPA filters in the train, the combined DF for the overall process is also calculated and presented in Table 1.

Table 1. Decontamination factors

Component	Soil to Off Gas	Scrubber	Overall
Al	6.6×10^{4}	1.1×10^{5}	7.3×10^{7}
B	NM[a]	1.4×10^{2}	NM
Ca	1.9×10^{5}	1.0×10^{2}	1.9×10^{15}
Fe	1.1×10^{5}	3.5×10^{1}	3.8×10^{9}
Mg	1.6×10^{5}	1.5×10^{2}	2.4×10^{15}
Mn	NM	2.2×10^{2}	NM
Mo	NM	6.9×10^{2}	NM
Si	1.5×10^{5}	4.7×10^{2}	7.0×10^{15}
Zn	NM	2.3×10^{1}	NM
F^-	6.8×10^{2}	1.7×10^{3}	1.2×10^{9}
Cl^-	1.2×10^{5}	3.8×10^{2}	4.5×10^{5}
NO	$>5.3 \times 10^{1}$	1.3×10^{5}	$>6.9 \times 10^{1}$
PO_4^{-3}	8.6×10^{1}	1.8×10^{2}	1.5×10^{7}
SO_4^{-2}	1.5×10^{5}	$>9.8 \times 10^{1}$	$>1.5 \times 10^{2}$

(a) NM = not measured.

The hood and off-gas line were smeared to determine the quantity of materials collected on these surfaces. Typically, less than 10 wt% of the total material released to the off-gas system was collected on the hood and off-gas jumper. For example, 2.3 wt% of the silicon and less than 1 wt% of the F^-, Cl^-, and SO_4^{-2} were collected ahead of the scrubber. The exceptions were the alkaline earths (Mg - 9.3 wt%, Ca - 12 wt%, Sr - 17 wt%) and phosphates (26 wt%). The amount of plateout of those species associated with oxidation of the hood and pipe materials (iron, chromium, nickel) could not be quantified.

Water Removal

A water mass balance provides valuable information regarding how soil moisture and volatile organics behave under large-scale processing conditions. Mechanisms have been postulated that describe the behavior of organics when processed by ISV (5). The postulated mechanisms in that paper support empirical observations that organics behave similarly to that of water. A water mass balance was performed by the LSRT to demonstrate that the soil moisture is completely removed by the ISV process. The water mass balances are achieved by the following:

$$m \cdot X_{H_2O}/\rho_l + V_{air} \cdot Yi_{H_2O} \cdot \rho_g/\rho_l = V_{air} \cdot Ye_{H_2O} \cdot \rho_g/\rho_l + \Delta V_{liq}$$

where
- m = mass of soil dried during the large-scale test, kg
- X_{H_2O} = mass fraction of water in the soil
- ρ_l = density of water
- V_{air} = volume of air drawn through the hood during the test
- Yi_{H_2O} = volume fraction of water vapor in ambient air
- ρ_g = density of water vapor
- Ye_{H_2O} = volume fraction of water vapor in the stack, and
- ΔV_{liq} = accumulation (or loss) of scrub liquid in the tanks.

The mass of soil treated was determined to be 700 t of vitrified soil, plus 23 cm of dry soil surrounding the vitrified block (which is typically measured in ISV tests), for a total of 750 t. With a 4.5 wt% water content in the soil, 33,800 L of water were treated during the test. With ambient conditions varying from 28°C at 25 wt% humidity to 15°C at 71 wt% humidity during the test, the equivalent amount of water lost from the scrub tanks during the test accounts for a V_{liq} of -5100 L. Since a humidity meter was not located on the stack, Ye_{H2O} was determined based on 100% saturation at the exit of the scrub system's mist eliminator. The average temperature at this point was 30°C. At 30°C, the equivalent amount of water exhausted from the stack was 47,500 L. Since the left and right sides of the mass balance equation are equivalent (42,800 L ~ 42,400L), we conclude that water associated with the area being treated is completely removed and treated by the process before being released to the atmosphere. Also, because liquid organics are expected to behave similarly to water, the water balance supports the existing empirical observations that 97 wt% of organics are destroyed or removed and treated by the process.

CONCLUSIONS OF PROCESS RESULTS

The results of the radioactive test indicate that the process is ready for deployment at soil sites contaminated with radioactive materials and heavy metals. However, treatability testing with actual site samples before application is strongly recommended.

Results indicate that ISV can be applied more broadly to various waste management problems. Nonetheless, it is recognized that no single treatment process is applicable to all waste management needs. Within this context, ISV is a powerful new tool to consider and evaluate for remediating radioactive, mixed hazardous, and hazardous chemical waste sites falling within its treatment capabilities.

REFERENCES

(1) J. L. Buelt, C. L. Timmerman, K. H. Oma, V. F. FitzPatrick, and J. G. Carter, "In Situ Vitrification of Transuranic Waste: An Updated Systems Evaluation and Applications Assessment," PNL-4800, Suppl. 1, Pacific Northwest Laboratory, Richland, WA (1987).

(2) C. L. Timmerman and K. H. Oma, "An In Situ Vitrification Pilot-Scale Radioactive Test," PNL-5240, Pacific Northwest Laboratory, Richland, WA (1984).

(3) J. L. Buelt and J. G. Carter, "Description and Capabilities of the Large-Scale In Situ Vitrification Process," PNL-5738, Pacific Northwest Laboratory, Richland, WA (1986).

(4) J. Stanek, "Electric Melting of Glass," Elsevier Scientific Publishing Company, NY (1977).

(5) Battelle Northwest, "Application of In Situ Vitrification to Organic-Contaminated Soils and Sludges," PNWD-1264, Battelle Northwest Laboratories, Richland, WA (1988).

18. UMTRA VICINITY PROPERTIES IN GRAND JUNCTION, COLORADO

Donald MacDonald
UNC Geotech

The Grand Junction Vicinity Properties Program is conducted by UNC as part of the DOE UMTRA Program. DOE has identified over 3,500 individual properties under this program and estimates that the total will exceed 4,000. Since 1985, 2,500 of these have been decontaminated, and verification surveys are underway. Based on these surveys, DOE has certified 1,500 sites as completed and meeting relevant EPA standards.

Vicinity properties range from vacant lots and individual residential structures to commercial buildings and industrial complexes. About 50 percent of the sites involve simple contamination of vacant lots and residences where tailings were used as fill in back yards, patios, and driveways. In 20 percent of the sites, tailings were used in or under the structures, in concrete aggregate, or in mortar. The balance (30 percent) are commercial properties: public buildings, shopping areas, filling stations, and industrial sites. Among the commercial properties, about 70 sites involve some industrial process and contain hazardous wastes in addition to uranium mill tailings. Termed "commingled" wastes, these present a remediation problem. Uranium mill tailings are exempt from RCRA unless contaminated with RCRA wastes; if contaminated with RCRA wastes, then all RCRA requirements apply.

DOE studied the scope of the problem and considered possible options for handling or disposing of these commingled wastes. Handling/disposal options examined included: temporary storage pending availability of approved State repository, permanent disposal in UMTRA site, physical treatment (incineration, solidification), chemical treatment (remilling/chemical leaching), biological treatment, and delisting (apply for exemption from RCRA requirements). It was recognized at the outset that some of these were impractical.

The options were evaluated under the following criteria (in order of relative importance): safety/environmental impact, chemical type, technical feasibility, cost, and institutional issues. Each option was scored for desirability under each criteria to develop a relative ranking. The top three options under this ranking were delisting, temporary storage, and permanent storage at an UMTRA disposal site. Temporary disposal is not considered desirable, but since the remediation of vicinity properties has progressed faster than the mill site part of the UMTRA program, it may be a necessary interim step to disposal in an UMTRA site. However, it also became evident that additional information was needed to determine the full extent of the problem, and the Commingled Waste Investigation Project (CWIP) was developed.

Under the CWIP, DOE will follow the EPA site investigation procedures in analyzing and assessing the commingled waste sites. Work plans will be developed for each site covering sampling and analysis procedures, health and safety plans, and quality assurance protocols. DOE will make a walk-through inspection of each site, observing any soil discoloration, odors, or other

signs of contamination. Historical research for past history of the site includes owner interviews, checks of city directories and local records, and analysis of aerial photographs (these are available back to the early 1930s for the Grand Junction area). Standard hazardous waste site procedures are followed: an exclusion zone established, protection level determined, and appropriate sampling procedures followed.

Many of the 70 properties suspected of having commingled wastes are old filling stations, possibly having abandoned underground storage tanks which may have leaked fuel. Five such situations have been found to date; these were handled by removing and windrowing the fuel-contaminated soil until it would pass the ignitability test. Another site, where lead arsenate was manufactured in the 1920s, was contaminated with arsenic. An old municipal landfill containing many old car batteries had lead contamination. At an industrial site, Grand Junction Steel, there were indications of elevated organic levels.

19. A DEPLETED URANIUM SLUDGE BASIN IN MASSACHUSETTS

Donald A. Barbour
Nuclear Metals, Inc.

HISTORY

NMI is an NRC licensed manufacturer of depleted uranium products. DU alloy billets are sealed in copper cans prior to extrusion into machining stock. The resultant copper coating was formerly removed prior to machining by pickling in nitric acid. Spent acid was neutralized with lime and discharged into an unlined holding basin. Sludge was accumulated during the 27 year period 1958-1985. Process modifications adopted in 1985 included new reagents which are regenerated in a closed loop system and reused, enabling NMI to terminate discharges to the basin. A Hypalon cover was installed in November 1986 to further isolate the sludge from the environment. Since then, the surface of the sludge has subsided some 1 to 2 feet. This is attributed to drainage of liquid.

CHARACTER OF THE BASIN (PRIOR TO COVERING AND SUBSIDENCE)

The basin contained, prior to subsidence, approximately 5500 cubic yards of lime sludge. Within this lime sludge are some 900,000 pounds of copper and 500,000 pounds of depleted uranium. The chemical forms of these materials are hydrated oxides or hydroxides, with some water of crystallization chemically bound and mechanically held with the oxides. Other absorbed water also exists which contains nitrates (~4%) and some small percentage of water soluble machine coolant and oil (~4%). Other metals and acids from R&D projects also made a very small contribution to total basin sludge volume (est. <1%). Gravel and other inerts are known to exist. In addition, the original constituents of the lime (calcium and some magnesium) are also present as oxides. A specific gravity of 1.33 has been determined for a composite sample of basin sludge, yielding a total basin weight of some 6,200 tons. Preliminary tests, including TCLP for metals and zero head space extraction for volatile organics, indicates that the sludge is not a RCRA "mixed waste."

REGULATORY SETTING

The holding basin has been recognized for a long time as a temporary expedient. The disposition of the accumulated sludge has been discussed during annual NRC inspections and is being formally addressed during the license renewal process. This was understood to be the vehicle by which a remediation strategy would be posed and approved. The Concord Board of Health was kept informed of NMI's plans. On 3 October 1988, new state legislation took effect, bringing another regulatory agency into the picture. The Massachusetts Contingency Plan (MCP) establishes mechanisms for identifying and effecting the remediation of hazardous waste disposal sites in the state. The Department of Environmental Quality Engineering (DEQE) administers the new program. Major staffing augmentation was planned to enable DEQE to cope with the additional workload, but financial troubles in

the state resulted in personnel reductions instead. Because of its previous program responsibilities, DEQE has no resident radiological expertise. The MCP process includes the requirements for substantial formal documentation.

STATUS OF ACTIONS

An NMI working group identified a spectrum of nine possible alternatives ranging from the "do nothing" to processing the sludge for resource recovery of its uranium and copper. Others included in situ vitrification, warehouse storage, and both packaged and bulk disposal as low-level radioactive waste. Alternatives were evaluated against criteria that covered regulatory sufficiency, technological risk, long term corporate liability, community acceptability, and project costs. The most promising options were determined to be bulk disposal and resource recovery, both of which could well be applied. Extraction of a representative lot of about 20,000 pounds of sludge is planned for this spring to support a demonstration of the resource recovery technology and the determination of the full scale economics of this option.

ISSUES AND CHALLENGES

NMI will be attempting to develop a remediation strategy that will comply with the requirements and timetables of both DEQE and the NRC. A major issue will be to negotiate cleanup standards for residual uranium in the soil beneath the basin. The amount requiring removal will significantly affect project economics. The ultimate challenge will be to deal harmoniously with two regulatory agencies, town officials, and the community so that the remediation of the basin can be effected efficiently and without excessive delays.

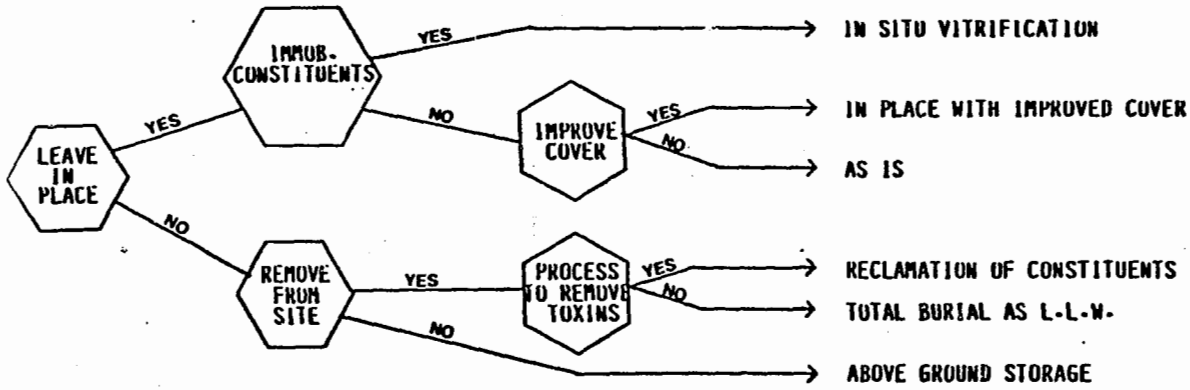


Figure 1. Holding Basin Sludge Disposition Options

20. CORRECTIVE ACTION INVESTIGATION OF A MIXED WASTE CONTAMINATED PERCOLATION POND

Lois C. VanDeusen
INEL, EG&G Idaho, Inc.
F. Hunter Weiler
Department of Energy

ABSTRACT

The Idaho National Engineering Laboratory (INEL), located in southeast Idaho and operated by the Department of Energy (DOE), has had the largest number of nuclear reactors during its lifetime of any location in the United States. The Test Reactor Area (TRA), one facility within the INEL, has been the home of three major test reactors, one of which is still operational. The TRA Warm Waste Pond is a three-celled percolation pond that has received waste water from these reactor operations since 1952. The pond is estimated to have received over 27,700 lbs. of chromium in addition to about 5.2×10^4 curies of radioactive materials. Because of known migration of contaminants to a perched-water zone, the pond is scheduled for corrective actions under a Resource Conservation and Recovery Act (RCRA) Consent Order and Compliance Agreement with Region X, Environmental Protection Agency (EPA). The pond will probably be included on the National Priority List by the spring of 1989. Field investigations were initiated in 1987 and continued in 1988 to pursue possible corrective or remedial actions. This paper describes the efforts to date, including a description of the unique problems and physical restrictions associated with sampling the pond while it is in use and sampling through the gravel and cobblestones that line the pond.

INTRODUCTION[1]

This paper describes the sampling that has been completed and the techniques utilized to mitigate sampling concerns in the corrective action investigation of the Test Reactor Area (TRA) Warm Waste Pond at the Idaho National Engineering Laboratory (INEL). The INEL is located in southeast Idaho and operated by the Department of Energy (DOE). The Test Reactor Area, one facility within the INEL, has been the home of three major test reactors, one of which is still operational. The TRA Warm Waste Pond has received wastes from these reactors since 1952. The Warm Waste Pond is located approximately 200 ft. east of TRA (Figure 1). The Warm Waste Pond was designed to handle low-level radioactive wastewater and consists of three cells. The first cell was excavated in 1952 and has bottom dimensions of 150 by 250 ft., 2:1 side slopes, and a depth of 15 ft. Because of decreased permeability and increased discharge to the cell, a second cell was excavated in 1957 with bottom dimensions of 125 by 250 ft., 2:1 side slopes, and a depth of 15 ft. The combined capacity of the two cells, when full, is approximately 9.7×10^6 gallons. About 1962, the permeability of both cells

---

a. Prepared for the U.S. Department of Energy, Idaho Operations Office under Contract No. DE-AC07-761D01570.

again decreased, so the bottoms of both cells were dredged and about 2 ft. of cobble rock was reportedly placed in the 1952 and 1957 cells, although it was not found during drilling.

The third and largest cell was excavated in 1964 with bottom dimensions of 250 ft. by 400 ft., 2:1 side slopes, and a maximum depth of approximately 6 ft. The capacity of the third cell is 4×10^6 gallons when the water is 5 ft. deep. Wastes have not been discharged to this cell since 1972 and the cell has been dry since the mid-1970s. None of the three cells is lined, but some sealing has occurred from chemical precipitation, sedimentation and deposition by algae.

The cells received all liquid wastes produced with TRA, except sewage, from 1952 to 1962. About 27,700 lbs. of chromium (used as a corrosion inhibitor) from reactor cooling water blowdown, 12,100 lbs. of waste from laboratory wastewater, 8.8×10^6 lbs. of corrosives from the demineralization plant, and 5.2×10^4 curies of radioactive materials have been discharged to the Warm Waste Pond. Before 1964, non-radioactive chromate wastes were discharged to the pond. After 1964, the wastewater streams containing chromates were discharged to a deep-disposal well located near the Warm Waste Pond. In 1972, the use of chromates as a corrosion inhibitor was discontinued at TRA. Liquid waste separation was initiated in 1962. A separate Chemical Waste Pond was excavated (see Figure 1) just north of the Warm Waste Pond to receive the demineralization plant discharges. These discharges contain high concentrations of salts; consequently, water originating in the Chemical Waste Pond can be traced in the perched-water zone because the water has a high specific conductance. In 1982, a Cold Waste Pond was put into service. It is located just south of the Warm Waste Pond. The Cold Waste Pond receives non-radioactive cooling water which is moderate in specific conductance and has no detectable tritium. Cells 1952 and 1957 of the Warm Waste Pond still receive low-level radioactive waste water. Tritium, as tritiated water, is one of the most abundant radionuclides discharged to these cells. Since tritium is only discharged to the Warm Waste Pond, tritium is a marker for water originating in that pond.

Chromium disposal at TRA began in 1952, but groundwater sampling for the contaminant did not begin until 1962. Even then, only a few groundwater samples were collected before 1965, and a good baseline was not established before the TRA Injection Well went into use in 1964. However, it is assumed that chromium reached the aquifer beneath TRA shortly after disposal began. Chromium contamination detected in the aquifer in 1963 probably originated from the Warm Water Pond effluent, as the injection well was not yet in use.

Measurements made by the United States Geological Survey (USGS) show that chromium in the aquifer in the early 1960s was essentially all hexavalent chromium. No recent data is available on the valence state of chromium in the aquifer and perched-water zone. Hexavalent chromium is very soluble and mobile because it is present in water as an anion. When chromium is reduced to the trivalent state, it becomes very insoluble. The valence state and the form in which chromium is present in sediments and basalts must be determined by additional investigations before appropriate corrective actions can be designed.

PRELIMINARY AND REMEDIAL INVESTIGATION SAMPLING

Investigation of the Warm Water Pond is planned in four phases: the preliminary investigation and three phases of the remedial investigation. In the preliminary investigation, six grab samples of the sludge from the bottom of the pond cells 1952 and 1957 were analyzed for 40 Code of Federal Regulations Part 264, Appendix VIII constituents using Environmental Protection Agency (EPA) approved procedures. The maximum concentrations of hazardous and radioactive substances in the pond sediment were estimated from the analysis results and a list was developed of the Appendix VIII chemical constituents present in the sediments. The pond sludge was found to contain hexavalent (Cr^{+6}) and trivalent (Cr^{+3}) chromium, mercury (Hg), lead (Pb), arsenic (As), beryllium (Be), cadmium (Cd), copper (Cu), silver (Ag), Sulfides, organic carbons, zinc (Zn), phthalates, pentachlorophenol, and acetone in concentrations above background. Principal radionuclides identified above background were cobalt-60, cesium-134 and -137, tritium, europium-154, and strontium-90.

The three phases of the remedial investigation are designed to examine strata progressively to greater depths, as necessary, to identify spatial distribution of contaminants in surficial sediment and to determine the depth of contaminant penetration. The results of the remedial investigations will enable selection of appropriate remedial action(s). Phase I of the remedial investigation included sampling the sediment and gravelly soil of the pond to a depth of 10 ft. and drilling three auger holes adjacent to the Warm Water Pond through the layer of surficial sediment to the basalt. Phase II sampling is scheduled for 1989. Phase III sampling will be performed if analysis results show further characterization of the pond is necessary.

Systematic sampling on an unaligned grid was the chosen sampling design for identifying the six sampling locations per pond cell for Phase I of the remedial investigation sampling within the pond. Each cell was divided into six sections and one sample location was chosen within each section. The first sample location was randomly located by using a random digits table to choose the initial X and Y coordinates. The initial X and Y coordinate was then used with other random digits from the random digits table to identify sampling locations in the remaining sections of each cell. At each sampling location in the cells, samples were collected and analyzed to ascertain contaminant concentration at each 2 ft. level (i.e., 0-2 ft., 2-4 ft., etc.,) to a total depth of 10 ft.

The locations of the three auger holes were selected by drawing a grid across a figure depicting the area where saturated conditions have existed in shallow sediments near the TRA Warm Waste Pond. Auger hole locations were chosen at three of the intersecting points of the grid within the mapped saturated zone of the shallow sediments and immediately adjacent to the pond.

During Phase I of the remedial investigation sampling performed in May, June and July of 1988, several major concerns were encountered. The first concern was the coarse nature of the alluvial soil at TRA which made the drilling and coring difficult. The second concern was the need to continue waste water disposal to the Warm Waste Pond from TRA until approximately

1991. Sampling through water may result in cross contamination of strata and samples and increased risk to personnel while working on or near the water. The third concern was the radioactive constituents in the sediment of the pond because of the potential radiation exposure to personnel. The fourth major concern was the weather in the high desert plateau of eastern Idaho. The wind increased the risk of personnel contamination and contamination spread. Heat stress may result when personnel are exposed to temperatures greater than 70°F while wearing protective clothing. Mitigation of these concerns was the governing principle in selecting some of the sampling methods and techniques.

The first major concern was the 6 to 12-in diameter cobble rock reported to be in the pond and the gravelly soil at TRA which made coring and drilling difficult. Records of the pond do not show the strata in the pond. Employees who worked on the pond "in the old days" remembered that when the 1952 and 1957 cells plugged up with silt, a drag line was used to dredge the bottom of the cells and about 2 ft. of 6 to 12-in. diameter cobble rock was dumped into the cells to increase drainage. Coarse gravelly soil was found but no large cobble rock. However, the gravelly, dense soil was difficult to sample and use of the slide hammer was necessary to drive the casing and split spoons into the soil and to retrieve the split spoons. Initially a jackhammer was used in the dry cell to drive the split spoon and casing but this technique was abandoned below the 2 ft. level. Driving the split spoon sampler and casing into the deeper gravelly dense soil caused the jackhammer drive pin to fail repeatedly. These breakdowns resulted in about 7 to 10 days delay in sampling the dry pond as well as the costs of repairs, additional spare parts, and modifications in techniques. One split spoon was abandoned at the 6-8 ft. level when a jack was damaged in an attempt to retrieve the split spoon.

