DOE/OR/21950-777
FINAL

FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM (FUSRAP)
CONTRACT NO. DE-AC05-91OR21950

INITIAL SCREENING OF ALTERNATIVES REPORT FOR THE ST. LOUIS SITE

ST. LOUIS, MISSOURI

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
ESC-FUSRAP

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Former Sites Restoration Division
U.S. DEPARTMENT OF ENERGY

92-500ML/100192

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ACRONYMS

AEC	Atomic Energy Commission
ANL	Argonne National Laboratory
ARARs	applicable or relevant and appropriate requirements
BNAE	base/neutral and acid extractable
BNI	Bechtel National, Incorporated
BRA	Baseline Risk Assessment
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminants of concern
CRAC	Central Risk Assessment Council
DCF	dose conversion factor
DOE	Department of Energy
EPA	Environmental Protection Agency
EIS	Environmental Impact Statement
ESP	electrostatic precipitator
FS	Feasibility Study
FUSRAP	Formerly Utilized Sites Remedial Action Program
HISS	Hazelwood Interim Storage Site
ICRP	International Commission on Radiological Protection
ISA	Initial Screening of Alternatives
LSA	low specific activity
LLW	low-level waste
MCL	maximum contaminant level
MED	Manhattan Engineer District
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NEPA	National Environmental Policy Act
NOI	Notice of Intent
NORM	naturally occurring radioactive material
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
O&M	operation and maintenance
ORAU	Oak Ridge Associated Universities
ORNL	Oak Ridge National Laboratory
PAH	polynuclear aromatic hydrocarbons
PRG	preliminary remediation goals
POTW	Publicly Owned Treatment Works
RCRA	Resource Conversation and Recovery Act
RfD	reference dose

ACRONYMS (continued)

RI	Remedial Investigation
RI/FS-EIS	Remedial Investigation/Feasibility Study-Environmental Impact Statement
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act
SFMP	Surplus Facilities Management Program
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
TCL	Target Compound List
TDS	total dissolved solids
TCLP	toxicity characteristic leaching procedure
TLD	Thermo Luminescent Dosimeter
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
VOC	volatile organic compound
WLM	working level month

ABBREVIATIONS

cm	centimeter
CO_2	carbon dioxide
ft	feet
h	hour
ha	hectare
in.	inch
km	kilometer
m	meter
m^2	square meter
m^3	cubic meter
mi	mile
pCi/g	picoCuries per gram
pCi/L	picoCuries per liter
ppb	parts per billion
Ra	radium
Rn	radon
sec	second
Th	thorium
U	uranium
yd	yard
yd^3	cubic yard

1. INTRODUCTION

The U. S. Department of Energy (DOE) has implemented a program for the management and cleanup of radioactive contamination on a set of properties, collectively referred to as the St. Louis site, in St. Louis, Missouri. This report presents the findings of an initial evaluation (screening) of potential alternatives available for cleanup of the St. Louis site under DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP is managed by DOE to characterize and remediate sites where residual radioactivity remains from activities carried out under contract to the Manhattan Engineer District (MED) and Atomic Energy Commission (AEC) during the early years of the nation's atomic energy program.

The planning and documentation of DOE's proposed activities at the St. Louis site is being conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the National Environmental Policy Act (NEPA). This process includes preparation of a Notice of Intent (NOI), Remedial Investigation/Feasibility Study-Environmental Impact Statement (RI/FS-EIS) Workplan, RI/FS-EIS, and a Record of Decision (ROD). The RI/FS-EIS document, will describe the nature and extent of contamination present at the site, alternatives for site remediation and potential environmental impacts associated with each remedial alternative. The NOI is a NEPA document. The RI/FS-EIS Workplan, RI/FS-EIS, and ROD are integrated CERCLA/NEPA documents.

An FS-EIS is conducted to identify and evaluate a range of cost effective remedial alternatives that protect human health and the environment. The FS incorporates the provisions of the Superfund Amendments and Reauthorization Act (SARA) of 1986, CERCLA, and the National Contingency Plan (NCP). The EIS incorporates NEPA requirements. In accordance with Environmental Protection Agency guidance (EPA 1988), the FS is conducted in three phases:

- Phase I, which involves the identification and formulation of remedial action objectives, identification of remedial technologies, and the development of remedial alternatives;

- Phase II, which involves refinement of the alternatives and initial screening of the alternatives; and

- Phase III, which involves the detailed analyses of the remedial alternatives.

This initial screening of alternatives (ISA) report for the contaminated media at the St. Louis site combines Phase I and II of the FS-EIS process. This report has been prepared to provide regulatory agencies and the public the opportunity to review and comment on alternatives which are being considered for the cleanup of the St. Louis site. In Phase III of the FS-EIS, a detailed analysis will be completed on each of the remedial alternatives retained through initial screening. Alternatives will be further defined with respect to the quantities of contaminated media to be addressed and the technology performance requirements. Modifications to remedial options identified during Phase I are made, if necessary.

The revised NCP requires that nine evaluation criteria be used to form the basis of the comparative analysis of alternatives. The nine criteria described in the NCP and used in the Phase III detailed evaluation are as follows:

- protection of public health and the environment,
- compliance with ARARs,
- reduction of waste toxicity, mobility, or volume,
- short-term effectiveness,
- long-term effectiveness and permanence,
- implementability,
- cost,
- community acceptance, and
- state acceptance.

The criteria of effectiveness, implementability, and cost used in the initial screening phase are applied in greater depth during this phase of evaluation. Each factor is examined with respect to the short- and long-term impacts. The capability to protect human health and the environment and to reduce the toxicity, mobility, and volume of the contaminants are analyzed under the effectiveness criteria.

Implementability includes consideration of technical and administrative feasibility as well as the constructability of the components of the remedial alternative. Finally, a cost analysis is performed on the newly refined and detailed alternatives to quantify both capital and annual operating expenses.

In accordance with the applicable provisions of CERCLA and NEPA requirements, the potential environmental consequences of the alternatives are discussed and analyzed. This discussion and analysis include: the significant environmental impacts of the alternatives; any adverse environmental effects which cannot be avoided; the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity; and any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented. In addition, the analyses will include discussion of the following:

- direct effects and their significance;

- indirect effects and their significance;

- possible conflicts between the alternatives and the objectives of federal, regional, state, and local (and, where applicable, Indian tribe) land use plans, policies, and controls for the areas of concern;

- environmental effects of the alternatives;

- energy requirements and conservation potential for various alternatives and mitigative measures;

- natural or depletable resource requirements and conservation potential of various alternatives and mitigative measures;

- urban quality, historic and cultural resources, and the design of the environment, including the reuse and conservation potential of various alternatives and mitigative measures;

- cumulative impacts; and

- means to mitigate adverse environmental impacts.

Phase III of the FS-EIS process for the St. Louis site will be documented in the subsequent FS-EIS Report.

1.1 PURPOSE AND SCOPE OF STUDY

The purpose of this ISA Report is to identify and screen potential remedial technologies, and assemble and develop alternatives that protect human health and the environment, and address contamination of the site as a whole. This ISA Report will provide to DOE, regulatory agencies, and thc public preliminary information on potential rcmedial alternatives for the site. According to NCP guidelines, the alternatives should encompass a wide range of options including a no-action alternative. After alternatives are identified, they are screened to reduce the number of potential alternatives that will undergo a more detailed and thorough evaluation.

The ISA is the first phase of the FS-EIS process. After remedial technologies are identified and assessed with respect to effectiveness, implementability, and cost, and alternatives developed and screened through the ISA, a detailed evaluation is conducted during the FS-EIS of the remaining alternatives. The detailed evaluation will consider each of the CERCLA evaluation criteria in more detail and address environmental impacts of each alternative.

1.2 ORGANIZATION OF REPORT

The outline for this report follows DOE guidelines and combines the important features of the EPA guidance document for conducting RIs and FSs under CERCLA, and NEPA guidelines.

Section 1 provides a general introduction and includes a presentation of the purpose and scope of the study, and overview of the FS-EIS process, a brief description of the site being investigated, the history of activities associated with the site, and the nature and extent of contamination. A brief summary of the Baseline Risk Assessment (BRA) along with the objectives for remediation are also provided in this section.

In Section 2, remedial options are screened and evaluated to identify those that are applicable to the specific site conditions. Criteria used in screening technologies include waste-limiting [i.e., the ability to treat the contaminants of concern (COCs) at the site], and site-limiting characteristics (i.e., the implementability of the technology to the site conditions). The evaluation criteria included effectiveness, implementability, and cost.

Section 3 presents a comprehensive list of remedial alternatives developed for the site. These alternatives were developed by combining the remedial options that were retained through the previous screening and evaluation process.

Section 4 and 5 present recommendations for additional studies to develop the required information to implement remedial alternatives.

1.3 SITE BACKGROUND

The St. Louis site consists of the St. Louis Downtown Site (SLDS), the St. Louis Airport Site (SLAPS), SLAPS Vicinity Properties, and the Latty Avenue Properties [Hazelwood Interim Storage Site (HISS), Futura Coatings, Inc., and vicinity properties]. Figure 1-1 shows their regional setting.

SLAPS, and Latty Avenue Properties are on EPA's National Priorities List (NPL), a list of sites identified for remedial action under CERCLA. Since SLDS is the source of waste material at the other three locations, it has been included in the FS-EIS. SLDS is not on the NPL.

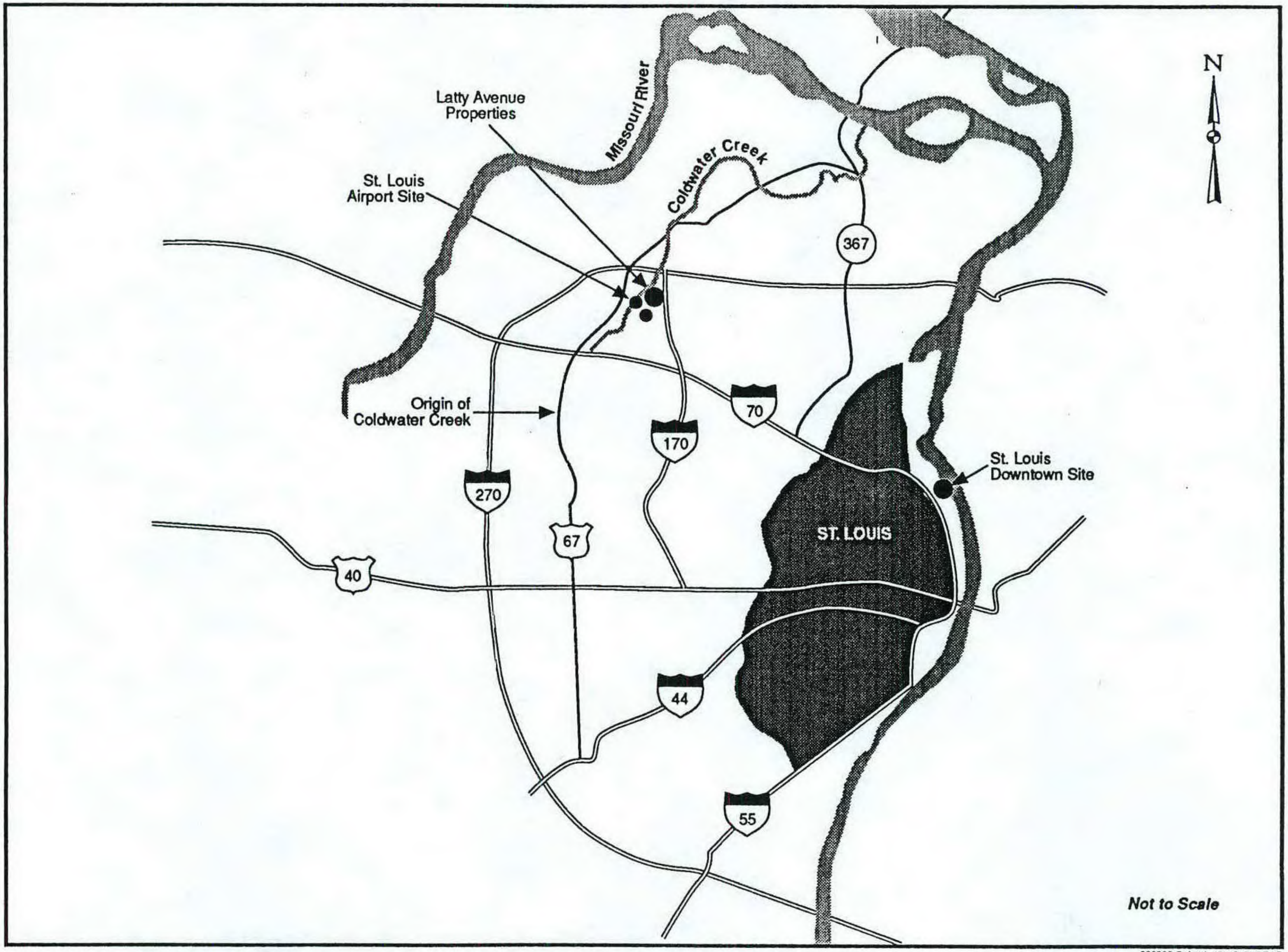


Figure 1-1. Locations of FUSRAP Properties in the St. Louis, Missouri Area

Characterization surveys at the site were conducted from 1977 to present. Analytical results of radiological and chemical characterization surveys conducted on these properties are contained in various published documents (BNI 1983, 1987, and 1992; ORNL 1985 and 1986a). Field investigations were performed to determine the extent of radioactive contamination, to delineate any chemical contamination associated with such radioactive contamination, and to characterize certain properties' geological and hydrogeological features.

The following sections provide brief descriptions of the locations, history of operations at the properties, and a brief summary of the characterization survey results. The discussion provided below on the nature and extent of contamination for the site has been summarized from the RI summary report prepared by Bechtel National, Inc. (BNI). A brief summary of results from ongoing quantitative risk assessments, and remedial action objectives for the sites are also included (BNI 1992).

1.3.1 SLDS and Vicinity Properties

SLDS is in an industrial area on the eastern border of St. Louis, approximately 90 m (300 ft) west of the Mississippi River and 17.7 km (11 mi) southeast of SLAPS. The population within 48.3 km (30 mi) of the property is 1,300,000, including 22,000 within 1.6 km (1 mi) of the property. Mallinckrodt, Inc. owns SLDS and produces various chemical products. The property covers approximately 18.2 ha (45 acres) and contains many buildings and facilities (Figure 1-2). Mallinckrodt maintains 24-hour security at the property. SLDS is traversed by three railroad lines and numerous spurs. Runoff from the property is controlled by a system of combined sewers that direct excess flow to the Mississippi River and non-excess flow to a POTW. There is an extensive network of utility lines both above and below the ground. Underground utilities include sewer, sprinkler, water, and natural gas lines. Overhead utilities include electricity, telephone, and plant process pipes (BNI 1992).

Investigations at SLDS revealed offsite adjacent properties containing radioactive contamination associated with MED and AEC activities at SLDS. The following areas bordering SLDS are referred to as vicinity properties: McKinley Iron Company; Thomas and Proetz Lumber Company; St. Louis Terminal Railroad Association; Norfolk and Western Railroad; and Chicago, Burlington, and Quincy Railroad (Figure 1-2).

SLDS is no longer located in a floodplain of the Mississippi River since the floodwall/dike was completed in the early 1970s. The unconsolidated overburden materials at the property are stratified clays, silts, sand, and gravels. The subsurface materials have little lateral or vertical continuity because most of the materials were deposited by the river and the shallow materials were disturbed by human activity. Most of the property is covered by either concrete or asphalt, which interferes with the natural runoff and recharge mechanism for shallow subsurface materials.

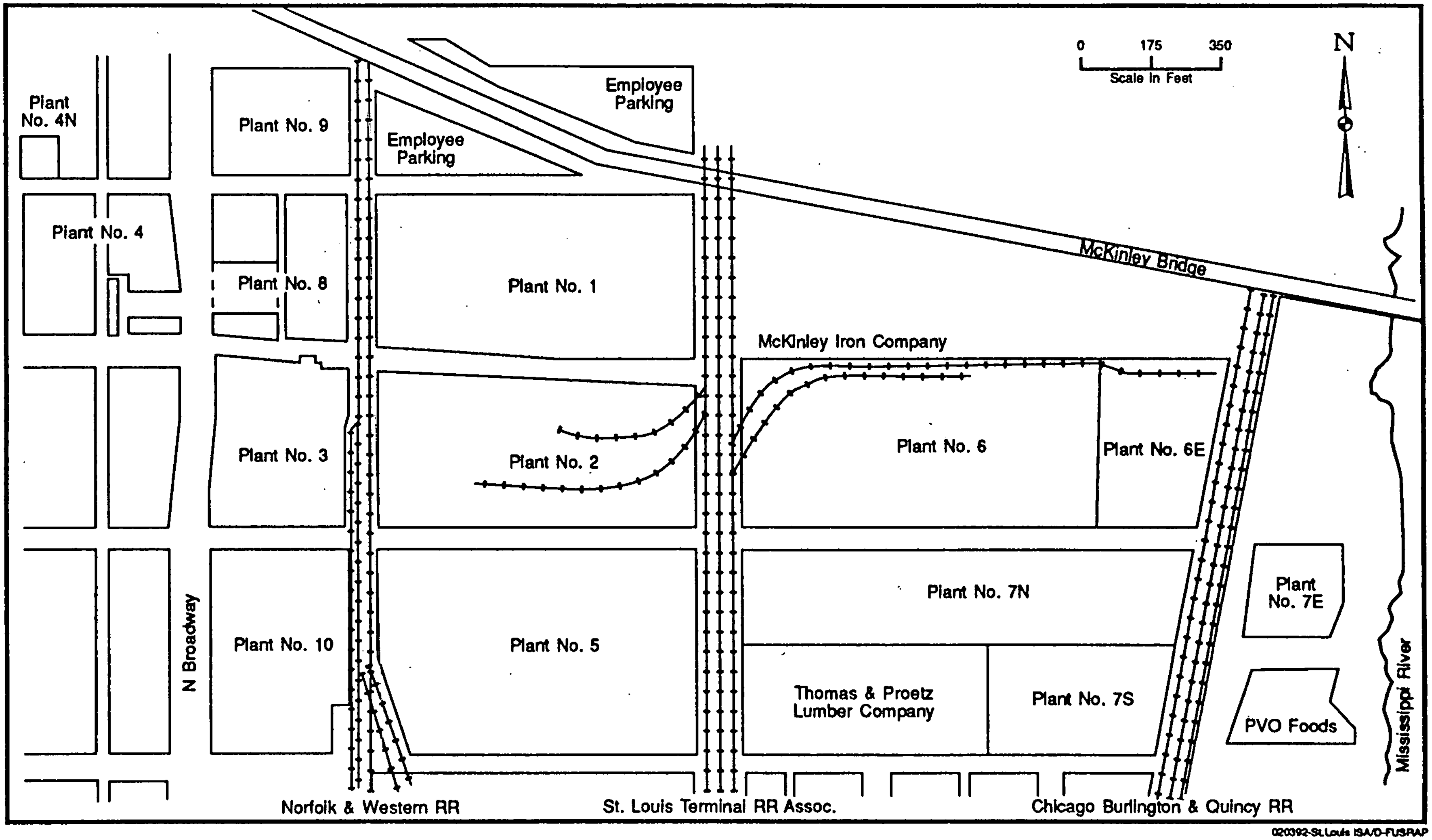


Figure 1-2. Plan View of SLDS and its Vicinity Properties

Lithologic drill logs of completed monitoring wells were used in the compilation of subsurface profiles and material descriptions. Two unconsolidated hydrostratigraphic units and one bedrock unit were distinguished; differentiation between the unconsolidated units is based on dissimilar hydraulic properties. A variable layer of rubble and fill averaging 3.2 m (13 ft) present at most borehole locations consists of unconsolidated brick, reinforced concrete, organic material, coal slag with minor sand, and silt as the matrix.

The distribution and relationship of subsurface materials encountered at SLDS are characterized by a shallow depth to bedrock of 5.9 m (19.5 ft) on the western edge of the property. The bedrock slope has a moderate gradient of 0.03 cm/cm (0.03 ft/ft) to an average depth of 24 m (80 ft) near the river. The lower unit is not present beneath the western half of the property, and the boundary is unknown (BNI 1992).

The upper unit, a clayey silt with interbedded silty clay, clay, silt, and sandy silt, varies in thickness from 4 to 10 m (12 to 30 ft). It is laterally discontinuous and the interbeds alternate randomly. The percentage of fine-grained sands tends to increase in the southern portion of the property. Traces of sand stringers were noted in some locations. The soil is olive gray to light olive gray, and hydraulic conductivity values in this unit range from 3 to 357 m/yr (10 to 1,190 ft/yr). In general, elevated radionuclide concentrations are confined to the rubble and fill materials above the upper unit. However, in some instances, elevated radionuclide concentrations extend to the upper unit (BNI 1992).

Evaluation of data obtained from the field investigation and of published reports indicates that an alluvial aquifer exists at SLDS under semiconfined conditions. Water level measurements have been taken weekly at SLDS since July 1988, in addition to some measurements taken in April 1988. Groundwater level contour elevations consistently indicate an easterly (towards the Mississippi River) groundwater flow direction in the upper unit. Adjacent to the Mississippi River, in the lower unit, the groundwater level contours indicate a flow direction to the northwest and a trough-like depression in the groundwater level elevation in the area of two wells (Wells B16W07D and B16W05D). The hydrograph for these wells suggests that this depression may represent a transient condition associated with equilibration of groundwater levels in response to a change in river stage. Hydraulic gradients calculated from contour maps range from 0.01 to 0.02 cm/cm (0.01 to 0.02 ft/ft), depending on the river stage (BNI 1992).

Groundwater recharge occurs primarily from infiltration of surface run-on due to precipitation and snow melt, contributions from the river, and possible leakage (and thus recharge) from underground utilities. Because most of the property is covered by either asphalt, concrete, or the physical plant, recharge is not uniform. Groundwater flows generally to the east of the facility. Underground utility lines running under the east end of the plant appear to influence flow direction in this area.

From 1942 to 1957, the former Mallinckrodt Chemical Works performed work at SLDS under contracts with MED and AEC. The work included development of uranium-processing techniques, production of forms of uranium compounds and metal, and recovery of uranium metal from residues and scrap.

