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Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-91OR21949

HAZELWOOD INTERIM STORAGE SITE ENVIRONMENTAL SURVEILLANCE REPORT FOR CALENDAR YEAR 1993

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Hazelwood, Missouri

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HAZELWOOD INTERIM STORAGE SITE

ENVIRONMENTAL SURVEILLANCE REPORT

FOR CALENDAR YEAR 1993

9170 LATTY AVENUE

BERKELEY, MISSOURI

JUNE 1994

Prepared for

United States Department of Energy

Oak Ridge Operations Office

Under Contract No. DE-AC05-91OR21949

By

Bechtel National, Inc.

Oak Ridge, Tennessee

Bechtel Job No. 14501

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INTRODUCTION

This report summarizes the results of environmental surveillance activities conducted at the Hazelwood Interim Storage Site (HISS) during calendar year 1993. It includes an overview of site operations, the basis for monitoring for radioactive and non-radioactive parameters, summaries of environmental programs at HISS, a summary of the results, and the calculated hypothetical radiation dose to the offsite population. Environmental surveillance activities were conducted in accordance with the site environmental monitoring plan, which describes the rationale and design criteria for the surveillance program, the frequency of sampling and analysis, specific sampling and analysis procedures, and quality assurance requirements.

The U.S. Department of Energy (DOE) began environmental monitoring of HISS in 1984, when the site was assigned to DOE by Congress through the Energy and Water Development Appropriations Act and subsequently to DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was established in 1974 to identify and decontaminate or otherwise control sites where residual radioactive materials remain from the early years of the nation's atomic energy program.

Contamination at HISS originated from uranium processing work conducted at Mallinckrodt Chemical Works at the St. Louis Downtown Site (SLDS) from 1942 through 1957 under contract with the U.S. Atomic Energy Commission and its predecessor, the U.S. Army Corps of Engineers, Manhattan Engineer District. Uranium ore and uranium- and radium-bearing process residues from SLDS were stored at the St. Louis Airport Site and were later purchased by a private company and moved to 9170 Latty Avenue for storage and resale. By 1974 most of the material was sold and removed from the Latty Avenue property, leaving behind only residual contamination. The two storage piles present at the site today contain radioactively contaminated soils that were excavated during partial cleanup activities at the site in 1977 and 1985 and during installation of a municipal storm sewer system along Latty Avenue in 1986. HISS is included on the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL).

Environmental remediation of HISS is being conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the protocol for remediating low-level radioactive contamination at FUSRAP sites, and applicable DOE requirements authorized by the Atomic Energy Act of 1954 as amended. CERCLA and its implementing regulations are the primary sources of federal regulatory authority for response actions to be conducted at HISS. In addition, because HISS is on the NPL, a federal facilities agreement (FFA) negotiated between DOE and EPA incorporates the procedural and documentation requirements of CERCLA and its implementing regulations and establishes the respective roles of each agency during site remediation. As required by CERCLA, the applicable or relevant and appropriate requirements of federal and state laws are incorporated in the development of remediation goals for HISS.

Another primary environmental statute, the National Environmental Policy Act (NEPA), requires federal agencies to analyze the potential environmental impacts of proposed major activities, including those of environmental restoration projects such as the one being conducted as HISS. DOE policy requires the integration of NEPA requirements with the procedural and documentation requirements of CERCLA, thereby minimizing duplication of effort and the commitment of resources needed to implement both statutes separately. For HISS, the environmental impact statement required by NEPA has been integrated with the remedial investigation and feasibility study components of CERCLA. The resulting document is a remedial investigation/feasibility study-environmental impact statement.

During 1993, site activities included routine grounds and equipment maintenance and environmental surveillance. This environmental surveillance report summarizes the results of the ongoing environmental surveillance program conducted at HISS during the year. Radon concentrations in the air and radon flux (the radon emission rate for a specific surface area) were well below the limits imposed by DOE and EPA. For 1993, HISS was in compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAPs) under 40 CFR Part 61 Subpart H (radioactive emissions not including radon) and Subpart Q (radon emissions). All stormwater monitoring results were within the limits imposed by the site National Pollutant Discharge Elimination System (NPDES) permit (MO-0111252). The average gamma exposure rate at the boundary of the site was well below the DOE guideline for all sources. Concentrations of radioisotopes in surface water and groundwater were below DOE and EPA guidelines for drinking water. Because there are no EPA regulations prescribing limits on the concentrations of radioactive contaminants in sediment, the FUSRAP surface soil criteria are used as a conservative standard of comparison. At some locations, concentrations of thorium-230 in the sediment exceeded those guidelines. These are areas that will require future remediation based on today's guidelines.

This report contains information about site operations, the environmental surveillance program, surveillance results, and environmental compliance activities during 1993. Copies of the report are distributed to government officials and agencies, members of Congress, environmental and civic groups, the news media, and other interested individuals. Results of the HISS environmental surveillance program have been published each year since the program began in 1984. The reports for 1993 and all previous years are included in the Administrative Record file at the DOE Public Information Center, 9170 Latty Avenue, Berkeley, Missouri 63134, and at the St. Louis City Library and the St. Louis County Library (Prairie Commons Branch). Copies may be obtained at the DOE Public Information Center. The data used to compile this environmental surveillance report are available upon request.

The telephone number at the DOE Public Information Center is (314) 524-4083. Additionally, DOE maintains a 24-hour, toll-free telephone number, 1-800-253-9759. An answering machine records comments or questions. The machine is checked frequently, and all calls are documented and returned.

HISTORY OF THE HAZELWOOD INTERIM STORAGE SITE

HISS is located at 9170 Latty Avenue (formerly 9200 Latty Avenue) in the city of Berkeley in St. Louis County, Missouri (Figure 1) and occupies approximately 5.5 acres.

In early 1966 uranium ore and uranium- and radium-bearing process residues that had been stored at the St. Louis Airport Site, approximately 0.5 mile south of HISS, were purchased by the Continental Mining and Milling Company of Chicago, Illinois, and moved to a storage site on Latty Avenue, a part of which is the present-day HISS. These residues were generated by a plant at the St. Louis Downtown Site from 1942 through 1957 under contract with the U.S. Atomic Energy Commission and its predecessor, the U.S. Army Corps of Engineers, Manhattan Engineer District.

In January 1967 the Commercial Discount Corporation of Chicago purchased the residues. Much of the material was dried and sold to the Cotter Corporation, which shipped the material to facilities in Canon City, Colorado. In December 1969, Cotter purchased the remaining source material. From August through November 1970, Cotter dried some of the remaining residues at the site and shipped them to its mill in Canon City.

In April 1974 Cotter informed the newly established U.S. Nuclear Regulatory Commission (NRC) that some of the residues had been shipped in mid-1973 to Canon City without drying and that the remainder had been diluted with site soil and transported, without NRC consent, to a landfill in St. Louis County. Reportedly, approximately 12 to 18 in. of topsoil was removed with the residues. The NRC license for storage was terminated because it was believed that all residues had been removed. The Latty Avenue property was released for sale.