The following method was used to collect the sediment and soil in the pond. In the wet cells, a split spoon sampler was driven 2 ft. into the sediment and soil and retrieved. A 3-in. diameter casing was then driven 2 ft. into the sediment and soil. A removable, pointed plug (boulder buster), sized to fit just inside the 3-in. casing and measured to extend just beyond the end of the casing, was attached to a drive rod and was used to break up and push aside the gravelly soil to prevent the casing from filling with soil. It was loose enough, however, to allow water to flow around it. After the casing had been driven, the boulder buster was removed and the water was bailed out of the casing. A split spoon sample was collected from the 2-4 ft. level. The split spoon was driven using a 140-lb. slide hammer system and retrieved using either a slide hammer system or a winch, depending on the effort required. After retrieval of the split spoon, the boulder buster was replaced and the casing driven another two feet. This sequence was repeated until all the samples were collected at a sampling location. In the dry cell, the first 2-ft. split spoon sample was driven using a jackhammer and retrieved using a jack. The deeper samples were collected using the slide hammer system to drive the sampler and to retrieve it. This method worked well in both the wet and dry pond cells. However, driving the split spoon sampler and the casing through the coarse, dense soils was very slow. Typical penetration resistance for the split spoon sampler required 50-100 blows of the slide hammer per foot of soil penetration. Penetration

resistance for the casing with the boulder buster in place was considerably greater. As a general rule, penetration resistance was higher in the dry cell than in the wet cells. In the dry cell, the penetration resistance for the split spoon sampler was as high as 500-700 blows per foot.

Sample recoveries varied considerably, and appeared to be related to the moisture content of the soil. Where the soil was either wet or dry, percent recovery ranged from zero to about 50%. Where the soil was moist or damp, the recovery typically was greater than 50%.

The second major concern was sampling through water which increased the potential physical hazard to personnel and the potential cross contamination of samples and strata beneath the pond. Since waste water disposal to cells 1952 and 1957 is continuing, the cells contained approximately eight feet of water at the deepest point during Phase I sampling. As a result, special sampling techniques were implemented.

Sampling through water may result in cross contamination of strata and samples and intensify contamination spread to deeper zones beneath the pond. To mitigate these concerns, the previously described sampling method was used. At all but one sample site, the sludge and soil sealed the casing to prevent water flowing back into the casing. (The inlet to pond 1957 was found to be soft sludge to the 8-10 ft. level and the casing filled with water repeatedly.) This technique minimized the cross contamination of strata and samples. After sampling was completed in each sample hole, granular bentonite was poured into the casing and hydrated with demineralized water. Sealing the sample hole minimized contamination spread through the sample hole to the sediments beneath the pond as a result of sampling.

The potential risk of personnel injury while transferring equipment and samples between the boat(s) and shore and operating heavy sampling equipment in a boat in 8 ft. of water was another concern. A 7-ft. by 18-ft. flat bottomed aluminum Jon boat equipped with an auxiliary plywood floor was used as the sampling platform in ponds. A rectangular hole was cut in the bottom of the boat and an 18-in. high hole casing welded in place to provide a port to allow sampling through the bottom of the boat. This method is safer and more efficient than sampling from the side of the boat. A quadripod was mounted in slots in the plywood in the bottom of the boat. A 5-hp motorized cathead (mounted to the frame of the quadripod) powered a 140-lb. slide-hammer weight supported by the quadripod that was used to drive sample-hole casing and split spoon samplers. Personnel were instructed in boating techniques and used a buddy system (one person would hold the boat while another person(s) disembarked or moved equipment into or out of the boat) during transfer of personnel and equipment between boats and to the shore or dock.

The third major concern was the radioactive constituents in the sediments of the pond. The water in the 1952 and 1957 cells was beneficial because it acted as a radiation shield which decreased radiation exposure for personnel and increased the amount of time per person per day that could be spent sampling the wet cells. The maximum radiation fields found at selected sites in the sludge in the wet cells was 90 mrem per hour (beta-gamma). With

18 in. of water as shielding, the dose rate was potentially reduced to less than 5 mrem per hour (beta-gamma).

The radiation field in the dry cell was generally 10 to 50 mrem per hour which limited the amount of time an individual could spend working in the dry cell to about 2 to 6 hours before the as low as reasonably achievable (ALARA) exposure limit (set by management) of 50 millirem per person per day was received. In addition to thermoluminescent dosimeters (TLD), pencil dosimeters were used so personnel could monitor their own exposure throughout each day. To meet commitments and continue sampling, crews were rotated among the sampling duties in the wet cells, sampling the dry cell, and sample packaging and equipment decontamination. As many sampling activities as possible were conducted away from the pond to keep radiation exposures as low as possible.

The fourth major concern was the weather, specifically the wind (which increased the potential for personnel exposure and possible spread of contaminants beyond the area already contaminated) and temperature (above 70°F, heat stress could result). The pond is located on a high desert plateau with an average elevation of 5000 ft. above sea level. Southwest winds predominate over the INEL and the second most frequent winds come from the northeast. The relatively dry air and infrequent low clouds permit intense solar heating of the surface during the day and rapid radiational cooling at night. These factors combine to give a large diurnal range of temperature near the ground. The annual wind speed 20 ft. above the ground ranges from a low average hourly velocity of 7.5 miles per hour to a high average hourly velocity of 51 mph. The potential for personnel exposure to airborne radioactive and chemical contaminants was greatest from the disturbed dry sediments in the dry cell and during bottling of dry samples. Disturbing the sediments also increased the potential for contamination spread beyond the area already contaminated. A 20 mph maximum wind velocity limit was selected to reduce the potential for contamination spread and personnel exposure. Work began at 6:00 a.m. each day in order to get as much sampling as possible completed before the wind velocity limit was exceeded. Plywood was used as a platform for sample collection activities in the dry cell to reduce sediment disturbance. Wind screens were set up around the two sample staging areas (one near the dry cell and one near the wet cells) to reduce the wind disturbance during sample preparation and packaging. Plastic covered tables were set on plastic covered plywood within the wind screen to contain any spilled material and to facilitate cleanup between samples. Split spoons were opened and samples were composited and transferred to the sample containers in the sample staging area.

Air temperature also affected personnel during sampling. Average monthly maximum temperatures at the INEL range from 86°F in July to 27°F in January. Average monthly minimum temperatures range from 49°F in July to 4°F in January. Through 1984 the warmest temperature recorded was 101°F and the coldest was -47°F. Temperatures ranged in the 80s and 90s in the afternoon most days during the last two weeks of June and all of July so measures were taken to prevent heat stress. Fifteen minute breaks were taken every hour. A shade was set up but it was torn apart by the wind in about two weeks, so the equipment storage trailers were used as break areas.

SUMMARY

Phase I of the remedial investigation sampling at the TRA Warm Waste Pond was completed July 22, 1988. Work delays as a result of the wind, technique modifications and breakdowns caused by the gravelly soil increased the time required for sampling by about 25%. Envirodyne Engineers, Inc. laboratory personnel are performing the chemical analysis of the samples and the EG&G Idaho Radiation Measurements Laboratory is responsible for the radioactive sample analysis. Analysis of samples for hexavalent chromium was performed by Envirodyne personnel at EG&G Idaho facilities during the sampling to meet the required analysis holding times specified by the Environmental Protection Agency (EPA). Data analyses will be completed by October 1, 1988. EG&G Idaho personnel will verify the data and the data will be used to determine well locations for Phase II of the remedial investigation of the pond. Because chromium and tritium have been found in a perched-water zone downgradient from the pond, the pond is scheduled for corrective actions under a Resource Conservation and Recovery Act (RCRA) Consent Order and Compliance Agreement with Region X, EPA and may be included on the National Priority List by the spring of 1989.

REFERENCES

G. E. Start (ed), Climatography of the Idaho National Engineering Laboratory, IDO-12048A and B, National Oceanic and Atmospheric Administration, October 1984.

G. R. Yanskey, E. H. Markee, Jr., and A P. Richter, Climatography of the Idaho National Engineering Laboratory, IDO-12048, National Oceanic and Atmospheric Administration, 1966.

Envirodyne Engineers, Inc., Site Sampling and Quality Assurance Procedures for Test Reactor Area Warm Waste Pond--Phase B, 1988.

L. C. Van Deusen, TRA Warm Waste Pond Corrective Action Workplan, Revision 1, EG&G Idaho, Inc., February 1988.

B. R. Baldwin, BRB-08-88, EG&G Idaho, Inc., Exposure Rate Assessments for TRA Warm Waste Pond, April 22, 1988.

C. L. Hertzler, CLH-06-88, EG&G Idaho, Inc., Warm Waste Pond 1988 Sampling Design, March 30, 1988.

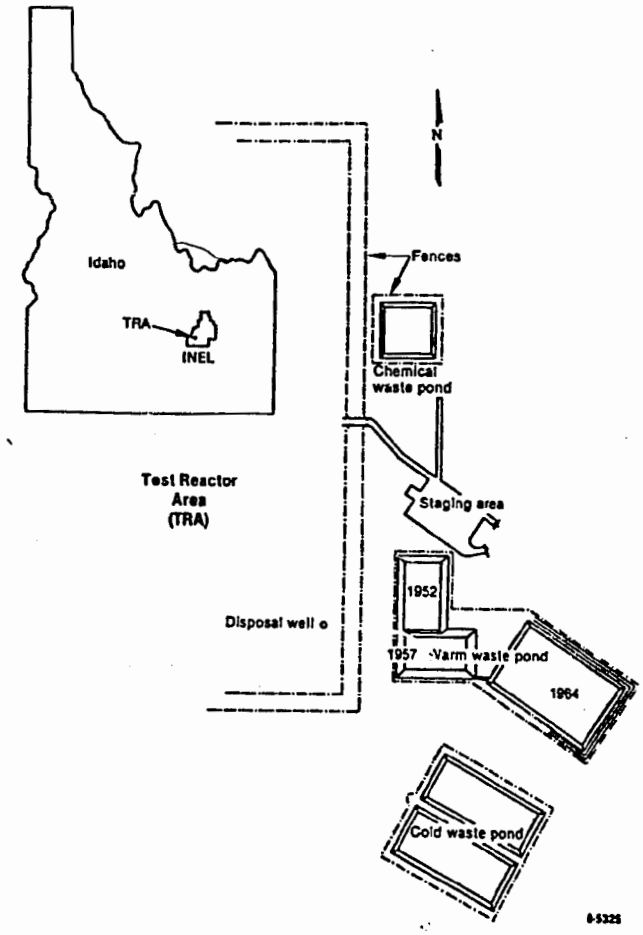


Figure 1. Location of the Chemical, Warm Waste, and Cold Waste Ponds and the Disposal Well.

21. SITE CHARACTERIZATION AND CLEANUP AT THE BABCOCK AND WILCOX APOLLO AND PARKS TOWNSHIP, PENNSYLVANIA FACILITIES

Tom F. Aud
Babcock & Wilcox

Babcock & Wilcox has three radioactively contaminated sites in Pennsylvania, one at Apollo and two in nearby Parks Township. These sites are NRC-licensed B&W facilities along the Kiskiminetas River, about 25 to 30 miles northeast of Pittsburgh. The previous owner, Nuclear Materials and Equipment Company (NUMEC), began operating the facilities in 1956, producing a number of products for the nuclear industry. Products included both high- and low-enriched uranium (HEU and LEU), mixed oxides, and other related nuclear products. In 1971, B&W acquired the facilities from ARCO (Atlantic Richfield Company), who had acquired the facilities about three years earlier from NUMEC to provide a source of supply for the nuclear raw materials for its nuclear power activities.

The five-acre Apollo site is located in the Borough of Apollo, a town of 3000-5000 residents, along the Kiskiminetas River and Route 66. The facility proper includes a 50,000 ft^2 plant that is surrounded on three sides by the Metal Services, Inc. (MSI) facility. This plant was used in the 1970's and into the early 1980's for manufacturing LEU fuel for the commercial nuclear markets and for two steps of a three-step HEU fuel process. A nearby 4,000 ft^2 building on the site was used as a decontamination laundry, for B&W, as well as other nuclear industries in the Pittsburgh area. B&W terminated manufacturing operations at the facility about 1982. The manufacturing equipment was removed and either relocated to other licensed facilities or shipped to Barnwell for burial. Decontamination activities were undertaken within the facility.

A routine survey by Oak Ridge Associated Universities (ORAU) in 1986 revealed radioactive hot spots in the parking lot, and the NRC issued a Confirmatory Action Letter requiring that these areas be removed. B&W conducted a full site characterization and discovered that contamination was more extensive than originally thought. Cleanup has been underway for over two years; over 5,000 samples have been taken and some areas of soil contamination averaging over 200 pCi/g have been found. Uranium, thorium, and some mixed fission materials are the principal contaminants. Contaminated soil has been removed from offsite locations, the alcove area between the B&W facility and the adjoining MSI plant, and part of the river bank. The soil is being stored on-site pending a decision as to the method of disposal.

Contaminated areas still to be addressed, in addition to the on-site buildings, include a deep sewer line, some areas along the river bank near the former sewer outfall, and a "breezeway" area between the B&W and MSI facilities. Additional sites may be found as sampling continues. Meanwhile, the site remains under NRC license and is being used for component storage, soil decontamination research and development activities, and staging for instrument and equipment decontamination efforts.

The Parks Township sites are seven miles north of Apollo, also along the Kiskiminetas River and Route 66. The first site here is a former manufacturing complex, which encompassed a building where B&W manufactured mixed oxides, and a metals building where B&W did some plutonium work and manufactured source material, hafnium, and zirconium crystal bars. HEU was manufactured in the T-2 facility on the hill; this building has been stripped of equipment, and some decontamination has been done. All of these facilities are operating under a NRC license.

The second Parks Township site, known as the burial ground, is not part of the NRC license at Parks Township but is on B&W property. Our records indicate that between 1962 and 1970, the former facility owners buried waste in nine trenches on the hill side. In 1982, a routine NRC inspection found some hot spots there which B&W remediated. Apparently in the 1960s, during an investigation of missing high-enriched uranium, the owners were required to excavate the trenches, and the hot spots remained from surface storage of contaminated material during excavation. B&W considers this site remediated and has no further plans for it.

These are not RCRA or Superfund sites. At the end of operations at the Apollo and Parks Township sites, B&W will be required to submit a decommissioning plan to NRC for approval. All of the areas will have to be fully decontaminated to levels permitting unrestricted use of the facilities. Meanwhile, B&W is continuing decontamination work on unused areas in the plutonium facility and the laundry building. Remediation priorities include: characterization and removal of offsite contaminated soil, cleanup and burial of plutonium contamination from unused areas, cleanup of any other unused areas at both Apollo and Parks Township, and finding an alternative to burial of soil at a Low Level Waste Burial Site. B&W has budgeted in excess of $2.0 million for remediation work in this fiscal year.

Issues of concern include: contaminated soils, burial prices, release limits, mixed waste, public perception, and third-party liability. B&W has taken over 5,000 soil samples from the parking lot area; although the contamination is all above free-release levels, it is not a threat to workers or the general public. Costs of transportation and burial at a licensed facility for this contaminated material are about $55/ft^3 and expected to increase. There is a need for better communications with the local people and public groups. Products from these facilities, whihc had at least three owners during its lifetime, went to various Federal programs, therefore, the possibility of third-party liability is being explored.

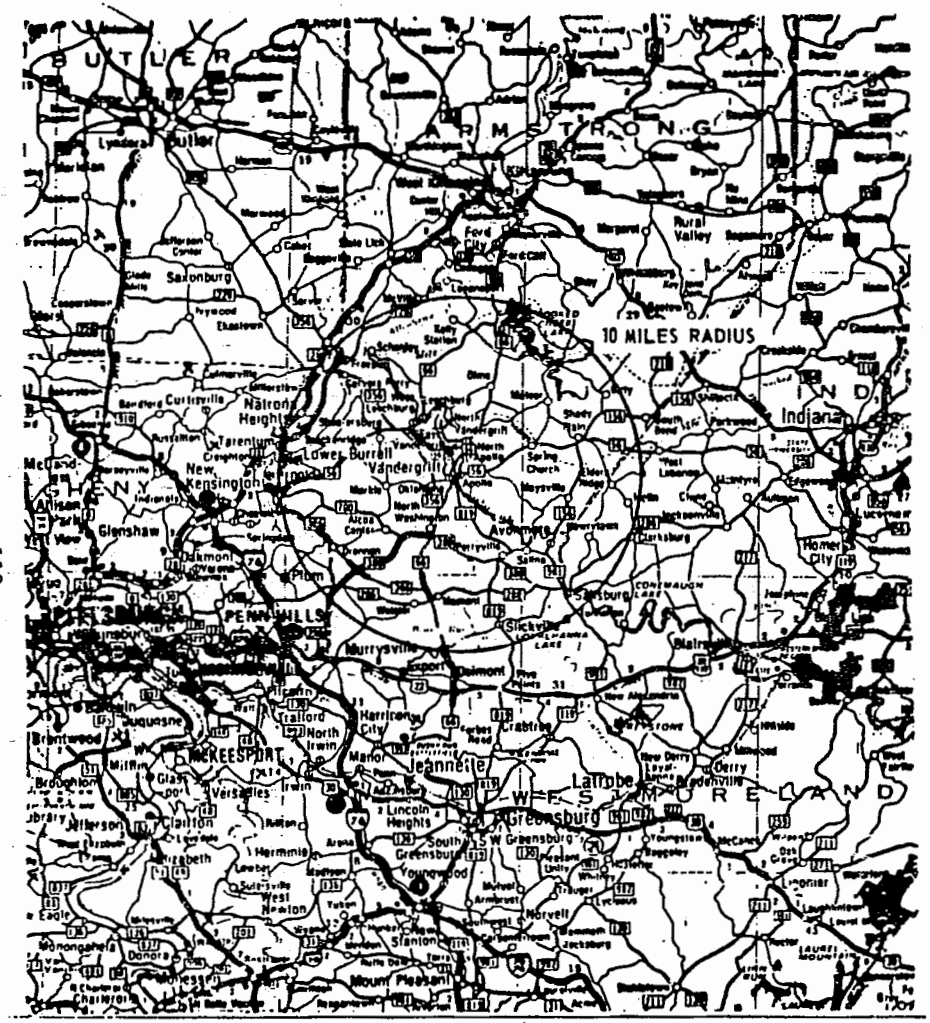


Figure 1. Map showing location of Apollo, PA, and towns within 10 miles radius

Figure 2. Map of Apollo, PA and location of facility (center of circle)

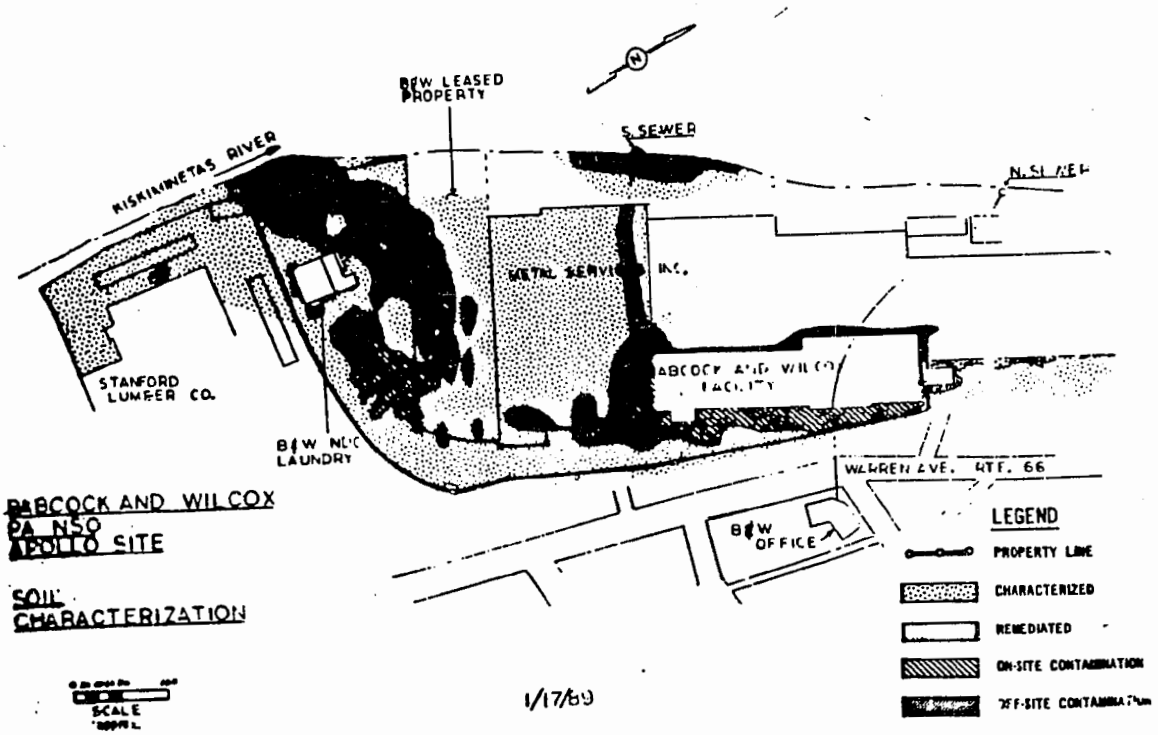


Figure 3. Apollo Site, showing contaminated areas and status of remediation

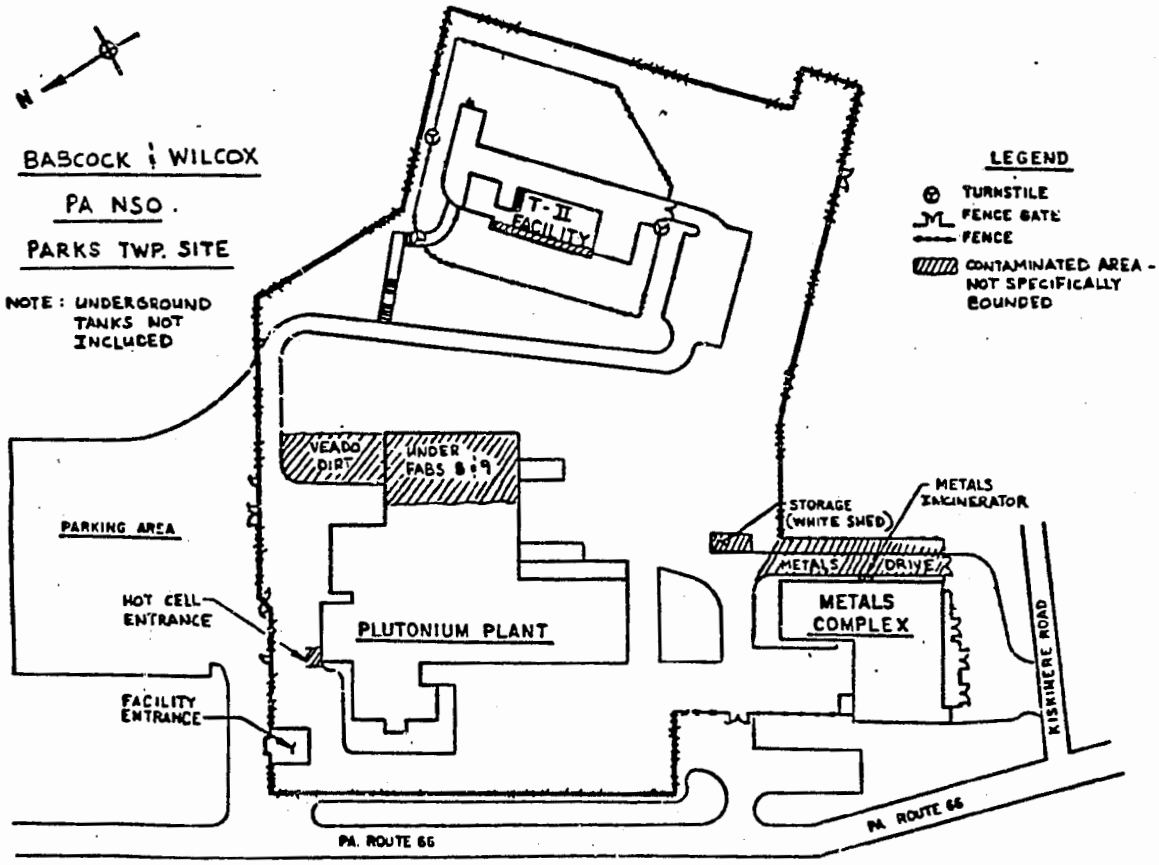


Figure 4. Parks Township site, showing facilities and contaminated areas

22. MAXEY FLATS LOW-LEVEL RADIOACTIVE WASTE SITE

Chuck Wakamo
David Kluesner
Environmental Protection Agency

The Maxey Flats Disposal Site is located on a flat-topped ridge called Maxey Flats, approximately 65 mi east of Lexington, KY (figure 1). The Commonwealth of Kentucky owns 280 acres at the site. Approximately 40 acres of the site is designated as a restricted area (figure 2); about 25 acres of the restricted area have been used for disposal of low-level radioactive wastes (LLRW).