From 1942 to 1945, work was performed in Plants 1, 2, and 4 (now Plant 10). In 1946, manufacturing of uranium dioxide from pitchblende ore began at the newly constructed Plant 6. During the processing, uranium orc was digested in acid and filtered to form uranyl nitrate; then, a solvent extraction procedure and denitration were conducted to create uranium oxide. Hydrofluoric acid was then used to fluorinate the uranium oxide to create uranium tetrafluoride (green salt), which was subsequently reduced with heat and magnesium to produce uranium metal.

Mallinckrodt personnel conducted decontamination activities at Plants 1 and 2 from 1948 through 1950. These decontamination efforts were focused to meet AEC criteria in effect at that time, and the plants were released for use without radiological restrictions in 1951.

During 1950 and 1951, operations began at Plants 6E and 7 and Plant 4 (now Plant 10) was modified and used as a metallurgical pilot plant for processing uranium metal until it closed in 1956. AEC operations in Plant 6E ended in 1957; AEC managed decontamination efforts (removal of contaminated buildings, equipment, and soil) in Plants 4 and 6E to meet AEC criteria in effect at that time and returned the plants to Mallinckrodt in 1962 for use without radiological restrictions. Since 1962, some buildings have been razed, and new buildings have been constructed at Plants 4 and 6 (BNI 1992).

Plant 7 was designed to produce green salt and it also stored reactor cores and removed metallic uranium from slag by a wet grinding/mill flotation process (Mason 1977). Plant 7 was released for use with no radiological restrictions in 1962 following decontamination that met AEC criteria effective then and is now used primarily for storage.

In 1977, the Oak Ridge National Laboratory (ORNL) conducted a radiological survey of portions of SLDS at the request of DOE (ORNL 1981). Results of this survey showed that alpha and beta-gamma contamination levels exceeded guidelines for release of the property for use without radiological restrictions. Elevated gamma radiation levels were measured at some outdoor locations and in some of the buildings used to process the uranium ore. Uranium (U)-238 concentrations as high as 20,000 pCi/g and radium (Ra)-226 concentrations as high as 2,700 pCi/g were found in subsurface soil. Radon and radon daughter concentrations in three buildings exceeded guidelines for nonoccupational radiation exposure. Based on results of the ORNL survey, DOE initiated the RI activities to characterize the nature and extent of contamination.

1.3.2 SLAPS and Vicinity Properties

SLAPS is in St. Louis County, approximately 24 km (15 mi) from downtown St. Louis, 17.7 km (11 mi) from SLDS, and immediately north of Lambert-St. Louis International Airport (Figure 1-3). SLAPS is bounded by the Norfolk and Western Railroad and Banshee Road on the south, Coldwater Creek on the west, and McDonnell Boulevard and adjacent recreational fields on the north and east. The property covers 8.8 ha (21.7 acres) and is surrounded by security fencing. Within a half mile of the property, more than two-thirds of the land is used for transportation-related purposes because of its proximity to the airport. The remaining land is used primarily for commercial/industrial functions (Figure 1-4).

There are no overhead utility lines on SLAPS. A water main crosses the northwest corner and runs parallel to the property on the north; a small onsite line connected to the water main supplies the mobile site facility. There are no sewer lines on the property; the facility is serviced by a holding tank.

No sizeable residential population centers exist within 1.6 km (1 mi) of SLAPS; the nearest population center (75 to 100 people) is approximately 0.8 km (0.5 mi) west of the property in an industrially-zoned area of Hazelwood. The next nearest population center is approximately 1.6 km (1 mi) northwest of SLAPS along Chapel Ridge Drive, with about 1,500 people. Most of the Hazelwood population is north of Interstate 270, more than 2.4 km (1.5 mi) north of SLAPS.

SLAPS vicinity properties include Coldwater Creek and its vicinity properties to the west; adjacent ball fields to the north and east; Norfolk and Western Railroad properties to the south and along the haul roads. Banshee Road to the south; ditches to the north and south; and St. Louis Airport Authority property to the south. Also included are the transportation routes: McDonnell Boulevard, Pershall Road, Hazelwood Avenue, Eva Avenue, Frost Avenue, and vicinity properties. These routes (referred to as the haul roads) are believed to have been used during waste transfer among the St. Louis properties. Figure 1-5 shows the locations of SLAPS vicinity properties.

Radioactive contamination on the vicinity properties has resulted from movement of contaminated soils from SLAPS by surface runoff and by spillage from transport vehicles. In addition, road and underground utility improvements have caused migration of contamination onto adjacent land. Railroad cars were also used to transport contaminated wastes to and from SLAPS, and material from these cars is believed to have spilled onto the railroad property and then migrated onto adjacent properties.

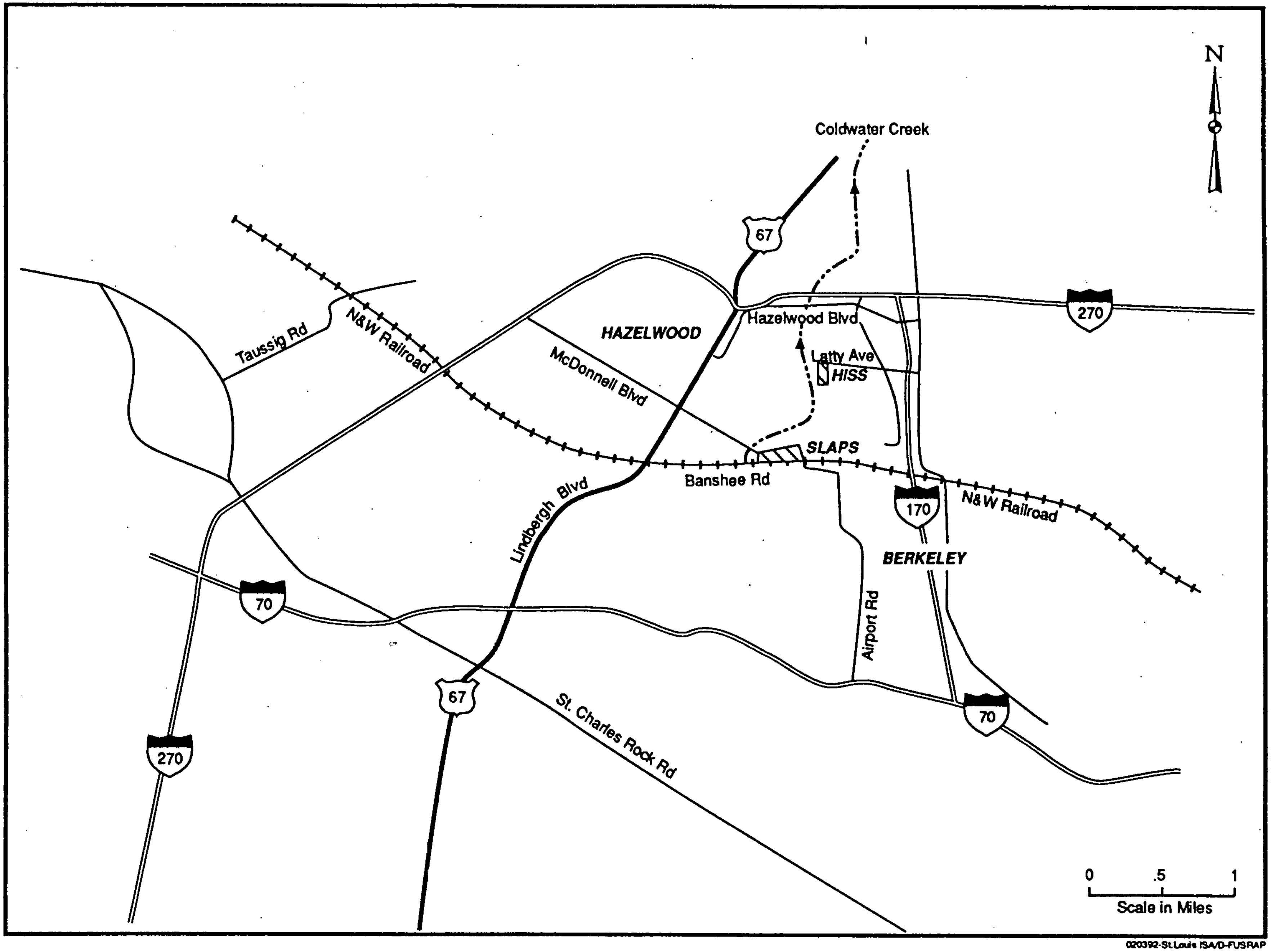
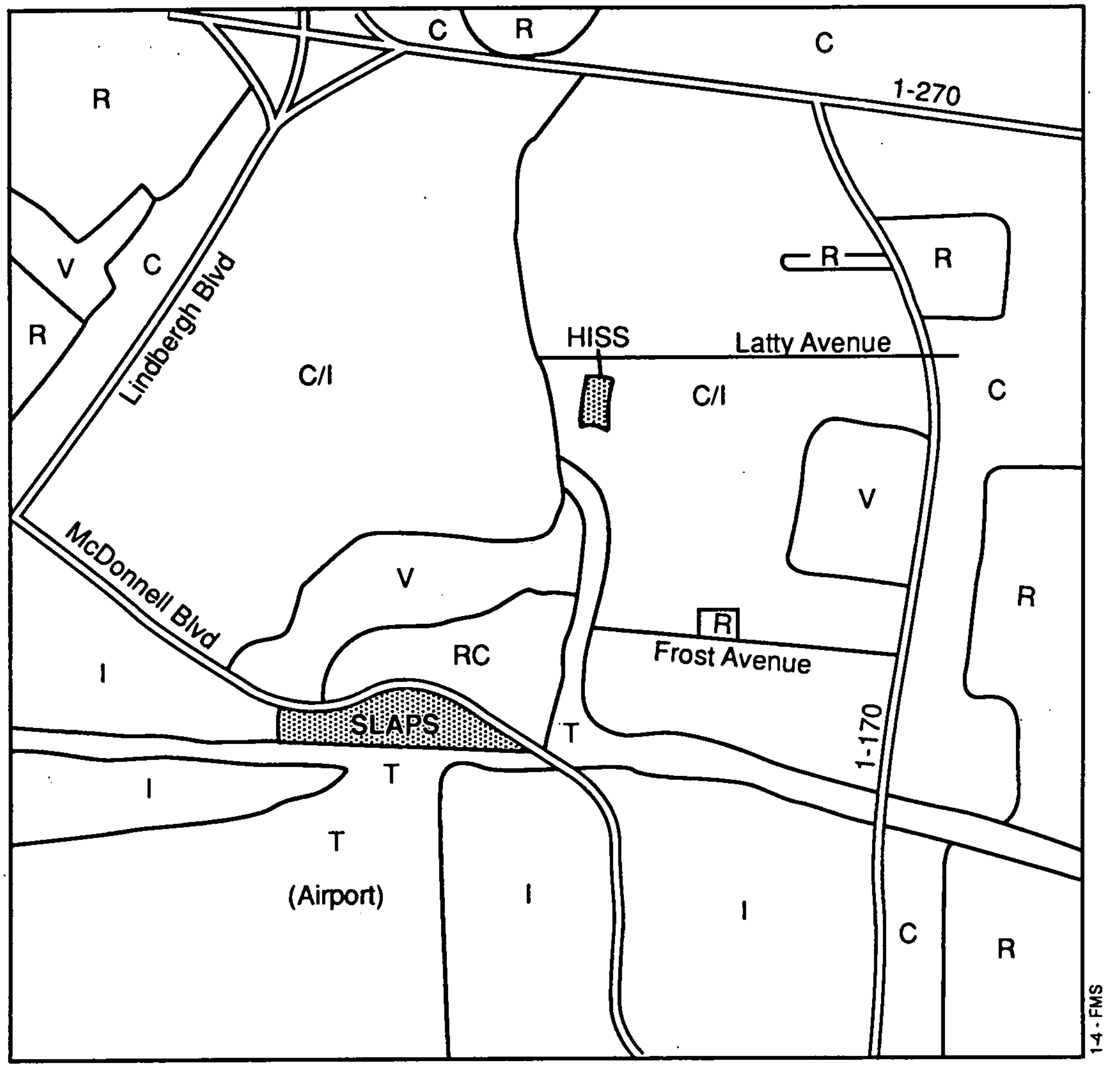


Figure 1-3. Location of SLAPS



Based on aerial photographs. Site visits and USGS topographic map 1:24000 scale. Florissant, MO (Revised 1982)

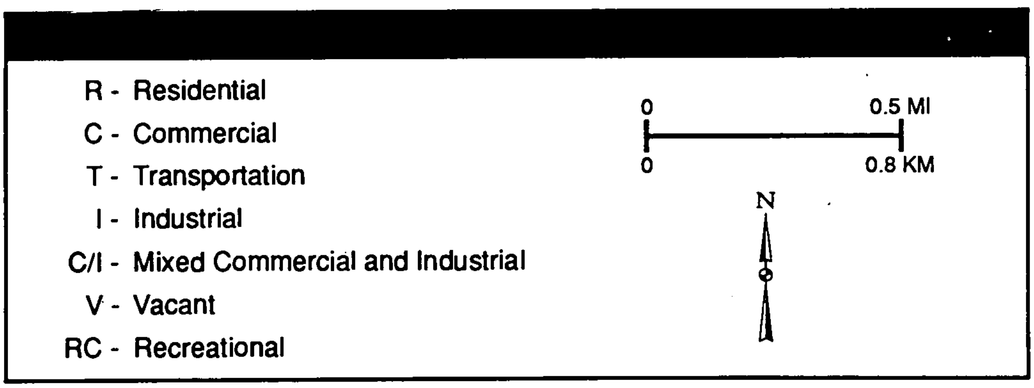


Figure 1-4. Generalized Land Use in the Vicinity of SLAPS

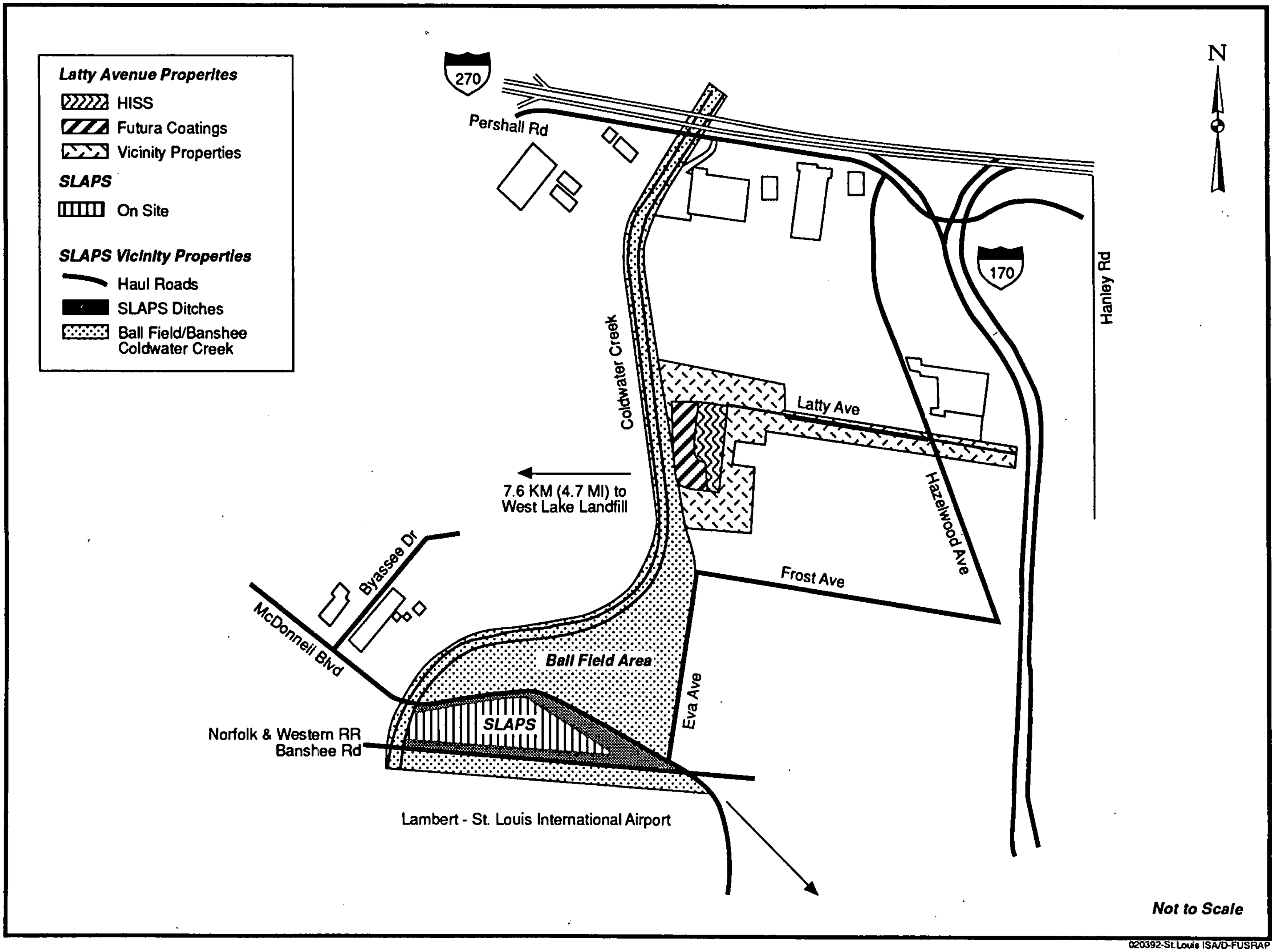


Figure 1-5. Locations of SLAPS Vicinity Properties

SLAPS is located in a geologic structure known as the Florissant Basin. The basin developed in nearly flat-lying bedrock, and is filled with Pleistocene- to Holocene-age sediments. Most surface water drains into Coldwater Creek, which borders the west side of SLAPS. Lake and river sediments comprise the unconsolidated material beneath the property.

Because radiological and chemical boreholes were only advanced to shallow depths, lithologic drill logs of geologic boreholes were used to compile subsurface profiles and material descriptions. Classification of the materials was simplified to facilitate correlation of the distribution of materials. Based on a review of the subsurface geologic profiles, the top layer is fill material of variable composition, ranging in thickness from 0 to 4.3 m (0 to 14 ft). Rebar, scrap metal, reinforced concrete, glass, and slag are distributed within loose-to-compacted silt, sand, and gravel.

Beneath the fill material, the predominant materials encountered are clay and clayey silts with an average thickness of 10 to 13 m (30 to 40 ft). Laboratory tests performed to determine the clay mineralogy of the soils show that the percentage of clay content increases at an average depth of 14.5 to 15 m (45 to 50 ft). Laboratory testing of clays from each geologic unit indicates that the clays have low plasticity, as determined by Atterberg limits test. Abundant zones of decomposed organic material were also encountered. The basal overburden material is clay with an increasing amount of fine- to very fine-grained sand and occasional sandy gravel at the contact with the limestone bedrock (BNI 1992).

Field and laboratory hydraulic conductivity measurements were taken on overburden materials. Field measurements were made using an open end, falling head test. Laboratory measurements were taken on undisturbed soil samples using a triaxial cell permeometer with backpressure. The measured hydraulic conductivity values range from 0.006 to 77 m/yr (0.02 to 231 ft/yr). The large range of values is a result of the hydraulic conductivity differences between the various unconsolidated units (BNI 1992).

Limestone bedrock was encountered at an average depth of 16.5 m (55 ft) below the eastern portion of SLAPS, increasing to 27 m (90 ft) below the western boundary. Field hydraulic conductivity measurements, taken in the limestone material using a constant head, single packer test, range from 0.26 to 3.6 m/yr (0.8 to 10.9 ft/yr) (BNI 1992).

A sequence of shale, coal, clay, and limestone layers was encountered beneath the central eastern portion of SLAPS. No permeability tests were conducted in this material.

Groundwater occurs in the unconsolidated overburden material at a depth of approximately 3.3 m (10 ft). Three hydrogeologic units have been identified at the property: the upper groundwater system, a clayey aquitard, and the lower groundwater system. The upper groundwater system is unconfined (phreatic) and the lower groundwater system is confined or semi-confined (artesian or leaky artesian). The clayey aquitard acts as a confining layer for the lower groundwater system (BNI 1992).

Water level measurements for some wells have generally been obtained weekly since 1988. Hydrographs showing 1989 groundwater level data for the wells indicate that a downward gradient exists at SLAPS. An exception to this can be found in two wells adjacent to Coldwater Creek, which would be expected to exhibit an upward gradient due to the discharge of groundwater to the creek. Groundwater flow for the upper and lower groundwater aquifers at SLAPS is toward Coldwater Creek.

MED acquired SLAPS in 1946 and used it to store uranium-bearing residues from SLDS from 1946 until 1966. In 1966, the residues were purchased by Continental Mining and Milling Company of Chicago, removed from SLAPS, and placed in storage at Latty Avenue under AEC license. After most of the residues were removed from SLAPS, the structures were demolished and buried on the property, and 0.3 to 1.0 m (1 to 3 ft) of clean fill material was spread over the entire area to achieve surface radioactivity levels acceptable at that time (BNI 1992).

In 1973, the U.S. Government and the City of St. Louis agreed to transfer ownership of SLAPS by quitclaim deed from AEC to the St. Louis Airport Authority. The 1985 Energy and Water Development Appropriations Act authorized DOE to reacquire the property for use as a permanent disposal site; the need for reacquisition will be determined after completion of the RI/FS-EIS for the St. Louis site (BNI 1992).

In 1982, DOE directed BNI to perform a radiological characterization of the ditches to the north and south of SLAPS, and of portions of Coldwater Creek (BNI 1983). Results of this survey indicated gamma-emitting contamination including concentrations of thorium (Th)-230 exceeding DOE remedial action guidelines.

In December 1984, ORNL conducted a mobile gamma scanning survey of potential transportation routes to and from SLAPS and the Latty Avenue Properties and found anomalies on McDonnell Boulevard, Hazelwood Avenue, and Pershall Road (ORNL 1985). Results of the ORNL survey of the roadsides showed areas where gamma exposure rates exceed background radiation levels. Gamma exposure rates of up to 90 μR/h were found on the surface of McDonnell Boulevard. Based on the results of the ORNL gamma scan, additional sampling along these roads was initiated to detect Th-230 in excess of DOE guidelines. Samples were necessary because Th-230 (an alpha radiation emitter) cannot be detected in situ.