The property, which is now owned by Jarboe Realty and Investment Company, is divided by a chain link fence into two sections. The western section (9200 Latty Avenue) is leased by Futura Coatings, Inc., and the eastern section (9170 Latty Avenue), HISS, is leased by DOE for use as an interim storage facility for low-level radioactively contaminated

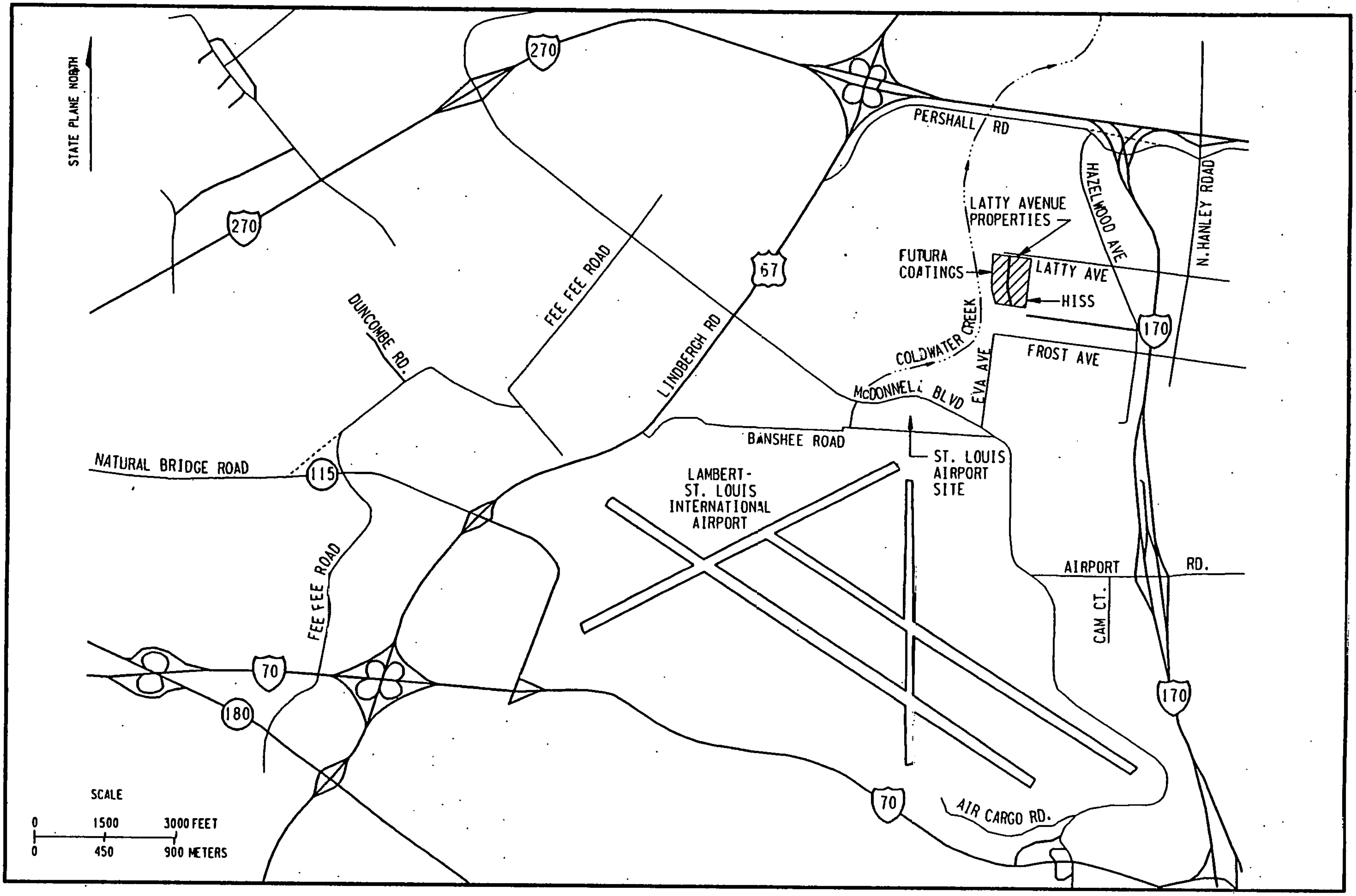

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Figure 1
Location of HISS

materials. HISS includes three office trailers, a decontamination pad, a storage building, a water storage tank, and two interim storage piles (Figure 2). The piles are covered with a low-permeability geomembrane (aliphatic urethane elastomer) secured with steel cables and a geogrid fabric. The piles contain approximately 31,600 cubic yards of low-level radioactively contaminated soil that is being held in interim storage until a suitable permanent disposal alternative is selected. The main pile was generated as a result of cleanup activities at the site in 1977 and 1985, and the secondary pile was generated during installation of a municipal storm sewer system along Latty Avenue in 1986, when contamination was excavated from some vicinity properties. The piles have surface areas of approximately 59,700 and 16,100 square feet. The radionuclides found in the soil stored onsite are uranium-238, thorium-230, and radium-226. The site is entirely fenced, and access is restricted.