Maxey Flats is in rural, rugged topography, covered primarily by deciduous forest, and sparsely populated. Approximately 25 people live within 1/2 mi of the site. The climate is Eastern temperate and humid, with about 44 inches annual precipitation.

SITE HISTORY

The Commonwealth, as an AEC Agreement State, licensed the Maxey Flats Nuclear Waste Disposal Site (MFDS) for disposal of low-level radioactive waste in 1963. The site accepted approximately 4.75 million cubic feet of radioactive waste until closed in December 1977. The wastes, generated by medical, academic, and industrial facilities and by State and Federal agencies, contained approximately 2.5 million curies of by-product material, 240,000 kg of source material, and 430 kg of special nuclear material, including 64 kg of plutonium. From 85 to 95 percent of the material is classified as low-level; the remainder is a mixture of uranium and thorium waste and transuranic radioactive materials.

Disposal was by shallow land burial. Wastes were placed in 52 trenches, numerous high specific-activity source wells, and several special pits (figure 3). The trenches were generally unlined, from 15 to 670 ft long, 10 to 70 ft wide, and 10 to 30 ft deep. The wastes were dumped into the open trenches; then the trenches were backfilled with the excavated material to reduce radiation exposure to acceptable levels. The backfilled trench was mounded and compacted to promote run-off of surface water and the surface area planted with shallow rooted vegetation to inhibit erosion.

In 1972, leachate pumping operations were initiated at the site to mitigate the effects of trench overflow. In mid-1973, an evaporator was installed onsite to reduce the volume of liquids. The site was closed in December 1977 after lateral seepage of radionuclides into an adjacent newly constructed trench was detected. The flow was about 25 ft below the surface along a lower sand-stone marker bed which forms the bottom of most of the trenches. Surface water from rainfall and run-off had infiltrated the closed disposal trenches; since 1981, the State has covered the trench and drainage ways with a plastic (pvc) membrane to inhibit surface water infiltration.

The State is in the process of decommissioning the site, and it appears that it will be closed in accordance with Superfund. Because of the trench leachate, the State indicated to EPA that the site should receive a high

priority for remediation and closure. The State is maintaining custody of the site and stabilization activities. The site has been placed on the NPL and notices sent to 832 PRPs. Approximately 80 PRPs signed an Administrative Order agreeing to conduct an RI/FS of the site. Field work commenced in September 1987 and was completed in April 1988.

CURRENT STATUS

Currently, migration of tritium from the restricted area results from leachate movement through fractures in the geologic units adjacent to and underlying the trenches. Earlier, two principal pathways of tritium migration were surface runoff from trench overflow and fallout from the evaporator plume. Operation of the evaporator was terminated, and a pumping program has eliminated overflow. Infiltration is minimized by the plastic membrane over the disposal area.

GEOLOGY

The local geology consists of sedimentary rocks of Silurian, Devonian, and Mississippian ages, dipping to the southeast at less than 25 ft/mi. A generalized geologic cross-section is shown in figure 4. The Nancy Member of the Borden Formation is the uppermost unit at the MFDS. Two sandstone interbeds, ranging from less than a few inches to over 24 inches thick, serve as markers within the shale. The top of the lower marker bed is about 20 to 25 ft below surface.

Rock units in the area contain major vertical or near-vertical, widely spaced fractures, typically in sets, with many minor fracture sets also present. Seeps occur at fractures in all exposed formations at the site. These are most common in the thin, highly fractured sandstone beds of the Nancy and Farmers Members, reflecting the higher hydraulic conductivity of these units.

Stratigraphic units beneath the site are predominantly aquitards, with groundwater movement confined to the bedding planes, joints, and fractures.

REMEDIAL INVESTIGATION

During the field investigations, over 600 samples were collected and analyzed for the full Target Compound List, the Target Analyte List, RCRA characteristics, and tritium. Sampling included air, surface waters, stream sediments, soils, groundwater, leachate, and biota. It appears that both organic and inorganic hazardous chemical constituents may be present. Radionuclide data are voluminous but chemical data to support a health assessment are limited. Based on this field work, the extent and probable magnitude of the contamination and health risks attributable to the site have been estimated.

Tritium has been detected at levels averaging 50 pCi/mL migrating down the east and west hillslopes along the soil/rock interface (figure 5). It was detected onsite in ground water at levels ranging from 98 to 2 million pCi/mL. The greatest concentrations were in ground water of the Lower Marker Bed. It

is also present onsite in surface water retention ponds and weirs at levels of 10 to 60 pCi/mL. Co-60 was the only other radionuclide detected along the hillslope that could be attributed to the site. Low levels of tritium and trace organics were detected offsite in stream waters and sediments.

Two different methods of risk assessment are used for the MFDS wastes: one for radioactive waste materials and another for the toxicity of chemical wastes (figure 6). Major release and exposure pathways (hydrologic and atmospheric) were evaluated to estimate health impacts, locations, and populations affected (figures 7 and 8). Risks from the radioactive contamination have been calculated using site data and accepted models. Four potential exposure pathways have been identified: surface water, sediment ingestion, evapotranspiration, and deer consumption. A fifth pathway, ingestion of ground water, is being developed.

The Feasibility Study is underway to identify remedial measures; a partial list includes prevention of vertical and lateral water infiltration into the waste trenches and exfiltration from the waste trenches; dewatering the waste trenches; surface water management; and a long-term cap design to prevent infiltration and assure slope stability. Criteria for selection of containment and treatment technologies at MFDS include preventing infiltration of rainwater and ground water to the trench areas, preventing sub-surface migration of trench leachate, promoting site drainage and minimizing the potential for erosion, implementing institutional controls to prevent unrestricted use of the site, and implementing performance and environmental monitoring systems.

The Feasibility Study Report is being revised, and preparations are underway for Remedial Design/Remedial Action Consent Decree negotiations with the PRPs. A Record of Decision is anticipated by the end of 1989.

REFERENCES

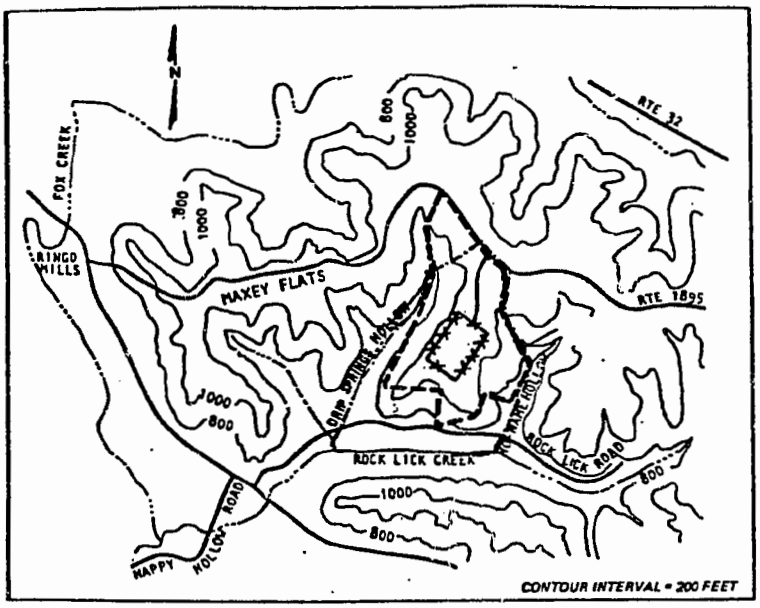
Clark, D.T., "A History and Preliminary Inventory Report on the Kentucky Radioactive Waste Disposal Site." Radiation Data and Reports, v. 14, #10, p.573-584, 1973.

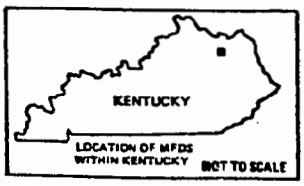
Haight, C.P., et al., "Maxey Flats Low-level Waste Disposal Site Closure Activities." Proceedings of Eighth Annual DOE Low-level Waste Management Forum, COND-860990, p.32-50, 1986.

Kirby, L.J., et al., "Chemical Species of Migrating Radionuclides at Commercial Shallow Land Burial Sites" - Quarterly Progress Report, p.14, July - September 1983. Prepared for the U.S. Nuclear Regulatory Commission by Pacific Northwest Laboratory, PNL-4432-6.

"Results of the Environmental Monitoring Program at the Maxey Flats Nuclear Waste Disposal site in Fleming County, KY, 1984." Westinghouse, 1985. Prepared for the Kentucky Department for Environmental Protection.

Haight, C.P., and Mills, H.D., "Remedial Action - Maxey Flats Low-level Waste Disposal Site, CERCLA Action." Kentucky Department for Environmental Protection, Frankfort, KY, DOE Conf. 1987.





EXPLANATION

MFDS PROPERTY BOUNDARY

FENCE ENCLOSING BURIAL AREA (AREA 1)

APPROXIMATE BOUNDARY OF AREA 2

Figure 1. Location of Maxey Flats Disposal Site

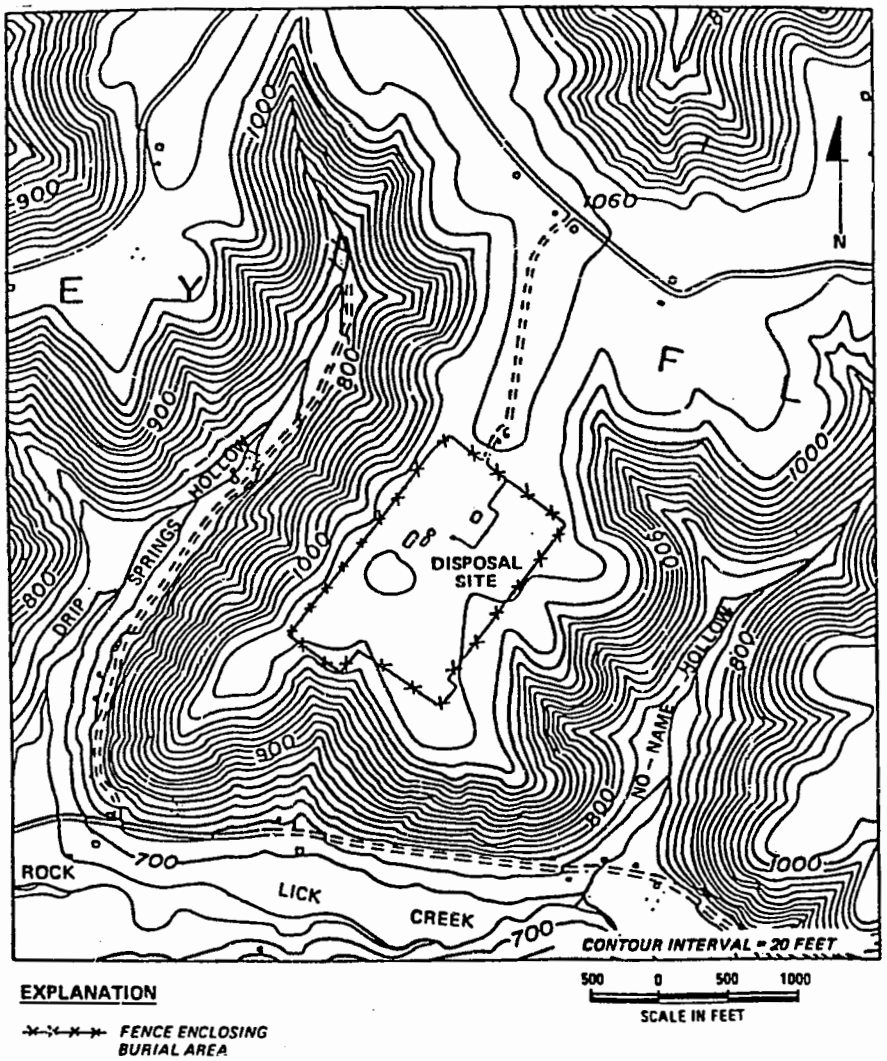


Figure 2. Maxey Flats Disposal Site Restricted Area.

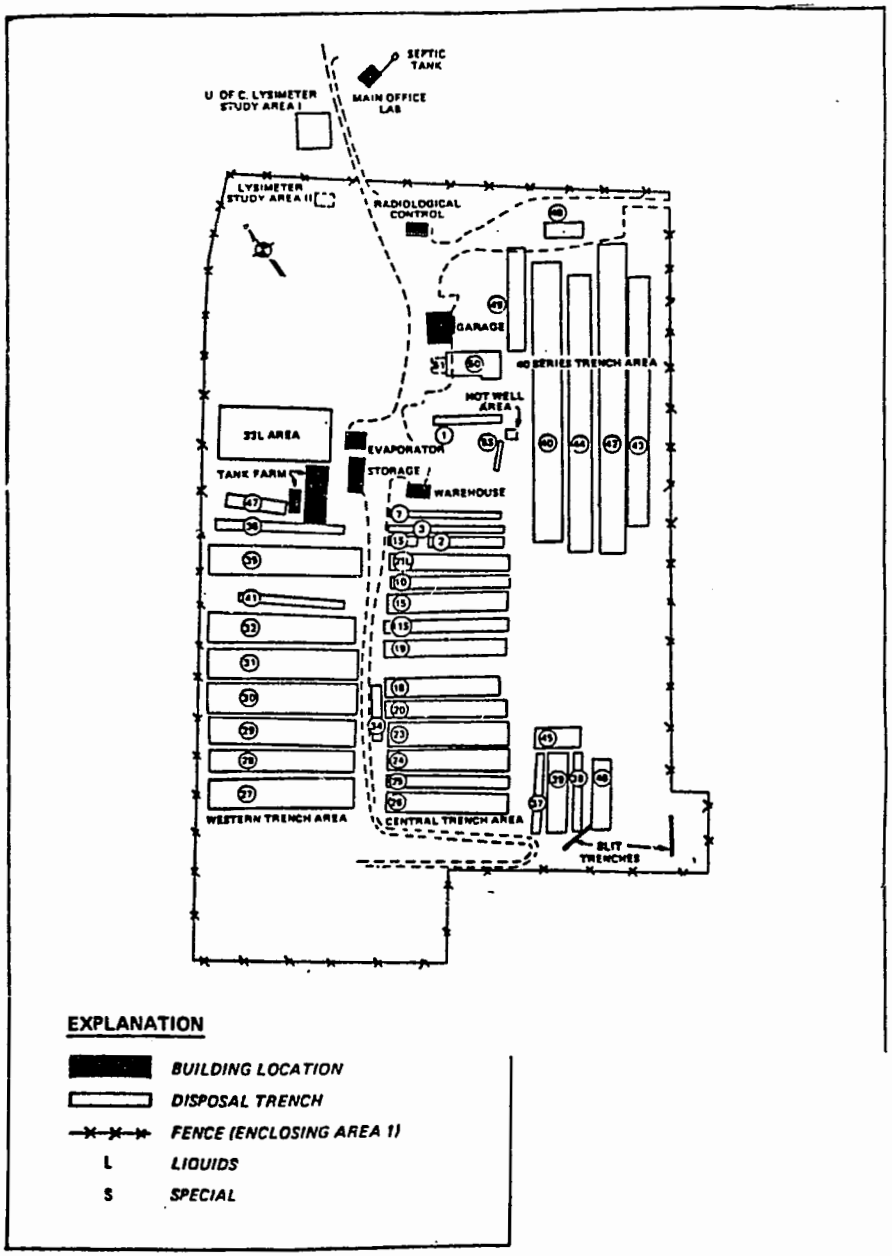


Figure 3. Disposal Trenches.

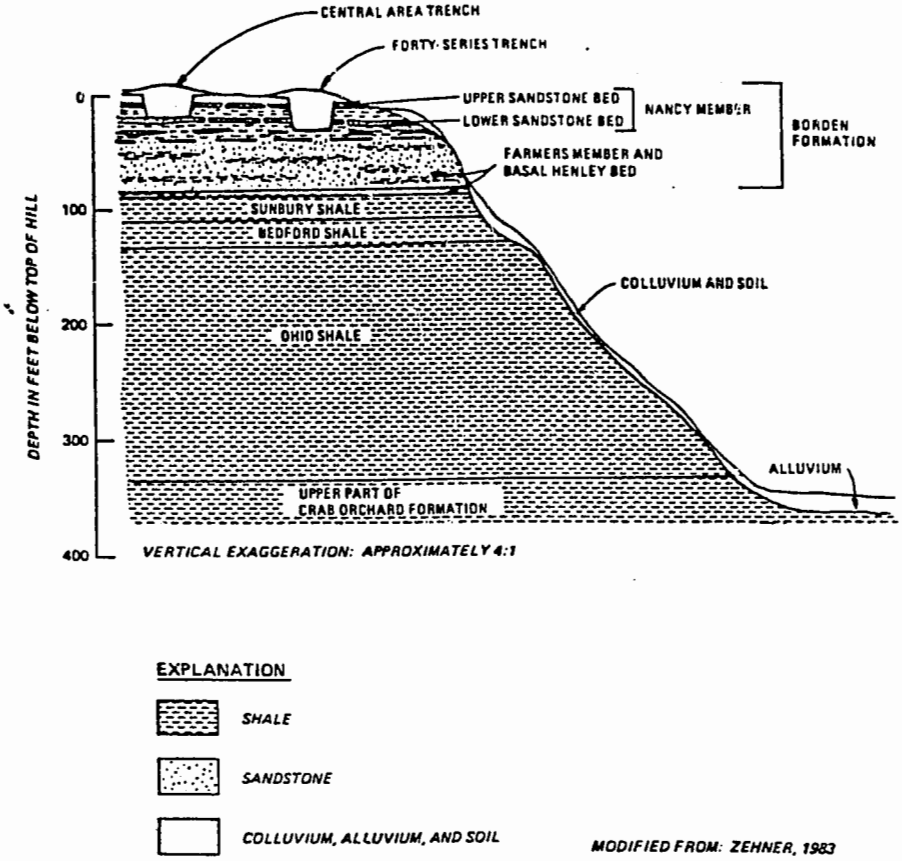


Figure 4. Sketch showing general stratigrphy at Maxey Flats Disposal Site

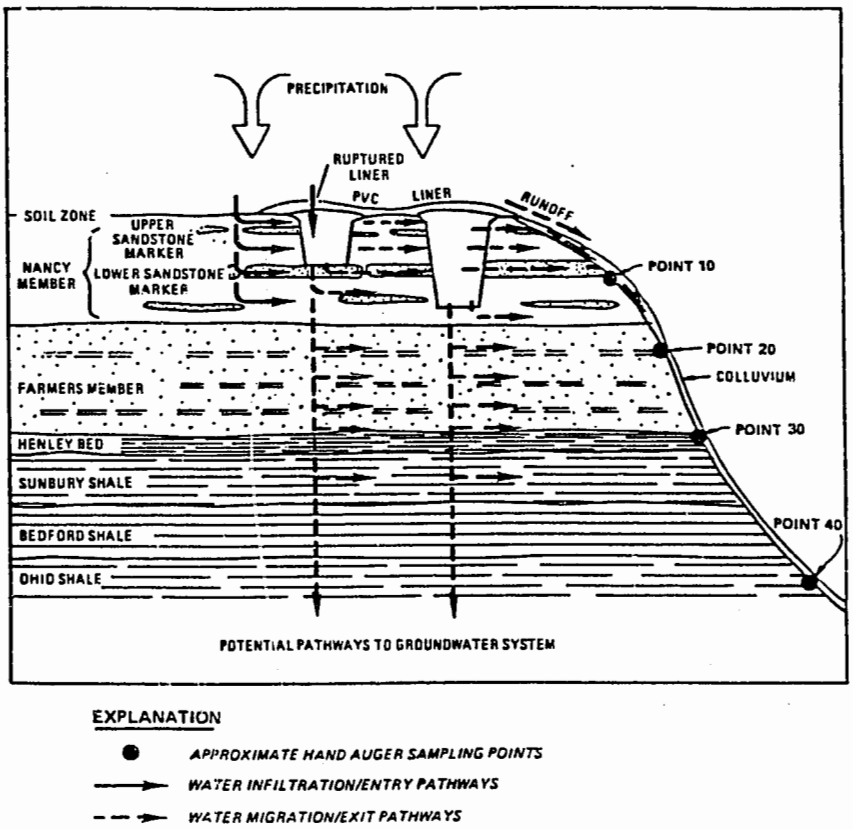


Figure 5. Sketch showing stratigraphy and sampling points at Maxey Flats.