In 1985, a radiological survey was performed on McDonnell Boulevard, Hazelwood Avenue, and Pershall Road (ORNL 1986). Analytical results for soil samples showed Th-230 to be the major contaminant.

In 1986, BNI conducted an extensive radiological and limited chemical characterization at SLAPS. Results showed radioactive contamination extending as deep as 5.5 m (18 ft) (BNI 1987a).

A radiological characterization of the SLAPS vicinity properties was performed from 1986 through 1990 to define the extent and boundaries of the contamination and to evaluate disposal alternatives.

1.3.3 HISS, Latty Avenue Properties, and Other Vicinity Properties

The Latty Avenue Properties are located along Latty Avenue and include HISS, Futura Coatings, Inc., and six vicinity properties (Figures 1-6 and 1-7). HISS and Futura cover a 4.5-ha (11-acre) tract in Hazelwood and are approximately 3.2 km (2 mi) northeast of the control tower of Lambert-St. Louis International Airport. The vicinity properties are adjacent to HISS and Latty Avenue, mostly within the corporate limits of Berkeley.

HISS is a level, grassy area with access roads, two mobile offices, a vehicle decontamination facility storage building, and two stockpiles of contaminated soil and debris in interim storage. In preparing the western portion of the property for commercial use by Futura, the present owner demolished one building, excavated several areas to level the property, paved several areas, and erected new buildings. The excavated material was placed in interim storage at HISS, which is leased by DOE. A chain-link fence completely surrounds HISS and Futura.

The Latty Avenue Properties are zoned for industrial use, and the surrounding area is primarily industrial and commercial. Stormwater runoff flows into a municipal storm sewer and ditches/tributaries that drain into Coldwater Creek. HISS is served by city water and electricity, with overhead electric and telephone lines and underground gas and sanitary sewer lines extending to the Futura buildings; however, there are no sanitary sewer lines to HISS and the site facilities use holding tanks. Sanitary sewer lines are located along the eastern boundary. The vicinity properties are relatively level and have been developed with commercial buildings; paved parking lots; and open, grassy areas along Latty Avenue.

Because Futura Coatings has a contiguous boundary with HISS, these two properties were treated as one unit during the geological and hydrogeological investigations. Sixteen monitoring wells were installed at HISS/Futura. The geological and hydrogeological conditions at HISS/Futura are similar to those found at SLAPS. The differences are summarized below.

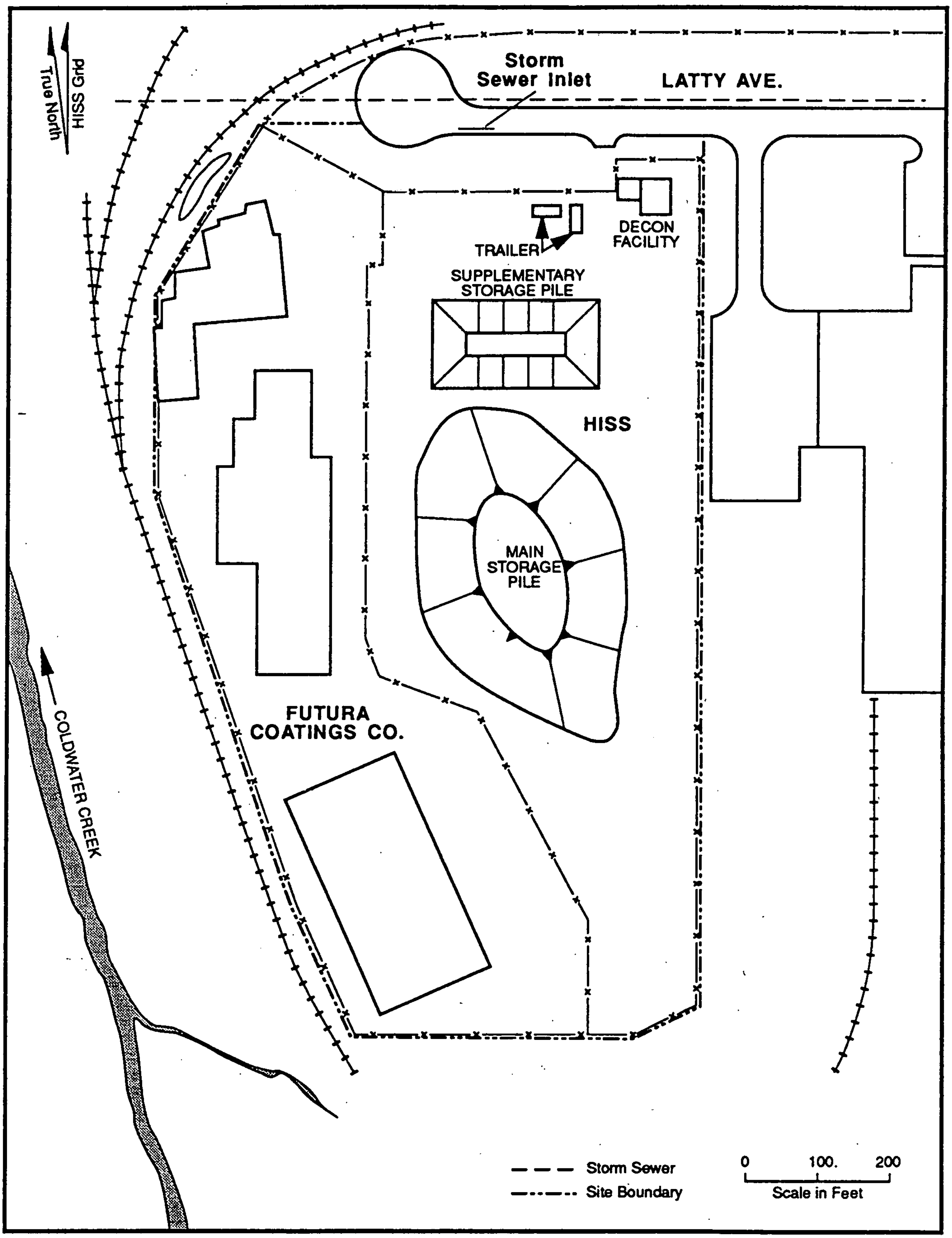


Figure 1-6. Locations of HISS and FUTURA Coatings

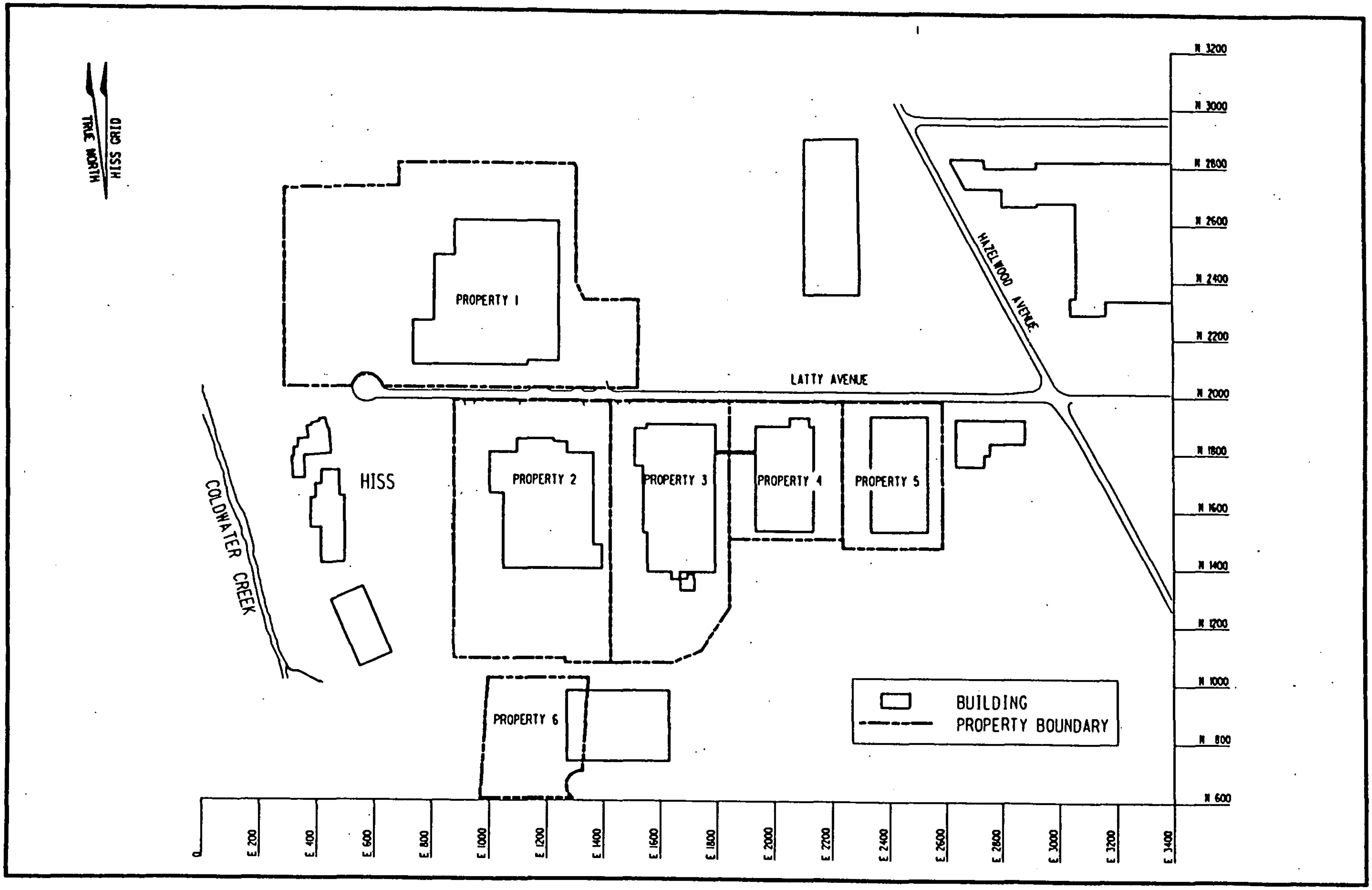


Figure 1-7. Locations of Latty Avenue and Vicinity Properties

The overburden at HISS/Futura generally consists of a layer of topsoil or fill material less than 2 m (6 ft) thick that overlies loess composed of yellowish-brown silty clays and clayey silts. The loess generally extends to depths of approximately 6.7 to 8.3 m (20 to 25 ft) across the properties. Beneath the loess, to an undetermined depth, are greenish to olive gray clayey silt and silty clay lacustrine (lake bed) deposits. All monitoring wells at HISS/Futura were installed above bedrock; no drill holes penetrated bedrock. Field hydraulic tests were conducted during the installation of seven monitoring wells at HISS/Futura; the measured hydraulic conductivity values range from 3.7 to 347.5 m/yr (11.2 to 1,060 ft/yr). Only the uppermost groundwater system was investigated and monitored. One geologic borehole was drilled to a depth of 18 m (60 ft) without encountering a lower groundwater system. At SLAPS, the lower groundwater system is encountered between 14 and 24 m (45 to 80 ft) below ground surface. Thus, it is unknown whether the lower groundwater system is present at HISS/Futura (BNI 1992).

Hydrographs showing 1989 groundwater level data from monitoring wells at HISS/Futura indicate that the groundwater level elevations fall within or slightly below the range of groundwater elevations at SLAPS. The hydrographs exhibit a typical seasonal pattern in groundwater levels, with the highest groundwater levels occurring in the spring and the lowest levels in the winter. Potentiometric surface maps for spring and late fall were developed. Both maps show that the groundwater flow pattern is radial, which contrasts with the groundwater flow pattern at SLAPS, which is toward Coldwater Creek. The cause of the radial flow pattern at HISS/Futura is still under investigation. Hydraulic gradients were determined from the two potentiometric surface maps to be along flow lines that represent groundwater flow paths beneath the contaminated stockpile area. The hydraulic gradients range from 0.007 in the spring to 0.013 in the late fall (BNI 1992).

The residues transferred from SLAPS to HISS in 1966 included 13 tons of uranium and 32,500 tons of leached barium sulfate containing seven tons of uranium. All of these residues and wastes were placed directly on the ground. The Commercial Discount Corporation of Chicago purchased the residues in January 1967, dried them, and shipped much of the material to Cotter Corporation facilities in Canon City, Colorado. The material remaining at Latty Avenue was sold to Cotter in 1969. In 1970, Cotter dried and shipped some of the remaining residues to its mills in Canon City. These residues included approximately 10,000 tons of Colorado raffinate (a term given to the residue by those who did the original processing at Mallinckrodt) and 8,700 tons of leached barium sulfate (BNI 1992).

In 1973, Cotter shipped undried Colorado raffinate to Canon City and transported the leached barium sulfate, diluted with 30 to 40 cm (12 to 18 in.) of topsoil, to a landfill in western St. Louis County. Cotter informed the Nuclear Regulatory Commission (NRC) of this activity in early 1974 (BNI 1992).

In 1976, NRC took measurements at HISS/Futura. These measurements indicated residual uranium and thorium concentrations and gamma exposure levels exceeding existing guidelines for release of the property without radiological restrictions. Radiological characterization of HISS was performed by ORNL in 1977, prior to occupation by the present owner. Surface contamination exceeding DOE guidelines for thorium and radium was found in and around the buildings and in the soil to depths of 45 cm (18 in.) (ORNL 1977).

In June 1977, Jarboe Reality and Investments purchased the building and grounds at Latty Avenue. Jarboe Reality and Investments (located on the western portion of the property) prepared the property for use by demolishing some buildings, erecting new buildings, which became Futura Coatings, Inc. and clearing a 1.4-ha (3.5-acre) tract of land surrounding the area. Material resulting from this cleanup was placed in interim storage on the eastern portion of the property (ORAU 1981).

In 1981, ORAU characterized the storage pile at HISS. Additionally, a radiological survey was performed on the northern and eastern boundaries of HISS for NRC (ORAU 1981).

In September 1983, a preliminary survey of properties in the vicinity of HISS was performed to determine whether radioactive contamination in excess of guidelines was present. The potentially contaminated areas identified were more thoroughly surveyed by ORNL in January and February 1984.

In 1985, DOE provided radiological support for workers involved in street improvements along Latty Avenue. Based on results of surveys performed during that time, 10,700 m^3 (14,000 yd^3) of soil was excavated and added to the interim storage pile on the eastern portion of the property. In 1986, a storm sewer was installed along Latty Avenue. The installation of this sewer generated 3,517 m^3 (4,600 yd^3) of contaminated soil that was placed in a second storage pile at HISS. Approximately 24,500 m^3 (32,000 yd^3) of contaminated soil and debris is contained in the two covered piles at HISS.

1.4 ENVIRONMENTAL SETTING

1.4.1 Climate

The St. Louis area has a modified continental climate. In most years, temperatures reach 0°C (32°F) or lower for fewer than 20 to 25 days. Summers are warm, with maximum temperatures of 32°C (90°F) or higher occurring an average of 35 to 40 days per year. Normal annual precipitation for the St. Louis area is about 92 cm (35 inches). Winds are predominantly from the south, with a mean speed of 15 km/h (9.5 mph).

1.4.2 Ecological Resources

Site vegetation consists of a mixture of prairie species, disturbance-related aggressive species, and remnant of landscape plantings, i.e., plants typical to old fields and less-maintained landscaped lawns. Typical species include various grasses, wild carrot, aster, clover, dandelion, goldenrod, dock, milkweed, ragweed, and thistle. The vertebrate fauna of the area consists of species that have adapted to urban encroachment, e.g., house sparrow, red-winged blackbird, cardinal, goldfinch, and common crow. Mammals are represented by the house mouse, striped skunk, squirrel, and the cottontail rabbit. Burrowing mammals (e.g., woodchuck and eastern mole) have ranges and habitats that encompass the site (ANL 1992).

Aside from the Missouri and the Mississippi Rivers, the major aquatic habitat in the immediate area of SLAPS and HISS is Coldwater Creek. Aquatic flora and fauna of Coldwater Creek immediately downstream of the Lambert-St. Louis International Airport are restricted to species tolerant of the polluted water and turbid, silty conditions. Fish include carp, green sunfish, black bullhead, and seven species of minnows and suckers. The invertebrate community is dominated by aquatic worms and midge larvae (ANL 1992).

1.4.3. Geology and Stratigraphy

Bedrock in the St. Louis area consists of sequences of sandstones, shales, and limestones, and more recent (past 500,000 years) deposits of glacial tills, loess, and fluvium from the major rivers.

SLDS is on the western boundary of the Mississippi River, 11 km (7 mi) downstream of the confluence of the Mississippi and Missouri rivers. Much of SLDS property is covered by either concrete or asphalt, which interferes with the natural runoff and recharge mechanism for surficial materials. Under this cover, a layer of rubble and fill (disturbed material) with an average thickness of 4 m (13 ft) is present over most of the property. Beneath the fill are unconsolidated deposits of stratified clays, silts, sands, and gravels. Beneath these deposits is limestone bedrock at a depth ranging from 5.9 m (19.5 ft) on the western side of the property to 24.4 m (80 ft) near the Mississippi River. Continuity of these materials varies both horizontally and laterally (BNI 1992).

At SLAPS, the site stratigraphy is divided into six units; the upper four units are composed of unconsolidated materials, including fill, loess, lacustrine, and glacial deposits with varying continuity and thicknesses of 15.2 to 24.4 m (50 to 80 ft). Beneath the unconsolidated deposits are bedrock units of undifferentiated rocks and limestone (BNI 1992).

The stratigraphy at the Latty Avenue Properties is similar to that observed at SLAPS, although the subsurface characterizations of the stratigraphy has been less extensive.

1.4.4 Surface Water and Groundwater

The major surface water bodies in the area are the Mississippi, Missouri, and Meramec rivers, which supply most of the drinking and industrial water for the St. Louis area. All of the water intakes are located upstream of SLDS, except one. This intake is on the east bank of the Mississippi River, 3.2 km (2 mi) downstream from SLDS, and it supplies only a small percentage of the water requirements for the city of East St. Louis, Illinois. It should be noted that water samples collected from the downstream intake show natural background activity levels.

The principal aquifers in the St. Louis area are located in the alluvial deposits associated with the major rivers. Groundwater also occurs in unconsolidated and gravel channel fills, and shallow and deep bedrock aquifers. Most of the bedrock is relatively impermeable, although not thought to be confining, and yields little water to wells. The bedrock aquifers typically yield less than 3 L/s (50 gpm), and water quality tends to deteriorate with depth as a result of increasing salinity and increased concentrations of other dissolved minerals.

SLDS is underlain by a portion of the Mississippi River alluvial aquifer, which is composed of unconsolidated deposits. The alluvial aquifer is thought to be hydraulically connected to the underlying upper bedrock and to the Mississippi River. The average groundwater velocity at SLDS is estimated to be 3 to 6 m/yr (10 to 20 ft/yr) in the lower aquifer units, and 0.03 to 0.3 m/yr (0.1 to 1 ft/yr) in the upper unit (BNI 1992).

The primary surface water feature at SLAPS and Latty Avenue Properties is Coldwater Creek. At McDonnell Boulevard, the creek has an upstream drainage area of approximately 119 km^2 (46 mi^2). The creek empties into the Missouri River which flows into the Mississippi River. The creek is not used for drinking water, although two municipal water intakes are present on the Mississippi River downstream of the discharge of Coldwater Creek. Water quality in Coldwater Creek is generally poor. Pollutants enter the stream in stormwater runoff from residential areas, commercial and industrial facilities and from Lambert-St. Louis International Airport. The creek receives point wastewater discharges under National Pollutant Discharge Elimination System (NPDES) permits from three industrial facilities which discharge nonpolluted cooling water from two small non-industrial sewage treatment facilities and from the large regional Coldwater Creek Sewage Treatment Plant. A toxic agent study was conducted in 1983 on the creek. Even though the study indicated that the creek was relatively free of priority pollutants, other recent studies of the aquatic fauna indicate that the stream is severely polluted. The nature and source of this pollution is not definitively known, but could result from short term events such as pollutants carried in stormwater (i.e., salt, oil, antifreeze, jet fuel, etc.) (BNI 1992).

A qualitative survey of the aquatic benthic invertebrate fauna at six sites along Coldwater Creek was performed in 1981. An extremely low diversity of aquatic organisms was found during the study. Field studies conducted in 1981 indicated that the stream supported limited populations of such pollution-tolerant fish species as fathead minnows, golden shiners and black bullheads. These studies indicated that the poor water quality of Coldwater Creek has limited the species diversity and type of aquatic organisms present in the watershed. There are no threatened, rare, or endangered species in Coldwater Creek. It should be noted that a detailed evaluation of impacts to the environment will be conducted during the FS-EIS development phase (ANL 1992).

At SLAPS and the Latty Avenue Properties, the bedrock groundwater is very hard and high in dissolved solids. At lower total dissolved solids (TDS) concentrations, calcium/magnesium/bicarbonate-type water is predominant. In groundwater with high TDS concentrations, sodium chloride is the dominant constituent. Major alluvia aquifers in the area are the basal sand and gravel channel fills and terrace deposits of the Meramec and Missouri rivers. Alluvial deposits may vary considerably in thickness and type of material, thereby making it difficult to establish well yield capabilities. Preliminary investigations indicate that clay is the predominant material encountered in the unconsolidated overburden. The approximate thickness and material distributions vary across the property. A clayey, fine-grained sand was consistently encountered near and parallel to Coldwater Creek. Discharge in the area is thought to be westward toward Coldwater Creek for the near-surface system and northward toward the Missouri River for the regional or deep flow direction (BNI 1992).

1.4.5 Land Use and Demography

1.4.5.1 St. Louis Downtown Site and Vicinity Properties

SLDS is located in an industrial area on the eastern border of St. Louis, about 90 m (300 ft) west of the Mississippi River. Mallinckrodt, Inc. owns the 18-ha (45-acre) site and currently uses it as a plant for the production of specialty chemicals. Numerous buildings and facilities cover a large portion of the facility, and much of the remainder is covered with asphalt or concrete. Access to the facility is limited to approximately 900 employees, 200 subcontracting construction workers, and authorized visitors (BNI 1992).