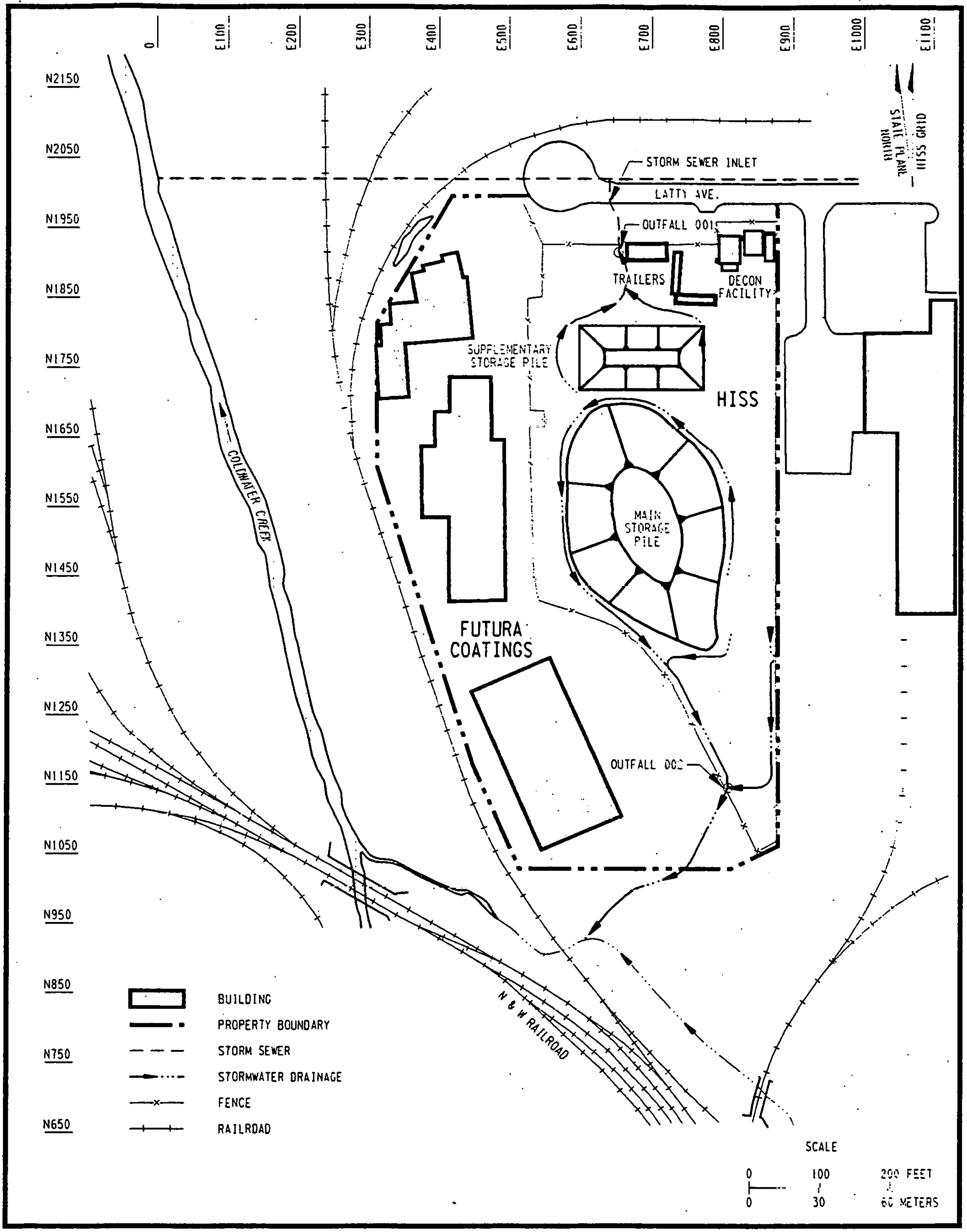

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Figure 2
Hazelwood Interim Storage Site

THE ENVIRONMENTAL SURVEILLANCE PROGRAM AT HISS

The goals of the environmental surveillance program at HISS are to identify and quantify the effect of site activities on the environment and public health. DOE wants to be certain that site conditions do not have a significant effect on public health or the environment and that activities at the site comply with all environmental laws and regulations. Through the environmental surveillance program, DOE routinely collects the environmental data needed for evaluating the site.

Surveillance Program Description

The surveillance program includes methods for determining exposure to radiation from both external and internal sources. Gamma radiation measurements taken along the boundary of the site are used to assess external exposure. Additionally, the program monitors all routes (or pathways) by which contaminants could migrate from the site to the offsite environment where they could potentially become sources of exposure to the public. Potential pathways include migration of dissolved radionuclides in stormwater or dispersion of radon gas in the air.

Monitoring devices and sampling stations are located to be most effective in detecting potential contamination sources and ensuring that no contaminants are migrating from the site. In locating the sampling stations, the surveillance program considers factors such as wind direction, site terrain, and the paths through which water flows on and off the site. Other considerations include regulatory requirements, sampling frequency, and the kinds of sampling devices and laboratory analyses that are best for detecting or measuring a specific contaminant.

After an environmental surveillance program is established, it is continuously evaluated and modified for effectiveness. Sampling and monitoring stations are relocated, new ones are added, and old ones are eliminated as information needs change.

Environmental Surveillance

The environmental surveillance program at HISS is summarized in Table 1. The radioactive contaminants at HISS are thorium-230, radium-226, uranium-238, and their associated decay products, such as the gas (radon) they emit. Therefore, the surveillance program includes monitoring for radon gas and external gamma radiation in air; sampling surface water and sediment for thorium-230, radium-226, and total uranium; and sampling groundwater for those radionuclides and for a set of common groundwater constituents used in characterizing groundwater quality. Annual radon flux measurements are taken on the surfaces of the piles. Additionally, in accordance with the site NPDES permit (MO-0111252), stormwater runoff leaving the site is monitored quarterly for various radioactive parameters and chemical indicators, and monthly for settleable solids. Rainfall and flow rate are measured daily. Figures 3 and 4 show the environmental sampling and monitoring locations at HISS.

To monitor radon and external gamma radiation in air, DOE places radiological detection devices at locations along the fenceline surrounding HISS. Similar monitors are placed at locations well away from the site to measure "background" radiation. The radiological detection devices are in place 24 hours a day, year round. The fenceline locations represent the closest that a member of the public could come to the contaminated material stored at the site. The amount of radon or external gamma radiation measured at the fenceline, therefore, represents the maximum that could potentially be encountered by a member of the public. To receive the maximum, a person would have to stand at the fenceline 24 hours a day year round. To monitor radon flux, DOE places detectors in a grid configuration directly on the surface of the piles to measure the rate at which radon emanates from the surface of the pile over a 24-hour period. The data collected from the environmental surveillance program are used for the assessment of doses to the public and not to onsite workers. Workers onsite participate in other monitoring programs to assess their personal exposure to radioactive material.

Table 1

HISS Environmental Surveillance Program Summary

Sample Type	Number of Sampling Locations (Number of QC field duplicates)	Primary Analyses Performed	Frequency of Sampling for Chemical Analyses	Frequency of Sampling or Detector Exchanges for Radiological Analyses
Radon	11 (1)	Radon concentrations in air	Not applicable	Continuous
External gamma radiation[a]	11 (1)	External gamma radiation exposure rates	Not applicable	Continuous
Groundwater	6 (1)	Radium-226, thorium-230, total uranium	Not applicable	Semiannually
	3 (1)	Sodium, potassium, calcium, magnesium, calcium carbonate, calcium bicarbonate, sulfate, nitrate, phosphorus, chlorine, and total dissolved solids	Annually	Not applicable
Surface water and sediment	6 (1)	Radium-226, thorium-230, total uranium	Not applicable	Semiannually
Stormwater runoff	2	Settleable solids	Monthly	Not applicable
		Total organic carbon, total organic halides, pH, specific conductance, gross alpha, gross beta, lead-210, radium-226, radium-228, thorium-230, thorium-232, and total uranium	Quarterly	Quarterly
		Rainfall, flowrate	Not applicable	Not applicable
Radon flux	90 (9 minimum)	Radon flux	Not applicable	Annually

[a]Two dosimeters are collected from each monitoring location for each monitoring period.