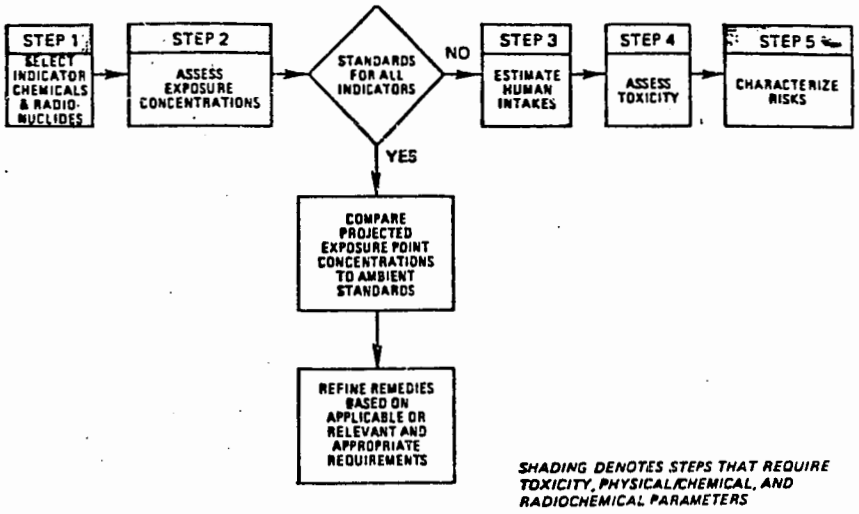


Figure 6. Steps in risk assessment methodology

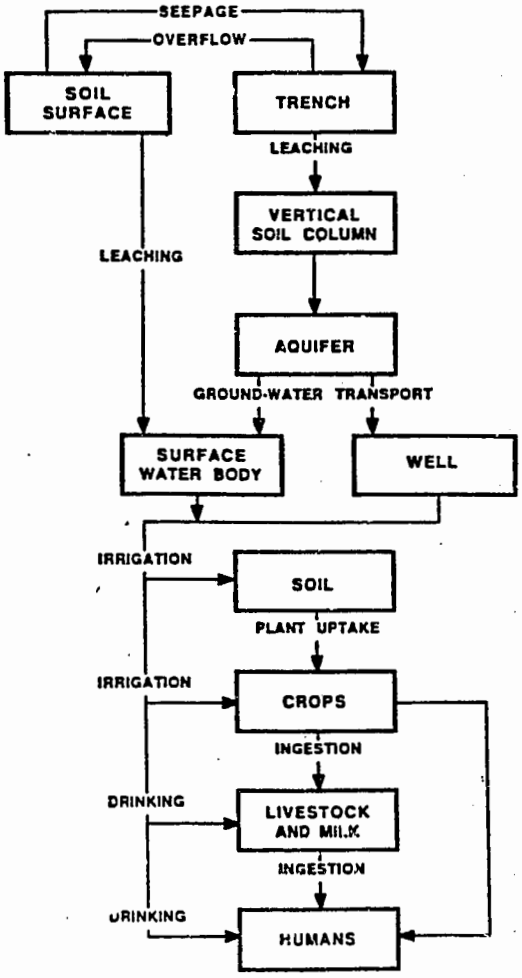


Figure 7. Hydrologic environmental transport pathways.

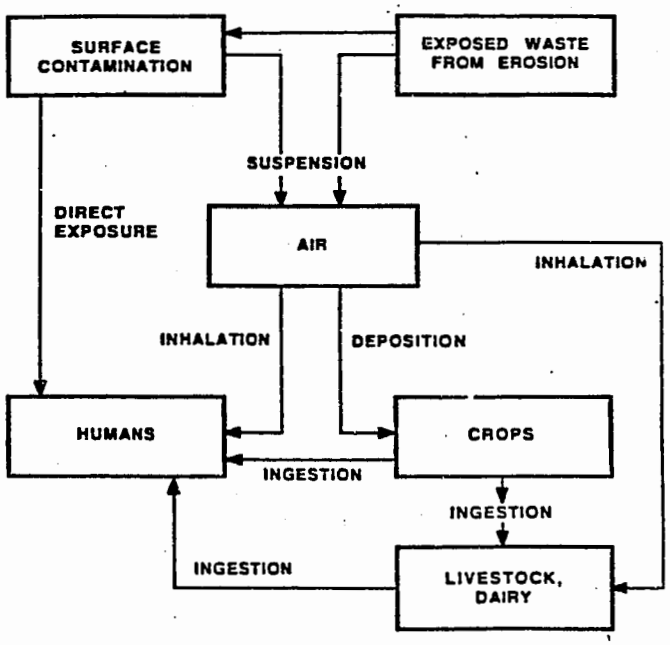


Figure 8. Atmospheric environmental transport pathways.

23. THE PROPOSED HANFORD COMPLIANCE AND CLEANUP PROGRAM

Paul T. Day
Environmental Protection Agency

The United States Government has, since 1943, manufactured nuclear materials for the nation's defense programs at Hanford, Washington, in nuclear reactors and chemical processing plants (figure 1). Wastes generated at these facilities have been treated, stored, or disposed of in a variety of ways. Some of the wastes contain radioactive materials, some contain chemical materials, and a third category, called mixed waste, is a mixture of both radioactive and hazardous wastes. The majority of Hanford wastes are mixed wastes.

The U.S. Department of Energy (DOE), which operates the Hanford Site, plans to begin the cleanup of its waste sites and obtain Federal/State permits for treating, storing, and disposing of hazardous wastes. The U.S. Environmental Protection Agency (EPA) and the Washington Department of Ecology will oversee DOE's actions under Federal and State waste management laws.

The three parties have negotiated for more than a year regarding the authorities of each agency, timing and funding of cleanup activities, specific actions to be taken, and procedures to be followed. The negotiations resulted in four documents:

- A Federal Facility Agreement and Consent Order, which describes the roles, responsibilities, and authority of the three agencies in the cleanup, compliance, and permitting processes. It also sets up dispute resolution processes and describes how the agreement will be enforced.

- A Proposed Action Plan to implement the cleanup and permitting efforts. The plan includes milestones for initiating and completing specific work and procedures the three agencies will follow.

- A Community Relations Plan, which describes how the public will be informed and involved throughout the cleanup and permitting processes.

- A Cooperative Funding Agreement, which provides funding to the State of Washington for oversight expenses.

The documents describe a 30-year program to address an estimated 5 billion yd^3 of chemical and radioactive wastes that have accumulated over the past 45 years at Hanford. The estimated cost is $2.8 billion over the first 5 years. Much research and investigation of site conditions still is needed before costs can be set for the entire 30-year program.

Four public workshop meetings were held in late March on the Agreement in Richland, Seattle, Spokane, and Vancouver; and additional public meetings are scheduled.

CURRENT WASTE PRACTICES AT HANFORD

Because many activities continue at Hanford, radioactive and hazardous waste facilities that have operated recently are subject to the Federal Resource Conservation and Recovery Act (RCRA) and the Washington State Hazardous Waste Management Act (WSHWMA). The statutes require the State to control the treatment, storage, and disposal of hazardous waste and EPA to handle the cleanup of past practices at these active facilities.

COMPLIANCE WITH INTERIM RULES

The Action Plan requires DOE to meet specific milestones for bringing all its facilities into compliance with all Federal and State rules. These rules, called "Interim Status Standards," apply until Ecology and EPA have issued permits that establish specific operating requirements for each Hanford facility. A very important interim requirement is ground-water monitoring around each hazardous waste facility.

PERMITS REQUIRED

The WSHWMA and RCRA require that hazardous waste facilities that went into operation after November 19, 1980, comply with the permitting and closure requirements of the two regulations. The hazardous waste permit application is divided into two parts. Part A describes general information about the facility and the waste being handled. Part B provides detailed technical data regarding the waste characteristics and operating conditions of the hazardous waste facility.

Due to the complexity of the Hanford operations, Part A of the application has been divided into groups of hazardous waste units. For example, all 149 single-shell waste tanks are included in one Part A group. Some of these waste unit groups will be included in the RCRA permit (Part B), while others will be closed in accordance with RCRA and the WSHWMA. Those units that will be closed with waste remaining in place, such as a landfill, will be in the post-closure portion of the RCRA permit. For ease of review, separate permit application or closure plan documents will be submitted for each waste unit grouping. DOE's waste unit groups include Treatment, Storage and Disposal (TSD) units. Most existing disposal units at Hanford must be upgraded or closed.

Public participation will be an important part of the permitting process, with public workshops and hearings (when appropriate) scheduled at each decision point of the permit process.

KEY TREATMENT, STORAGE, AND DISPOSAL MILESTONES

Operating units and those undergoing closure will be assessed for compliance with appropriate Federal and State requirements by April 1989. Nineteen (nonhazardous) liquid effluent waste streams will either be treated or be eliminated by June 1995. All permit applications, closure plans, and post-closure permit applications for TSDs will be submitted to EPA and the Washington Department of Ecology by May 1996.

PAST CONTAMINATION OF THE LAND AND GROUND WATER

In addition to the currently operating facilities, a number of inactive sites at Hanford show chemical and/or radioactive waste contamination. The sites range from small chemical spills to large waste burial landfills and liquid waste cribs, similar to but larger than septic drain fields.

These closed contaminated sites are called "past-practice units." Hanford has approximately 1,000 such units. Due to the large number of sites and their closeness to each other, they will be organized into 74 groups called "operable units."

CLEANUP PLANS

The first units to be cleaned up are those that initially appear to represent the greatest threat to human health or the environment. Criteria include:

-Amount of waste involved
-Type and concentration of the waste
-Health effects and toxicity of the waste
-Potential for movement through air, water, or soil

Each operable unit will go through a scoping phase to gather all existing data and develop an overall management strategy. A work plan will be available for public review and comment.

Two Federal laws, RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund"), apply to the cleanup program. The cleanup processes are similar for RCRA and CERCLA, as shown in figure 2.

As each operable unit investigation proceeds, the public can review the major documents produced. After a public comment period on the investigation results and cleanup plan, the appropriate regulatory agency will make the final decision on cleanup at each operable unit. Ecology and EPA will then set an enforceable schedule for the cleanup, and DOE must carry out the cleanup. Key milestones in the past-practices cleanup include:

- Additional laboratory capacity for analyzing wastes will be available by January 1992.

- Work plans for investigating the first 20 operable units will be submitted by April 1992. Six per year will be submitted thereafter.

- Investigations of all operable units will be completed by September 2005.

- Cleanup of all past-practice units will be completed by September 2018.

SINGLE SHELL TANKS

A major issue in the Hanford cleanup program is the handling of single-shell tank wastes. These underground tanks, some dating back to 1944, store more than 36 million gallons of highly radioactive and chemically toxic wastes. Much of the liquid that can be pumped out has been removed from the tanks and stored in newer, double-shell tanks, although an estimated 6.8 million pumpable gallons of liquids remain.

Sixty-six of the single-shell tanks are known to have leaked at least 500,000 gallons since 1956. There is extensive soil contamination beneath the tanks but no proof of ground-water contamination from the leaks.

The Interagency Agreement calls for an extensive management program for the single-shell tanks. The tanks must be pumped to the extent possible. The remaining wastes must be characterized, and a plan for removing, treating, and disposing of the waste and tanks in accordance with State and Federal requirements must be developed.

Key tank waste milestones include:

- An effective technology for safe removal of single-shell tank wastes will be developed by June 1994.

- Fourteen "grout" campaigns will be completed by September 1994. Each campaign converts approximately 1 million gallons of liquid grout into a concrete-like substance.

- Remaining pumpable liquid waste will be removed from all single-shell tanks by September 1995, except for two high-heat tanks, which will be pumped by September 1996.

- The Hanford Waste Vitrification Plant will begin operation by December 1999. The resulting glass-like substance will eventually be shipped to the nation's high-level radioactive waste repository, probably in Nevada.

- All single-shell tanks will be cleaned up and the area closed under RCRA standards by June 2018.

ENFORCEABILITY

A major goal in the negotiations was to produce an agreement that would endure by ensuring compliance with Hanford work commitments and schedules. This requires that the Agreement be binding on the DOE and that a mechanism be in place to make the Agreement enforceable. In addition to assurances built into the agreement, the Department of Justice has reviewed the enforceability provisions of the Agreement and has endorsed them in a letter that is part of the Agreement. Major enforcement features of the Agreement include:

-All requirements of the Agreement and the Action Plan are enforceable in court by the State and by any citizen.

-EPA, together with the State, can levy penalties on DOE for failure to meet the schedules for investigation and cleanup of past contamination.

-The Washington Department of Ecology has the final decision on all disputes with DOE regarding treatment, storage, and disposal facilities, and EPA has the final decision on all disputes regarding past-practice units.

-EPA and Ecology have reserved all their legal enforcement tools if DOE does not comply, if there is an emergency at the site, or if DOE will not include newly discovered problems under the Agreement.

FUNDING FOR THE AGREEMENT

To meet milestones agreed to by the three parties, $2.8 billion will be required over the first 5 years. Without an agreement, the first 5 years' funding would be constrained by budget guidelines that limit funding growth to 3 percent per year and would total only $1.4 billion.

KEY 1989 AND 1990 ACTIVITIES

- Installation of ground-water monitoring well systems to assess contamination.

- Accelerated removal of pumpable liquids from single-shell tanks storing liquid and solid radioactive wastes.

- Accelerated characterization of wastes in the single-shell tanks and development of the technology required to remove the solid wastes from the tanks.

- Initiation of investigation of past-practice disposal sites.

- Accelerated treatment and disposal of stored double-shell tank wastes in grout.

Although milestones for permitting and cleanup are established, funding will depend on yearly appropriations by Congress.

The DOE will provide the State with funds for environmental oversight and other costs associated with the state's role in the Agreement based on yearly workload through 2018. This includes $500,000 through September 1989 and $2,400,000 from October 1989 through September 1991 (subject to availability of appropriated funds).

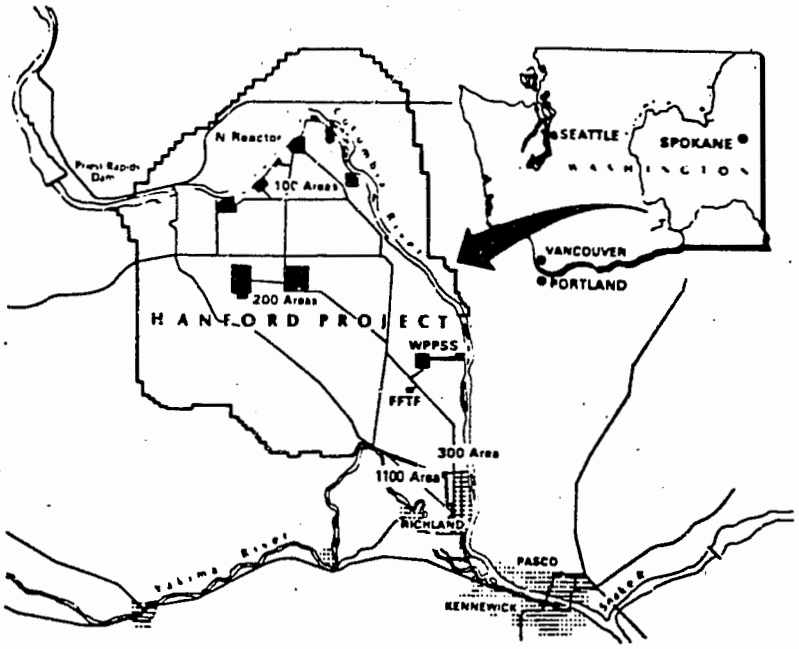
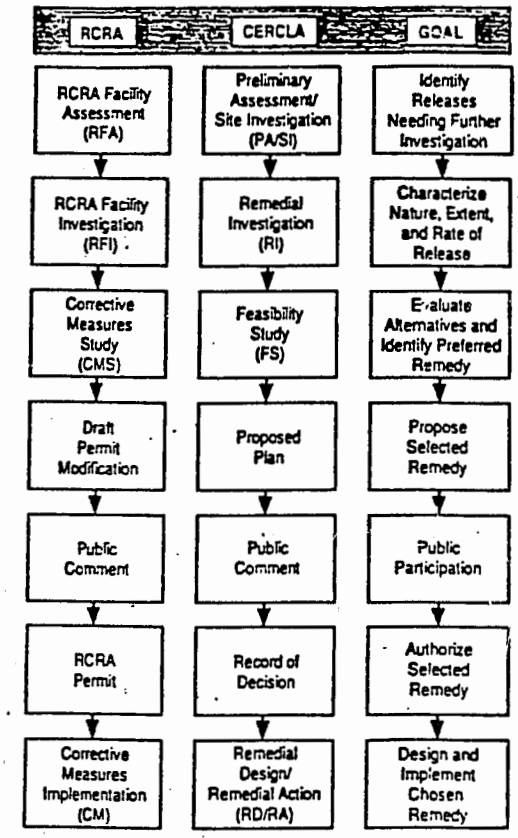


Figure 1. The Hanford Site



CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

RCRA = Resource Conservation and Recovery Act

Note: Interim remedial actions or interim measures can be performed at any point in the remedial/corrective action process.

Figure 2. The Cleanup processes for RCRA and CERCLA

24. RADIUM CONTAMINATION AT 930 YORK STREET, CINCINNATI: A BRIEF HISTORY

Robert W. Bowlus
Environmental Protection Agenc

The Keleket X-Ray Corporation (previously spelled Kelley-Koett) operated a plant on the first two floors of 930 York Street, Cincinnati during the early 1950s. The Safegard Corporation, a manufacturer of life preservers, occupied the third floor.

Keleket manufactured X-ray equipment and radiation detection instruments. A platinum capsule containing finely powdered radium sulfate was used to calibrate the instruments. On July 24, 1951, the capsule ruptured and the radium sulfate dust was carried on air currents throughout the room, out into the alley, and into the rear part of the second floor through open windows. Contamination was also carried on employees' hands, shoes, and clothing into various areas of the building.

The ensuing investigation and 10-month cleanup involved the Cincinnati Health Department, the University of Cincinnati, the U.S. Public Health Service (PHS), and the U.S. Atomic Energy Commission (AEC), among others. Decontamination was done to meet the permissible contamination limits recommended by the PHS. Contaminated surfaces were cleaned or removed. Decontamination efforts included shipping 474 55-gallon drums of contaminated material and equipment to Oak Ridge, Tennessee, for burial. Fixed contamination that could not be removed from building surfaces was covered with concrete, linoleum, or paint.

Of 44.8 mCi (44.8 mg) of radium sulfate originally in the container, only about 1/3 could be found at the site of the accident. As a very conservative working estimate, it is assumed that the remaining 30 mCi is scattered within the building. Such contamination would be in wall and floor voids, in wiring and plumbing chases, behind woodwork and fixtures, under paint, under concrete and linoleum, and inside drainpipes. Since the original decontamination was finished, no radiation has been detected outside the building.

The PHS approved the building for re-occupancy in May 1952 and recommended (1) that the building be re-surveyed periodically for contamination, (2) that safety precautions be followed during any structural, electrical, or plumbing work, and (3) that food, drug, and/or cosmetic storage or handling not be allowed in the building. Until the building was vacated in 1976, the Cincinnati Health Department (CHD) inspected the building periodically to ensure that the occupants, Keleket, Safegard, and, later, Prather Products, were taking proper precautions.

In 1981, the CHD learned that the building had been sold to Robert Renner and that he had been living there, sweeping up dust and peeling paint, and operating an architectural antiques business on the premises. When Mr. Renner was examined with a whole-body counter at the Argonne National Laboratory in Illinois, no internal contamination was found. Mr. Renner ceased operating his business there and moved out.

Personnel from the U.S. Department of Energy surveyed the building for radon and radon progeny in 1982 and found areas of surface contamination in excess of guidelines in several rooms throughout the building. They recommended that the building not be used for continuous or frequent human occupancy and that a surveillance program be established to ensure that contamination did not spread.

In January 1984, EPA personnel inspected the building with Health Department personnel and the owner and observed that the condition of the building had "significantly deteriorated" and that it was open to public ingress. EPA personnel began preparing documentation to request a cleanup of the building under Superfund. The justification for use of Superfund is the public health hazard that would occur if there was a fire in the building, which would release radium-bearing smoke into the community.

Health Department personnel have checked the security of the building at least monthly from mid-1984 to the present. There has been extensive vandalism and evidence of two small fires. Nearly all the salvageable metal items (radiators, wiring, stair treads, etc.) were removed from the building. As vandalism and deterioration have worsened, it is likely that contamination previously covered has become exposed. Health Department personnel have found contamination during the past 2 years in places where paint has peeled off and concrete has come loose.

In July 1987, approval was given through the EPA and the Centers for Disease Control (CDC) for an Action Memo to be drafted to authorize a Superfund cleanup of the site, and by April 1988 a disposal site for the low-level radioactive waste was available. Cleanup was projected to begin within 9 to 12 months.

In May 1988, it was found that some of the facing brick on the southwest corner of the front building had fallen into the alley, probably as a result of extensive water damage. Health and Fire Division personnel checked the scene and found no significant radioactivity. The Building Department hired a wrecking firm to remove the remaining loose brick. EPA personnel checked all the bricks for radioactivity as they were removed. The Building Department and Public Works Department are cooperating at the Health Department's request, to fence the alleyway and prevent public access to the area around the damaged wall. EPA personnel are working to accelerate the Superfund process and enable the cleanup to start as soon as possible.