Land use within a 1.6-km (1-mi) radius of SLDS reflects a mixture of public, agricultural, industrial, commercial, and residential activities. Three of the vicinity properties are commercial/industrial properties where site features such as topography and land use are similar to those of SLDS. These are the McKinley Iron Company, the Thomas & Proetz Lumber Company, and PVO Foods. The other three vicinity properties are railroad properties that bisect SLDS from north to south. At the city property adjacent to SLDS, the surface is not paved and the property is accessible to the public. The city property is located on the west bank of the Mississippi River (BNI 1992).

1.4.5.2 SLAPS and Vicinity Properties

SLAPS is approximately 24 km (15 mi) from downtown St. Louis and immediately north of the Lambert-St. Louis International Airport. SLAPS is located between the Norfolk & Western Railroad and Banshee Road on the south, Coldwater Creek on the west, and McDonnell Boulevard and adjacent recreational fields on the north and east. The property covers 8.8 ha (21.7 acres) and is enclosed by security fencing. Land uses adjacent to the property are varied. Largely because of its proximity to the airport, more than two-thirds of the land within a 0.8-km (0.5-mi) radius is used for transportation-related purposes. The remaining land in the immediate vicinity is primarily commercial and recreational. There are no permanent buildings or facilities remaining at SLAPS. The property is grassy, with a slight incline to the east. Maintenance and surveillance, including environmental monitoring, are the only activities currently taking place at SLAPS. The nearest population center is more than 2.4 km (1.5 mi) north of the property. Approximately 1 mile northwest of SLAPS along Chapel Ridge Drive is a small residential center with about 1,500 people (BNI 1992).

The vicinity properties associated with SLAPS include Coldwater Creek, ballfield area, St. Louis Airport Authority property, Banshee Road, ditches north and south of SLAPS, and various haul roads. The St. Louis Airport Authority Property is located south of SLAPS and is used for transportation. At these locations, maximum activity levels of U-238, Ra-226, Th-230, and Th-232 in soil were 1,600 pCi/gm, 5,620 pCi/gm, 26,000 pCi/gm and 63 pCi/gm respectively (BNI 1992).

Of the approximately 67 vicinity properties along the haul roads that have been designated for evaluation of cleanup alternatives, five are occupied by homes and are zoned as residential properties. The remaining properties are zoned commercial/industrial/municipal.

Coldwater Creek, which borders the western side of SLAPS, is also considered a vicinity property. Coldwater Creek originates about 5.8 km (3.6 mi) south of the property, flows for a distance of 153 m (500 ft) along the western side of SLAPS, and discharges into the Missouri River about 24 km (15 mi) northeast of the property. The creek, including the portion that is near SLAPS, is accessible to the public. The water in Coldwater Creek is not a source of drinking water for the adjacent locality. The 10 vicinity properties near Coldwater Creek are all privately owned. The seven railroad properties are privately owned and are currently in use (BNI 1992).

1.4.5.3 Latty Avenue Properties

The Latty Avenue Properties include the Futura Coatings property, HISS, and six commercial/industrial properties on Latty Avenue. The Futura Coatings property is a commercial establishment for the manufacturing of plastic coatings. HISS currently houses two temporary waste storage piles, a 12- by 56-foot trailer used as office space for the property caretaker, and a 24- by 56-foot trailer used as a public information office. The residential areas nearest HISS are about 0.5 km (0.3 mi) to the east in the city of Berkeley. Located about 1.2 to 1.6 km (0.75 to 1.0 mi) east and southeast of the property in Hazelwood and Berkeley are several high-density residential areas that include single-family homes and apartment buildings (ANL 1992). The Latty Avenue vicinity properties include a pressed-wood container company, automobile brake and lighting company, freight company, and office for a motor oil and chemical company.

1.5 NATURE AND EXTENT OF CONTAMINATION

1.5.1 SLDS and Vicinity Properties

Characterization results for soil samples collected at SLDS indicate contamination is widespread across the property. Radioactive material is present in areas near or beneath buildings associated with MED/AEC operations. Two exceptions are Plant 5 and the city property along the Mississippi River, which were not associated with MED/AEC operations but contain levels of radioactivity exceeding DOE guidelines.

DOE applies as low as reasonably achievable (ALARA) principles to set soil cleanup guidelines. For Ra-226, Ra-228, Th-230, and Th-232 DOE guidelines recommend 5 pCi/g when averaged over the first 15 centimeters of soil below the surface; and 15 pCi/g when averaged over any 15 centimeter thick soil layer below the surface layer. In addition, DOE calculates uranium cleanup guidelines for soil on a site-specific basis. For the St. Louis site, the guidance for residual U-238 activity in soil was calculated at 50 pCi/g (BNI 1992).

The radioactive contaminants at SLDS are U-238, Ra-226, Th-232, and Th-230 and their associated decay products. Depths of contamination range from the surface to 7 m (23 ft) at SLDS proper and to 13 m (42 ft) at an adjacent property owned by the city of St. Louis. In general, chemical characterization results indicate that radioactively-contaminated soil at the property does not exhibit any Resource Conservation and Recovery Act (RCRA)-hazardous waste characteristics. However, a small percentage of the samples taken have failed the out-dated extraction procedure toxicity (EP-TOX) criterion for lead (BNI 1992). (It should be noted that additional soil samples are planned to be collected and tested for RCRA characteristics using the updated toxic characteristic leaching procedure [TLCP] test.)

Volatile organic compounds (VOCs) were detected in very low concentrations across the property; base/neutral and acid extractable (BNAE) compounds were found in higher concentrations than were VOCs, but they are typically not very mobile in soil. The organic compounds detected are commonly found in industrial areas.

The current estimate for the volume of radioactively contaminated soil that exceeds DOE guidelines at SLDS is approximately 170,800 m^3 (223,600 yd^3). In addition, contaminated building materials account for approximately 17,100 m^3 (22,400 yd^3) (BNI 1992).

Groundwater monitoring results for SLDS show that all radionuclide levels, except uranium levels in one monitoring well, are near typical background values. Groundwater background values established at a location 0.5 miles southwest of HISS and 1.5 miles southwest of SLAPS indicate concentrations for total uranium, Ra-226, and Th-230 range from less than 3 to 4 pCi/L, 0.6 to 1.1 pCi/L, and 0.2 to 0.4 pCi/L respectively. The one well that showed the presence of uranium, consistently showed elevated levels of total uranium (107 to 193 pCi/L), which indicates that uranium in this area may be leaching into the groundwater. Chemical results for groundwater monitoring indicate very low concentrations of 10 VOCs, seven of which were found in another monitoring well. Twelve metals were detected in groundwater. With the exception of zinc, the metals found in groundwater do not correspond with the metals found most frequently in soil (BNI 1992).

Sediment samples taken from the manholes at SLDS exhibited radioactive contamination; therefore, remedial action will be required on portions of the stormwater and sanitary sewers at the property.

Building surveys show that U-238 is the primary radioactive contaminant in the majority (15) of the onsite buildings. Ra-226 is the primary contaminant in two of the buildings surveyed. Building K1E has radon concentrations exceeding the DOE annual guideline of 3 pCi/L for habitable structures. This building is used only for storage at this time. Personnel do not regularly work inside the structure (BNI 1992).

1.5.2 SLAPS and Vicinity Properties

Radiological characterization results for soil at SLAPS reveal that much of the ground surface is contaminated with Ra-226, Th-230, and Th-232 in excess of DOE guidelines. Depths of contamination range from the ground surface to approximately 5.4 m (18 ft), but the contamination was generally found at 1.2 to 2.4 m (4 to 8 ft). VOCs are, in general, unevenly distributed across the property at varying depths, but none of the VOCs found are believed to have been used during uranium processing. BNAE compounds were detected in 52 of 90 soil samples collected. Most of the metals with concentrations that exceed background appear to be confined to near-surface depths [0 to 2 m (0 to 6 ft)]. Approximately 191,150 m^3 (250,000 yd^3) of contaminated soil in excess of the DOE guidelines are present at SLAPS (BNI 1992).

Groundwater monitoring results for SLAPS show that concentrations of total uranium, Ra-226, and Th-230 in several of the shallow wells at SLAPS are elevated compared to concentrations in background locations. The groundwater monitoring wells with elevated concentrations are believed to be near pockets of buried radioactive residues. Other nearby wells have substantially lower concentrations. Because SLAPS is fenced, the public has no access to these wells. There is no known consumption of groundwater in the vicinity of the property. Groundwater samples collected and analyzed for chemicals had very low concentrations of five VOCs, which may account for the slightly elevated levels of total organic halides found during sampling. The five organic compounds detected were: Endosulfin I detected in two samples at 0.06 and 0.09 ppb; 1,2- dichloroethene detected in two samples at 77 and 95 ppb; trichloroethene found in two samples at 110 and 130 ppb; toluene detected at 11, 61 and 170 ppb in 3 samples and: bis(2-ethlyhexyl) phthalate ranging in concentrations from 15 to 2,200 ppb. Phthalate is a typical laboratory contaminant and is typically found in groundwater from commercial/industrial areas. Some of the metals detected in groundwater are the same as those found in soil at the property. Total organic carbon and pH values are within the range of background levels for these constituents (BNI 1992).

Surface water samples collected from Coldwater Creek adjacent to the property since 1985 indicate that measured concentrations of total uranium, Ra-226, and Th-230 remain relatively stable and are similar to upstream concentrations. Average annual radon concentrations at SLAPS range from 0.1 to 3.6 pCi/L (BNI 1992).

Elevated levels of U-238, Ra-226, Th-230, and Th-232 were detected on some vicinity properties, with Th-230 being the primary contaminant of concern. The highest concentrations of Th-230 were found on the Norfolk and Western Railroad property adjacent to 9200 Latty Avenue (26,000 pCi/g) and in the ditches adjacent to SLAPS (15,000 pCi/g). Limited chemical characterization was conducted at the ballfield area and Coldwater Creek. Ten metals were detected in excess of background levels. VOC concentrations at the property are extremely low, with all Target Compound List (TCL) compounds at sample detection limits. One sample analyzed for pesticides/polychlorinated biphenyls had levels of dieldrin above the sample detection limit (BNI 1992).

Analytical results for sediment samples collected from the sides and center of Coldwater Creek beginning at SLAPS and continuing downstream to HISS reveal radioactive contamination at numerous locations, typically in the top 15 cm (6 in.) of sediment. Additional sampling of sediment downstream in Coldwater Creek revealed elevated concentrations of Th-230 extending approximately 9.6 km (6 mi) north of Pershall Road. However, the contamination is spotty and appears to be located in bends of the creek where natural settling would occur (BNI 1992).

The current volume estimate for radioactively contaminated soils in excess of the DOE guidelines at the ditches adjacent to SLAPS is approximately 21,562 m^3 (28,200 yd^3). At the ball field area, the radioactive contamination averages 0.3 m (1 ft) in depth, and the estimated volume of contaminated material is 38,026 m^2 (49,730 yd^3) (BNI 1992).

Four sediment samples were taken from Coldwater Creek and analyzed for chemicals. Metals results revealed four analytes that exceed both the sample detection limits and background levels; no mobile ions exceed background concentrations. Nine BNAE compounds (all polyaromatic hydrocarbons) and one VOC (acetone in low concentrations) were detected in the samples (BNI 1992).

1.5.3 HISS, Latty Avenue Properties, and Other Vicinity Properties

Th-230 is the primary contaminant in soil at the HISS property, with lesser amounts of U-238 and Ra-226 present. The depth of contamination ranges from the ground surface to 2 m (6 ft) with an average depth of 1 m (3 ft). Chemical results for soil indicate that 16 metals at concentrations greater than background are typically found in areas containing radioactive waste. One sample contained a VOC (toluene) that exceeds the detection limits but occurred in a low concentration (2.9 ppb). No TCL compounds were detected at concentrations exceeding the sample detection limit. BNAE analyses revealed two samples with hydrocarbon compounds that were unidentifiable (BNI 1992).

The estimated volume of radioactively contaminated soil at HISS in excess of the DOE guidelines, including the soil and debris in the storage piles, is approximately 53,520 m^3 (70,000 yd^3). The estimated volume of radioactively contaminated soil at Futura in excess of DOE guidelines is approximately 25,996 m^3 (34,000 yd^3) (BNI 1992).

In general, analytical results from quarterly sampling of the monitoring wells indicate that the radionuclides in groundwater are at background levels. The total uranium concentration in a well in the northwestern corner of the property is an exception, with the highest annual average from 1985 through 1989 of 82 pCi/L. The only organic compound found above detection limits during chemical sampling was bis(2-ethyl hexyl)phthalate. This compound was also detected in laboratory blanks at comparable levels and is thought to be the result of laboratory contamination. Seven metals were detected at background levels, and four metals were found at slightly elevated concentrations (BNI 1992).

Analytical results for surface water and sediment samples indicate that radionuclide concentrations have remained near background levels since 1985. The only exception is sediment samples taken from Coldwater Creek, downstream of HISS, which have concentrations of Th-230 ranging from 0.1 to 300 pCi/g (BNI 1992).

Annual average radon concentrations at HISS range from 2 to 22 x 10^{-10} μCi/ml (0.2 to 2.2 pCi/L), including background [5 x 10^{-10} μCi/ml (0.5 pCi/L)]. This average is below the DOE guideline of 3 pCi/L. Radon concentrations measured in HISS trailers are below the DOE guideline: 1.21 pCi/L in the BNI FUSRAP office trailer and 1.25 pCi/L in the public information office trailer. External gamma radiation levels were measured with TLDs at HISS at the same locations where radon was measured. Results in 1984 ranged from 0 to 1,106 mR/yr. Since 1985, measured levels have ranged from 0 to 287 mR/yr (BNI 1992).

At Futura Coatings, Inc., another Latty Avenue property, Ra-226, Th-232, and Th-230 were all found in soil at concentrations exceeding guidelines. Th-230 concentrations were detected at levels as high as 2,000 pCi/g and may be greater than indicated because the samples analyzed were primarily those with no associated gamma-emitting radionuclides present in above-guideline concentrations. The depth of contamination ranges from the surface to approximately 4.6 m (15 ft). Chemical sampling indicates that the waste does not exhibit RCRA-hazardous waste characteristics, the chemicals appear to be primarily associated with the radioactive waste. Fourteen metals are present at concentrations exceeding background levels, no concentrations of mobile ions exceed background, two VOC compounds (toluene and trichlorofluoromethane) were detected at very low concentrations (15 ppb and 1.3 ppb, respectively), and two BNAE compounds were detected. No TCL compounds were found above detection limits (BNI 1992).

No radioactive contamination was found in Futura buildings exceeding the maximum concentrations specified by DOE guidelines. Radon and air particulate monitoring in the buildings demonstrate that these structures comply with DOE guidelines for radon and the DOE radiation protection standard.

Radiological characterization of soil on the six vicinity properties indicates elevated levels of both Th-230 and Ra-226, with Th-230 (maximum concentration 5,700 pCi/g) being the primary contaminant of concern. The total estimated volume of radioactively contaminated soil for all six Latty Avenue vicinity properties is approximately 81,812 m^3 (107,000 yd^3) (BNI 1992).

Potential waste transportation routes were identified based on historical and recent maps. Samples from 28 intersections on these routes between HISS and the landfill in western St. Louis County (231 samples) were collected and analyzed for U-238, Ra-226, Th-232, and Th-230. Only two of the 231 samples exhibit Th-230 (the primary contaminant of concern) concentrations exceeding the DOE cleanup guideline.

In summary, analytical results of the surveys indicate that the highest contamination levels are at SLDS, SLAPS, and HISS, with the principal radioactive contaminants being Th-230, U-238, and Ra-226. Access to these properties is restricted. The vicinity properties, which were not directly associated with uranium processing or waste storage, exhibit lower concentrations of radionuclides; the principal radioactive contaminant is Th-230.

1.6 SUMMARY OF BRA

This section provides a discussion of the findings of the draft BRA conducted to evaluate potential risks to human health and the environment from contaminants at the St. Louis site. The discussion of the draft BRA considers the contaminants of concern at the site (Section 1.6.1) exposure assessment (Section 1.6.2), toxicity assessment (Section 1.6.3), health risk characterization (Section 1.6.4), and preliminary conclusions and recommendations (Section 1.6.5). The following information is taken from the draft BRA document, therefore it may undergo further revision (ANL 1992).

1.6.1 Contaminants of Concern

The COCs for the St. Louis site were determined based on history of site operations and available characterization and environmental monitoring data. An evaluation procedure as recommended by EPA guidance was applied to St. Louis site data to determine the list of radionuclides and chemicals of concern. The procedure screened all detected contaminants with regard to parameters such as analytical methods used, comparison with background, relative toxicity, and role as essential nutrients.

Based on a review of the data, the radionuclides in the U-238, Th-232, and U-235 decay series are the major radioactive contaminants of concern. The decay series is shown in Figures 1-8, 1-9, and 1-10 respectively. The contaminants of concern that were identified (Table 1-1) also included inorganic chemicals (19 metals and 2 inorganic anions) and a number of organic compounds.

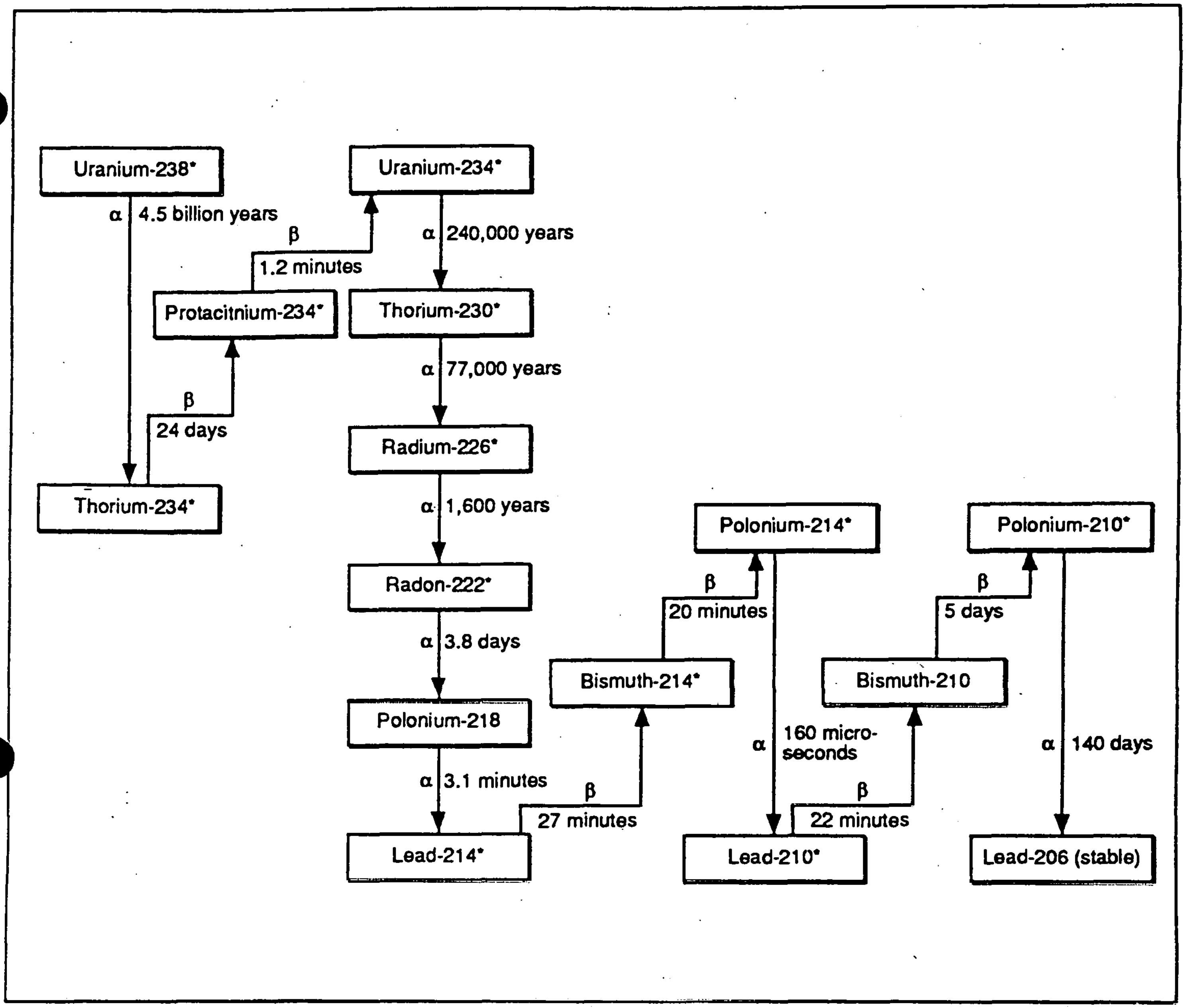
The radioactive contaminants of concern have been identified in soil, groundwater, surface water, sediment or sludge, and structural surfaces. The chemical contaminants have been identified in soil and groundwater.

1.6.2 Exposure Assessment

1.6.2.1 Contaminant Fate and Transport

Potential human exposure pathways were identified on the basis of the presence of a complete pathway, i.e., the presence of a source and a mechanism of contaminant release, an environmental transport medium, a point of human contact with the contaminated source or medium, and a route of human exposure at that point.

The primary sources of contamination at the SLDS area are surface and subsurface soil and contaminated structural surfaces. At SLAPS and HISS (including all associated vicinity properties), the main source of contamination is surface and subsurface soil. In addition, two covered stockpiles of contaminated material stored at HISS are potential sources of exposure.