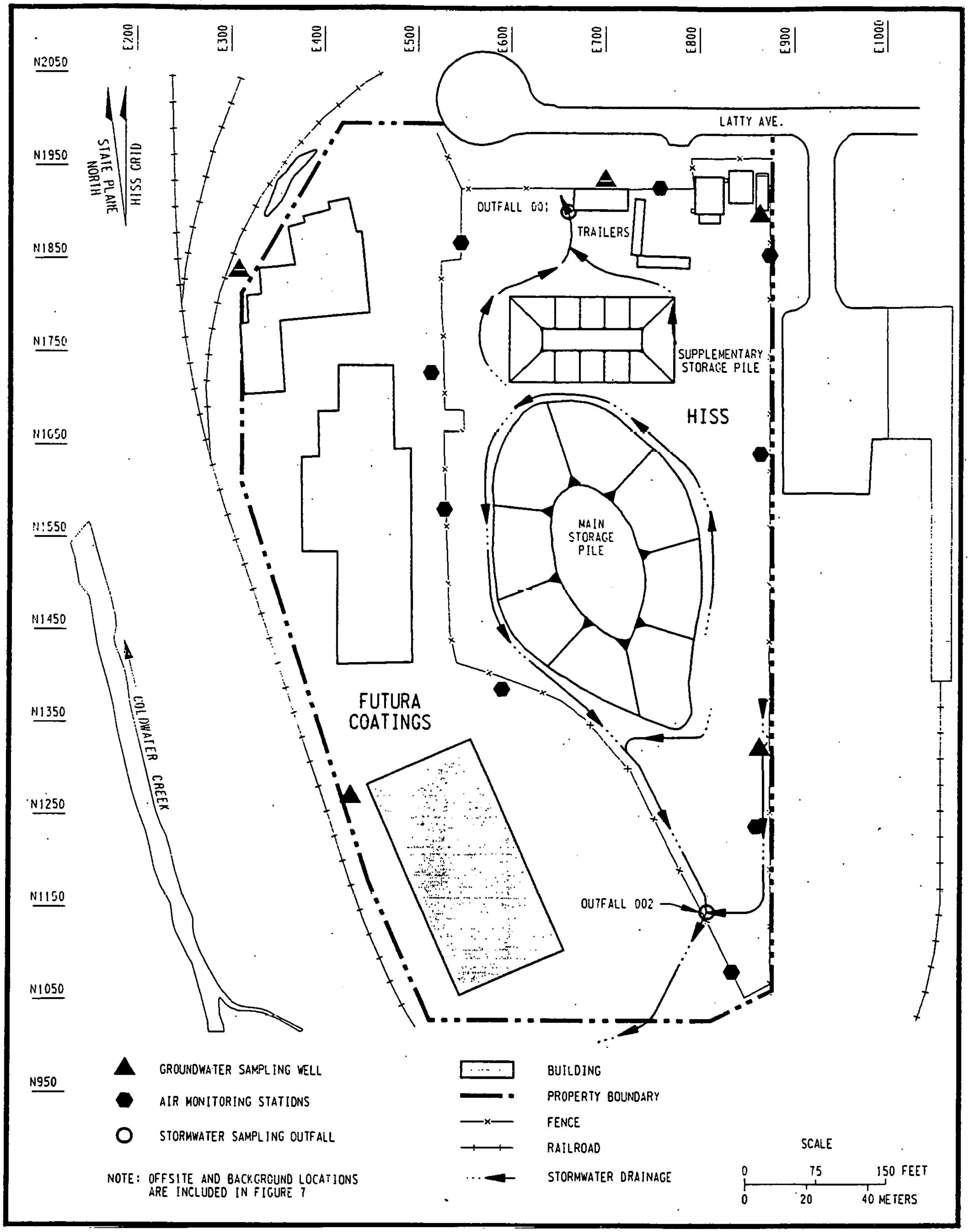

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Figure 3
Locations of OnSite Groundwater and Stormwater Sampling and Air Monitoring Station Locations

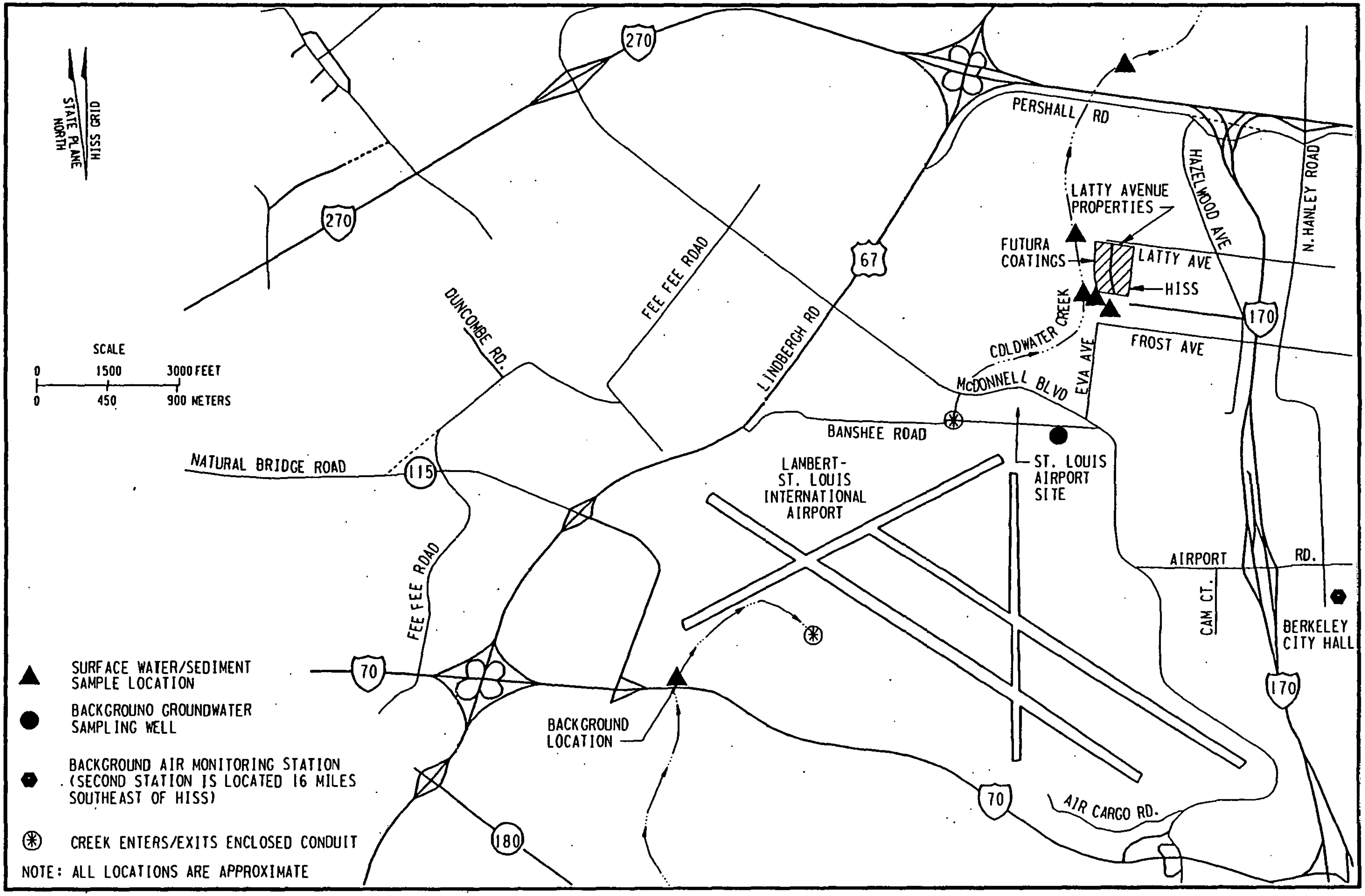

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Figure 4
Locations of Offsite and Background Surface Water, Sediment, and Groundwater Sampling and Air Monitoring Stations in the Vicinity of HISS

DOE uses a system of wells to sample the groundwater beneath the site. One well that represents background for the groundwater system is located in an area known to be unaffected by the site. This background well measures the amount of radioactive contaminants that occur naturally in the local environment. By comparing the samples from the background well with the samples from the other wells, DOE can determine whether contaminants at the site are affecting groundwater.