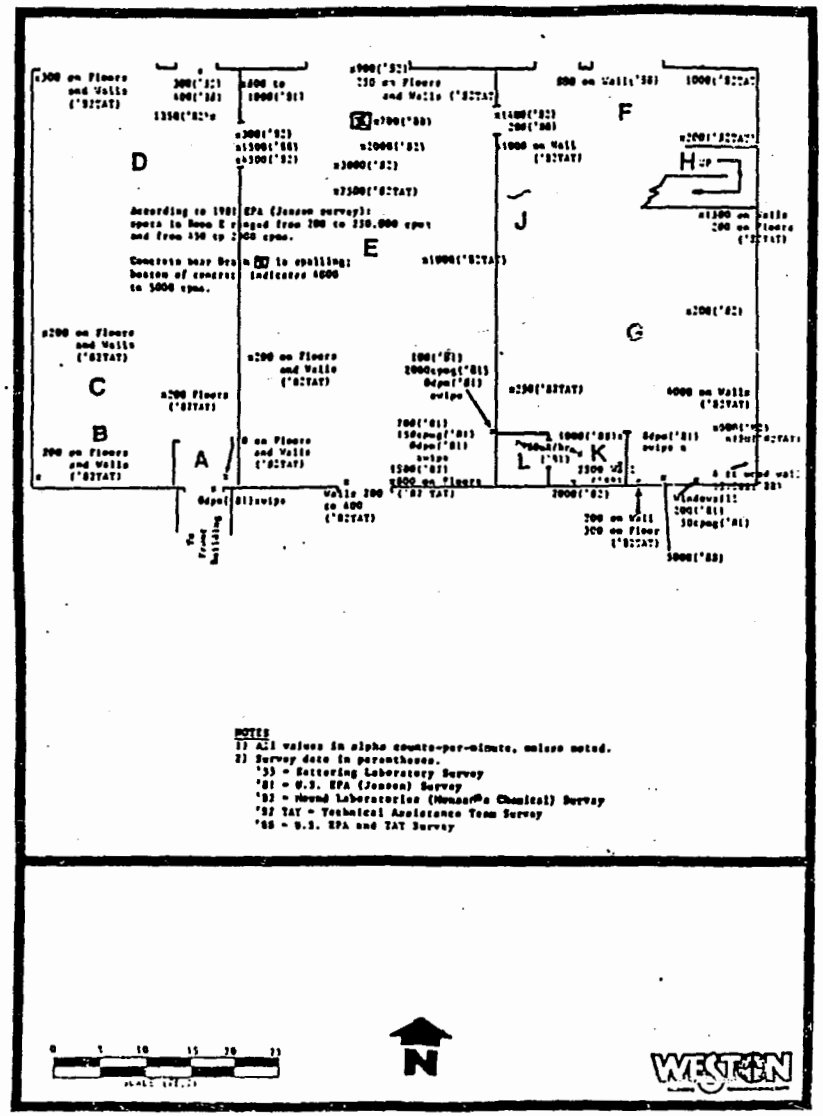


Figure 1. Rear Building First Floor
Kelly Koett Instrument Company
Cincinnati, Ohio

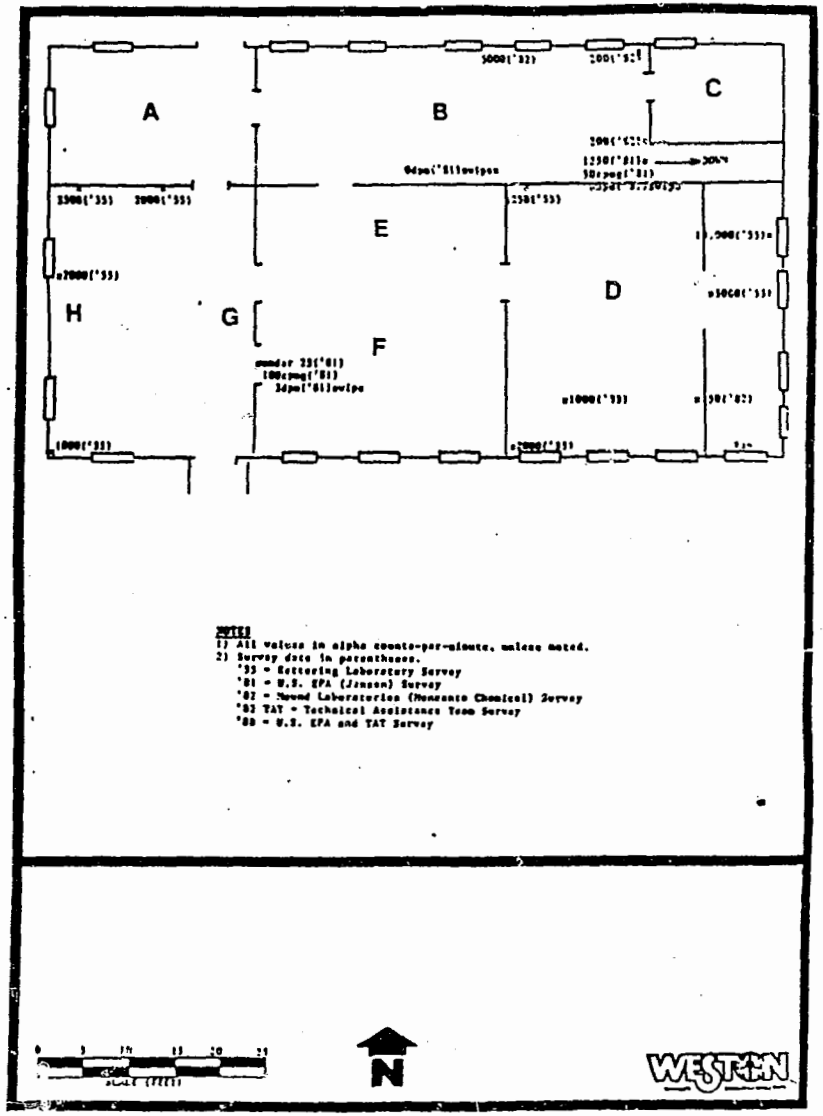


Figure 2. Rear Building Second Floor
Kelly Koett Instrument Company
Cincinnati, Ohio

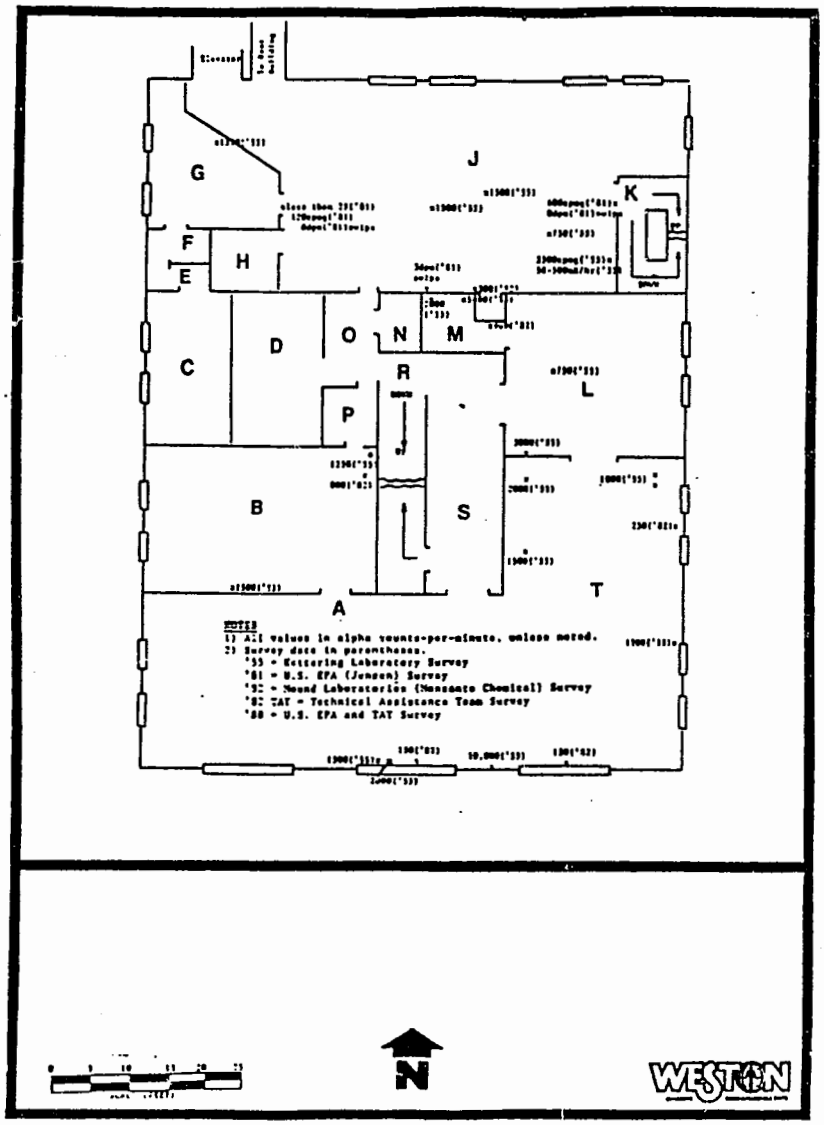


Figure 3. Front Building Second Floor
Kelly Koett Instrument Company
Cincinnati, Ohio

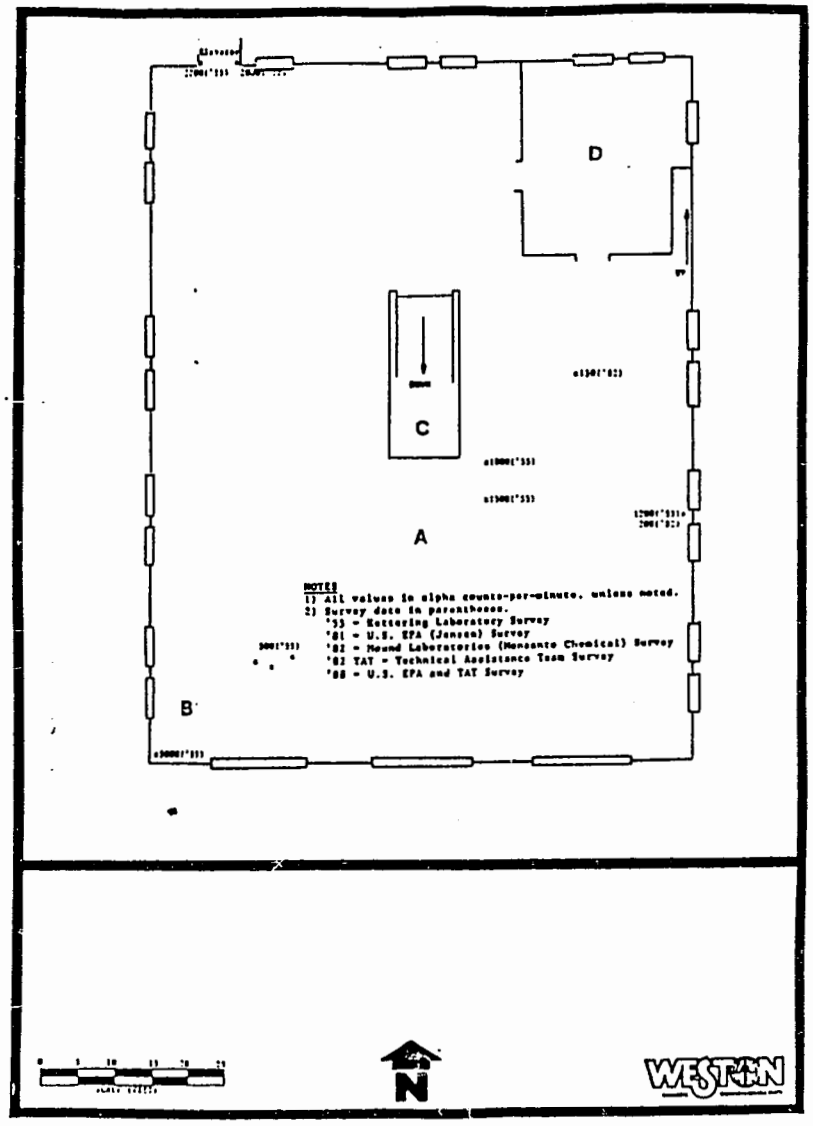


Figure 4. Front Building Third Floor
Kelly Koett Instrument Company
Cincinnati, Ohio

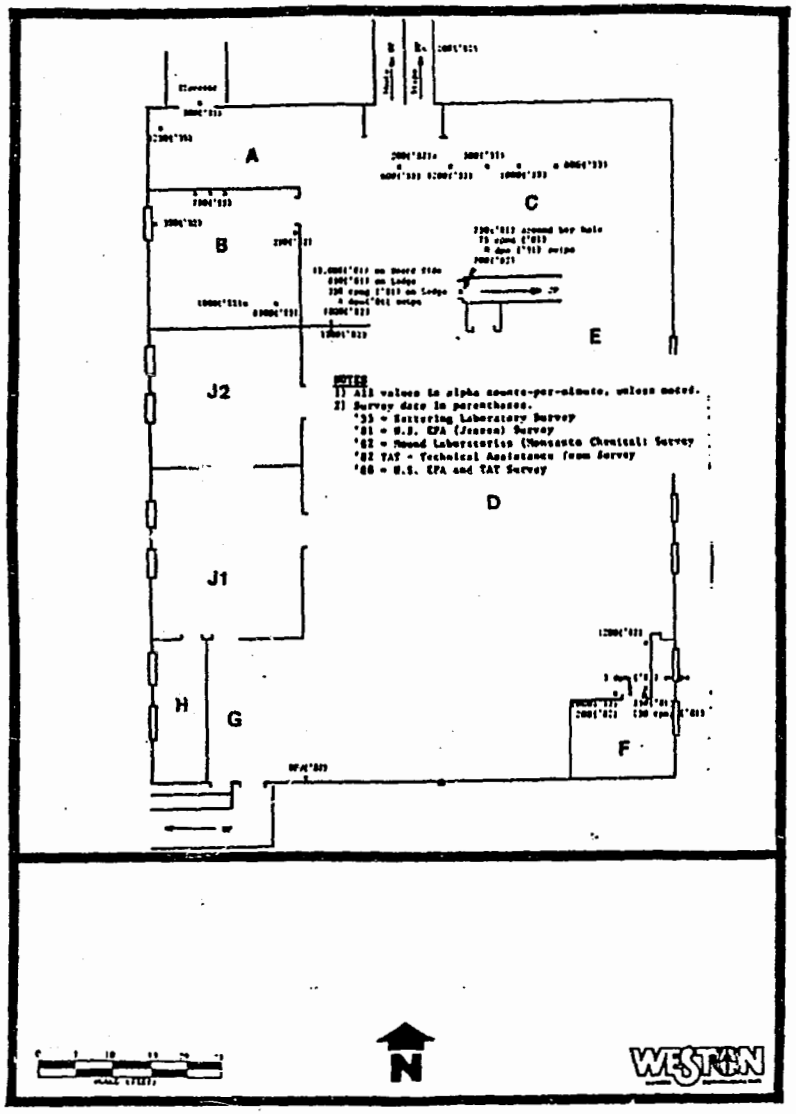


Figure 5. Front Building Basement
Kelly Koett Instrument Company
Cincinnati, Ohio

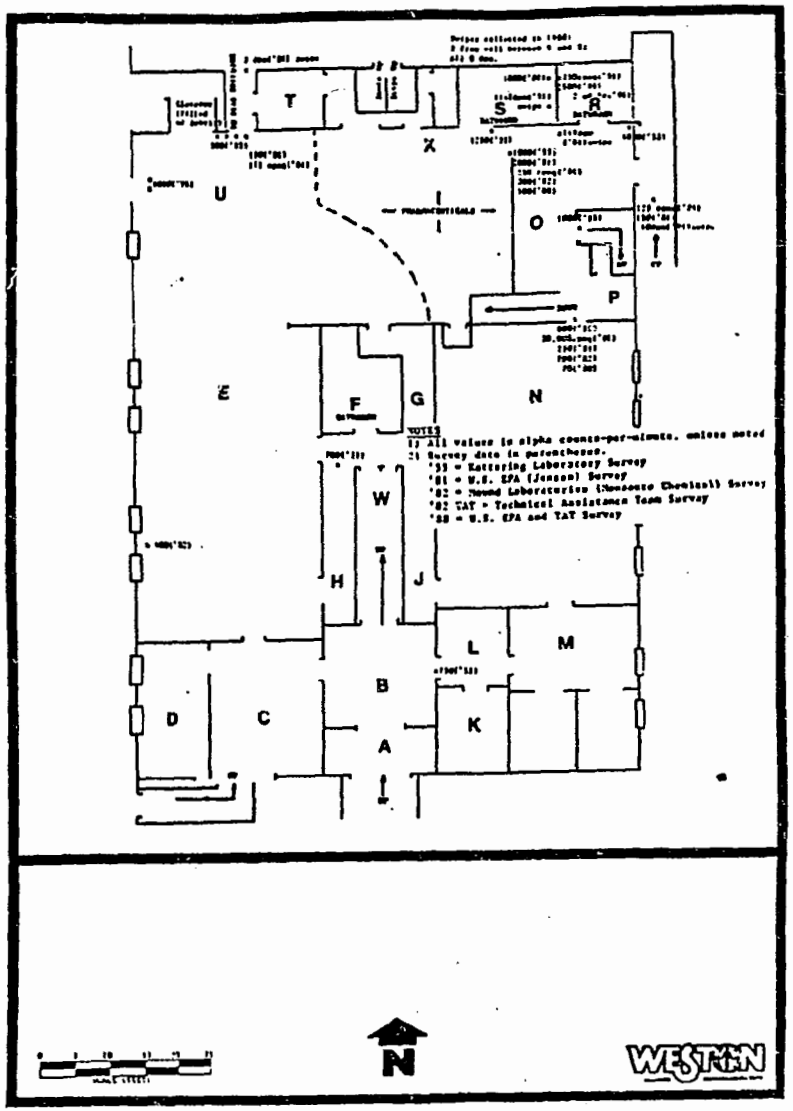


Figure 6. Front Building First Floor
Kelly Koett Instrument Company
Cincinnati, Ohio

25. URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT

Donald Dubois
Jacobs Engineering Group, Inc.

The Uranium Mill Tailings Remedial Action Project was established by DOE to carry out the remediation mandate in Title I of the Uranium Mill Tailings Remediation Control Act of 1978. The Act provided for the cleanup and control of tailings from designated inactive uranium mills to eliminate potential environmental health hazards such as those already identified at several of the sites. The Act provided for sharing of direct remedial action costs by the affected State (90 percent Federal/10 percent State), cooperative agreements with States and Indian Tribes, establishment of cleanup standards by EPA, and concurrence by NRC, the State and Indian Tribes (if on Reservations) in remedial actions.

There are 24 designated sites in 10 States, and 5,056 vicinity properties (adjoining lands and structures) have been identified to date for cleanup. The program involves the cleanup and removal of tailings from vicinity properties at the designated sites, consolidating the tailings and contaminated materials and encapsulating them either onsite or at alternate sites. Disposal pile and cover material must be designed to protect the tailings from natural erosion and both deliberate or inadvertent human intrusion.