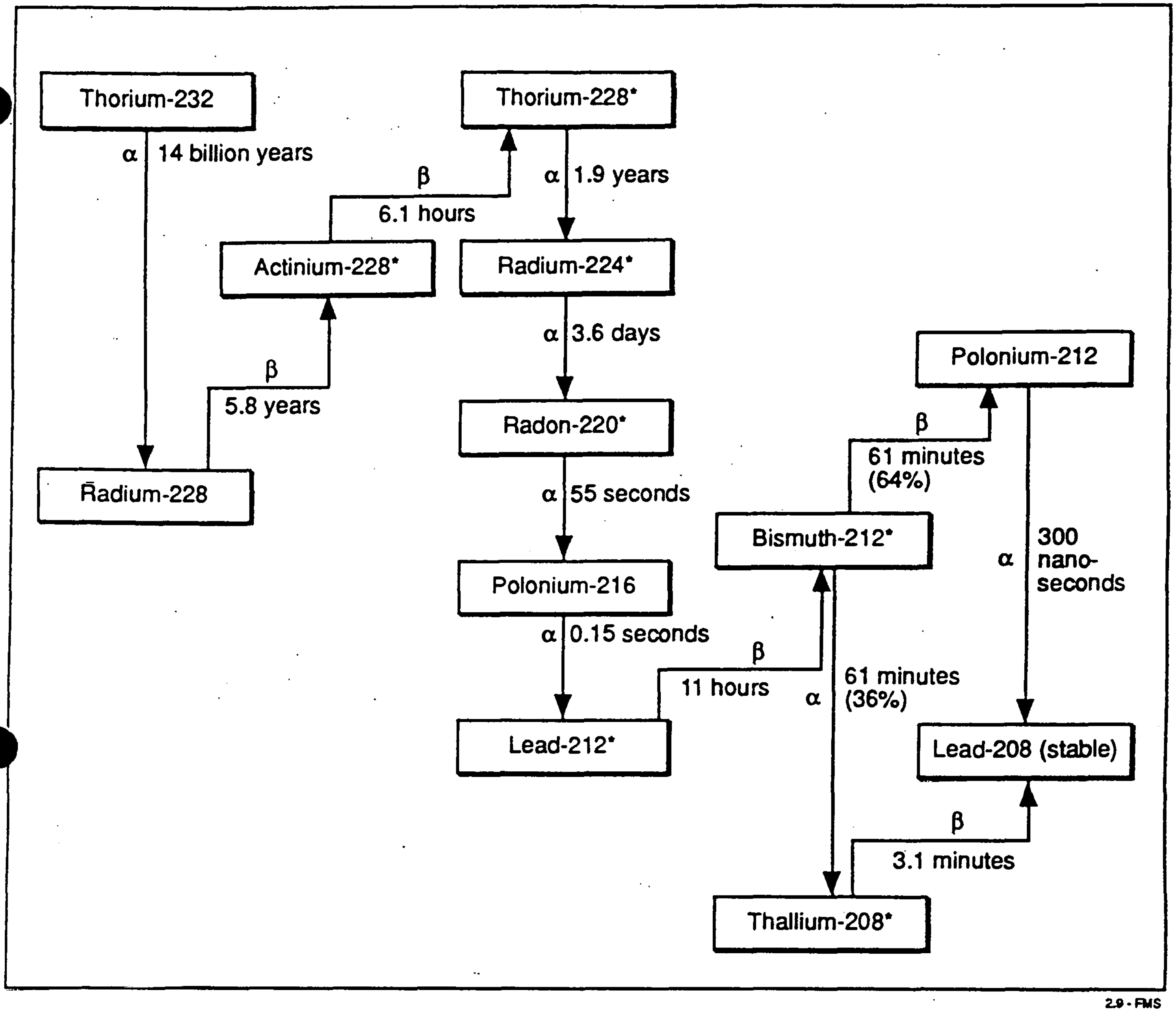


BNI 1991

NOTES

- Only the dominant decay mode is shown.
- The times shown are half-lives.
- The symbols α and β indicate alpha and beta decay.
- An asterisk indicates that the isotope is also a gamma emitter.

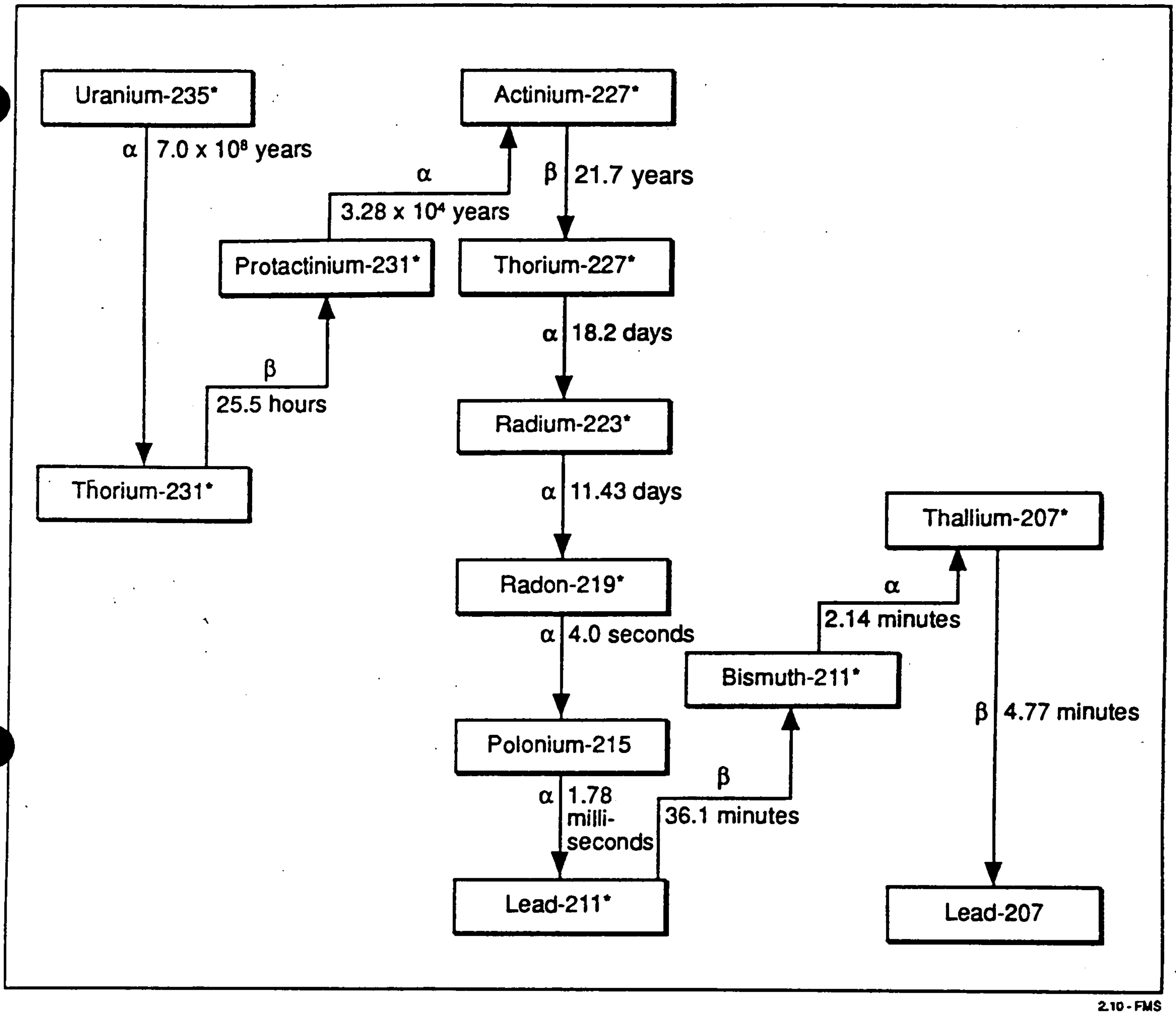
Figure 1-8. Uranium-238 Radioactive Decay Series



NOTES

- Only the dominant decay mode is shown.
- The times shown are half-lives.
- The symbols α and β indicate alpha and beta decay.
- An asterisk indicates that the isotope is also a gamma emitter.

Figure 1-9. Thorium-232 Radioactive Decay Series



NOTES

- Only the dominant decay mode is shown.
- The times shown are half-lives.
- The symbols α and β indicate alpha and beta decay.
- An asterisk indicates that the isotope is also a gamma emitter.

Figure 1-10. Actinium (Uranium-235) Radioactive Decay Series

Table 1-1. Contaminants of Concern for the Human Health Assessment

Radionuclides	Metals	Inorganic Anions	Organic Compounds
Actinium-227	Antimony	Fluoride	Benzene
Lead-210+D	Arsenic	Nitrate	Bis(2-ethylhexyl)phthalate
Protactinium-231	Barium		Chlorobenzene
Radium-226+D	Beryllium		4,4'-DDT
Radium-228+D	Boron		1,2-Dichlorobenzene
Radon-222	Cadmium		1,2-Dichloroethene
Thorium-228+D	Chromium		1,2-Dichloropropane
Thorium-230	Cobalt		Endosulfan
Thorium-232	Copper		PAHs[a]
Uranium-234	Lead		PCBs
Uranium-235+D	Manganese		Toluene
Uranium-238	Molybdenum		Trichlorethene
	Nickel		Vinyl Chloride
	Selenium		
	Silver		
	Thallium		
	Uranium		
	Vanadium		
	Zinc		

[a] Only the carcinogenic PAHs at the site are included in this risk assessment: these are benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

D Daughter products

The environmental release mechanisms and transport pathways that were considered under current conditions were external gamma radiation from radioactively contaminated materials (including soil and structural surfaces), radon gas generation from radium-contaminated soil, and wind dispersal of fugitive dust generated from contaminated site soil. Additional release mechanisms and transport pathways considered in the future units include leaching of soil contaminants to groundwater and bio-uptake of soil contaminants by plants with subsequent ingestion of contaminated drinking water and produce, respectively (ANL 1992).

1.6.2.2 Potential Receptors and Routes of Exposure

Receptors identified for current and hypothetical site use conditions at the site properties, and the pathways assessed (i.e., quantified) for each of these receptors are presented in detail in the BRA prepared for the sites. The receptors identified for current site use include an employee and a maintenance worker at the SLDS and the SLDS vicinity properties, a recreational user at the city property adjacent to the SLDS; a trespasser and a maintenance worker at the SLAPS; a recreational user at the ballfield, a child commuter and a resident at the residential vicinity properties, a recreational user at Coldwater Creek, an employee at Futura Coatings property and all commercial/municipal/transportational vicinity properties, and a trespasser and a maintenance worker at HISS (ANl 1992).

The pathways assessed for current units were external gamma irradiation, incidental soil ingestion, inhalation of particulates, and inhalation of Rn-222 and its decay products. Potential exposure to chemical contaminants for the current receptors at SLDS was not assessed because most of the site is covered with buildings and paving. Exposure to groundwater at the sites was not considered. Groundwater is considered to be of poor quality and is not used as a source of drinking water (ANL 1992).

The hypothetical future receptors were identified as a future resident at all properties except at Coldwater Creek, where a recreational user receptor was assessed. In addition to the pathways assessed for current receptors, potential risk from the ingestion and inhalation of contaminants in groundwater and the ingestion of homegrown produce were also assessed for the future residents. Although considered to be unlikely, a future resident unit at SLDS with buildings and paving surfaces removed was also included (ANL 1992).

1.6.2.3 Exposure Point Concentration, Doses, and Intakes

Estimation of chemical intakes for each pathway were based on procedures documented in the EPA guidance for human health risk evaluation (EPA 1989), with adaptations relevant to St. Louis site conditions and exposure units. Radiological doses were estimated in terms of the 50-year committed effective dose equivalent (CEDE). The RESRAD computer code (Gilbert et al. 1989) was used to calculate radiological doses.

1.6.3 Toxicity Assessment

Potential carcinogenic risks from exposures to radiation were estimated using generally accepted values to convert from estimated doses [in mrem or in working level month (WLM) for radon exposures] to the likelihood of cancer induction. The potential for carcinogenic and noncarcinogenic effects of human exposure to chemicals was quantified using standard EPA slope factors and reference doses (RfDs) (ANL 1992).

1.6.4 Risk Characterization

Potential carcinogenic risks for both radiological and chemical exposures were assessed in terms of the increased probability that an individual will develop cancer over the course of a lifetime. EPA has identified a target range of 1×10^{-6} to 1×10^{-4} for the maximum acceptable incremental cancer risk to an individual from exposures at NPL sites.

1.6.4.1 Risk Estimates for Current Site Use

The radiological risks (including the radon pathway) estimated for current site use by residential, commuter, and recreational receptors at the ballfield, residential vicinity properties and at Coldwater Creek, were within the target risk range (i.e., 1×10^{-4} to 1×10^{-6}) generally considered acceptable by EPA. The recreational use scenario for the city property produced an estimate of risk that did not exceed the 10^{-4} level. Where evaluated, the carcinogenic risk from radon and its decay products was a major portion of the overall risk from radionuclides.

The total chemical carcinogenic risk combining all pathways for each current receptor was within the target risk range recommended by EPA, except for the maintenance worker at HISS. The total carcinogenic risk estimated for the maintenance worker at HISS was 1.1×10^{-4}, with the primary contribution from arsenic via the soil ingestion pathway (ANL 1992).

The chemical hazard index estimated for every current receptor was under the reference index of 1 with the exception of the receptors at HISS. The trespasser and maintenance worker receptors at HISS incurred hazard indexes of 1.4 and 7.6, respectively, with primary contribution from thallium (85 percent) via the soil ingestion pathway (ANL 1992).

1.6.4.2 Risk Estimates for Hypothetical Future Site Use

The future scenarios assessed in the risk assessment were those considered to be conservative depictions of potential means of exposure. The future scenario considered for the St. Louis site was that of a hypothetical onsite resident, except for Coldwater Creek where a hypothetical recreational user was assumed.

For the future scenarios, a potential resident at the HISS property would incur the highest risk from exposure to radionuclides. Inhalation of radon and its decay products is the highest contributor of all radiological pathways assessed for the future resident receptor at all properties, causing the total carcinogenic risk to be as high as 7.0×10^{-2} for a future resident at SLAPS. Ingestion of groundwater and of homegrown produce are the highest of the nonradon radiological exposure sources, and at some sites were the major sources. A recreational user was assessed for future scenario at Coldwater Creek. The highest total carcinogenic risk from all exposure rates for radionuclides was 1.1×10^{-1} for a future resident at SLAPS (ANL 1992).

The chemical carcinogenic risks for the future resident at the St. Louis site are primarily due to ingestion of groundwater containing arsenic and beryllium. The future resident at HISS would incur the highest chemical carcinogenic risk from the ingestion of soil and groundwater (ANL 1992).

Combining the radionuclide and chemical exposure identifies the SLAPS maintenance worker to have the highest carcinogenic risk at 1.1×10^{-3}.

1.6.5 Preliminary Conclusions and Recommendations

From the results of the human health risk assessment, it can be concluded that the highest potential health impacts associated with the St. Louis site result from postulated future residential use of contaminated properties. Under current site conditions and uses and on the basis of the assumptions used for this BRA, the potential health impacts to the maintenance worker at the site are at the upper end of EPA's target risk range or above the level of concern for noncarcinogenic effects. However, actual risk to this receptor may, in reality, be much lower because of health and safety and other precautionary measures already observed by the maintenance workers at this site. In addition, results from a conservative trespasser scenario assessed for the HISS site indicated potential risk within the target risk range for chemical exposure and just slightly above the target risk range for radiological exposure (ANL 1992).

Because of the inherent uncertainties in the risk assessment process, the results of the human health assessment should not be taken to represent absolute risk. Rather, they should be considered to represent the most important sources of potential risk at the site, which, once identified, may be evaluated in more detail and dealt with as appropriate in the remedial action process.

1.7 OBJECTIVES OF REMEDIAL ACTIONS

Based on the risk assessment conducted for the site, the highest potential health impacts resulted from future exposures at the site. Under current site conditions, the potential risks to human health and the environment can be classified as minimal. The objectives for remedial actions at the sites are summarized below.

1.7.1 Purpose and Need for Decision

As specified in the NCP (NCP: 55 FR 8666), the principal objective of the FS is to develop, evaluate, and select appropriate alternatives for waste site remediation. EPA indicates that this effort should be fully integrated with the results of the RI.

In the FS, remedial action objectives for contamination at the waste site are developed for two primary purposes:

- as a tool in selecting of the most appropriate remedial alternative; and
- as a benchmark for determining or projecting when waste site remediation has been successfully accomplished.

The overriding objective is to ensure protection of human health and the environment by eliminating or controlling risks posed by all exposure pathways of concern.

1.7.2 Remedial Objectives

The overall objectives of remedial action at the St. Louis site are to eliminate, reduce, or otherwise mitigate the potential for release of hazardous contaminants from the soils, sediments, and groundwater at the site, and to minimize threats to the public and the environment resulting from these contaminants. The specific objectives of the proposed remedial actions are to:

- eliminate or reduce public and environmental hazards associated with the contaminated soils, sediments, and groundwater at the site;
- minimize potential health hazards to onsite personnel performing the remedial actions; and
- facilitate subsequent response actions at the site, if required.

For the purpose of the current task of identification and evaluation of technologies, certain assumptions were made for the cleanup levels and health and environmental standards that will be relevant and applicable. The specific cleanup concentrations and ARARs will be identified during the detailed evaluation phase of the FS-EIS. For all areas released for unrestricted use, it was assumed that concentrations of Ra-226, Ra-228, Th-230, and Th-232 will not exceed 5 pCi/g when averaged over the first 15 centimeter of soil below the surface; and 15 pCi/g when averaged over any 15 centimeter thick soil layer below the surface layer. These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232, and assume secular equilibrium. If both Th-230 and Ra-226 or both Th-232 and Ra-228 are present and are not in secular equilibrium, the appropriate guideline is applied as a limit for the radionuclide with the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that the sum of the ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed one. (DOE Order No. 5400.5, Chapter IV).

These guidelines also represent allowable residual concentrations above background averaged across any 15 cm-thick layer to any depth, and over any contiguous 100 m^2 surface area. In addition, it was assumed that all applicable regulations pertaining to transportation, packaging and shipping, interim storage, and final disposal would be relevant and appropriate requirements. The cleanup level for uranium in soils and sediments is calculated on a site-specific basis taking into consideration the exposure pathways and the risks associated with each pathway. For the St. Louis site, a concentration of 50 pCi/g of residual U-238 activity has been computed as a preliminary health-based limit.

2. IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

2.1 INTRODUCTION

The purpose of this screening is to produce a range of suitable technologies and remedial options that can be assembled into complete remedial alternatives capable of mitigating risk associated with the existing contamination at the St. Louis site. In accordance with EPA guidance (EPA 1988), a structured process has been conducted to identify and screen potential technologies for remediation of the Missouri sites.

The process consists of: 1) developing basic response actions (i.e., collection, treatment and disposal of contamination) that address the remedial action objectives and cover the scope of possible remediation activities for the affected sites, 2) identifying remedial options (e.g., soil washing, institutional controls) that could be applied to each of the response actions, and 3) a preliminary evaluation and an initial screening of the remedial options. Evaluation of the viable remedial options was based on the criteria of effectiveness, implementability, and cost to define the set of options that can be used to develop alternatives that address the site as a whole.

The affected media of concern at the St. Louis site consists of subsurface and surface soils, Coldwater Creek sediments, groundwater, surface water, and buildings and structures (principally at SLDS). The total volume of contaminated soils and building debris/rubble at the St. Louis site exceeding the DOE guidelines is estimated at approximately 900,000 yd^3.

For the purpose of screening technologies and process options, the contaminated media have been placed into three major groupings — groundwater/surface water, soils/sediments, and buildings/structures— since the remediation options are essentially the same for media within the three groups.

The following presentation of the initial screening and preliminary evaluation of remedial options consists of a general listing of the basic response actions for remediation of the St. Louis site (Section 2.2) and identification of viable remedial options for soils/sediments (Section 2.3), surface water/groundwater (Section 2.4), and buildings/structures (Section 2.5). The preliminary evaluation and initial screening results of the viable remedial options are presented in Section 2.6. The potentially applicable remedial options that were retained for further consideration are summarized in Section 2.7.

2.2 GENERAL RESPONSE ACTIONS

General response actions are measures which satisfy remedial action objectives. Soils and sediments are the major contaminated media at the sites. Remedial actions proposed are aimed at reducing impacts to human health and the environment from future exposures.

The general response actions considered appropriate for the contaminated soils at the sites, surface water and sediments in Coldwater Creek, groundwater, and buildings and structures include the following:

- no action,
- institutional controls,
- containment,
- contaminant collection/removal,
- treatment (in situ, onsite, offsite or any ancillary treatment processes), and
- disposal/discharge (onsite, offsite; includes interim storage actions that might be required, and transportation and containerization actions required prior to disposal.).

2.3 IDENTIFICATION OF REMEDIAL OPTIONS FOR CONTAMINATED SOILS/SEDIMENTS

For each response action described in Section 2.2, the universe of remedial options was reviewed for applicability to the soil and sediment contamination and basic site conditions at the St. Louis site. This preliminary review is designed to establish the overall set of remedial options and to eliminate those options that do not realistically apply to the site. The results of this review are presented in Table 2-1.

2.3.1 No Action for Soils and Sediments

Under no action, no remedial alternative would be implemented and the current status of the sites would continue unabated. This response action will be retained throughout the FS-EIS evaluation, as it represents the current site conditions, and serves as a baseline option for the CERCLA and NEPA evaluation process.

Table 2-1. Identification of Remedial Options for Soils/Sediments at the St. Louis Site

Response Action	Remedial Options	Description of Remedial Option	Comments
1. No Action	None	No action taken to reduce risk. May include an environmental monitoring program.	Required for consideration by NCP and NEPA.
2. Institutional Controls/Site Maintenance	Site Security • Fencing/Signs	Restrict access with fence; post warning signs.	Easily implementable at SLAPS, SLDS, and HISS, but not at other locations.
	Land Use/Controls • Deed Restrictions/Property Requisition	Initiate deed restrictions to constrain future use of the site. Could also include purchase of land and easements as necessary to implement remedial actions.	Implementable, but may require buying of property.
	Environmental Monitoring • Monitoring of Media	Periodic sampling to identify increasing or decreasing risks.	Implementable at all locations.
3. Containment	Capping		A cap would reduce direct contact exposure to contaminated soils and reduce leachate production.
	• Clay	Place compacted clay with soil over contaminated media.	Potentially applicable in reducing direct contact exposure. Would be compatible with addressing radioactive contaminants as well.
	• Asphalt	Spray application of a layer of asphalt over areas of contamination.	Potentially applicable.
	• Concrete	Installation of concrete slabs over contaminated areas.	Potentially applicable.
	• Multi-layered Cap	Layers of different media over areas of contamination.	Potentially applicable.
	Soil Cover • Topsoil and Vegetative Layer	Place topsoil and vegetative layer over areas of contamination.	Potentially applicable in reducing contact with contaminated soils/sediments.