This same "before and after" principle is used in monitoring the effect of the site on surface water and sediment. A background sampling location is used to monitor surface water and sediment unaffected by HISS; other locations monitor the surface water and sediment in places that might be influenced by the site. All samples are analyzed by laboratories that are required to meet strict quality control requirements.

Regulatory Limits for Chemical Releases

Regulations for chemical contaminants set limits on the amount of a substance a facility may release to the environment. These limits are determined by computer models that use data such as stream carrying capacity and aquatic toxicity studies. The regulations also stress that releases should be minimized to the extent that best available technology allows.

Pollutants discharged to waters of the United States are regulated under the Clean Water Act (CWA) NPDES program through regulations promulgated and implemented by the State of Missouri. The federal government grants regulatory authority for implementation of CWA provisions to those states with a regulatory program that is at least as stringent as the federal program. The Missouri Department of Natural Resources regulates stormwater discharge under its state-authorized NPDES permit program.

FUSRAP holds a permit for HISS to discharge stormwater runoff from two outfalls; consequently, nonradioactive and radioactive constituents are sampled as part of routine stormwater monitoring at the site. Stormwater runoff samples are analyzed for several nonradiological parameters, including settleable solids and pH, for which the site NPDES permit imposes a specific limit.

Chemicals are not considered to be primary contaminants at HISS based on site characterization data, which indicate that the material stored at HISS does not exhibit any hazardous waste characteristics as defined by the Resource Conservation and Recovery Act (BNI 1990). Consequently, sampling and analysis for nonradioactive contaminants in groundwater, surface water, and sediment are not routinely conducted as part of the environmental surveillance program at HISS. However, on an annual basis, groundwater samples from three wells at HISS (and one field duplicate for quality assurance purposes) are analyzed for sodium, potassium, magnesium, calcium, carbonate, bicarbonate, and total dissolved solids. These parameters are monitored for the sole purpose of assessing groundwater quality at the site; the chemical constituents monitored are not considered contaminants. Groundwater in the vicinity of HISS is not used as a drinking water source. A complete summary of all chemical analytes is provided in Table 1.

Surveillance Results for Nonradiological Parameters at HISS

During 1993 concentrations of settleable solids in stormwater discharge from HISS were less than the minimum concentration the EPA-approved analytical method is capable of measuring and were therefore below the permit limit. Stormwater discharge pH measurements also fell within the range specified in the permit.

Regulatory Limits for Radiological Releases

The primary federal statute governing air emissions is the Clean Air Act (CAA). The potential sources of air emissions from HISS are radioactively contaminated particulates and radon gas emissions from the waste piles and the remainder of the site. HISS is not required to have any state or federal air permits. Subpart H ("National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities") and Subpart Q ("National Emission Standards for Radon Emissions from Department of Energy Facilities") of NESHAPs are applicable. Compliance with the emission standard for other radionuclides under Subpart H was evaluated using the EPA Clean Air Act Assessment Package-1988 (CAP-88) PC computer model. On an annual basis, radon flux measurements are taken on the surface of the piles at HISS to measure the rate at which radon emanates from the piles. The results are used to evaluate compliance with the NESHAPs Subpart Q standard of 20 $pCi/m^2/sec$. (See Appendix A for an explanation of units.)

DOE has established total quantity limits, derived concentration guides, and dose limits for radioactive releases from DOE facilities. Some regulations for radioactive contaminants set a limit on the amount or concentration of radioactivity that may be released; others set a limit on the dose a person could receive from releases. Conservative limits are set for the dose a person could receive from all sources, from airborne releases, and from manmade beta-gamma emitters in drinking water. DOE Order 5400.5, "Radiation Protection of the Public and the Environment," sets conservative limits to which FUSRAP must adhere.

DOE Order 5400.5 specifies that the radiation dose to any member of the public resulting from DOE operations should not exceed 100 mrem/yr above background, excluding medical procedures, residual fallout from past nuclear accidents and weapons tests, and consumer products. The radiation standards in DOE Order 5400.5 include EPA recommendations for limiting the doses from atmospheric releases and from drinking water. These recommendations state that the dose to an individual must not exceed 10 millirem per year (mrem/yr) from releases of radioactivity to the air. The 10 mrem/yr does not include radon because radon is subject to specific DOE limits. The regulations also state that the concentration of manmade beta-gamma radiation in drinking water must not exceed a dose of 4 mrem/yr. There is no separate limit for liquid releases alone, but these releases are included in the 100 mrem/yr for all pathways. Figure 5 illustrates the contribution from HISS to the dose to the public compared with the dose from background radiation and the DOE guideline of 100 mrem/yr.

The Safe Drinking Water Act (SDWA) was enacted by Congress in 1974 to regulate drinking water systems, require EPA to set national standards for levels of contaminants in drinking water, and provide for protection of aquifers. Under the 1986 Superfund Amendments and Reauthorization Act, drinking water standards and goals set under the SDWA became groundwater standards for CERCLA cleanups. SDWA maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) are applicable and relevant or appropriate requirements (ARARs) under CERCLA for the environmental