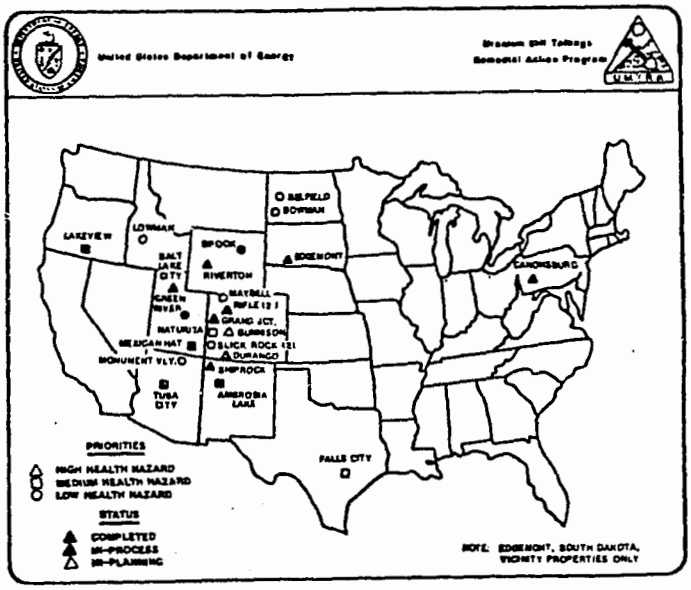


Figure 1. UMTRA Site Locations

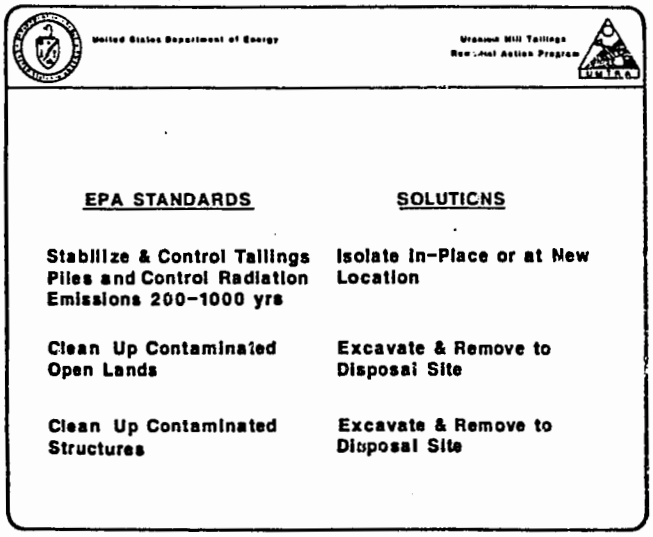


Figure 2. Requirements & Solutions

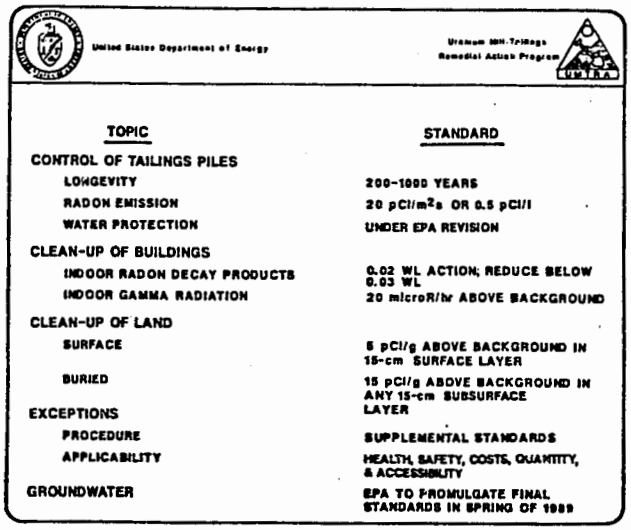


Figure 3. Summary of EPA Standards

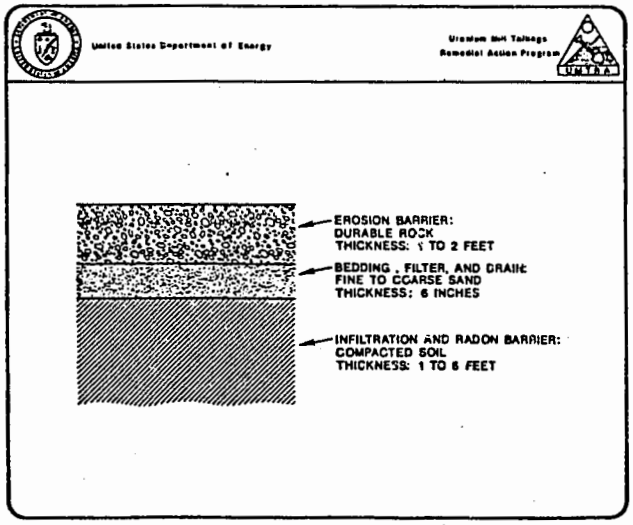


Figure 4. Standard Cover Detail

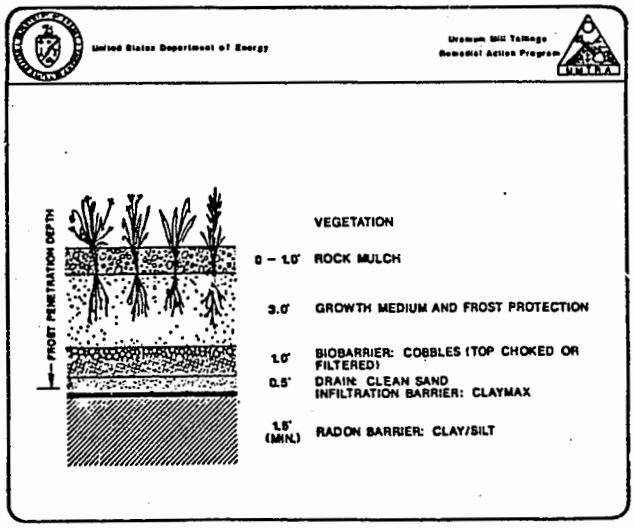


Figure 5. Checklist Cover Detail

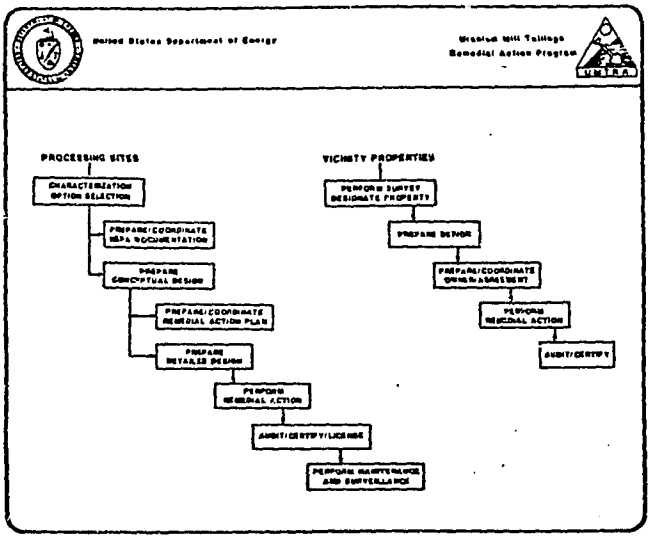


Figure 6. Activities Flow Diagram

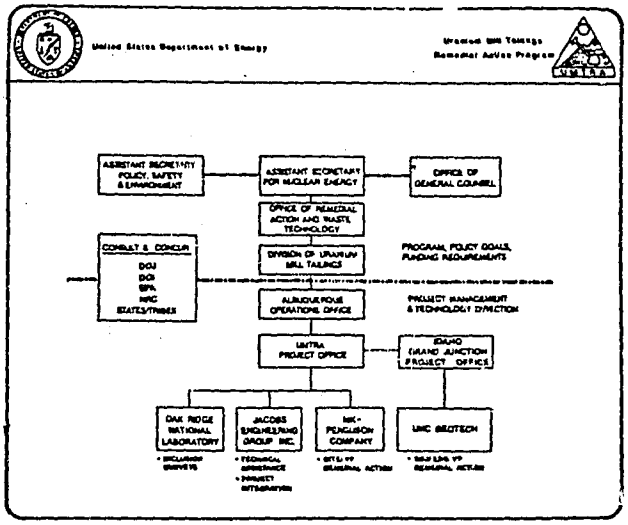


Figure 7. UMTRA Project Participant Structure

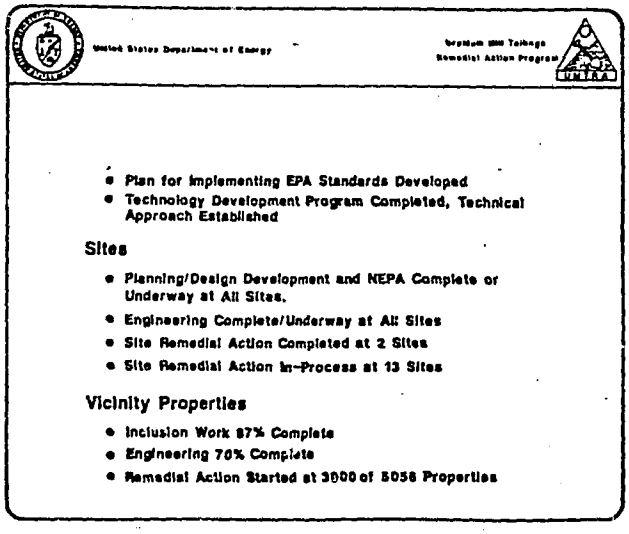
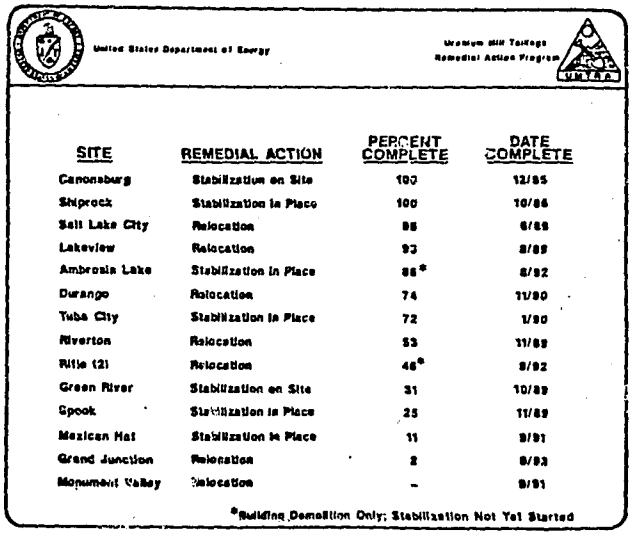


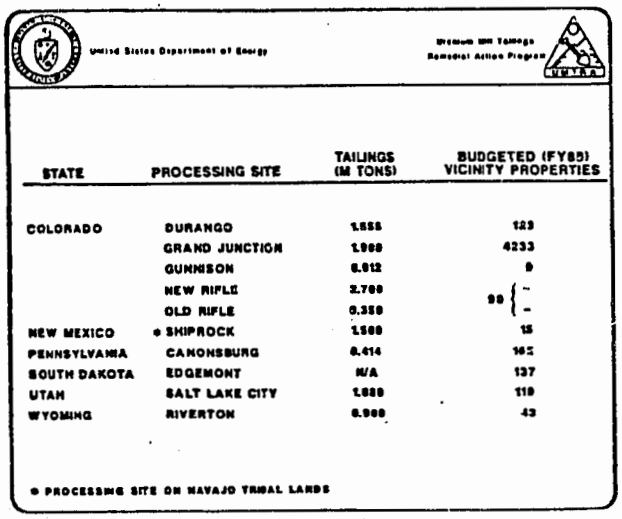
Figure 8. Accomplishments



SITE	REMEDIAL ACTION	PERCENT COMPLETE	DATE COMPLETE
Canonsburg	Stabilization on Site	100	12/85
Shiprock	Stabilization in Place	100	10/86
Salt Lake City	Relocation	98	6/89
Lakeview	Relocation	93	8/89
Ambrosia Lake	Stabilization in Place	88*	8/92
Durango	Relocation	74	11/90
Tuba City	Stabilization in Place	72	1/90
Riverton	Relocation	53	11/89
Rifle (2)	Relocation	48*	8/92
Green River	Stabilization on Site	31	10/89
Spook	Stabilization in Place	25	11/89
Mexican Hat	Stabilization in Place	11	9/91
Grand Junction	Relocation	2	9/93
Monument Valley	Relocation	-	9/91

*Building Demolition Only; Stabilization Not Yet Started

Figure 9. Site Status



United States Department of Energy

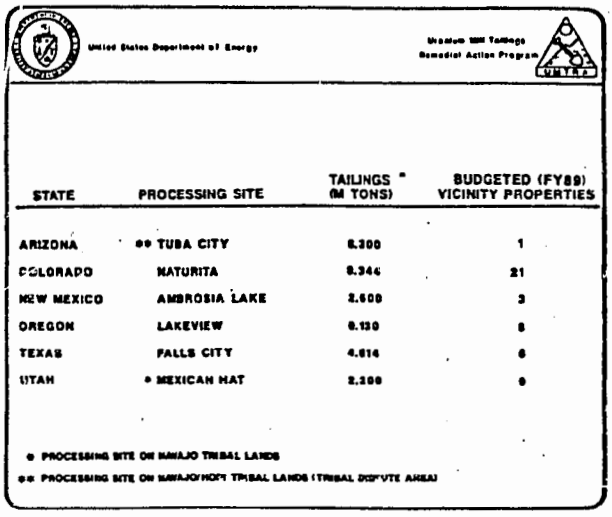
Uranium Mill Tailings Remedial Action Program

UMTRA

STATE	PROCESSING SITE	TAILINGS (M TONS)	BUDGETED (FY85) VICINITY PROPERTIES
COLORADO	DURANGO	1.655	123
	GRAND JUNCTION	1.988	4233
	GUNNISON	0.812	9
	NEW RIFLE	2.780	99
	OLD RIFLE	0.350	
NEW MEXICO	* SHIPROCK	1.500	15
PENNSYLVANIA	CANONSBURG	0.414	162
SOUTH DAKOTA	EDGEMONT	N/A	137
UTAH	SALT LAKE CITY	1.080	119
WYOMING	RIVERTON	0.900	43

* PROCESSING SITE ON NAVAJO TRIBAL LANDS

Figure 10. High Priority Sites Summary



United States Department of Energy

Uranium Mill Tailings Remedial Action Program

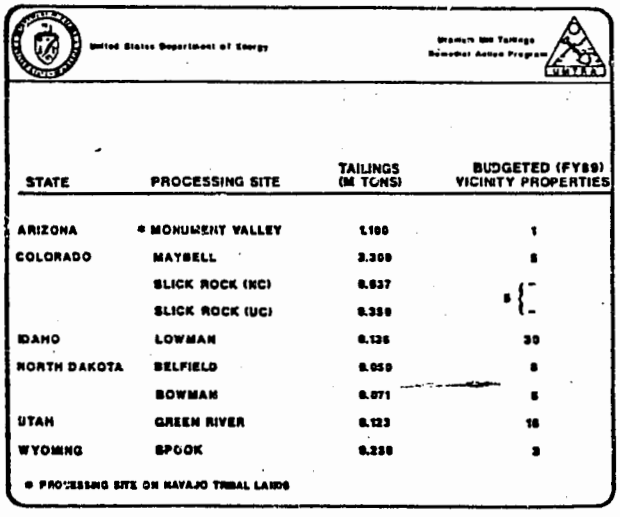
UMTRA

STATE	PROCESSING SITE	TAILINGS * (M TONS)	BUDGETED (FY89) VICINITY PROPERTIES
ARIZONA	** TUBA CITY	6.300	1
COLORADO	NATURITA	0.344	21
NEW MEXICO	AMBROSIA LAKE	2.600	3
OREGON	LAKEVIEW	0.130	8
TEXAS	FALLS CITY	4.614	6
UTAH	* MEXICAN HAT	2.200	6

* PROCESSING SITE ON NAVAJO TRIBAL LANDS

** PROCESSING SITE ON NAVAJO/HOPI TRIBAL LANDS (TRIBAL DISPUTE AREA)

Figure 11. Medium Priority Sites Summary



United States Department of Energy

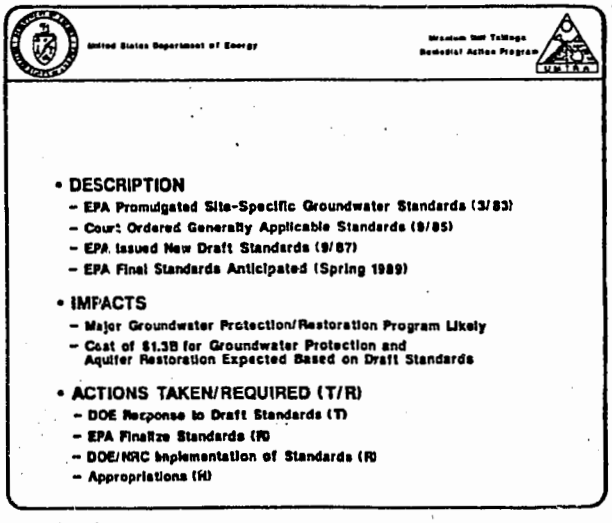
Uranium Mill Tailings Remedial Action Program

UMTRA

STATE	PROCESSING SITE	TAILINGS (M TONS)	BUDGETED (FY89) VICINITY PROPERTIES
ARIZONA	* MONUMENT VALLEY	1.100	1
COLORADO	MAYBELL	2.300	8
	SLICK ROCK (NC)	0.637	5
	SLICK ROCK (UC)	0.350	
IDAHO	LOWMAN	0.135	30
NORTH DAKOTA	BELFIELD	0.050	8
	BOWMAN	0.071	5
UTAH	GREEN RIVER	0.123	16
WYOMING	SPOOK	0.250	3

* PROCESSING SITE ON NAVAJO TRIBAL LANDS

Figure 12. Low Priority Sites Summary



United States Department of Energy

Uranium Mill Tailings Remedial Action Program

UMTRA

- **DESCRIPTION**
  - EPA Promulgated Site-Specific Groundwater Standards (3/83)
  - Court Ordered Generally Applicable Standards (9/85)
  - EPA Issued New Draft Standards (9/87)
  - EPA Final Standards Anticipated (Spring 1989)
- **IMPACTS**
  - Major Groundwater Protection/Restoration Program Likely
  - Cost of $1.3B for Groundwater Protection and Aquifer Restoration Expected Based on Draft Standards
- **ACTIONS TAKEN/REQUIRED (T/R)**
  - DOE Response to Draft Standards (T)
  - EPA Finalize Standards (R)
  - DOE/NRC Implementation of Standards (R)
  - Appropriations (R)

Figure 13. Issue: Implementation of Revised EPA Groundwater Standards

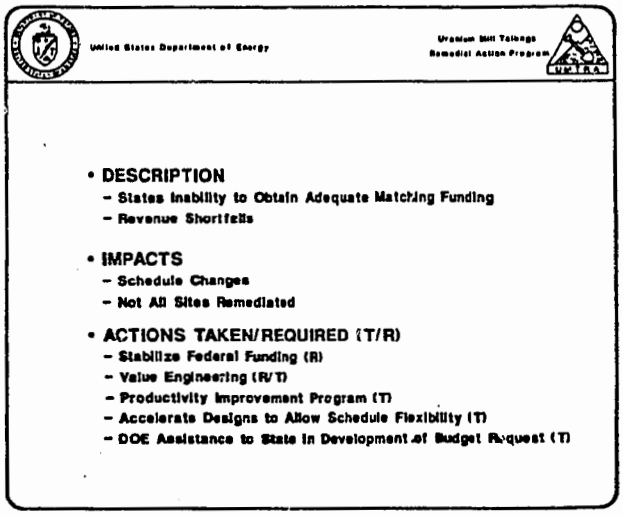


Figure 14. Issue: States Funding

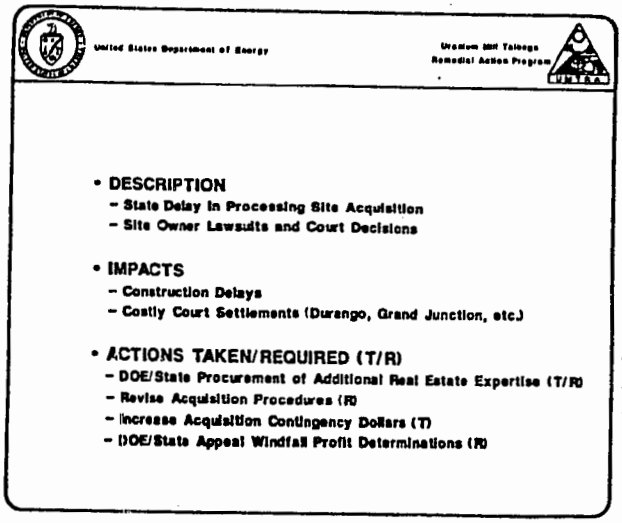


Figure 15. Issue: Site Acquisition

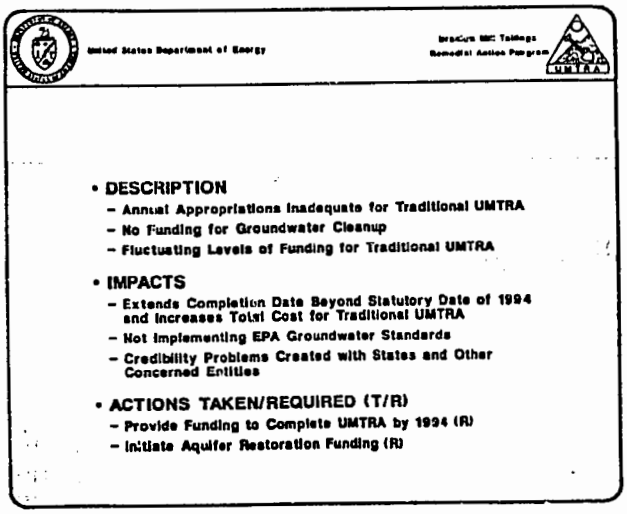


Figure 16. Issue: Federal Funding

26. TRANSURANIUM ELEMENT CONTAMINATED SOIL CLEANUP

Edward T. Bramlitt
Defense Nuclear Agency

The Defense Nuclear Agency (DNA) manages two sites, Enewetak and Johnston Atoll, contaminated with plutonium from atmospheric nuclear weapon tests. Weapons plutonium includes a short-lived isotope which decays to americium; both elements are present in vintage plutonium. Plutonium and americium are transuranium (TRU) elements. A "TRU cleanup" gets rid of both plutonium and americium contamination.

The cleanup at Enewetak between 1977 and 1980 required some 8,000 persons and more than $140 million. DNA started the cleanup at Johnston when the Enewetak effort ended. It is still on-going; the most ambitious phase of cleanup begins this year.

At Enewetak, about 100,000 yd^3 of contaminated soil were excavated from 5 islands and hauled across Enewetak Lagoon by barges to an island for disposal. Soil was mixed with cement and pumped as a concrete slurry into the crater from a 1958 nuclear test. The crater was eventually over-filled to a height of 30 ft and capped with 15-in thick sections of concrete. This was an unpopular remedy, a compromise between relocating soil to a disposal facility in the States and dumping it in the ocean. The crater island is permanently quarantined from the Enewetak people.

From its Enewetak experience, DNA learned that something better had to be done to clean up Johnston Atoll.

ENEWETAK TRU CLEANUP GUIDELINES

The Department of Energy (DOE) provided guidance for Department of Defense (DOD) cleanup at Enewetak. The basic DOE guide was: remove soil when TRU specific activity is greater than 1.5 kbq/kg of soil. DOE measured TRU in soil to guide cleanup. An in situ measurement method was used, averaging TRU concentration over the top .03 of a meter of ground. Cleanup decisions were based on specific activity averaged over a quarter hectare, about two-thirds of an acre. Six samples were used to get an average specific activity. Thus, the cleanup removed soil with a surface activity exceeding 2 uCi/m^2, and Enewetak people now live on land which has TRU measuring less than 2 uCi (74 kbq) per square meter.

EPA TRU GUIDELINES, SOIL SCREENING LEVEL

The Environmental Protection Agency (EPA) guidance to Federal agencies for TRU in the environment includes a soil screening level (SSL) below which corrective actions will not normally be required. The screening level is 7.4 kbq/m^2, an order of magnitude more stringent than the surface activity cleanup guide previously set by DOE for Enewetak.

The EPA guidance allows sampling the top .01 m of ground to determine compliance with the screening level. In terms of specific activity and

typical coral soils, the screening level is equivalent to 500 bq/kg. Soil with TRU levels less than the screening level can be used without radiological control or cleanup. Soil cleaned to the screening level can be released for unrestricted use.

JOHNSTON ATOLL RADIOLOGICALLY CONTAMINATED AREA

At Johnston Atoll, there is about as much TRU soil as was moved to the crater at Enewetak. DNA has consolidated the contaminated soil on a 15-ha site, giving the controlled area an elevation which averages about 2 m higher than that of the rest of the island. It is the highest land in this part of the Pacific.

The radiological area occupies a significant portion of the atoll. There is only 260 ha of land; about half is used for aircraft operations and the rest for industrial and residential purposes. The contaminated area was used for many years under radiological restrictions, but they were a severe hindrance to beneficial use. Further, if the soil were not contaminated, it too would be used, to reduce the need to import soil to meet construction requirements.

For the past 15 years, DNA has been manually decontaminating soil at Johnston. A hot spot is found by radiation detector, dug up, divided, and monitored. Through repetitive monitoring and division, one can often end up with a single hot particle. Sometimes it will be big enough to see; at other times, it may not be visible to the eye but will respond to a radiation detector.

Nature also decontaminates soil, as when plutonium accumulates behind weirs set up to retard soil run-off during heavy rains.

CLEAN SOIL GUIDELINES

The Johnston Atoll cleanup guidelines are shown in figure 1. DNA tests soil in two ways. One determines average specific activity for each tenth cubic meter increment. If there are more than 500 bq/kg of soil, the increment is considered to have distributed contamination. The second way determines average total activity for each hundredth cubic meter increment. If there are more than 5 kbq, the increment is presumed to contain a hot particle of contamination. The first guide derives from the EPA soil screening level; DNA created the second.

MINING TRU FROM JOHNSTON ATOLL SOIL

The process of extracting a metal from soil is mining. Mining divides source material into concentrate and tailings. In classic mining, concentrate is the valuable resource and tailings are waste. In mining for cleanup, the situation is reversed. The concentrate includes the radioactive elements and is disposed of as radiological waste. Tailings are clean soil and suitable for fill with underground piping, bedding for pavement, aggregate or sand for concrete, and other uses. Mining plutonium from soil can be a way to decontaminate soil.

In the mid-1980s, DNA tested mining technologies for possible automated cleanup of Johnston Atoll soil. Several technologies were promising on a laboratory scale, and a pilot plant was operated on the island. The plant used a gravimetric method which had proven successful for mining heavy metals. About 600 m^3 of contaminated soil were processed, producing about 10 m^3 of concentrate containing the bulk of the TRU. The tailings had TRU at less than 500 bq/kg, the EPA soil screening level. This mining reduced the volume of contaminated soil by about 98 percent, and convinced DNA to go forward with a full-scale plant.

SOIL CLEANUP PLANT

The full-scale plant was constructed at Johnston Atoll last fall; performance tests were completed in March 1989. Soil flow through the cleanup plant is traced in figure 2. There is a screen at the start of soil flow to size soil: soil particles greater than 1 inch are separated for storage; those less than 1 inch go to a crusher. This sorting is done because preliminary sampling indicated that soil greater than 1 inch is clean. Clean soil is removed for separate processing; otherwise, it would dilute contaminated soil.

Crushed soil is then checked for contamination and sorted into clean soil for beneficial use or contaminated soil for mining. This sorting is done because sampling shows that about 50 percent of soil collected from the radiological control area is clean, and DNA attempts to avoid cleanup through dilution.

The mining unit produces tailings and concentrate. Tailings are checked for contamination. If clean, they follow the path to beneficial use; otherwise, they are either prepared for disposal or recycled for a second attempt at cleanup. Mine concentrate also may be prepared for disposal or recycled.

The mining unit uses water to move soil and clean through gravimetric separation of heavier particles from light particles. Water cycles through ponds to allow fine particles, less than 50 um, to settle. The plant is an assembly of standard sand-and-gravel type equipment including conveyers, a rock crusher, vibrating screens, and storage silo, plus radiation detectors to determine the type of soil (contaminated or clean) and direct the flow. Conveyers carry the soil in layers about 1.9 cm thick, 1 cm beneath the detectors, which count radiation and send signals to a computer. A microprocessor determines if counts exceed cleanup guidelines and operates a gate to divert the soil accordingly.

A pants-leg gate directs soil to one conveyer if radiation counts indicate the soil is clean and to another conveyer if it is contaminated. The gate is activated by compressed air on signal, switching from one direction to the other in less than 1 sec. Clean soil is conveyed along a stacker boom. The boom swings in a large arc and can stack as much as 1,500 m^3 of soil before soil must be removed. A silo is used to store a day's supply of contaminated soil for the mining operation.

Soil from the silo is conveyed to the top of a gravimetric separator, where a stream of water then moves it over a bed of steel balls on a metal screen. Pumps pulse water up through the soil. Heavy particles work their way through

the bed of balls and are collected at the separator bottom. This concentrate then flows to a smaller separator providing a second stage of cleanup.

The final concentrate is discharged to collectors for disposal. DNA uses tri-wall cardboard boxes lined with plastic sheet to receive contaminated soil. A radiation detector is suspended above the box so that the concentrate can be assayed as it is received.

The in situ method used for concentrate assay can be very accurate because of its well-defined geometry; a detector is centered at precise distances above disk sources. Each 2-cm thick layer of soil is counted, and data transmitted to computer for assay. The final result is a report of total container activity in the format needed for transport and disposal. A container of concentrate typically weighs about 1,500 kg.

Clean soil from the gravimetric mining unit is conveyed up a stacker boom and stacked in small piles representing output for various periods of operating time. The volume of these cone-shaped piles can be calculated for comparison with plant flow meters and its weight can be determined from volume-density for a comparative check with conveyer belt weigh scales. Clean soil is routinely checked by an in situ radiation measurement method. DNA's quality assurance procedures also include provisions for frequent grab samples and radiochemical analysis.