Table 2-1. (continued)

Response Action	Remedial Options	Description of Remedial Option	Comments
4. Collection	<u>Excavation</u>	Physical removal of contaminated soil/sediment (by bulldozer, backhoe, dragline, or clamshell bucket).	Implementable; however, considerations should be given to address impacts that could result to human health and environment, especially at Coldwater Creek and residential vicinity properties.
5. Treatment			
• Onsite/Offsite	<u>Volume Reduction Processes</u>	Volume reduction processes can be accomplished by physical or chemical methods. Chemical extraction techniques use chemicals to extract the contaminants from soils. Physical separation techniques are mechanical methods for separating mixtures of soils to obtain a concentrated form of the desired fraction. Other ancillary treatment technologies may be required to support containment, treatment or disposal actions.	Considering the nature of contamination in the soils and the presence of clay in the soils reducing the required permeability, in situ treatment was not considered applicable. Resultant extract may result in the generation of mixed wastes for further treatment and/or disposal.
	• Soil Washing	Contaminants extracted from soil using water, surfactants, acids, or bases. Detoxified soil is returned to site or disposed of offsite. Concentrated wastewater requires additional treatment.	Potentially effective for treatment of uranium, but not as much for radium and thorium. Volatile and nonvolatile organics and metals can be treated as well. Interference results from fine solids.
	• Organic Solvent Extraction	Contaminants extracted from soil using organic solvents. Detoxified soil is returned to site or disposed of offsite. Concentrated wastewater requires additional treatment for chemicals and soluble radionuclides.	Potentially effective for treatment of radionuclides (principally uranium and radium), and volatile and nonvolatile organics and metals. Interference results from fine solids.

Table 2-1. (continued)

Response Action	Remedial Options	Description of Remedial Option	Comments
5. Treatment (continued)	Volume Reduction Processes (continued)		
	• Screening	Mechanical separation of particles based on size.	Screens are subject to plugging which could decrease efficiency.
	• Classification	Separation of particles occurs according to their settling rate in a fluid, usually water.	Soils with a lot of clay and sandy soil with humus material are very difficult to process.
	• Flotation	Used for separation of particles in the size range of 0.1 to 0.01 mm.	A suitable additive should be added usually to make flotation effective.
	• Gravity separation	Separation of particles occurs due to difference in material density. Separation is also influenced by particle size, shape, and weight.	One drawback of gravity concentration equipment is the low handling capacity. Clean water is also required.
	Immobilization Processes		
	• Vitrification	High temperature is used to reduce organic compounds to carbon monoxide, hydrogen, and carbon. Radionuclides and inorganic compounds become entrained in glass and siliceous metals.	Potentially effective for radioactive contaminants, volatile and nonvolatile metals, and organic compounds.
	• Solidification	Immobilize contaminants by adding a solidifying agent (e.g., polymer, cement, fly ash, lime) to excavated soils; mix and cure to form a solid low-permeability matrix.	Demonstrated effectiveness for treatment of radionuclides, and volatile and nonvolatile metals. Treatability testing may be necessary to obtain the appropriate mix of reagents.

Table 2-1. (continued)

Response Action	Remedial Options	Description of Remedial Option	Comments
6. Disposal/Discharge		Disposal of contaminated soils can be accomplished onsite or offsite. Prior to disposal, interim storage may be required. Storage can be onsite in covered piles or indoors in a properly designed building. Offsite storage can be at a federally managed facility. Material may have to be appropriately containerized prior to disposal and transported in bulk via trucks or rail.	
	<u>Onsite Disposal</u>		
	• Designed Land Encapsulation	Excavated soils are redeposited onsite at a location that has been provided with complete barrier protection.	May be difficult to implement because of public opposition. Potentially applicable.
	<u>Offsite Disposal</u>		
	• Offsite Disposal at Dedicated In-State Facility	Disposal occurs in a designed land encapsulation cell at a location within the state of Missouri.	Locating a site may be politically and socially sensitive. Potentially applicable.
	• Federal Facility	Disposal occurs at an existing federally-managed facility with the capacity to accept wastes.	Potentially applicable.
	• FUSRAP Dedicated Facility	Disposal occurs at a federally-managed dedicated FUSRAP facility.	Potentially applicable.
	• Offsite Disposal at Commercially Licensed Facility	Excavated soils are redeposited offsite at a location that has all pertinent licenses and permits to accept site wastes.	Potentially applicable. An appropriately-licensed offsite facility location may be difficult to identify.
	• Land Spreading	Low-level contaminated waste is excavated, transported, and spread on unused land ensuring that radioactivity levels approach the natural background level.	Selection of a site would be a politically and socially sensitive issue. Land spreading also may contribute to a nonpoint source pollution problem generated by native soils.

Table 2-1. (continued)

Response Action	Remedial Options	Description of Remedial Option	Comments
6. Disposal/Discharge (continued)	• Disposal in Geologic Repositories	Underground mines are used to provide secure and remote containment of contaminated soil.	Use of an abandoned mine would involve the cost of reconstruction and may pose safety problems.
	• Disposal in Geologic Repositories	Existing, worked-out, underground mines are used to provide secure and remote containment to contaminated wastes.	Use of an existing, underground, abandoned mine would involve the cost of reconstruction and may pose safety hazards.
	• Beneficial Reuse	Contaminated soils are buried under hard surface public roads or airport runways.	Same as for land spreading.

2.3.2 Institutional Controls/Site Maintenance for Soils and Sediments

Institutional control measures employ options that restrict access to contaminated areas by physical means (e.g., fencing) or by establishing controls through legal channels (e.g., deed restrictions). Technologies associated with this category involve activities capable of reducing exposure to the contamination but do not reduce the volume, mobility, or toxicity of the contaminants. Environmental monitoring is usually a component of such options to determine migration and natural attenuation of contaminants at the site. Available institutional controls (fencing/posting of signs at the site, deed restrictions, and continued monitoring) can be maintained at the St. Louis site. At properties DOE does not own — such as the haul roads, Coldwater Creek and SLDS — deed restrictions and other physical access restrictions may be difficult to apply. In order to implement fencing/sign access controls, properties may have to be purchased. The National Contingency Plan (NCP) 40 CFR 300 states that institutional controls may be employed. Specifically, the plan says "EPA expects to use institutional controls such as ... deed restrictions to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants, or contaminants."

2.3.3 Containment for Soils and Sediments

Containment actions include technologies that involve little or no treatment but protect human health and the environment by physically precluding contact with the contamination. The contaminated media is not chemically or physically changed, nor are the volumes of contaminated media reduced. Containment response actions also provide means by which contaminant migration and exposure routes are reduced or eliminated by physical barriers.

Engineered caps and soil covers can be used to cover the contaminated soils and sediment at appropriate locations at the site to prevent direct contact of the waste by the public, and to minimize the diffusion of radon gas. Barrier materials can be either natural low-permeability soils (e.g., clay) or synthetic membrane liners, or both. A cap might consist of several feet of compacted clay, and extending a few feet beyond the perimeter of the contaminated area. Capping does nothing to eliminate the source of radioactivity from the areas of concern. It simply impedes release by shielding and trapping. Specific capping options include clay, asphalt, concrete, and multi-layered caps.

2.3.4 Contaminant Collection/Removal for Soils and Sediments

These response actions do not involve treatment but may be used in conjunction with treatment and/or disposal methods when developing remedial alternatives. They include excavation/removal of soils and sediments.

For soils and sediments, removal of the contaminated areas of concern would involve excavation/removal through physical means (i.e., using a backhoe, dragline, bulldozers, front-end loaders and scrapers). The total extent of contamination in the soils/sediments at the site is expected to be approximately 635,000 m^3 (830,000 yd^3). If this response action were used, surface water runoff controls would need to be considered during the excavation/removal process.

2.3.5 Treatment for Soils and Sediments

Treatment options include technologies that specifically reduce the toxicity, mobility, and/or volume of contaminants by physical, chemical, or biological processes. CERCLA, as amended, favors treatment processes that reduce contaminant mobility, toxicity, or volume, unless site conditions limit feasibility. Radioactive contaminants are not destroyed by treatment technologies. The volume of contaminated material may be reduced, but the concentration of contaminants will be much higher in the reduced volume. Some type of containment and/or disposal will be required as an element of the final remedy for the St. Louis site. Treatment options that will be considered could serve to reduce the volume of wastes that will have to be disposed of, or immobilize the contaminants for ultimate disposal.

For the initial screening efforts, the treatment options for soils and sediments have been categorized into three basic methods: in situ treatment, onsite treatment, and offsite treatment as described below.

In situ

Application of in situ treatment for the contaminated media allows the hazardous nature of the media to be addressed in place. In situ treatment is preferable when removal is not feasible and in situ permeabilities promote easy dispersion of treatment reagents. The advantages of in situ treatment are:

- it does not require handling the media and thus reduces the risk of exposure, as well as, the risk associated with excavation and transport,
- disposal of waste materials is minimized, and
- it results in minimal disturbance to existing site.

For the in situ treatment option, immobilization technologies such as vitrification and solidification, and in situ chemical extraction methods can be considered. In situ vitrification can be used to convert radioactively-contaminated soils into a stable, glass-like solid mass. This is accomplished by setting up electrodes within the boundary of the contaminated soils at the site and passing an electric current through the electrodes. The soils within the boundary are heated to their melting temperatures and solidify to a glassy mass upon cooling. There are several drawbacks to in situ vitrification. The high temperatures required for the process will destroy any life forms in the soils not only within the vitrification boundary but, for a large area outside the boundary. It would also be difficult to ensure that all wastes have been vitrified within the in situ matrix. Conducting the process in situ would mean that only centralized areas of contamination could be vitrified and scattered hot spots of contamination could not be treated. For example, implementation of in situ vitrification at vicinity properties would be impractical due to the highly dispersed and heterogenous nature of affected media. Because of the uncertainty of the effectiveness of the in situ process, and the significant negative environmental impacts that would result, the in situ vitrification option will not be considered further.

In situ solidification can be achieved by injecting a solidifying agent into the contaminated material in place. If successful, the contaminated material will be bound together within a solidified matrix. Application of in situ solidification requires extensive and detailed testing on a bench and pilot scale. It may be difficult to ensure whether solidification has been effective on the complete soil mass. Because the method is being conducted in situ, only centralized areas of contamination can be treated and scattered pockets of contamination may have to be addressed by some other method. Implementation at vicinity properties, for example, is impractical because of the highly dispersed and heterogenous nature of the affected media. The treated area and the large surrounding area of buffer zone may be restricted in future land use. Because of the uncertainty in the effectiveness and implementability of the technology and the significant negative impacts, in situ stabilization/solidification will not be considered further.

Some form of in situ chemical extraction could be attempted by injecting a solubilizing solution into the ground through injection wells. Recovery wells would then have to be installed to withdraw the solution and treat it further to remove the radioactive contaminants. In situ solution mining has been used by the uranium extraction and processing industry in areas with high radioactivity levels in the western U. S. For the St. Louis site, extensive site testing and evaluation would have to be conducted at a bench and pilot scale to determine if this technology would be effective for the low activity levels in the site soils. The technology has been principally used in sandy soils found in the western U. S. The soils at the St. Louis site are not sandy and comprise a complex mixture of clay and silts. Contamination of the groundwater aquifer could occur because of the inherent difficulty in controlling the treatment process. Because of the uncertainty regarding the effectiveness of the technology on the site soils, and negative environmental impacts that could result, this technology has been eliminated from further consideration. In situ treatment methods will, therefore, not be considered further.

Onsite Treatment

The onsite treatment response allows for the treatment of contaminated media to be addressed in above-ground units within the site boundaries. It first requires removal of the contaminated media.

Onsite treatment has several advantages over in situ treatment. First, it allows for the treatment of contaminated material in aboveground units where the process environment can be controlled to provide greater reliability and effectiveness for any given treatment process over in situ applications. Second, the treatment technology for aboveground processes is more advanced than for in situ treatment applications. Finally, the advantages of consolidating the material to be treated and the ability to mix or otherwise handle it, greatly increase the cost effectiveness of most treatment processes over in situ applications.

Onsite treatment technologies evaluated include volume reduction technologies and those that immobilize the radionuclides within a waste matrix. The result of using volume reduction techniques is a smaller volume of more concentrated radioactive waste that will require transportation and disposal, and a volume of materials of much lower activity that may be subject to disposal as a nonradioactive waste. Technologies identified for volume reduction can be classified as chemical recovery of radionuclides or as physical separation of materials into fractions of different activities. Physical separation can include screening, classification, flotation, or gravity separation.

Immobilization technologies reduce the leachability of the radioactive contaminants by binding them within an impervious matrix, and minimize radon emissions by reducing the material porosity. Stabilization/solidification and vitrification have been identified as immobilization technologies that can be considered for the St. Louis site. Immobilization technologies can also be used as a preprocessing step prior to ultimate disposal. The technologies would facilitate transportation and offsite disposal of radioactive contaminants with the use of containers.

Offsite Treatment

This response involves the contaminated media being completely removed from the site and treatment performed at a full-scale, fixed offsite facility. Potential treatment processes would include those discussed under onsite treatment. The process of offsite treatment involves removing the contaminated media, possible pretreatment, containerization, and transportation to an offsite facility. This facility would require appropriate permits to accept the wastes. All permits required for the transportation of the waste must be obtained as well.

There are no known or anticipated offsite facilities for treatment of the waste present at the St. Louis site. Several options are available to dispose of the contaminated soils and these are discussed in Section 2.3.6. Before any offsite facility can be sited, extensive pilot tests, design and permitting procedures would have to be conducted.

2.3.6 Disposal/Discharge for Soils and Sediments

Disposal/discharge actions address the ultimate fate of the collected or treated contaminated materials. For the St. Louis soils, these actions could involve storing materials on an interim basis until a final disposal site is identified, and containerization and transportation options prior to ultimate disposal of the soils. As mentioned earlier, during remediation of a site containing radionuclides, there are always some materials that will require final disposal.

At the St. Louis site, removing and storing waste materials may be necessary, in the short-term, to facilitate a phased approach to remediation entailing excavation, pretreatment, and disposal. In particular, it may be required until a final disposal site is identified. Interim storage can be accomplished onsite or offsite. Onsite interim storage options could include covered waste piles, outdoor storage of containerized soil, and indoor storage. All storage options considered must prevent dispersal of contaminated material by wind or runoff and limit radon emissions to acceptable levels. In addition, gamma radiation exposures to personnel onsite and the public should be within acceptable levels.

Transportation options include truck, barge, or rail. Transportation of the contaminated soils/sediments from the St. Louis site will require compliance with regulations controlling the radioactivity level of the soils. Waste soils may have to be containerized appropriately to provide shielding requirements and comply with applicable Department of Transportation (DOT) and disposal facility waste acceptance criteria of the receiving facility. Appropriate containers include 55-gallon drums, steel or wood boxes, and bulk transportation. (Immobilization technologies would be used to bind the soils into a solid block.)

Onsite disposal enables the treated media to be handled onsite without the need for offsite transportation requirements. Disposal could occur in a designed encapsulated cell which would be built onsite. The soil would be moved only when the cell is constructed.

Offsite disposal/discharge involves completely removing either treated or untreated media and disposing of it offsite. All necessary permits for transportation and disposal of the waste would have to be obtained. Offsite disposal options could include: disposal at an existing federally-managed facility; land encapsulation at a designed facility within the state of Missouri; disposal at a commercially-licensed facility; disposal at a FUSRAP dedicated facility; land spreading; disposal in geologic repositories; and road bed dispersal.

2.4 IDENTIFICATION OF TECHNOLOGIES FOR GROUNDWATER AND SURFACE WATER

Table 2-2 summarizes the preliminary review of remedial options that can address the contamination in the groundwater and control surface water flow at the St. Louis site. Surface water control options would be required during dredging of contaminated sediments from selected hot spots in the creek. The results of this review are briefly outlined by response actions as follows.

2.4.1 No Action for Surface Water and Groundwater

Under no action, no remedial action is taken to reduce risk and the current status remains unchanged. This remedial option will remain applicable throughout the FS-EIS evaluation as it represents the current site conditions, and serves as the baseline case for the CERCLA and NEPA evaluation process.

2.4.2 Institutional Controls for Surface Water and Groundwater

Institutional controls (access restrictions, deed restrictions, and site posting) are considered potentially applicable for the St. Louis site. Access and deed restrictions and site posting may control public access through the use of fencing, signs or controlled property ownership.

2.4.3 Containment Options for Surface Water and Groundwater

For groundwater containment, actions involve separating the contamination source from the water and controlling migration of groundwater from the site through the installation of vertical or horizontal barriers. The barrier walls which might be in the form of slurry walls, grout curtains, or steel sheet piling must be constructed down to an impermeable natural horizontal barrier such as a clay zone or bedrock, in order to effectively impede groundwater flow. This may be difficult to implement. A barrier wall would be more effective in conjunction with a surface cap.

Table 2-2. Identification of Remedial Options for Surface Water/Groundwater at the St. Louis Site

Response Action	Remedial Option	Description of Remedial Option	Comments
1. No Action	None	No action taken to reduce risk. Will include water quality analyses to monitor contaminant migration and assess future environmental impacts.	Required for consideration by NCP and NEPA.
2. Institutional Controls/Site Maintenance	Institutional Actions		
	• Deed Restrictions/Physical Site Access	Implement zoning and deed restrictions to prohibit use of groundwater and surface water within and around the sites.	Groundwater is currently not used as a potable supply. Groundwater restrictions may be implemented in the future. Controls at Coldwater Creek may be difficult to implement.
	Environmental Monitoring		
	• Groundwater Monitoring	Perform water quality analyses to monitor contaminant migration and assess future environmental impacts.	Strategic locations should be chosen for monitoring.
3. Containment and Surface Water Controls	Vertical Barriers		Slurry walls, grout curtains, or sheet piling need to be keyed into low-permeability strata. This may be difficult to implement.
	• Slurry Walls	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry.	
	• Grout Curtains	Subsurface barriers created by pressure injecting grout in a regular pattern of drilled holes.	
	• Vibrating Beams	Vibrating force to advance beams into ground with injection of slurry as beam is withdrawn.	
	• Steel Sheet Piling	Excavating and installing sheet piles around area of contamination.	
	Horizontal Barriers		
	• Grout Injection	Pressure injection of grout through a pattern of drilled holes across the site.	Unproven techniques. Grout injection can be used to seal localized fractures.
	• Block Displacement	Along with vertical barriers, injection of grout into notched injection holes.	Unproven techniques.
	Revegetation		
	• Grasses, Legumes, Shrubs, Trees	Planting of trees, grass, and shrubs to stabilize the surface and reduce erosion by wind and water. Also, contributes to development of fertile soils and better site appearance.	Can be compatible with a cap or soil cover. Can be applicable at all sites except developed areas at SLDS and railroad properties. Should be used with most alternatives.

Table 2-2. (continued)

Response Action	Remedial Option	Description of Remedial Option	Comments
3. Containment and Surface Water Controls (continued)	<u>Grading</u> • Scarification and Contour Furrowing	Use procedures to reshape the land surface in order to manage surface runoff, infiltration, and erosion.	Can be implemented at certain locations along Cold Water Creek to prevent flooding water from transporting contaminated sediments from creek bed.
	<u>Diversion Systems</u> • Dikes and Berms	Well compacted earthen ridges or ledges constructed immediately upslope from or along the perimeter of contaminated areas.	Not applicable for large amounts of surface water flow; provides only short-term protection. Will not be applicable at locations along creek downstream from the sites where the surface water flows are large.
	• Levees and Floodwalls	Earthen embankments that function as flood protection structure in areas subject to flooding. Create a barrier to confine flood waters. Floodwalls perform similar functions, but are constructed of concrete.	Contain only floodwaters; not applicable to flooding from storm water runoff behind levees and floodwater. Not considered to be required at Coldwater Creek and drainage ditches.
	• Encase in Pipeflow	Divert surface water flow through pipes in stream bed; prevent further contaminants of sediments.	Not applicable for large surface water flows.
4. Collection	<u>Pumping</u> • Extraction Wells	Series of wells to extract contaminated groundwater.	Collected water from extraction wells or extraction/injection wells. System would be pumped, diverted, or transported to treatment unit.
	• Extraction/Injection Wells	Injection wells are used to inject treated water and direct groundwater flow toward extraction wells.	
	<u>Subsurface Drains</u> • Interceptor Trenches	Perforated pipe in trenches backfilled with porous media to collected contaminated groundwater.	Collected water would be directed to a treatment unit.

Table 2-2. (continued)

Response Action	Remedial Option	Description of Remedial Option	Comments
5. Treatment	Physical Processes	Treatment can encompass physical or chemical processes. In addition, ancillary treatment technologies may be required to support the treatment technologies. These include aeration, filtration, and dewatering prior to disposal.	
	• Air Stripping	Reduce concentrations of volatile organic compounds through intimate contact of extracted groundwater or surface water with air. Gaseous phase may require further treatment to meet air regulations.	Certain semivolatile compounds cannot be reduced to acceptable levels due to low volatility. Off gases require collection/treatment. Applicable only for VOCs and radon.
	• Steam Stripping	Remove VOCs through intimate contact of extracted groundwater or surface water with steam. Similar to air stripping, but steam is used to elevate temperatures and enhance removal of volatiles.	Same as above.
	• Carbon Adsorption	Reduce concentrations of aqueous or gaseous phase compounds through adsorption onto activated carbon. May also be used as a polishing step following treatment such as air and steam stripping.	High solids in aqueous stream will "plug" carbon bed. Carbon must be replaced periodically when capacity is exhausted. This process is especially effective for radon removal and other "hard-to-treat" compounds.
	• Thin Film Evaporation	Remove contaminants from aqueous phase by vaporizing water from contaminants. Process produces a concentrated waste stream that requires further treatment.	Can be used to concentrate waste streams, especially those containing radionuclides.
	• Reverse Osmosis	Involves the use of high pressure to force water through a membrane, leaving contaminants behind.	High inorganic and/or suspended solids will "clog" filter. Not proven reliable for organics with low molecular weight (<200). Can be applied to remove radionuclides such as radium and uranium.
	• Resin Adsorption	Contaminants are transferred from the dissolved state to the surface of the resin. Can be regenerated by removing the contaminants with solvent.	Full-scale testing has demonstrated effectiveness for VOCs and metals. Limited demonstration for selective removal of radionuclides.