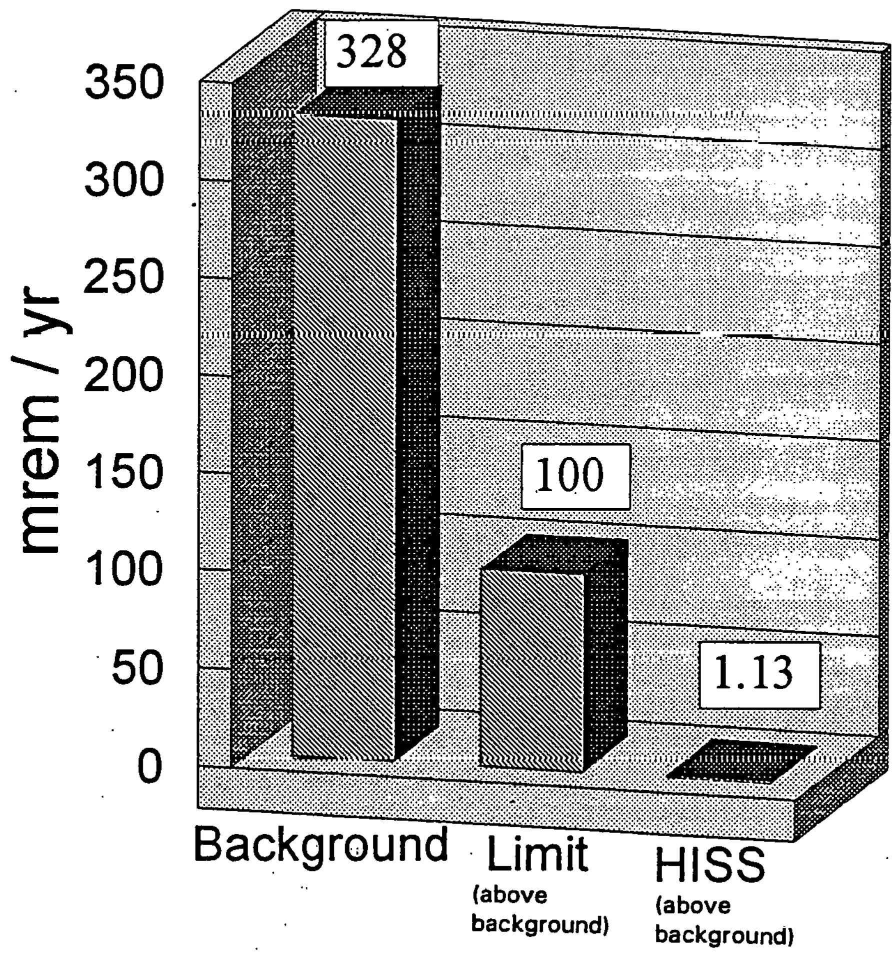

Figure 5
Comparison of Dose from the Site with Background and DOE Guideline

remediation of HISS. The radionuclide concentrations in surface water and groundwater are compared to those specified in applicable sections of promulgated state and proposed EPA MCLs for radionuclides in drinking water. Comparison with MCLs is a conservative approach for HISS groundwater because groundwater in the vicinity of HISS is not used as a drinking water source.

Surveillance Results for Radiological Parameters at HISS

Since environmental surveillance at the site began in 1984, analytical results have consistently shown that HISS is making no significant contribution to the radioactivity in the environment. The results of surveillance for 1993 again showed this to be true. The additional 1993 radiation dose to the offsite population attributable to HISS is very close to zero.

The 1993 results for radon monitoring at HISS showed that measurements at the fenceline were nearly the same as background and were far below the DOE guideline of 3.0 pCi/L. As with most gases, radon dissipates quickly and does not affect the offsite population.

Radon flux monitoring conducted in the summer of 1993 showed that the site was fully in compliance with the standard specified in the federal Clean Air Act, NESHAPs Subpart Q. The rate at which radon was emitted from the pile was well below the 20 $pCi/m^2/sec$ standard established in the act.

External gamma exposure monitoring results for 1993 showed an average exposure rate of 55 milliroentgen per year (mR/yr) along the eastern site fenceline. (One milliroentgen is approximately equal to one millirem, described in Appendix A.) This measurement does not include the normal background gamma exposure rate of 89 mrem/yr. Measurements taken at HISS ranged from background to 129 mrem/yr above background. Above-background measurements were recorded at four of the nine monitoring locations at the site. As in previous years, exposure rates measured at the monitoring station at the southern end of the site were above the 100 mrem/yr DOE guideline for all pathways; this is the only location exceeding the guideline. Historical information shows that this area was used for storage of leached barium sulfate residues, which contained appreciable amounts of radium; consequently, the elevated gamma exposure rate at the southern end of the site reflects localized subsurface contamination. However, the offsite area at the south end of the site is heavily wooded, and it is unlikely that an individual would occupy that area long enough during the course of a year (that is, for nearly 24 hours a day for one year) for the individual to receive a dose exceeding the DOE guideline. Radioactive contamination signs are posted along the fence.

The property nearest the area receiving the highest dose is an industrial facility about 150 feet away, occupied by employees for 40-hour/week shifts. The external gamma exposure rates at the industrial facility would be much lower than those measured at the surveillance locations because of the distance between the facility and the source of radiation. The maximum dose that employees at the facility could receive was calculated using conservative assumptions (which would tend to overestimate the possible dose). Hypothetically, the highest dose a person could have received from gamma radiation from HISS in 1993 would be equal to 0.13 mrem, a small fraction of the DOE guideline of 100 mrem/yr above background.

Results of groundwater monitoring for thorium, radium, and uranium showed that concentrations in some wells exceeded background during 1993. All concentrations were far below DOE guidelines and were below established state MCLs. Groundwater in the vicinity of HISS is not a drinking water source. Overall, radionuclide concentrations measured in groundwater associated with HISS are low and have consistently been low since monitoring began.

Sampling of surface water for radioactive parameters yielded results that were essentially the same as background except for some slightly elevated concentrations of uranium at a few locations. All measured concentrations were below DOE guidelines and state MCLs. These results are consistent with monitoring results from previous years.

As in previous years, sediment samples collected in 1993 from Coldwater Creek contained elevated concentrations of thorium-230 at some locations. Currently, there are no guidelines or regulations for radioactive contamination in sediments; however, surface soil guidelines may be used for comparative purposes. These guidelines are a conservative standard of comparison because surface soil is more easily accessible than submerged sediment and affords additional pathways for exposure. Two sediment samples collected in the fall contained concentrations of thorium-230 that exceeded the soil guideline; contamination in samples collected at those locations early in the previous spring were below the guideline. Heavy rain and flooding during spring and summer of 1993 are believed to have caused resuspension and migration of contaminants known to exist in Coldwater Creek.

The As-Low-As-Reasonably-Achievable (ALARA) Program

The goal of any ALARA program is to keep the exposure to radiation to members of the general public and onsite workers as low as reasonably achievable. To implement this program at FUSRAP sites, every reasonable effort is made to maintain exposures to radiation from the sites as far as possible below the established dose limits for both worker and public exposure.

Traditionally, ALARA guidelines have been established to limit the amount and concentrations of radioactive material that could be released into the environment from nuclear facilities. Current regulations governing releases of radioactive materials emphasize minimizing the dose received from a release rather than the quantity of the release; consequently, the ALARA guidelines at all FUSRAP sites have been established to limit the total dose resulting from exposure (both internal and external) to radioactivity.

ALARA is implemented at FUSRAP sites by continuously evaluating all site activities to determine any potential increase in the risk of exposure to radiation. Dose estimates are used to identify trends to determine best management practices that should be implemented to further reduce the dose to the general public and site workers. This program has been successful in limiting dose to levels that are nearly the same as background.

Dose

As radioactive materials decay, they release energy in the form of rays and particles. When people are exposed to radioactive materials, body tissues can absorb some of the released energy, resulting in an absorbed dose. (For example, when people feel warmth from sunlight, they are actually absorbing radiant energy emitted by the sun.) However, in terms of human health, it is the effect of the absorbed dose, rather than the actual amount of radiation emitted, that is important.

The potential health effects that can result from an absorbed dose depend on the amount and type of energy absorbed and on the part of the body exposed. The effective dose (ED) is used to express dose in terms of the potential health impact. Use of the ED allows doses from different types of radiation and doses to different parts of the body to be expressed in comparable units. ED is expressed in mrem.

The amount of radioactivity measured in environmental samples does not represent the actual radiological impact of the site on the environment and offsite public. To determine the potential health effects, releases from HISS are evaluated, and the maximum potential dose is calculated. Therefore, this report focuses on releases and maximum potential dose to explain the impact of the site on the surrounding communities.

Calculating Dose

With modern technology, very small amounts of radionuclides in environmental samples can be detected. Although air and liquid emissions from HISS are monitored, the radionuclides at the site have such low concentrations when dispersed into the environment that they are difficult to distinguish from natural background radiation. Consequently, it is difficult to directly measure the public's exposure to some of the radioactive materials that may be released from the site. Therefore, mathematical models must be used to estimate the concentrations of radionuclides present in the environment as a result of the measured releases to air and water. Beginning with the measured releases and factoring in many other conditions (e.g., wind direction, rainfall, population distribution, and, in some cases, actual measurements from environmental samples), estimated concentrations of the radionuclides are calculated. These estimated concentrations are used to calculate estimated doses from site releases.