Not all soil passes out the gravimetric unit as clean. Some material has plutonium attached to larger particles of soil.

CLEANUP PROJECT MILESTONES

DNA's soil cleanup milestones are listed in figure 3. The plant performance test was completed in March, except for data analysis and final report preparation. Results to date indicate the plant successfully cleans soil to the guidelines and DNA plans to proceed with a full-scale soil cleanup. The Agency has begun contract acquisition for plant operation and expects cleanup to begin by September 1989 and continue for at least 100 weeks. At that time, the plant will be dismantled and all radioactive waste and contamination removed from Johnston Atoll.

DNA is proceeding with the cleanup because it believes soil can be sufficiently cleaned so that it can be used without radiological restrictions. Figure 4 compares cleanup guides used at Enewetak, the EPA guidance to Federal agencies for transuranium elements in the environment, and the Johnston Atoll guides. (Enewetak concentration should be 1,500 rather than 2,200 bq/kg.) DNA's primary guideline is three times more stringent than that used at Enewetak; further, its sampling guide is an order of magnitude more conservative. The real difference in favor of the Johnston cleanup is the bottom line which indicates the much greater degree of confidence DNA has in soil cleaned at Johnston. At Enewetak, decisions were based on a handful of measurements, whereas at Johnston, there are thousands.

The performance test shows that DNA could lower its cleanup guides slightly. The Agency actually samples on increments about one-sixth of the design requirement.

BENEFITS

Benefits of soil cleanup at Johnston Atoll are listed in figure 5. Some of these benefits may not be applicable elsewhere. For example, other places may have easy access to soil for construction purposes. At Johnston, soil must be imported at a current cost of about $\$50/m^3$. It is possible to cleanup soil for a lower cost than this.

CLEANUP COSTS

Figure 6 compares the Enewetak and Johnston cleanups, both of which involved about the same quantity of TRU soil. The Johnston cost covers everything since 1980, including a comprehensive radiological survey of the atoll, decontamination and decommissioning of the missile launch complex which previously was in the radiological area, relocation of all contaminated soil to a single area, wages of all project personnel, and projected costs to operate the plant through cleanup completion.

ACTIVITY	GUIDE	SAMPLE
DISPERSED	< 500 Bq/Kg	0.1 m^3
PARTICLE*	< 5 KBq	0.01 m^3

*(*Equivalent Dispersed = 250 Bq/Kg)*

Figure 1. JA Clean Tru Soil

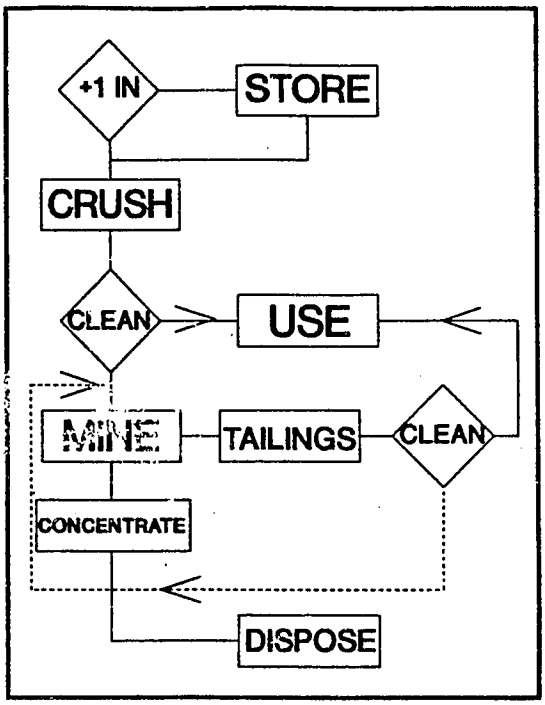


Figure 2. Soil Flow

ACTIVITY	DATE
PLANNING/FUNDING	OCT 87-MAR 88
DESIGN/PROCURE/DELIVER	MAR 88-OCT 88
SETUP/CHECKOUT	OCT 88-DEC-88
PERFORMANCE TESTING	FEB 89-MAR 89
CONTRACTING	APR 89-SEP 89
OPERATIONS	SEP 89-SEP 91
DISMANTLING	OCT 92-NOV 92
REMOVE PLANT/WASTE	NOV 92-MAR 93

Figure 3. JA Soil Cleanup Milestones

	DOE/EA	EPA	DNA/JA
Concentration (Bq/kg)	2200	500	500
Surface (KBq/m^2)	74	7.4	7.4
Particle (KBq)	NV	7.4	7.4
Sample Vol. (m^3)	12	NV	0.1
Samples (#/Ha)	24	NV	.19K*

Figure 4. Guide Comparisons

- Increase Useable Space
- Create Useable Soil
- Improve Environment
- Reduce Radiological Controls
- Conserve Disposal Space
- Enhance Accident Preparedness

Figure 5. Benefits

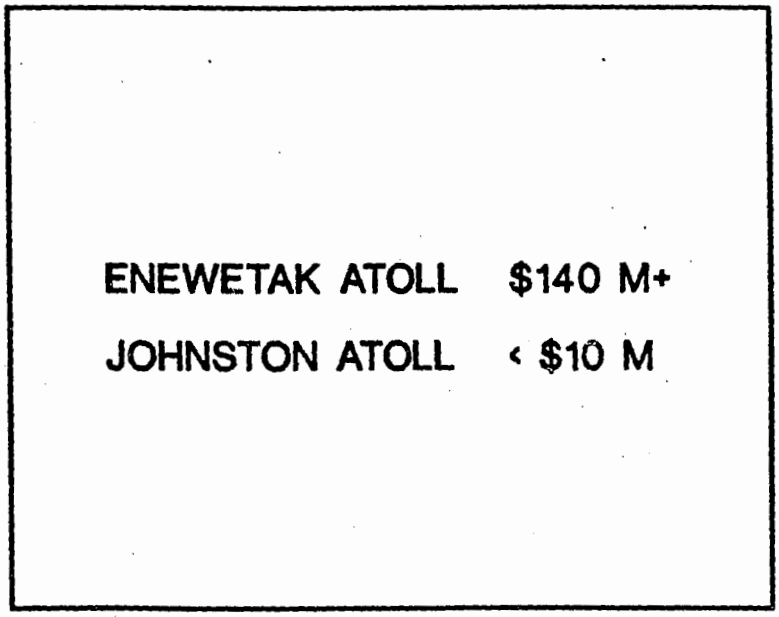


Figure 6. TRU Soil Cleanup Costs

27. RADIUM CHEMICAL COMPANY SITE SUMMARY

Shawn W. Googins, CHP
Environmental Protection Agency

The Radium Chemical Company (RCC) site is located in a light industrial and residential neighborhood in the Borough of Queens, New York. The site is at 60-06 27th Avenue, Woodside, and is immediately adjacent to the Brooklyn Queens Expressway, a major highway through the New York City area. It includes a 10,120-ft^2 building, with 7,850 ft^2 contaminated above New York State (NYS) limits for unrestricted release, and 4,000 ft^2 of surrounding land.

The RCC leased radium sources to hospitals, research facilities, and industrial firms throughout the United States and prepared radioluminous paints containing radium and tritium. The company moved to this site in 1955, abandoning another radioactively contaminated site at 235 East 44th Street, Manhattan, New York. During RCC's operations at the Woodside site it is estimated that approximately 1 Ci of radium sources was lost from the facility during shipment. Some of the lost sources were later recovered from the streets of New York City. The facility became an Environmental Protection Agency (EPA) removal action in 1985, at the request of the New York State Department of Environmental Conservation after the New York State Court declared the company abandoned.

Preliminary investigations indicate that contaminants include Ra-226, tritium, Sr-90 and various chemicals. The Ra-226 consists of about 120 Ci of sources previously used for cancer therapy, well logging, and research. Approximately 8 Ci of this are in the form of Ra-Be neutron sources. There is an undetermined quantity of powdered radium in paints, salts, solutions, and watch dials. There is an unknown quantity of tritium as tritiated water and in watch dials. Air sampling and smear surveys show that tritium is not a significant problem at the site; levels are either nondetectable or below NYS limits for unrestricted use. There is 50 mCi of Sr-90 present in eye applicator sources. Chemicals of concern at the site include hexanes, lacquers, hydroxymethylcellulose, 200 to 500 lb of mercury, ether, phosphoric acid, miscellaneous acids, bases, solvents, and approximately 300 lab pack containers.

Radiological contamination was found throughout the building interior, on the rooftop, and in the soil and storm drains. Alpha levels and exposure rates were particularly high in the glove box room, the vault, and the shipping area.

Radon levels range from 1 to 500 pCi/L inside the building; outside ambient air readings are between 0.5 and 0.8 pCi/L. Soil on the facility grounds ranges from 0.9 to 37 pCi/g, with 58 percent of the readings below 5 pCi/g and 15 percent greater than 15 pCi/g. Sediment from the storm drains ranges from 200 to 400 pCi/g.

RADIOLOGICAL CONDITIONS

Location	Exposure Rate mR/h	Alpha Levels dpm/100cm^2
Exterior:		
Walls	0.02 to 4.0	
Rooftop	0.1 to 50	general < 33 hot spots 600
Interior:		
Shipping area	0.1 to 50	50 to 1,200
Repair room	3.0 to 25	200 to 7,200
Work shop	0.5 to 300	100 to 99,000
Glove box room	0.5 to 50	200 to 480,000
Vault	100 to 5000	52,000
Offices	0.03 to 0.2	

Upon taking over site management at the request of the State, EPA established site security measures and developed contingency plans in cooperation with local officials. Security measures included exclusion of the owner and employees from the site and installation of a perimeter fence and a CCTV surveillance system. Contingency planning with State and local officials included conducting a dose assessment for potential accident scenarios, review of State and local emergency plans, and providing instruction to local ambulance, fire, police, and hospital emergency room personnel.

Trailers have been brought on site to provide work areas, offices, laboratory facilities, and storage space. The existing exhaust system for the building has been secured and capped; a HEPA ventilation system has been installed, tested, and is in operation. Shielding and remote manipulators are used where necessary for source handling. A remote video system has been installed in the high radiation areas. Site radiological work practices include airlocks, frisking, protective clothing, respiratory protection, step off and sticky pads, and a Radiation Work Permit system. All activities involving radiation exposures are preplanned to keep exposures as low as reasonably achievable.

Environmental monitoring at the site includes air monitoring (of radon, particulates, and exhaust system), surface contamination surveys, and exposure rate surveys. The onsite laboratory is equipped with a gross alpha/beta system, liquid scintillation, and gamma spectroscopy (Hyperpure or Intrinsic germanium).

28. LANDFILL CLOSURE TECHNOLOGY

Thomas E. Hakonson
Los Alamos National Laboratory

The Environmental Science Group (ESG) at Los Alamos National Laboratory (LANL) has been carrying out research projects to develop and evaluate technology to address some of the problems associated with Shallow Land Burial (SLB) of radioactive wastes. Much of the research findings and evolving technology are also applicable to similar problems encountered in landfill disposal of municipal, industrial, and hazardous solid wastes. This research, started in 1981, was funded by the Department of Energy's Low-Level Waste Management Program.

SLB typically involves burial of the wastes in trenches, usually with some backfill and a final cover. The site is then revegetated to control erosion and for aesthetic appearance. SLB sites for radioactive materials must be designed and constructed so as to perform satisfactorily for long periods of time without the need for continuing post-closure maintenance; 200 to 1000 years for the inactive uranium mill tailings remediation projects. Problems encountered to date or anticipated at these disposal sites include precipitation or surface water intrusion with contaminated leachate subsequently reaching local aquifiers, erosion of the cover material, and subsidence. While vegetation serves to control erosion and enhance the aesthetics of the site, penetration of plant roots through the cover, into the backfill and waste, compromise the integrity of the pile by providing conduits for water penetration into the pile. Vegetation can also mobilize waste and bring it to the ground surface by physiological uptake. Some of these processes affecting the integrity of waste sites are shown in figure 1.

A major difficulty in designing a suitable SLB facility is the lack of reliable and comprehensive data for the various elements of the disposal cell. In particular, sufficient information is not available to predict the long-term performance of various cover materials, designs, and construction. This is of critical importance in evaluating the potential for infiltration of precipitation and surface waters into and through the piles and radon emanations from the piles.

The Los Alamos Experimental Engineered Test Facility was established on an 8.6 ha site at LANL (figure 2) for field research to develop basic information on physical, chemical, and biological processes affecting SLB site operations. The end product is user-oriented engineering manuals with an emphasis on biointrusion barriers, migration barriers, and ground water and surface water management systems. Current work is being done on Area B, an inactive waste disposal site, (figure 3), intermediate scale, Integrated Systems test plot (figure 4), and in two caisson clusters for investigating subsurface flow and transport of chemicals (figure 5). These have allowed closely controlled and monitored studies of the effects of various soil profiles, and vegetative covers, on moisture regimes in a semi-arid area. Area B, a closed low-level radioactive waste disposal site, has a 5 percent slope and southeast aspect. Remediation in 1982 resulted in three distinct soil profiles across the site: east, west, and cobble-gravel. The west profile is typical of landfill covers

at Los Alamos, with about 15 cm of topsoil (Hackroy sandy clay loam) over 85 cm of crushed tuff. The east profile has large amounts of topsoil mixed in, giving it significantly higher water retention capacity. The "biobarrier" profile, a layer of cobble and gravel (a barrier to capillary moisture flow and biointrusion) is overlain by 45 cm of crushed tuff and 15 cm of topsoil as shown in figure 6. Vegetative cover treatments (bare, grass, and shrubs) were carried out on 8 x 24 m study plots that this site.

The Integrated Systems Test monitors water balance in an enhanced and a conventional trench cap design. The plots, about 3 x 10 m, are constructed and instrumented to provide data on runoff, soil water storage, and seepage. All components of the water balance could be measured, with provision for automated data acquisition for soil moisture. The enhanced cover design results in a stable, low maintenance, and cost effective system for preventing erosion, seepage, and biointrusion (see figures) compared to the conventional design.

The two caisson clusters are each comprised of 6 experimental caissons 3 m in diameter and 6 m deep, clustered around a central access and instrument caisson. Five smaller caissons, 0.5 m in diameter, were placed in the interstices. Access ports, spaced at intervals, allow access from the central caisson to both the large and small diameter caissons for emplacement of various test instruments and sensors and removal of soil and moisture samples (see figures). These arrays are especially useful for independent variable experiments.

The facilities have been utilized to carry out a wide range of field experiments: testing of biointrusion barriers, migration barrier testing, ground and surface water management systems, vegetation and cover designs, and allowed the verification and validation of models.

29. SUMMARY OF WORKSHOP ON THE MANAGEMENT OF URANIUM-BEARING WASTES AND CONTAMINATED SOILS

Thomas F. Lomenick
Waste Management Technology Center, ORNL

Recent requirements affecting the management of uranium wastes include:

- Department of Energy (DOE) Order 5820.2A which defines uranium waste as low-level wastes (LLW) and specifies that the waste must meet Federal, State, and local regulations.
- Environmental Protection Agency's (EPA) 40 CFR 193, which is expected to identify uranium wastes as LLW and specify that no individual receives a total dose greater than 25 mrem/yr as a result of these wastes.

The Uranium Task Force was established to provide an integrated and coordinated approach to the new and proposed, regulator-approved and performance-based systems for the disposal of uranium wastes. The Task Force goals were to:

- assess present uranium waste management practices at each facility;
- identify principal uranium waste problems;
- determine and define technical and other options for problem resolution;
- recommend a plan of action that relates to innovative technologies, regulatory and environmental initiatives, and the DOE-wide model approach to waste problem solutions.

Uranium Task Force reports cover facility descriptions; waste generation; waste identification, processing, and treatment; waste transportation; and waste storage and disposal.

A Workshop on the Management of Uranium-Bearing Wastes was sponsored by Martin Marietta Energy Systems and Nuclear Assurance Corporation on May 5, 1988, at Oak Ridge, TN. There were 131 attendees from government, industry, and academia. The workshop focused on a generalized approach to processing/recycling, treatment, storage/disposal, and regulatory/environmental protection. Solutions do not lie with any single organization, but must be found through joint participation by affected states, EPA, DOE, NRC, expert consultants, industry, environmental groups, and the public.

Uranium-bearing waste management is unique in that the generated quantities are great and the material is extremely long lived. General guidelines include:

- The 1988 deliberations and decisions are not final solutions but are progressive steps to meet current needs and guidelines.

- Our society is not risk-free, and it is not possible to work from the standpoint of zero release.

- Some reasonable release number above zero should be adopted and defended so that operating standards can be developed.

- Storage in concrete vaults etc. cannot be the long-range solution.

PROCESSING AND RECYCLING

The processors are conscious of environmental concerns and are more committed to environmental improvements in this area than is commonly acknowledged. They are aware of processing technology that will have improved environmental consequences, but processors need to have greater input in planning and decision-making. Problem areas include a critical need to reduce or eliminate aqueous wastes; existing antiquated facilities that present problems in reducing waste generation and reluctance to replace well-established processes; and efficient handling of wastes is commonly at odds with meeting production schedules.

STORAGE AND DISPOSAL

Below Regulatory Concern (BRC) wastes would be handled as sanitary landfill materials. Higher concentrations of wastes would be treated utilizing cement-based solidification processes and placed in concrete bunkers. The highest concentrations of wastes (which would exist in small quantities) would be emplaced in deep geologic formations or into the subsurface in arid/dry environments.

Long half-life materials should not be buried near the land surface when concentrations are above regulatory concern.

Depleted uranium (bulk metal, but not sludges and wastes of high volume and low concentration) is a resource.

In weighing the advantages of storage versus disposal of uranium wastes, storage is currently more attractive because of capital outlays. With less available space and larger inventories, disposal would be viewed more favorably.

NEED FOR BRC VALUE

The group recognized that the time has come for determination of a BRC value. Both the regulators and the waste managers are in favor of a BRC; limits must be established. As justification for BRC, it was reported that as much as 80 percent of the waste generated at Y-12 could fall into that category. This material could be safely disposed of in landfills with the understanding that derived doses would be well below a reference standard such as the 4-mrem/yr drinking water standard. BRC values are starting to surface in some parts of

the country; Texas, for example, has established BRC values for certain low-level wastes, and EPA has proposed a 4-mrem/yr standard in 40 CFR 193. Future DOE orders may address BRCs.

RESOLUTION OF WASTE TREATMENT ISSUES

Incineration was identified as an innovative and emerging technology that offers a relatively low-cost method for reducing the volume of much uranium-bearing wastes by factors of 100:1 or more, converting it to a homogenous, relatively inert residue.

Box monitors (curie counters) large enough to accept bags or boxes of waste 5 or 6 ft^3 in volume will facilitate sorting and segregation of waste. These appear capable of adequately assaying uranium-bearing wastes at concentrations of a few picocuries/gram. Present decontamination practices include the use of nitric or citric acid by the Portsmouth GDP for machinery decontamination.

Bioprocessing appears capable of removing 80 to 90 percent of the uranium content in liquid waste streams.

It appears that adequate durability/stability of some waste forms and solidification products; e.g., vitrification and possibly some cement-based solidification, over a 1000-year time horizon is achievable.

Waste Management Technology Center held a Workshop on the Management of Contaminated Soils at Knoxville, TN, on November 10, 1988; sessions covered present practices, characterization, regulations, and interim and performance-based policies.

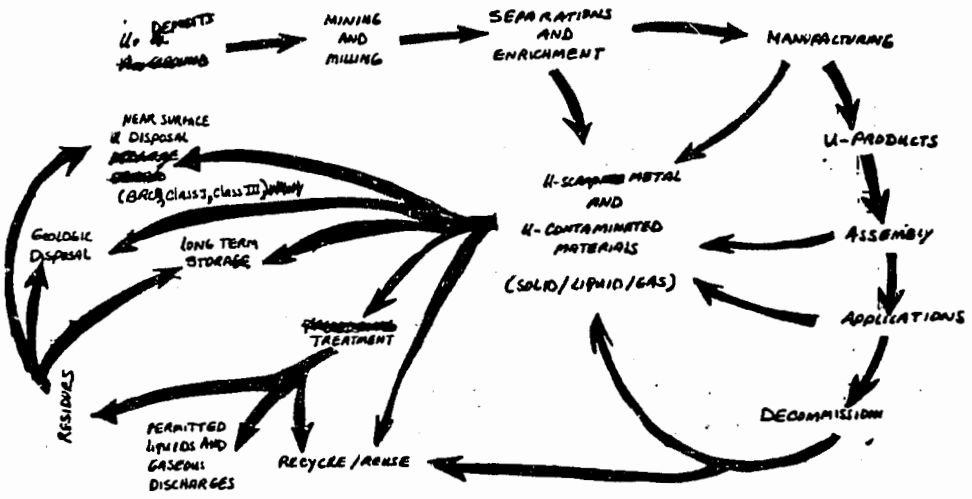


Figure 1. Uranium Managment Cycle in DOE System

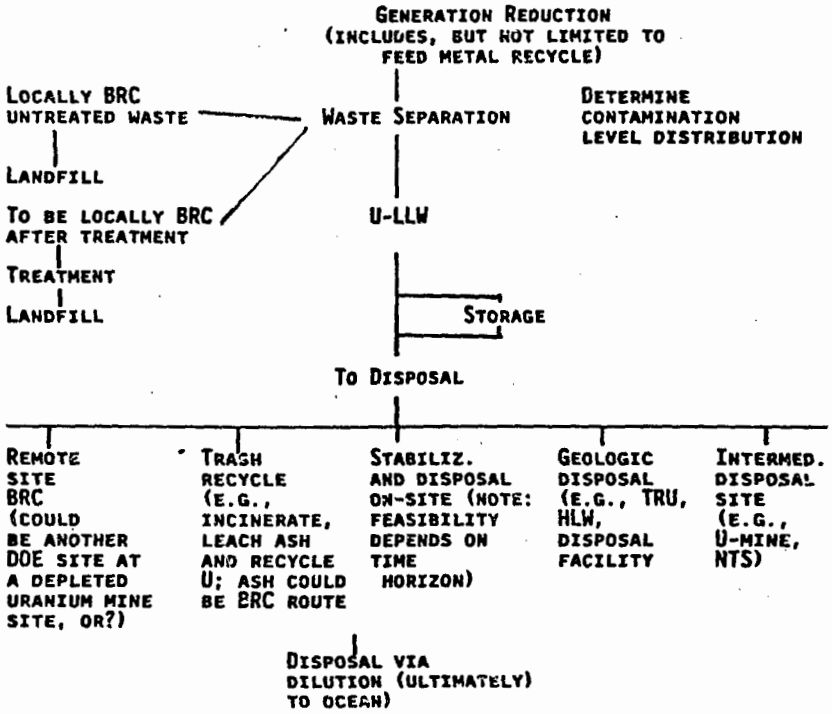


Figure 2. Uranium-bearing Waste Task Group New Generation U-Waste

Treatment Technique	Attributes	Liabilities
Incineration	o Destruction of organics o Flexible for any type waste o Final remediation for all organics	o Limited by valence form of certain metals o High operating/ maintenance costs o Capital intense o Permitting difficult o Reclamation
Solidification	o Low capital costs o Low operating/mgt. costs o Mobile (flexible) o High processing rates o Low unit rates	o Can't handle wood, resin beads o Increase in volume o May not be final remediation o Not applicable for certain organics
Stripping	o Low capital costs o Volatiles work well	o Difficult to prove effectiveness o Difficult to get uniform flow o Not for metals o Must be dry o Air emissions
Bioremediation	o Low costs o Non-volatile	o Generally at shallow depths o Hg volatility in high concentrations o Limited applications

Table 1. Soil Treatment Techniques

30. INTRODUCTORY REMARKS

Richard J. Guimond
Environmental Protection Agency

This workshop was developed by the Office of Radiation Programs and the Office of Emergency & Remedial Response as a result of requests from the Regional Offices. There are growing concerns in regard to the problems being encountered in the treatment or disposal of the large volumes of radioactively contaminated materials resulting from Superfund cleanups. Recent discussions between EPA Administrator Reilly and DOE Secretary Watkins promise to enhance coordination between the two agencies. There is a recognition that a lot is going on in the remediation of the radioactively contaminated sites, a lot of work is being done and experience gained, and we aren't always sure that we are doing enough coordination and integration to ensure that we achieve the most cost-effective cleanup.