Table 2-2. (continued)

Response Action	Remedial Option	Description of Remedial Option	Comments
5. Treatment (continued)	• Ion Exchange	Contaminated water is passed through a resin bed where ions are electrostatically exchanged between resin and water; regeneration of the exhausted resin would produce a concentrated waste stream, requiring further treatment.	Effective for removal of radionuclides and inorganics.
	• Evaporative Recovery	Water is vaporized to concentrate metals present in water. Process produces concentrated waste stream requiring further treatment.	Effective for removal of radionuclides and inorganics.
	• Electrodialysis	Another membrane separation process where the membrane is used for selective ion transport with the principal driving force being an electrical potential gradient.	Effective for selected radionuclides, inorganic, and some organic chemicals.
	• Ultrafiltration	Similar membrane separation process as reverse osmosis, but can separate organics of a subcolloidal nature as well as colloidal and particulate matter.	Effective if colloidal particles are required to be removed. It is doubtful whether colloidal particles will be present in the waters.
	Chemical Processes		
	• UV/Photolysis	UV radiation with ozone or hydrogen peroxide act to oxidize organic contaminants.	Volatile and semivolatile organics are broken down into nonspecific byproducts.
	• Wet Air Oxidation	Destroys organic compounds in an aqueous solution by inducing oxidation and hydrolysis reactions at high temperature and pressure.	Implementable, but radionuclides not likely to be affected since most are in an oxidized state.
	• Supercritical Water Oxidation	This process option is an even higher temperature and pressure version of wet air oxidation.	Implementable, but radionuclides not likely to be affected since most are in an oxidized state.
6. Disposal/ Discharge	Onsite Disposal/Discharge		
	• Reinjection	Reinject treated groundwater within the zone of groundwater contamination.	Limited to recharge/permeability rates of soils. Must comply with appropriate regulations. Illegal and accordingly not applicable in the state of Missouri.
	• Discharge to Surface Water	Discharge of treated water meeting NPDES discharge limits, into surrounding surface water.	Coldwater Creek is a potential receiving body.

Table 2-2. (continued)

Response Action	Remedial Option	Description of Remedial Option	Comments
6. Disposal/ Discharge (continued)	Offsite Discharge/Disposal		
	• RCRA Mixed/11(e)(2) Landfill	Secure treatment residue in an offsite landfill that is permitted to receive hazardous waste, mixed waste, or radioactive wastes, as appropriate.	Must comply with land disposal restrictions, especially those under the LLRWPAA of 1985 which requires that radioactive liquids be solidified or sorbed. See also options for disposal under soils/sediments treatment (Table 2-1).
	• POTW	Discharge water to city sewer system to be treated at the POTW.	Must obtain permit from city.
	• Incineration	Treat and dispose of residue in an offsite incineration facility.	Must comply with all regulatory requirements for incineration.

Surface water control systems would consist of stabilizing the stream bank to prevent erosion of stream sediments, and/or diversion of the surface water stream from the contaminated areas. At Coldwater Creek and other drainage areas resulting from the sites at SLAPS and HISS, stream bank stabilization can be accomplished through grading (i.e., scarification and contour furrowing), and revegetation (i.e., grasses, shrubs and trees). Diversion can be implemented through dikes and berms, levees, floodwalls, and pipe encasement.

2.4.4 Collection of Groundwater

The applicable remedial technologies identified for this response action include extraction wells and subsurface drains to collect contaminated groundwater.

The types of extraction wells that could be used for pumping contaminated groundwater include: well points, suction wells, ejector wells, and deep wells. The selection of the appropriate well considers, among other criteria, the depth of contamination and hydrologic and geologic characteristics of the aquifer.

Subsurface drains include any type of buried conduit used to convey and collect aqueous discharges by gravity flow. Conceptually, subsurface drains function like an infinite line of extraction wells.

2.4.5 Treatment of Groundwater

Of the multitude of physical, chemical, and biological process options available for remediation of groundwater identified in Table 2-2, only the biological option is not applicable. Radioactive contamination and heavy metals present in the water are not amenable to biological treatment. Other process options are expected to more effectively treat the water matrix. Similarly, due to the nature of the contamination (principally the radionuclides) present at the sites, in situ treatment is not considered an effective or implementable method for groundwater or surface water treatment at the site.

For treatment, a number of physical processes such as air and steam stripping, carbon adsorption, thin film evaporation, reverse osmosis, resin adsorption, ion exchange, evaporative recovery, electrodialysis, and ultrafiltration have been considered. All these processes address radionuclides (uranium, thorium, radium, and daughter products), as well as other inorganics and organics. Some processes, such as thin film evaporation and evaporative recovery, serve to concentrate waste streams, but offer no treatment.

UV/photolysis can be used to address the organic chemicals in the water, but does not treat radionuclides or inorganics. Wet air oxidation or supercritical water oxidation will not be effective for radionuclides because most of them are already in an oxidized state.

In addition, ancillary treatment technologies may be required as support technologies. Support technologies that were identified as appropriate treatment include aeration, filtration, precipitation/flocculation/sedimentation and dewatering methods.

2.4.6 Effluent Discharge/Disposal for Surface Water and Groundwater

Effluent discharge and disposal options for surface water and groundwater at the St. Louis site involves permitted facilities for discharge of treated water. All such options are considered applicable for further evaluation. Reinjection of treated water into the groundwater is not allowed by Missouri state regulations, and is not considered further.

2.5 IDENTIFICATION OF TECHNOLOGIES FOR BUILDINGS/STRUCTURES

Table 2-3 summarizes the preliminary review of remedial options applicable to remediation of buildings and structures at the St. Louis site. Contaminated buildings and structures are predominantly located at the SLDS site and the Futura Coatings building. There are no buildings at the SLAPS site. The results of this review are briefly outlined by response actions as follows.

2.5.1 No Action for Buildings and Structures

Under no action, no remedial action would be taken to reduce risk and the current status of the buildings and structures would remain unchanged. This remedial action will remain applicable throughout the FS-EIS evaluation as it represents the current site conditions, and serves as the baseline case for the CERCLA and NEPA evaluation process.

2.5.2 Institutional Controls for Buildings and Structures

Institutional controls that could be considered for the St. Louis site include site security/posting of signs, deed restrictions, and continued monitoring. Access restrictions with appropriate posting of signs and monitoring is already being conducted at SLDS and to some extent at Futura Coatings. Use of deed restrictions to prevent direct contact of the public with the contaminated areas of the buildings may be difficult

Table 2-3. Identification of Remedial Options for Buildings and Structures at the St. Louis Site

Response Action	Remedial Options	Description of Remedial Technology Process Option	Comments
1. No Action	None	No actions taken to reduce risk.	Required for consideration by NCP and NEPA.
2. Institutional Controls	<u>Institutional Actions</u>		
	• Deed Restrictions	Initiate deed restrictions to constrain future use and prevent direct contact with the building surfaces.	May be extremely difficult at non DOE-owned properties (e.g., SLDS and Futura Coatings).
	<u>Site Security</u>		
	• Fencing/Signs	Restrict access with a fence. Post warning sign.	These steps are already being implemented at SLDS and Futura. May be difficult to implement at non-DOE owned properties on long-term basis.
	<u>Environmental Monitoring</u>		
	• Monitoring of Ambient Air	Periodic sampling and monitoring of ambient air inside and outside buildings and structures.	Air monitoring is already being conducted at SLDS and Futura.
3. Containment	<u>Surface Sealing</u>	Surface sealing involves covering the contaminated surfaces with appropriate sealants to prevent direct contact with the contaminants, control mobility and further spread of contaminant.	
	• Painting	Use of paints on masonry, steel, and wooden surfaces.	Painting is being used at SLDS.
	• Application of Resin/Plastic	Spray application of plastic/resin to form an impermeable barrier.	
	• Use of other impermeable materials	This could include the use of plastic sheeting or wall board.	

Table 2-3. (continued)

Response Action	Remedial Options	Description of Remedial Technology Process Option	Comments
4. Collection	Demolition		Demolition of buildings and structures is a long-term process and will have to be scheduled in proper sequence with proper coordination with building owners.
	• Partial Demolition	Blasting, wrecking, sawing, drilling or crushing of appropriate section of buildings and structures.	This results in reduced volume of materials that will have to be disposed of.
	• Total Demolition	Complete demolition of buildings and structures using appropriate methods.	More easily done. Best suited if entire building is contaminated.
5. Decontamination	Physical Decontamination Procedures		
	• Scrubbing, scraping, scabbling, sanding grinding; pelletized CO_2 or sand blasting	All methods employ physical force to achieve mechanical separation of contaminant from the surface of the material.	Works best on wooden, steel, and masonry surfaces. Collection of dust and particulate matter is essential.
	Chemical Decontamination Procedures		
	• Use of water, solvents, acids and bases, and complexing agents	A variety of chemicals are used to dissolve contaminant present on the surface.	Waste water or extractants must be collected to prevent spread of contaminants and will require treatment/discharge/disposal.
	Radon Control		
	• Passive or Active Collection Systems	Trench vents are installed around buildings to collect radon gas that might migrate from the soil. An active system can be created by a negative pressure at the outlet of the trench vent.	Radon removal systems do not address gamma radiation.
	• Ventilation System inside building	Active ventilation system that brings air from the outside to dilute radon concentrations inside building.	Filter should be installed to reduce dust and particulate matter from entering building.
	• Electrostatic Precipitators	Is used to collect dust and suspended particulate matter from inside the buildings.	Effective for removal of radioactive particulates, as well as, radon daughters.

Table 2-3. (continued)

Response Action	Remedial Options	Description of Remedial Technology Process Option	Comments
6. Disposal	Onsite/Offsite Disposal		Any contaminated wastes generated from decontamination and dismantlement of building surfaces will be disposed of along with the contaminated soils from the sites. Disposal options will be the same as those identified under soils/sediments (Table 2-1).
	Offsite Disposal in a Solid Waste Landfill	Excavated materials with activity below specified criteria are transported to a solid waste landfill for disposal.	Activity of buildings and structures should be below required levels for disposal in a solid waste landfill.

to implement both at SLDS and Futura Coatings, because the properties are not owned by DOE. The implementation of institutional controls may involve the purchase of properties by DOE, as necessary.

2.5.3 Containment of Radionuclides on Buildings and Structures

The radionuclides present on the surfaces of buildings and structures can be contained by applying a sealant. This minimizes direct contact with the radioactive contaminants, control mobility, and prevents further spread of contamination into the ambient atmosphere. Sealing could be accomplished by painting, applying resins or plastics, and use of other impermeable materials. Use of surface sealants does not result in the removal of radioactive contaminants or the absorption of contaminants by the sealants, although some loose contaminants may be absorbed by the sealants. The mobility of the contaminants and further spread of contaminants into the ambient air is reduced. This reduces the potential for dermal contact and inhalation exposure.

2.5.4 Demolition of Buildings and Structures

This response action involves a variety of methods such as blasting, wrecking, sawing, drilling, and crushing of buildings, structures, or equipment. If the walls or the roof or other surfaces of the buildings or structures are contaminated, it may be appropriate to decontaminate or remove the contaminants before demolition. The appropriate demolition method to be used would have to be evaluated during the design stage. For the purpose of this screening document, all of the methods mentioned above will be considered appropriate.

2.5.5 Decontamination of Buildings and Structures

Several decontamination procedures can be implemented to remove the contaminants present inside buildings and structures. It is expected that most decontamination methods can reduce the contaminant levels below the applicable standards. If the decontamination efforts do not effectively remove the contaminants to the appropriate levels, the buildings and structures may have to be decommissioned, demolished and disposed of.

Decontamination can be accomplished by using solvents such as acids and bases, or mechanical methods by scrubbing, scraping, or grinding the building surfaces. Radon control involves ventilating buildings and areas to dilute the radon gas to acceptable levels or prevent its entry through active or passive collection systems.

2.5.6 Disposal of Materials from Remediation of Buildings and Structures

Options for disposal of demolished and decontaminated building materials are similar to that for soils and sediments. In addition to options for disposal of materials containing radionuclides, disposal at a solid waste landfill has been retained as well. The activity of soils in the rubble material should be below regulatory levels before it can be transported and disposed at a solid waste landfill.

2.6 PRELIMINARY EVALUATION AND INITIAL SCREENING OF REMEDIAL OPTIONS

In this step, the universe of potentially applicable remedial options is reduced by evaluating and screening the options with respect to certain criteria. This step allows those options that will not be viable for the St. Louis site to be eliminated from further consideration so that the focus is on those options that are effective and implementable in addressing the contamination at the site. Remedial options were evaluated using the criteria of effectiveness, implementability, and cost. Effectiveness is the most important criteria at this stage, with less effort and emphasis placed on implementability and cost.

Effectiveness Evaluation Criteria

Remedial options that have been identified were evaluated to ensure that they effectively protect human health and the environment and satisfy the general response actions defined for the media of concern. The ability and effectiveness of each specific remedial option to reduce the contaminant concentrations or exposure levels or to sufficiently recover contaminated media for subsequent treatment were evaluated in terms of protecting human health and the environment and the absence of adverse environmental impacts. The performance evaluation of a particular option involved a technical assessment of the process option to achieve the remedial action objectives. Another aspect of the performance evaluation was the useful life or the length of time that a technology process performs its intended function. As part of the effectiveness evaluation it was also determined how proven and reliable the process is with respect to the contaminants and conditions at the site. Reliability is an important concern because of the significant operation and maintenance requirements associated with most technology process options and the importance of protecting public health and the environment. Long-term management requirements for residual contamination and/or untreated wastes reduce the effectiveness of a technology. Therefore, the degree of long-term management required for each technology was considered as part of the evaluation of technology effectiveness.

Implementability Evaluation Criteria

Implementability criteria encompasses both the technical and institutional feasibility of carrying out a remedial option. Two criteria are considered in terms of implementability; first, the remedial option must be constructable, and second, the construction and implementation must be possible within a reasonable period of time. Constructability addressed both onsite and offsite conditions. Implementation time and the time period for beneficial results to be realized is critical to protecting public health and the environment. Safety is another aspect of the technical feasibility. Short- and long-term threats to public safety and the safety of site workers were identified. Fires, explosions, and exposure to hazardous substances were also considered. Measures that posed a great risk of exposure to onsite workers or to the public at large were eliminated.

The institutional aspects of implementability are also important. In the selection process for remedial technology process options, primary consideration was given to options that attained known applicable or relevant and appropriate requirements (ARARs). In addition, for each process option, the ability to obtain necessary approval from government agencies; availability of approved treatment, storage, and disposal sources, and capacities and availability of necessary equipment and skilled workers to implement the technology were considered.

Cost Evaluation Criteria

Cost played a smaller role in the initial screening of remedial options for the development of alternatives. Relative capital costs and operation and maintenance costs were used rather than detailed estimates. During this phase, the cost analysis was based on engineering judgment and each process option was evaluated as to whether costs were high, low, or moderate relative to other process options within the same remedial technology.

In addition, site- and waste-limiting characteristics that might influence the effectiveness and implementability of a remedial option were considered as well. Site- and waste-limiting parameters that were used in the preliminary evaluation and screening of remedial options included:

- waste volume,
- waste matrix,
- physical/chemical hazards (such as volatility, solubility, and specific chemical constituents in the waste matrix),
- present configuration that might influence the final disposition of the contaminated wastes, and
- environmental impacts of each option.

The preliminary evaluation and screening of remedial options were conducted separately for soils/sediments (Section 2.6.1), surface water/groundwater (Section 2.6.2), and buildings and structures (Section 2.6.3).

2.6.1 Preliminary Evaluation and Screening of Remedial Options for Soils and Sediments

The results of the preliminary evaluation and screening of remedial options for soils/sediments are presented in Table 2-4. Brief summaries of those results are provided in the following sections.

2.6.1.1 No Action

This response action remains applicable throughout the FS-EIS evaluation.

2.6.1.2 Institutional Controls for Soils and Sediments

The remedial options under this response action included site security, deed restrictions, and environmental monitoring. Except for the residential and commercial vicinity properties, the other sites including HISS, Futura Coatings, SLAPS and SLDS already have site security from a protective fence and locked gates that permit only authorized personnel to enter the sites. In addition to the security measures already in place, warning signs would be posted around the sites.

Restrictions on future development at DOE-owned properties would be incorporated into the property deed to limit land use should the property be sold in the future. Deed restrictions may not be effective on property DOE does not own such as SLDS and Futura Coatings.

Monitoring of soils and sediments would be conducted to ensure that contaminants are not dispersing offsite where they could impact public health and environment.

2.6.1.3 Containment for Soils and Sediments

The containment response protects human health and the environment by reducing direct contact with the contamination. The potential remedial technologies identified included in situ capping and providing a soil cover.

Migration of radionuclides to groundwater could still occur even with proper construction of a cap. Considering the half lives of most radionuclides, a cap may have to be maintained for several hundred years, which could be impractical. Capping can be accomplished by a clay or a multimedia cap, which are both potentially applicable. Asphalt and concrete caps were screened out because they are susceptible to cracking,

Table 2-4. Preliminary Evaluation and Initial Screening of Remedial Options for Soils/Sediments at the St. Louis Site

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screening Status
1. No Action	None	Will not be effective in reducing risk.	There are no process options.	None.	Retained; required for consideration by NCP and NEPA.
2. Institutional Controls/ Site Maintenance	Site Security				
	• Fencing/Signs	Fencing may reduce direct contact with contaminated soil to a certain extent, but will not comply with all remedial action objectives.	SLAPS, HISS, and SLDS are already fenced and security is already being implemented by owners. Implementation at other properties may be difficult.	Moderate capital; very low O&M costs.	Retained.
	Land Use/Controls				
	• Deed Restrictions	Effectiveness depends on continued future implementation. Does not reduce contamination.	Implementable only at DOE-owned properties. May be difficult to implement at sites not already owned by DOE.	Negligible costs.	Retained.
	• Property Acquisition	Site security easily enforced. Does not reduce contamination.	Implementable.	High	Eliminated.
	Environmental Monitoring				
	• Monitoring of Media	Useful for documenting and evaluating conditions, but does not reduce the risk by itself.	Implementable.	Low capital; moderate O&M costs.	Retained.
3. Containment	Capping				
	• Clay	Effective; susceptible to cracking (certain minimum moisture content should be maintained at all times), but has self-healing properties.	Implementable, but will restrict future land use. Capping of sediments may be difficult.	Moderate capital; low O&M costs.	Retained.

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Table 2-4. (continued)

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screening Status
3. Containment (continued)	<u>Capping (continued)</u>				
	• Asphalt	Effective.	Can be used, but is susceptible to cracking; also restricts land use.	Moderate capital; low O&M costs.	Eliminated.[*]
	• Concrete	Effective.	Can be used, but is susceptible to cracking; also restricts future land use.	Moderate capital; low O&M costs.	Eliminated.[*]
	• Multi-layered Cap	Effective and least susceptible to cracking.	Implementable, but will restrict future land use. Can be used as effectively as a clay cap with the same restrictions.	Moderate capital; low O&M costs.	Retained.
	<u>Soil Cover</u>				
	Topsoil and Vegetative Layer	Effective only in reducing direct contact exposure and not infiltration.	Implementable at site soils with low activity levels. Implementable as an interim measure due to inability to ensure long-term integrity.	Moderate capital; low O&M costs.	Retained.
4. Collection	<u>Excavation</u>	Will be effective in removing all areas of contamination to the required action levels.	Excavation of soils in some areas may be difficult due to specific land use in that area (e.g., where there are roads, buildings, and property rights requirements). Can be implemented easily at SLAPS, HISS, and vicinity properties.	High.	Retained.

[*]An asphalt and concrete cap have been eliminated in favor of a clay and multimedia cap. According to CERCLA guidance, one process option is chosen as representative of that particular remedial technology. More than one process option can be chosen if warranted. A clay or multimedia cap is best suited for the St. Louis site.

Table 2-4. (continued)

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screening Status
5. Treatment	<u>Volume Reduction Processes</u>				
	• Soil Washing	Will not be effective as much in removing thorium. Potentially effective as pretreatment to physical separations techniques. Extract water requires additional treatment.	Large quantities of water may be required. Locating site for treatment may require extensive permitting. Could utilize portable systems. Location will be best suited at SLAPS only. Cannot implement in areas where excavation is not feasible.	Moderate.	Retained.
	• Organic Solvent Extraction	Acid leaching would generate highly acidic extract requiring treatment. Other chemicals provide minimal removal of thorium.	Locating site for treatment may require extensive permitting. Could utilize portable systems. Location will be best suited at SLAPS only. Cannot implement in areas where excavation is not feasible.	High.	Retained.
	• Screening	Potentially effective in separating particles based on size. Fine particles with radioactivity can be separated. Saturated soils would require dewatering before screening.	Implementable, however, substantial additional information will be required and pilot tests will have to be conducted. Cannot be implemented in areas where excavation is not feasible.	High.	Retained.
	• Classification	Soils with high clay content as at SLDS and HISS will be difficult to process.	Cannot be implemented in areas where excavation is not feasible.	Moderate.	Retained.
	• Flotation	Particularly useful only in removing fine solids (size - 0.1 to 0.01 mm).	Cannot be implemented in areas where excavation is not feasible.	High.	Eliminated.

Table 2-4. (continued)

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screening Status
5. Treatment (continued)	Volume Reduction Processes (continued)				
	• Gravity Separation	Fine particles with radioactivity can be separated.	Implementable, however, substantial additional information will be required and pilot tests will have to be conducted. Cannot be implemented in areas where excavation is not feasible. Also, only a limited amount of solids can be processed at a time.	High.	Retained.
	Immobilization Processes				
	• Vitrification	Potentially effective in treating radioactive contaminants in the soil/sediment matrix. Not effective on wastes with high moisture content. Lime in soils and natural limestone in native soils may cause problems.	Implementable, however, energy requirements will be high. Cannot be implemented in areas where excavation is not feasible. Also, rubble piles at SLAPS and SLDS may be difficult to treat because of their metals content.	High.	Retained.
	• Solidification	With the use of available technologies radionuclides can be treated along with organics and inorganic chemicals. Organic contaminant could possibly hinder curing of solid matrix.	Implementable, but treatability testing will be required to determine optimum mix ratios. Cannot implement in areas where excavation is not feasible. Increased volume of waste requiring ultimate disposal.	High.	Retained.
6. Disposal/ Discharge	Onsite Disposal				
	• Onsite Disposal by Land Encapsulation	Effective, if an appropriate location can be found. Presence of radionuclides in waste could make siting a disposal area difficult.	May not be easily implementable. Social and political issues may hinder implementability. Must comply with all applicable regulations.	High.	Retained.