When maximum doses are calculated from releases to the air and water, the concept of a hypothetical individual who receives the maximum reasonable exposure from all pathways is used. Even though no such individual is known to exist, the concept of the maximally exposed individual is used to estimate the contribution from HISS to the dose of the offsite population; this ensures that the estimated dose is the highest any individual could realistically receive as a result of site operations. For the purpose of this calculation, this hypothetical maximally exposed individual is assumed to work within 150 feet of the site, 40 hours per week.

Table 2 presents estimates of the dose to the hypothetical maximally exposed member of the public from site operations in 1993. Actual doses to any member of the public are expected to be lower than these conservative estimates. It is important to remember that this estimated dose from HISS is only a part of the annual dose received by an individual; everyone is exposed to natural and man-made sources of radiation and receives a dose from that radiation regardless of exposure to radiation from HISS (see Figure 5).

Quality Assurance and Quality Control

When releases are monitored and radiation in the environment is measured, there must be confidence that the data are reliable. To ensure that the monitoring and measurement results are accurate, FUSRAP has a quality assurance and quality control program based on state and federal guidelines. The quality assurance program plan meets all applicable policy and format requirements of DOE Order 5700.6C. Subcontractor laboratories that provide services for FUSRAP must have established quality assurance and quality control programs and must participate in interlaboratory comparisons, evaluations, and audits of their facilities.

Table 2

Comparison of Calculated Maximum Doses from HISS During 1993 with Applicable Standards and Natural Background Radiation

Exposure Pathway	Dose to the Hypothetical Maximally Exposed Individual from HISS[a] (mrem/yr)	Applicable Standard[b] (mrem/yr)	Percent of Standard	Percent of Natural Background[c]
Direct gamma radiation[d]	0.13	NA[e]	NA	0.04
Drinking water	NA	4[f]	NA	NA
Airborne pathways	1.0	10[g]	10	0.30
All pathways[h]	1.13	100	1.1	0.34

[a]Effective dose.

[b]All the limits listed are given in DOE Order 5400.5, February 8, 1990, "Radiation Protection of the Public and the Environment."

[c]Natural background radiation in the HISS vicinity is 328 mrem/yr.

[d]Above natural background.

[e]At the fenceline, external gamma radiation is the most significant exposure pathway. The other exposure pathways considered in the 100 mrem annual exposure limit are negligible by comparison.

[f]DOE Order 5400.5 provides a standard of 4 mrem/yr from a DOE site for all drinking water sources. This limit applies to manmade beta-gamma radiation. Groundwater in the vicinity of HISS is not a drinking water source.

[g]The standard for airborne effluents, excluding radon, applies to the sum of the doses from all airborne pathways: inhalation, exposure to radionuclides deposited on the ground surface, submersion in a plume, and consumption of foods contaminated as a result of the deposition of radionuclides.

[h]Exposure pathways are added to compare calculated maximum doses from HISS releases with the DOE "all pathways" standard.

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APPENDIX A RADIATION AT A GLANCE

RADIATION AT A GLANCE

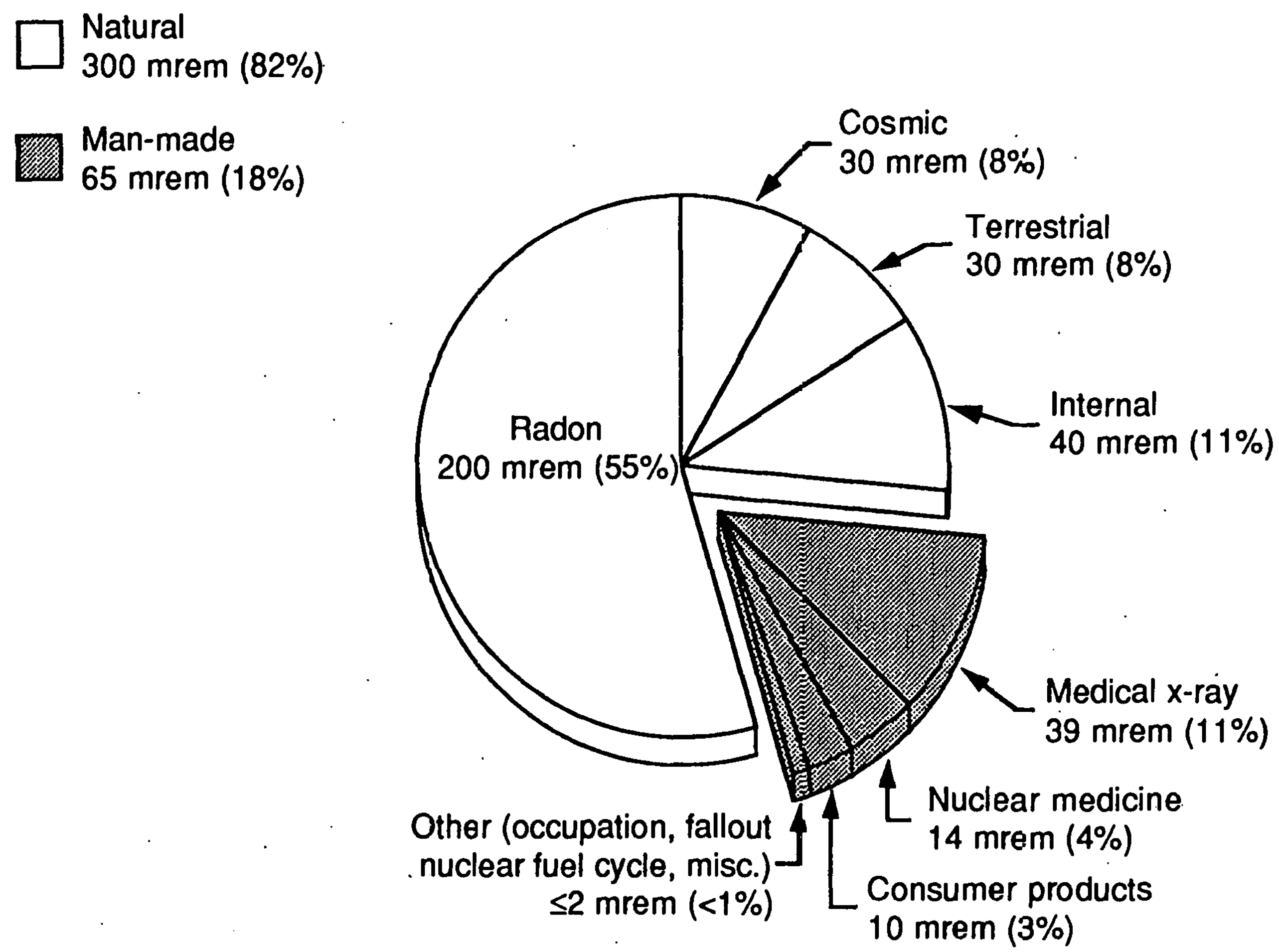
Of all activities at FUSRAP sites, those associated with radiation receive the most attention. What exactly is radiation and where does it come from? To answer these questions, it is best to start with a few basics.