The talks during the past two days demonstrate that we have quite an array of problems, a wide variety of sites with many different contamination issues. This is our first meeting held to address the full scope of radioactively contaminated sites and compare notes on what remediation methods we have used. Meetings such as this give us the opportunity to share our experience and gain insight as to which technologies and procedures show the most promise. Hopefully, this will help make everyone's job a bit easier in the future.

Through sharing our experiences, we can gain the maximum benefit between the EPA and DOE programs and thereby facilitate both the Superfund and the DOE cleanups. It would be easy for our two agencies to each go their own way and plow down separate paths. I would like these meetings to become a regular feature of our programs, we need more discussion of our problems, ideas, and solutions.

Expectations for our program are high and we must be sensitive to public perceptions in our remediation activities. We should recognize that people fear that which they do not understand or have confidence in and ensure that the investigation, planning and remediation processes are open and the public kept fully informed. We must work hard to gain the public's confidence; unfortunately we don't have it yet. It is important to remember that public confidence is easily lost and, once lost, is tough to regain. In each new project or program work hard from the beginning to build confidence and never lose it.

Where do we go from here? One thing we can do is build a network with other agencies, contractors, and within EPA to deal with these problems. We can develop mechanisms, procedures, and processes for better coordination and problem resolution. Finally, a group should be created within ORP to help in these matters. The group should consist of our staff and key contractors; it would help provide quick turnaround support to Superfund and RCRA staffs in the Regions and States on risk assessment, modeling, radiochemical analyses, quality control, and evaluation of ARARs.

30.1 PANEL: LISTING AND RANKING OF RADIOACTIVE SITES

Steve Caldwell
Environmental Protection Agency
Kathryn A. Higley
Department of Energy

MR. CALDWELL: We are revising the Hazard Ranking System (HRS) to operate at different tiers of information and utilize better data where available. Concern has been expressed about how the HRS considers radioactive materials in evaluating sites. We are considering alternatives to the December proposal and working with the Office of Radiation Programs for technical support. The new HRS should provide a far better system to deal with radioactive problems than the present system.

We are implementing the revised HRS even though it is not final. Except for the sites already in the pipeline, we will not use the old HRS anymore. We realize that some changes will be required, but data collection efforts now under way should be geared towards the data elements in the revised HRS.

MS. HIGLEY: We have noted that remediation is done in part to limit potential impact to the public. Unfortunately, costs of remediation have increased substantially, and we may be faced with assigning priorities in allocating cleanup funds. MEPAS, the Multi-Media Environmental Pollutant Assessment System, is a tool designed for DOE to determine priorities among its environmental problems.

Contaminants introduced into the environment can move through four major transport routes: overland, ground water, surface water, and atmospheric. The interrelationships between these transport pathways are very complex and not always obvious. Even though it's difficult, these need to be accounted for when evaluating or remediating a site.

MEPAS was designed to assist in site evaluation: to evaluate and address potential impacts and provide a relative ranking of sites. It's based on potential health impacts and has been used by the DOE in several hundred rankings at major facilities. MEPAS focuses on significance and computes relative risk to people using analytical, semi-analytical, and empirical equations to calculate contaminant movement through the environment.

The code starts with the source term and computes transport through air, overland, ground-water, and surface water components. It considers exposure of potential receptors - exposure to people through ingestion of food, water, inhalation of air, or as direct radiation - and computes a relative risk score. The exposure pathways of concern are similar to those in Rad Guide 1.109 but also include aquatic foods, drinking water ingestion, farm products, deposition of contaminants to vegetation, recreation, showering, ingestion of contaminated soils, and inhalation.

The code calculates a lifetime average exposure of individuals to radionuclides, chemical carcinogens, and chemical noncarcinogens. For

radionuclides, it computes an ICRP 2630 effective dose equivalent, based on lifetime exposure. For chemical carcinogens, it looks at lifetime average intake and milligrams per kilogram per day, using the EPA-developed cancer potency factors to project cancer risk. For noncarcinogenic chemicals, it compares exposure (lifetime averages in milligrams per kilogram per day) to reference dose limits to compute a relative impact assessment. It's a population-weighted score and considers total population at risk through all listed pathways. It can also look at the time of arrival of contaminants to pathways of concern and generate the Hazard Potential Index - a relative indication of impact.

The HPI score reflects the site, the constituent characteristics-chemical carcinogens, radioactive constituents, noncarcinogens - the toxicity of these particular compounds, and their ability to migrate in the environment. It is a transport and exposure code; it calculates release from a waste site, for example, using site-specific data to indicate the migration potential. The HPI score, a population-weighted risk score, provides a relative measure of impact. It's not a risk assessment per se but does indicate relative potential impact between sites.

This code runs on an IBM PC AT or compatible system. We've developed a user-friendly shell which helps the user define the particular transport pathways of concern. The computer generates worksheets or data input requirements that identify needed data. For a low-level waste site, this could include the depth to ground water, the type of soil cover, velocity of the ground water, and constituents of concern. Parameters can be entered directly, and the shell will create run files, which can then be reviewed for QA or QC before the shell runs the code.

To summarize, MEPAS has been used by the DOE at many of the DOE sites. It is available on an IBM PC. It provides an indication of relative impact by going through a traditional transport and exposure evaluation.

[Discussion/question from group]

RESPONSE: MEPAS was designed to be used by DOE after sites are listed on the NPL. Because it's a computer code, it can be used in an interactive fashion. The better data you have, the more accurate the result should be. It's designed to use readily available information - e.g., USGS data and meteorological data from airports - so that actual sampling is minimized.

[Discussion/question from group]

RESPONSE: The initial use of the code was to provide a population-weighted relative risk score. We can also generate maximum individual scores through each of the pathways of concern. We looked at the issue of addressing environmental degradation but that's very complex and costly. There's no easy way to compare deaths of nematodes vs. bunny rabbits vs. people.

[Discussion/question from group]

RESPONSE: Removal actions are taken in part because of the urgency of the problem. Virtually all evaluation systems look at risk somewhat independent of the time scale. RAPS/MEPAS has a long-term discounting effect. In terms of real urgency, you're talking in terms of days, weeks, months, couple of years. None of the systems that I'm familiar with try to get that extra dimension into the system, and I feel it would be very difficult to account for that in a set of objective factors. Such determinations are usually very site-specific and, while not necessarily subjective, are decisions to be made by experts.

[Discussion/question from group]

RESPONSE: Currently MEPAS has been limited to use in the environmental survey. I don't know how MEPAS would factor into the 5-year plan. In allocating funding, the assessment of potential impact to people is only part of the decision in remediation priorities. Defense Programs have used input from MEPAS in conjunction with other information to schedule programs.

30.2 PANEL: PROBLEMS IN INVESTIGATION/CHARACTERIZATION

Charles Phillips
Environmental Protection Agency
William N. Fitch
Bureau of Mines
Donald MacDonald
UNC Geotech
Lowell Ralston
S. Cohen & Associates, Inc.

MR. RALSTON: The Office of Radiation Programs, working with Superfund, drafted a manual for characterizing radiologically contaminated sites. This will provide site managers with agency-approved, detailed, health physics-based guidelines for characterizing threats posed by sites contaminated with radioactive materials. The manual includes or references specific protocols for conducting radiation surveillance, sampling and analysis, for health and safety programs, for exposure and toxicity assessments, and for risk characterization-all to be factored into decision making for the site.

Radionuclides are seldom adequately covered in existing Superfund manuals. Lacking detailed information, the RPMs characterize on a site-by-site basis. Because the characterizations differ, the risk assessments differ in their quality, and this can affect site remediation decisions. Our philosophy in drafting guidance is to work with site managers to provide tools needed to identify radiation problems and sources of assistance. In using the manual, project managers should consult with health physicists or other appropriate experts for assistance. It is not a cookbook; there is flexibility for professional judgment.

A draft was circulated to regional radiation offices and ORP laboratories of EERF and Las Vegas for comment and is now being extensively revised. We're reviewing the technical literature and a second draft is scheduled, hopefully, by September. We need advice on the types of guidance needed in this area.

[Discussion/questions from the group]

RESPONSE: We're currently looking at addressing mixed wastes. An overriding question is whether to sample once or twice - once for chemicals and once for radioactive materials. Do chemical labs have the permits necessary to handle radioactive materials? Do radioactive labs have the necessary tools and equipment on hand to analyze for chemicals?

MR. FITCH: As a PRP, I'd like to see this manual address some of the things that seem to have been omitted in many site surveys. We made decisions thinking we had a small problem based on a site characterization and finding as the problem unfolded that it was much larger. From the presentations during the past 2 days, our site is not unique; this is a common problem at radiological sites. A second question for the group is the applicability of techniques based on uranium defense systems or atomic power systems to other types of sites. Some things have happened with radium that seem quite

different than the experience of UMTRAP. Do the techniques provide adequate information at depths on these sites? I have seen a lot of surface surveys, and often, when we got in there, we found there were other things to deal with. The task force should look at verification of technology. From my perspective, I see quite a few limitations in those techniques. We have a mixed waste site and are in the process of paying for people to go back and drill holes beside where they drilled them 4 years ago.

MR. PHILLIPS: Thank you. The original cost estimates on these sites are usually about a tenth of what we end up spending, at best, so Bill's point is well taken.

[Discussion/questions from the group]

RESPONSE: One problem in site characterization is that a decision is made assuming there are 5 lb of contaminated material and then you find that there are really 5,000; that changes the decision you would have made.

MR. MACDONALD: How do you know when the site is clean? I will talk about the other end of the cycle, some of the things we've done in Grand Junction on vicinity properties to determine when the standard is met. Gauging each characterization to the site, as we did at vicinity properties in Grand Junction, is critical. We don't do 100 percent assessment on 4,000 properties. We do historical research and plan an assessment of between 60 and 80 percent. We can do this because we are dealing only with Ra-226 and daughter products. The key is to plan the characterization and assessment individually for each site.

We use several methods to determine when a property is clean so we can start the restoration process and return the property to its owner. We've created mobile field laboratories; we "can" samples and do a prompt radium and soil analysis in the field. We use two sodium iodide crystals opposed in a lead pig, something that can be built for under $10,000. We "can" a sample and read it out on a multichannel analyzer. Each mobile van is calibrated with the laboratory onsite. Also, we do verification samples; every sample that we "can" is taken back to the laboratory and run through the gamma spectrometer to confirm the field readings. We have found it difficult to calibrate or correlate gamma readings with radium and soil measurements.

Initially, we used just gamma measurements in the field, trying to compare counts per second to the radium content of the soil. We felt that we were doing a lot of over-excavating because of that, costly excavation of clean material. Working with the Colorado Department of Health, we developed this system of prompt radium and soil measurements in the field to guide our remedial actions, control costs, and reduce the amount of over-excavating. This is important in view of the costs - $300 a ton to dispose of contaminated material. Inevitably you're going to mix some clean and contaminated material. Limiting that by rapid measurements without delaying the contractor is something to keep in mind.

MR. PHILLIPS: We're going to continue to do in situ assessments and it behooves us to do the best job we can. I don't think the total thing is in this assessment. In a lot of cases, the assessment's done and then the rules change. An example is structures with alpha contamination; in most cases the entire structure and its contents are contaminated. Micro, as well as macro, assessments are needed to identify the chemical and physical nature of the contaminant, host material, and associated mineralogy.

30.3 PANEL: ARE STANDARDS ADEQUATE?

Larainne G. Koehler
Anthony B. Wolbarst
Environmental Protection Agency

MR. WOLBARST: Jack Russell and I are project officers in the Guides and Criteria Branch, developing criteria and/or standards to address the problem of residual radiation. EPA is responsible for setting standards to safeguard health and the environment, when nuclear power plants are cleaned up and released for unrestricted use and when Savannah River is cleaned up and opened to the public as a game park. We set criteria and standards for decontamination and site cleanups. How clean is clean? At present, those criteria and standards don't exist; however, we're beginning to lay the groundwork. Production of guidance and standards is a major concern of our office, and we are looking at several possible approaches.

Radiation protection programs in the United States stem from principles, policies, and guidance approved by the President. The first was prepared by the Federal Radiation Council and signed by President Eisenhower in 1960. That allowed a worker-exposure of 3 rem/quarter. Members of the general public could receive 500 mrem/yr. From 1960 to 1987, this controlled the exposure of both workers and the general public.

In 1987, President Reagan signed the "Radiation Protection Guidance to Federal Agencies for Occupational Exposure." Regulations of Federal agencies such as DOE, NRC, and OSHA must be consistent with this guidance. The guidance is essentially an extension of ICRP 26 and consists of 10 recommendations that endorse the need for justification and optimization. It elevates the ALARA principle to a fundamental principle of radiation protection, emphasizing limitation of dose to the worker and control of the workplace, so as to ensure that workers will not exceed a certain intake of radionuclides. It also covers other exposure areas such as members of the public, exposure to the unborn, people under 18, monitoring, and so on.

However, this does not control nuclear power plants. A revised version of 10 CFR 20, consistent with this, will be issued soon to provide better worker protection. An interagency working group of 12 Federal agencies is developing new Federal guidance for protection of members of the general public. This is in a preliminary phase and is expected to contain recommendations concerning justification, optimization of some sort, and possibly a 100-mrem limit for members of the general public.

Another issue is development of criteria and standards for residual radiation. There may be a recommendation made for setting authorized limits for sources or categories of sources; limits for categories of sources such that all sources together will not lead to an exposure of greater than 100 mrem.

There are no cleanup standards or criteria for the release of contaminated sites for unrestricted public use after cleanup. The ad hoc process leads to inconsistent cleanups, some of which have to be redone. It's a problem which clearly has to be remedied. EPA is considering criteria and standards for

cleanup of NORM, power plants, and other facilities and for the disposal of the resulting material. The problems are complicated and solutions are not clear.

This is at an early phase, and we would like your suggestions and input. Optimistically, the notice of proposed rulemaking for guidance for exposure limits to the general public might come out later this year, and the Notice of Proposed Rulemaking (NPR) for guidance for cleanup levels might come out in 1990 or 1991. That would be Federal guidance, not standards. This would be followed by the NPR for standards in 1991 or 1992 and advance notice for man-made and NORM disposal in 1992 or so.

Issues involved in setting these criteria include: determining the optimal cost/benefit balance, consideration of present and future individual risks, collective risks and cost to society, and forms that the criteria should take. There is a large variety of sites to be cleaned for unrestricted use. These vary in the activities involved, the lifetimes, chemical combinations, and so on. Should there be distinctions between new sites, active sites, and closed sites? The latter are generally far more expensive to treat. Should we try to develop guidance or standards? To what extent should we rely on institutional controls? Finally, of significant economic importance is the issue of recycling of equipment; e.g., valuable materials--copper pipes, nickel, and so on.

MS. KOEHLER: You've heard about some of the sites in Region 2, such as the Montclair/Glen Ridge site, and the problems New Jersey had in disposing of soil from that site. We needed to get houses below health criteria and were looking at technology and the limiting health-based values. The mill tailing standards are based on what is reasonably feasible for radon mitigation and, while legally applicable only to mill tailings, are frequently used as appropriate and relevant - ARAR - for cleanup at these sites. Is the next step gamma radiation? Ingestion potential? We had recommendations and reports from CDC looking at ingestion of soils from these yards. The mill tailings standards do not address these issues. Potentially, a health-based cleanup criteria would have to address such issues.

In one sense, we are in better shape than people dealing with sites that don't have radium or thorium because the ARARs there are even fuzzier. The Niagara Falls storage site has material like the K65 residues in the tanks at Fernald. The DOE would like to treat this material as mill tailings and bury it below some lower-level waste. The activity of the material is a few hundred thousand picocuries per gram radium; if it were transuranic, it would be high-level waste. Are mill tailings disposal methods appropriate for material of that high activity? The standards don't really cover this; it falls between the cracks. The position of EPA Region 2 is that DOE has to justify not being held to high-level waste standards. Since there's no disposal site and interim action is not going to result in any short-term exposures, it's in never-never land and unresolved.

At BOMARC, a site contaminated with plutonium from a weapons accident, the question arises as to cleanup standards. Standards were proposed for

transuranics in the late 1970s but were never made final. The draft standards specified a screening level and perhaps restricting access, but never mandated a cleanup. The applicability of the draft standards and cleanup levels is uncertain at this time.

Thus, there are many problems with lack of standards or with misapplied standards. For example, if you're going to use mill tailing standards as an ARAR for a site, read the EIS and background documents. The magic 5-15 numbers were not designed to have large volumes of material at 5 or 15. In the panel discussion on technologies you'll see that you get to a point where you're no longer looking at cleaning up to what's very close to background around houses. You're looking at treatment methods which will, hopefully, result in small volumes of high-level material and some fairly large volumes of material at the 10 and 15 level. Does that meet the intent of the mill tailings standards?

30.4 PANEL: TECHNOLOGIES - BEING DEVELOPED FAST ENOUGH?

Larry Coe
S. Cohen & Associates, Inc.
Paul Shapiro
Environmental Protection Agency
Craig Timmerman
Battelle Pacific Northwest Laboratory
Al Western
AWC, Inc.

MR. COE: During these past two days we've heard a lot about cleanup problems, with solutions ranging from not too difficult to nearly impossible. We've heard about waste forms varying from needles to building stones weighing a couple of hundred pounds - soil, sludges, icky stuff, and liquids of all kinds. The volumes have ranged, in cubic yards, from the hundreds to 2 with nine zeros after it. We've zeroed in on waste treatment, including soil washing, vitrification, chemical extraction, grouting, etc. The problem is huge. Technology may help solve some of these very difficult problems, and we have three people here to give their perspectives on technology.

MR. WESTERN: At Johnston Atoll, we adapted a hundred-year-old mining technology to the nuclear industry, using a one-unit gravity difference to separate a contaminant from soil particles. However, before we could apply this technology on a production basis, we had to develop the radiation detection capability to monitor a stream of dirt on a belt roughly a meter wide, moving about 30 ft/min, down to levels below regulatory concern. That was not an easy task--radiation detector technology has progressed over the years, and we're down in the grass now. What we did was not new; we applied other industry technologies to the nuclear side of the fence. Now several other outfits are looking at adapting other technologies - e.g., flotation separation techniques. So, let's look around to see what other technologies can be adapted with a little engineering to solve our contamination problems.

MR. SHAPIRO: EPA's Office of Environmental Engineering and Technology Demonstration is part of the Office of Research and Development (ORD) and does engineering research support across all agency programs. I'll start by mentioning two reports we've been involved in recently. Last year, we reviewed the technologies available for cleaning up radiologically contaminated soils and found essentially what has been reported here, that many of those technologies were proven on hazardous waste but never used to clean up radioactively contaminated waste sites. During this past year, a task-group from the Office of Radiation Programs, the Superfund program, and ORD has characterized 25 EPA radiation sites, looking at the contaminated matrixes (soil, water, and structures) and the nature of the contaminants. Then we did an assessment and a rating, based on Superfund criteria, of the effectiveness of technologies for remediating those problems at Superfund sites.

Both reports are available. We looked at the problem and, touching on a recent issue here, it was impossible to separate technologies from sites. You need to know something about what you're going to clean up - characterization of the sites - to do a match with potential technologies.

The 1986 Superfund law authorized a program to demonstrate alternative technologies for cleaning up Superfund sites, the Superfund Innovative Technology Evaluation, or SITE, Program. There are already about 10 demonstrations in the field, 2 of which have application for radiation sites. One is Geosafe's in situ vitrification, the outcome of the Battelle process developed by DOE funding. A second project that will start shortly is Retech Technology's incineration process which that will be tested, first by EPA then by DOE, in Butte. At the New Jersey sites, we've been pursuing a separate type of SITE Program with the State to promote technology demonstrations on cleanup at the Montclair/Glen Ridge sites.

We've started discussions with the Defense Programs part of DOE about their Hazardous Waste Remedial Action Program, or HAZRAP, seeking to use their capability and funding to develop new technologies. DOE would perform the site demonstrations, and EPA would do the analyses. This may turn out to be a perfect marriage.

Some technologies out there now are very likely to be usable - in situ vitrification, incineration, and others. However, it's not clear what will follow these, and R & D is needed now to provide a selection of new alternatives in the future. We have an opportunity for research to develop technologies under the 1991 budget; research proposals will be selected in about 10 days. Because of the small number of sites, the Superfund office has had little interest in this, so it is critical to inform the people in headquarters of any research needed to develop and demonstrate technologies for cleanup of these sites.

Rich Guimond discussed sharing information. We've recently developed the Alternative Treatment Technology Clearinghouse (ATTC). Some of the agencies and private organizations here collect information, and ATTC is one mechanism for sharing information about technologies. Looking ahead, EPA is giving increased attention to waste minimization or pollution prevention. There are opportunities for funding some research to reduce future radioactive wastes, to minimize future cleanup problems.

MR. TIMMERMAN: Battelle's Pacific Northwest Laboratory is a prime contractor for DOE and numerous industrial clients, giving us the perspective of both industry and government. An example of DOE's efforts in technology transfer is in situ vitrification. ISV was developed from concept to a commercial company, Geosafe, over an 8-year period. In perspective, with the increased governmental oversight related to safety, quality assurance, etc. such a concept would probably take three times as long to develop today.

Related to our technology development, we do a lot of treatability studies. EPA and the State recently came up with a small quantity exemption. This is a positive step; in our research, we're dealing with very small quantities, at

very minimal hazard to the environment. Before this exemption, we needed a Part A permit to do gram-quantity tests.

Adaptation of technology to radioactive contamination problems is a two-way street; many technology developments associated with the nuclear industry can also be applied directly to mixed wastes and to the hazardous chemical waste field.

[Discussion/questions from the group]

RESPONSE: Actually, there's not really a buildup; it's a fixed decay. We have done two specific tests on wastes containing radium, mill tailings, and a naturally occurring waste product. Based on these, the leach rate of encapsulated material meets NRC standards for radioactive material. Also, after vitrification, we see about a 10,000 or greater decrease in radon emanation from the vitrified radium bearing waste. Radium is decaying to radon within the glass structure but is physically contained and decays without release of the radon.