All matter is made up of extremely small particles called atoms. Atoms contain even smaller particles called protons, neutrons, and electrons. When an atom has a stable mix of protons and neutrons, it is nonradioactive. However, when atoms have too many of either protons or neutrons, these unstable atoms can break apart, or decay, in an attempt to become stable. As atoms decay, energy is released; this released energy is called radiation.

Sources of Radiation

Radiation originates from natural events that happen all the time, but it can also be made by man. Most of the radiation people are exposed to occurs naturally. It has always been present, and every person who has ever lived has been exposed to radiation. Although modern technology may seem to have greatly increased the exposure rate, this is not necessarily the case. Exposure to man-made radiation varies greatly based on a given individual's lifestyle choices and medical treatments.

Sources of natural, or background, radiation include internal radiation from food (we all have approximately 500,000 atoms disintegrating in our bodies every minute), cosmic radiation from the sun and from outside the solar system, and terrestrial radiation from rocks, soils, and minerals (Figure A-1). People have no control over the amount of natural radiation around them, and the amount of natural radiation stays about the same over time. The natural radiation present in the environment today is not much different than it was hundreds of years ago. In general, over 80 percent of the radiation the average person is exposed to is from natural sources. Man-made radiation accounts for less than 20 percent of the total, most of it from medical procedures.



Source: NCRP 1987.

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Figure A-1
Typical Annual Radiation Doses from Natural and Man-Made Sources

Man-made sources of radiation include consumer products, medical procedures, and the nuclear industry. Some consumer products such as smoke detectors and even porcelain dentures contain radioactive elements. Probably the best-known source of man-made radiation is nuclear medicine. For example, to conduct a brain, liver, lung, or bone scan, doctors inject patients with radioactive compounds and then use radiation detectors to make a diagnosis by examining the resulting image of the organ.

Man-made radioactive materials also include cesium-137 and strontium-90, present in the environment as a result of previous nuclear weapons testing. As with background radiation, exposure to other sources of radiation varies greatly depending on individual choices, such as smoking tobacco products (polonium-210) and eating certain foods (bananas contain potassium-40).

Levels of Radiation

The average dose caused by background radiation varies widely. In the United States, the average is about 300 mrem/yr; some people in other parts of the world receive a dose more than four times this amount. For example, in some areas of Brazil, doses to inhabitants can be more than 2,000 mrem/yr from background radiation. These wide variations are the result of several factors, most notably the types and amounts of radionuclides in the soil.

This diversity in background radiation is responsible for the large differences in doses. Because people live in areas with high levels of background radiation without proven harm, it is assumed by most in the scientific community that small variations in environmental radiation levels have an inconsequential, if any, effect on humans.

Measuring Radiation

To determine the possible effects of radiation on the health of the environment and people, these effects must be measured. More precisely, the potential for radiation to cause damage must be ascertained. Measurements of these potential effects are derived from the activity of each isotope and are expressed in terms of the absorbed dose to an individual and the effective dose or potential to cause biological damage.

Activity

When we measure the amount of radiation in the environment, what is actually being measured is the rate of radioactive decay, or radioactivity, of a given element. This radioactivity is expressed in a unit of measure known as a curie (Ci). A curie is a measure of radioactivity, not a set quantity of material. More specifically, one curie equals 37,000,000,000 (3.7×10^9) radioactive disintegrations per second. One gram of a radioactive substance may contain the same amount of radioactivity as several tons of another radioactive substance. For example, one gram of tritium (a radioactive form of hydrogen) emits about 10,000 Ci, while one gram of uranium emits about 0.000000333 (333×10^{-9}) Ci. Because the levels of radioactive contamination at most FUSRAP sites are very low, the picocurie is commonly used in reporting contaminant levels. One picocurie is equal to 1×10^{-12} curies. Contaminants in water are reported in picocuries per liter (pCi/L), and contaminants in soil are reported in picocuries per gram (pCi/g).

Absorbed Dose

The total amount of energy per mass unit absorbed as a result of exposure to radiation is expressed in a unit of measure known as a rad. However, in terms of human health, it is the effect of the absorbed energy that is important, not the actual amount of energy emitted.

Effective Dose

The measure of potential biological damage caused by exposure to and subsequent absorption of radiation is expressed in a unit of measure known as a rem. One rem of any type of radiation has the same total damaging effect, regardless of the source of the radiation. Because a rem represents a fairly large dose, dose is usually expressed as a millirem (mrem), or 1/1,000 of a rem. The larger the dose, the higher the potential for damage. The dose from FUSRAP site activities is a small fraction of the dose that residents in the area surrounding the site receive from natural background radiation. Table A-1 explains the potential health effects of a range of radiation doses.

Table A-1

Comparison and Description of Various Dose Levels

Dose	Description
1 mrem	Approximate daily dose from natural background radiation, including that due to radon.
2.5 mrem	Cosmic dose to a person on a one-way airplane flight from New York to Los Angeles.
4 mrem	Annual exposure limit from manmade radiation in drinking water.
10 mrem	Typical dose from one chest X-ray using modern equipment.
10 mrem	Annual exposure limit, set by EPA, for exposures from airborne emissions (excluding radon) from operations of nuclear fuel cycle facilities, including power plants, uranium mines, and mills.
25 mrem	Annual exposure limit from low-level waste-related exposures.
65 mrem	Average yearly dose to people in the United States from man-made sources.
60-80 mrem	Average yearly dose from cosmic radiation to people in the Rocky Mountain states.
83 mrem	Estimate of the largest dose any offsite person could have received from the March 28, 1979, Three Mile Island nuclear accident.
100 mrem	Annual limit of dose from all DOE facilities to a member of the public who is not a radiation worker.
110 mrem	Average occupational dose received by United States commercial radiation workers in 1980.
170 mrem	Average yearly dose to an airline flight crew member from cosmic radiation.
300 mrem	Average yearly dose to people in the United States from all sources of natural background radiation.
900 mrem	Average dose from a lower-intestine diagnostic X-ray series.
1,000-5,000 mrem	EPA's Protective Action Guidelines state that public officials should take emergency action when the dose to a member of the public from a nuclear accident will likely reach this range.

5,000 mrem	Annual limit for occupational exposure of radiation workers set by the U.S. Nuclear Regulatory Commission and DOE.
8,000 mrem	Average yearly dose to the lungs from smoking 1 ½ packs of cigarettes per day.
10,000 mrem	The BEIR V report estimated that an acute dose at this level would result in a lifetime excess risk of death from cancer, caused by the radiation, of 0.8 percent.
25,000 mrem	EPA's guideline for voluntary maximum dose to emergency workers for non-lifesaving work during an emergency.
75,000 mrem	EPA's guideline for maximum dose to emergency workers volunteering for lifesaving work.
50,000-600,000 mrem	Doses in this range received over a short period of time will produce radiation sickness in varying degrees. At the lower end of this range, people are expected to recover completely, given proper medical attention. At the top of this range, most people will die within 60 days.