Table 2-4. (continued)

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screening Status
6. Disposal/ Discharge (continued)	<u>Offsite Disposal</u>				
	• Offsite Existing Federal Facility	Effective, if an appropriate location can be found.	Implementable if sufficient capacity is available.	Moderate to High.	Retained.
	• Offsite dedicated FUSRAP Facility	Effective if an appropriate location can be found.	Implementable if satisfactory location can be found.	High.	Retained.
	• Offsite Disposal at a commercially licensed facility	Effective, if an appropriately licensed facility can be found.	Implementable if sufficient capacity is available. Must comply with all applicable regulations.	High.	Retained.
	• Land Spreading	Potential impacts to human health and the environment will still exist from the presence of radionuclides.	Must comply with all applicable regulations.	Moderate.	Eliminated.
	• Disposal in Geologic Repositories	Effective, if an appropriate location can be found. Typically considered for high activity soils.	May not be implementable because capacity may not be available. Must comply with all applicable regulations.	High.	Eliminated.
	• Ocean Disposal	Only low activity soils can be disposed. Not effective for higher activity wastes containing long-lived radionuclides.	Cannot be implemented anymore.	Not Applicable.	Eliminated.

Table 2-4. (continued)

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screening Status
6. Disposal/ Discharge (continued)	<u>Offsite Disposal (continued)</u>				
	• Road Bed Dispersal	Potentially effective for soils with low activity levels.	May not be easily implementable. Social and political issues may hinder implementability. Must comply with all applicable regulations.	Moderate to High.	Retained.
	• Offsite land encapsulation at a dedicated in-state facility	Effective if an appropriate location can be found and properly designed in accordance with all regulatory requirements.	May not be easily implementable. Social and political issues may hinder implementability. Must comply with all applicable regulations.	High.	Retained.

restrict future land use, and offer no distinct advantages over a clay or multimedia cap. A soil cover in the form of a topsoil and vegetative cover was also retained for potential application at some locations such as SLAPS and residential vicinity properties.

Cap design and construction should consider the need to:

- confine radon until the emanation rate from the wastes is essentially equivalent to ambient background. This means assuring sufficient decay has occurred as the radon diffuses to the surface, that the concentration released does not significantly increase ambient radon background. This could be accomplished by a cap which requires 6 to 10 half-lives for radon to reach the soil surface. (One half-life is 3.8 days.);

- attenuate the gamma radiation associated with the radium present (for normal soils, the depth of cover required for gamma radiation shielding is on the order of 60 cm);

- provide long-term minimization of water infiltration into the contaminated material;

- function with minimum maintenance;

- promote drainage and minimize erosion; and

- have a permeability less than or equal to the permeability of any bottom liner system present or the natural subsoils (EPA 1988).

Both the clay cap and the multimedia cap are effective and implementable in containing contaminated soils/sediments. The capital and O&M costs for the multimedia cap are slightly higher those that for a clay cap.

2.6.1.4 Contaminant Collection for Soils and Sediments

A variety of equipment is used to excavate soils including backhoes, cranes and attachments (draglines and clamshells), and dozers and loaders. Sediments can be excavated using mechanical hydraulic and pneumatic dredging equipment. It is expected that during excavation of soils and sediments using conventional equipment described above, typical dust and runoff control techniques will adequately protect workers and the public. However, if required, special procedures can be implemented to minimize worker exposure to dust and particulate matter.

Excavation would be highly effective in addressing the contaminated soils at the sites. At SLDS and residential vicinity properties excavation would have to be coordinated with the owners to ensure minimal disruption of ongoing activities. Excavation costs are expected to be high.

2.6.1.5 Treatment for Soils and Sediments

Treatment of the soils potentially can be accomplished through volume reduction and/or immobilization processes. Both physical and chemical separation processes can reduce the volume of contaminated soil. For the chemical recovery of radionuclides, volumes of soil may be treated with water, inorganic salts, mineral acids, or complexing agents to extract the metals from their solid matrix.

Chemical extraction processes can be employed in heap leaching or in more complex trains. These could include the use of acids, complex agents, or organic chemicals for extraction. In heap leaching, the waste soils are "heaped" onto an impermeable pad and the extracting chemical is allowed to percolate through the solid matrix. The leachate is collected for further processing. In more complex processes, there is better control of operating parameters such as temperature and residence time, and a sequence of operating steps are employed.

Acid leaching through the use of sulfuric or other mineral acids results in a high percentage of radium and thorium removal. Several studies have been conducted that indicate 70 to 80 percent removal of radium and 80 to 90 percent removal for thorium is possible from uranium mill tailings using hot fuming sulfuric acid. Another study showed that almost 86 percent of thorium, and 14 to 40 percent of radium was removed from uranium ores using dilute sulfuric acid in a countercurrent process. Nitric acid has also been shown to be effective in the extraction of radium and thorium. More than 95 percent of radium was removed from mill tailings using concentrated hydrochloric acid.

However, the main disadvantage of the acid leaching process is the increased operating and capital costs due to expensive reagents, high operating temperatures and the potential of equipment damage due to corrosivity. The acid extraction processes that have been studied to remove radionuclides have been applied to tailings and refuse piles resulting from uranium extraction processes with the goal of cost effectively reclaiming the radionuclides for resale. At the St. Louis site, the activity of the contaminated soils is rather low and recovery of the radionuclides for resale is not economically feasible.

Using complexing agents results in removal of uranium and radium. This process would not, however, effectively remove thorium. The method of extraction using complexing agents has not been field demonstrated for radioactively contaminated soils and tailings. Simple laboratory experiments have been conducted showing that radium forms stable complexes with some chemical agents, thereby suggesting the application in removing radium from soils.

Though the chemical extraction technologies have been extensively used in extracting uranium from mineral ores (high activity materials), their use in cleaning contaminated soils to acceptable limits has been limited to laboratory and pilot plant testing (EPA 1988). Soils at the St. Louis site have low activity and would require longer residence times resulting in larger volumes of more dilute solution. Proven technologies for chemical extraction have been demonstrated for the tailings resulting from uranium processing. The applicability of these technologies for the clayey nature of the St. Louis site soils would need to be evaluated through laboratory testing for suitability if treatment is the selected alternative.

Soil washing is another volume reduction process shown to effectively remove uranium. Relatively lower removal percentages have been observed for thorium and radium. The soil washing process uses water to extract the radionuclide contaminants. Contaminated soil is mixed with large quantities of water. The water with the soluble radionuclides is separated by wet screening or gravity separation methods. The radionuclides in the water are extracted using one of the treatment technologies discussed under surface water/groundwater. Water solubility studies have been performed primarily to examine the leachability of radionuclides from mill tailings (EPA 1988). The water solubility of radium salts varies. Chloride, bromide, nitrate, and hydroxide are stable while fluoride, carbonate, phosphate, biphosphate, and oxalate are only slightly water soluble. The sulfate salts are essentially insoluble in water. Extraction of radium from soil is dependent on the liquid to solid ratio and the optimum time for leaching. Generally, the extraction of radium with deionized water showed less than 10 percent removal in one study. Other studies have shown as little as 0.1 percent (Landa 1984), and only as much as 40 percent removal (Shearer et.al., 1964) under exceptionally high liquid to solid ratios (10,000:1). In one study (Seeley, 1977) water removed 75 percent of radium sulfate from very fine slime solids. The removal of thorium with water was reported to be 3 percent in a study of uranium mill tailings. Soil samples from other radioactively-contaminated sites were extracted with water and showed only 0.1 to 2.3 percent removal of radium and less than 1.5 percent of uranium. Recent bench scale tests run on FUSRAP soils from Maywood, New Jersey have shown soil washing is an effective volume reduction method for sandy soils containing uranium, thorium, and radium (Cohen 1991).

A soil washing technique conducted in bench scale has been shown to effectively remove organics and heavy metals from soils, based on the solubilization of the contaminants by a water solution containing selected surfactants and other additives, followed by steps to separate the contaminants and surfactants respectively, from the wash solution. The primary target of the treatment has been removal of organic contaminants. Substantial reduction of heavy metals contaminants (Co, Ni, Cr) also has been achieved. Non-toxic and non-flammable surfactants were used. The process has not been demonstrated using radionuclides and has been tested at bench-scale only (Presentation at ACS Hazardous Waste Technology Conference 1990).

Physical separation processes could include screening, gravity separation, classification, and flotation. Screening is the mechanical separation of particles on the basis of size. Screening is normally limited to materials larger than 250 microns with finer sizing obtained by other methods. The amount of moisture in the feed affects the efficiency of screening. A common problem with screens is the blinding of the screen aperture with particles that are just slightly oversize. Screening equipment may be either stationary or dynamic.

Gravity methods of separation are used to treat a variety of materials. These methods exploit differences in material densities to bring about separation. Therefore, separation is influenced by particle size, density, shape, and weight. All gravity separation devices keep particles slightly apart so that they are able to move relative to each other and thus separate into layers of dense and light minerals.

Physical separation processes require extensive pilot testing to determine the applicability of the processes on the complex mixture of soils found at the sites. Before pilot tests can be conducted, information on particle size distribution of the feed; radionuclide distribution with particle size; moisture content; mineralogical composition; dust control requirements and throughput required must be obtained. Physical separation processes that achieve separation of particles based on size and density (through the use of air or water as the mechanism) may be effective.

AWC Inc. developed a physical separation system (TRUclean Process) to remove plutonium contamination from coral soils. TRUclean moves contaminated soils in a liquid slurry through an array of machines which separate the radioactive contaminants from the host soils. After processing, the recovered decontaminated soils are available for unrestricted use. The radioactive components are isolated and packaged for disposal at a waste site. Subsequent testing, including FUSRAP-related soils, indicated that the system was capable of a modest volume reduction. The pilot TRUclean plant has been operated at throughputs of a cubic foot to several cubic meters per hour. Multiple passes are usually required. Reduction of high activity soil (> 100 pCi/g) to 5 pCi/g has not been demonstrated. Operational difficulties are encountered when processing soils with significant percentage of fines. Further, the full-scale plant throughput would only be expected to approach 15 cubic meters per hour. The TRUclean process was used on soils from the DOE FUSRAP Hazelwood, Mo. site. Decontamination to below 5 pCi/g was achieved on single yard quantities of materials originally containing up to 10 pCi/g. No process rates or times were given ("The Removal of Radioactive Contaminants from DOE FUSRAP Soil," AWC, Inc., June 25, 1987).

Classification has been retained, however it will require extensive pilot-scale testing before it can be determined to be applicable at the St. Louis site due to the high clay soil content. Flotation is a complex process and the effectiveness of the process depends upon particle size, rate of feed, control of chemical additives, and handling of the refined product. Flotation is expensive and is useful in particularly removing colloidal particles (size of 0.1 to 0.01 mm). At the St. Louis site, the percentage of such small particles is expected to be a small fraction. It is also not known whether these small particles contain radioactivity as well. Flotation was thus screened out.

Two immobilization technologies - vitrification and stabilization/solidification were considered and both were retained for further evaluation. These immobilization technologies would reduce the leachability of the radioactive materials and limit the spread of contaminants. The resultant product is also more easy to handle for further actions. Solidification and vitrification may also facilitate transportation and offsite disposal of radioactive contaminants with the use of containers. Solidification involves the addition of an appropriate binding matrix that produces a monolithic block of waste with high structural integrity. The contaminants do not interact chemically with the solidification agents but are mechanically bonded. A stabilization process involves addition of specific reagents which limit the solubility or mobility of waste constituents. Solidifying agents can include asphalt, cement, or resins.

Vitrification is a process in which the contaminated material is heated to its melting temperature, and allowed to cool when it solidifies to a glassy mass. Vitrification is a high energy consuming process. An offgas recovery system would be required to capture the gases that are generated and treat them appropriately before discharging to the atmosphere. Ex-situ vitrification can be performed in an electric furnace or in a rotary kiln.

With the selection of appropriate agents and with the benefit of results from bench- and laboratory-scale tests, solidification can effectively bind the contaminants in a solid matrix for further treatment and disposal. Vitrification has been shown to effectively treat wastes contaminated with radioactive contaminants. Implementing these treatment technologies would require compliance with all pertinent regulatory requirements, especially in citing an appropriate location where these treatment technologies can be performed.

2.6.1.6 Disposal/Discharge of Soils and Sediments

Onsite disposal of soils in a designed land encapsulation facility has been retained for further evaluation. Land encapsulation is a proven and well demonstrated technology. A disposal facility similar to the existing DOE conceptual design developed for the Uranium Mill Tailings Radiation Control Act (UMTRCA) program has been constructed at the Canonsburg, Pa. site and is believed to more than adequately protect public health with erosion-proof barriers designed to ensure long-term control of the radionuclides (CDM 1985).

Of the offsite disposal options, land spreading, ocean disposal, and disposal in geologic repositories (abandoned underground mines) were screened out. Offsite disposal at an existing federal facility, dedicated FUSRAP facility, a specially designed land encapsulation cell at a location within the State of Missouri, a commercially-licensed facility, road bed dispersal, and disposal in existing mine disposal facilities have been retained for further evaluation.

The land-spreading disposal option has not been demonstrated as a viable option at other contaminated sites. Selecting a site to receive the materials is a politically and socially sensitive issue. The types of materials that could be accepted would probably fall within a very narrow range of physical and chemical characteristics such that only a small portion of the soils from the sites could be disposed of and removed. Potential problems associated with emission of respirable particles containing low activity levels exist. Land spreading allows for uncontrolled contact with the atmosphere and hence, does not fully protect human health and the environment. This option, thus is inconsistent with DOE Orders. In addition, land spreading could contribute to non-point source pollution problems generated by native soil. Land spreading, therefore will not be considered as a disposal option.

Road bed dispersal or airport runway expansion involves excavating the contaminated soils and using it as fill material during construction of roads, highways, and airport runways. Selecting such a site in Missouri could be a politically and socially sensitive issue, and time consuming. Soils could potentially be transported to the St. Louis Airport and used as fill material for the planned runway expansion. If the material was used as fill, it would have to be demonstrated that groundwater in the subsurface is not impacted. In addition, potential hazards may exist to workers who might be exposed during the construction phase. However, these concerns are considered to be manageable, and this option, if determined to be protective, may provide a means for beneficial reuse of the excavated soils in a cost effective manner, particularly for very low activity soils. Therefore, road bed dispersal and/or disposal under airport runways will be retained as a potential remedial option.

The disposal of materials in the ocean is regulated under 40 CFR 220 through 225 and 277 through 229. Dumping is controlled via a permit system. Dumping of materials with trace quantities of radionuclides is authorized by 227.6(b)if the material will not cause significant undesirable effects, as tested according to 227.6(c). Although the FUSRAP wastes should easily pass any immediate hazard test criteria, the radionuclides are probably present in more than "trace" quantities, which would eliminate the ocean disposal option. In any event, radioactive materials must be contained per 40 CFR 227.11 to prevent their direct dispersion or dilution in ocean waters. 40 CFR 227.11(b)(1) requires that the materials decay to environmentally innocuous materials within the life expectancy of the container and/or the matrix. This requirement precludes the disposal of materials with long half-lives. Containers containing typical FUSRAP waste would require integrity for geologic time. Therefore ocean disposal will not be further considered.

Disposal of the contaminated soils in underground geological repositories is another option. Deep, underground, abandoned, worked-out mines, or other existing underground natural geological formations are typically considered for high activity wastes and may not be appropriate for the low activity soils at the St. Louis site. The use of a geological repository involves the cost of reconstruction and consequently may pose safety hazards. Mine disposal is also the most expensive of the disposal options. In summary, disposal in geologic repositories is not warranted for the low activity soils at the site and will not be considered further.

There is no DOE facility in the general area that could be used for disposal. Existing DOE-LLW disposal facilities include ORNL in Oak Ridge, Tennessee, the Hanford facility in Hanford, Washington, the Nevada Test Site (NTS) and the Idaho National Engineering Laboratory. Specific information on the location, licensing restrictions, volume limitations on soils that can be accepted, and the disposal costs are contained in Appendix A. All these facilities will be considered further as disposal options. A dedicated FUSRAP facility would be established preferably at an existing federal facility. The specific location for this facility would be evaluated based on geographic location and geological conditions.

There are several privately-owned commercial facilities that may provide disposal capacity for disposal of low-level radioactive waste including the Envirocare facility in Clive, Utah, the US Ecology-operated sites near Beatty, Nevada, and Richland, Washington, the Chem Nuclear Systems facility near Barnwell, South Carolina, American Nuclear Corporation-owned facility in the Gas Hills District of Wyoming, and the Texcorp Industrial-owned facility in Del Rio, Texas. In addition, US Ecology has filed license applications for two new low-level radioactive waste facilities in Ward Valley, California (22 miles west of Needles) and Butte, Nebraska to serve the Southwestern and the Central Interstate Compacts respectively. Chem Nuclear Systems presently has filed a license application for a low-level radioactive waste facility near Martinsville, Illinois for the Central Midwest Compact. Missouri is a member of the Midwest Compact for which Ohio has recently been designated as the host state. A license application for this facility is years away. The availability of the new waste sites to the St. Louis site soils will be evaluated as well. Specific information on the location, licensing restrictions, the volume limitations on soils that can be accepted, and the disposal costs for the commercially licensed waste sites are contained in Appendix A.

If no federal facility or commercially-licensed disposal facility is available, an offsite location in Missouri could be identified where an encapsulation cell could be designed and constructed. The requirements of such a cell would be similar to that of an onsite land encapsulation cell. Potential problems associated with this option would be difficulties in locating a site where a cell could be designed and constructed. Political and social issues, and regulatory requirements may contribute to the difficulty in implementing this option.

2.6.2 Preliminary Evaluation and Screening of Remedial Options for Surface Water and Groundwater

The results of the preliminary evaluation and screening of remedial options for surface water/groundwater are presented in Table 2-5. Brief summaries of those results are provided in the following sections.

2.6.2.1 No Action for Surface Water and Groundwater

This response action will remain applicable throughout the FS-EIS evaluation.

2.6.2.2 Institutional Controls for Surface Water and Groundwater

The available controls (i.e., deed restrictions and physical site access restrictions to prohibit the use of groundwater at the site), and continued monitoring of surface and groundwater are considered applicable for the St. Louis site. Groundwater at the site is currently not a source of drinking water. Deed restrictions could potentially be implemented that prevent the use of groundwater as a source of drinking water. Monitoring is being conducted through quarterly samples of the groundwater at SLDS, SLAPS, and HISS.

Table 2-5. Preliminary Evaluation and Initial Screening of Remedial Options for Surface Water and Groundwater at the St. Louis Site

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screening Status
1. No Action	None	Will not be effective in reducing risk.	No process options to implement.	No capital or O&M costs.	Retained; required for consideration by NCP and NEPA.
2. Institutional Controls/Site Maintenance	Institutional Actions				
	• Deed Restrictions/ Physical Site Access	Effectiveness depends on continued future implementation.	Implementable. May require obtaining property rights.	Negligible cost.	Retained.
	Environmental Monitoring				
	• Groundwater/ Surface Water Monitoring	Useful in documenting and evaluating conditions, but does not reduce the risk by itself.	Implementable. Would require access rights.	Low capital; moderate O&M costs.	Retained.
3. Containment and Surface Water Controls	Vertical Barriers				
	• Slurry Walls	Barrier design would require consideration of groundwater contaminants that may degrade barrier materials.	Potentially implementable at SLDS. Existing structures, land use, and presence of utilities may pose problems during implementation.	High, however is considered less expensive than other potential containment measures.	Retained.
	• Grout Curtains	Barrier design would require consideration of groundwater contaminants that may degrade barrier materials.	Existing structures, land use, and presence of utilities may make implementation difficult.	High.	Eliminated since slurry walls is a more established technology.
	• Vibrating Beams	Barrier design would require consideration of groundwater contaminants that may degrade barrier materials.	Existing structures, land use, and presence of utilities may pose problems during implementation.	High.	Eliminated. Overhead obstructions and noise problems make this a poor choice.

Table 2-5. (continued)

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screening Status
3. Containment and Surface Water Controls (continued)	<u>Vertical Barriers (continued)</u>				
	• Steel Sheet Piling	Can be effective option but requirements are very specific in nature.	Same as above. Could be installed only at specific locations.	High.	Eliminated. Overhead obstructions and difficulty of installation make this a very poor choice.
	<u>Horizontal Barriers</u>				
	• Grout Injection	Could be useful in containing waste source from contact with groundwater under buildings and structures at SLDS and Futura Coatings. Grout barrier would require consideration of groundwater contaminants that may degrade material.	Potentially implementable, however, technique has not been proven to a large extent. Could be used only in localized areas to contain source of contamination from contact with groundwater.	High capital costs. Low O&M costs.	Retained.
	• Block Displacement	Grout barrier would require consideration of groundwater contaminants that may degrade material.	Could be used only in localized areas to contain source of contamination from contact with groundwater.	High.	Eliminated, since the effectiveness of this technique has not been proven.
	<u>Revegetation</u>				
	• Grasses, Shrubs, and Trees	Effective in reducing erosion and stabilizing the surface of a covered disposal site, thereby improving the effectiveness of a cap. Phytotoxic chemicals in cover soil could impact growth of vegetation. May require soil treatment prior to planting.	Implementable. Applicable only to areas with soil cover. Not suitable potentially without grading, capping, and venting.	Moderate capital; Moderate O&M costs.	Retained for use as an interim measure to control erosion and reentrainment.

Table 2-5. (continued)

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screening Status
3. Containment and Surface Water Controls (continued)	Vertical Barriers				
	Grading				
	• Scarification and Contour Furrowing	Effective in controlling infiltration, diverting runoff, and minimizing erosion.	Implementable in Coldwater Creek only at strategic locations; more easily implementable at drainage ditches from site. Additional time may be required in certain areas with large boulders. Periodic regrading may be required. Large quantities of cover soil may be necessary.	Moderate costs.	Retained for use in specific locations along Coldwater Creek.
	Diversion Systems				
	• Dikes and Berms	Effective as a short-term measure in controlling and diverting flow.	Implementable. Not effective for unsloped drainage areas larger than 5 acres. Also, not applicable for large amounts of surface water flow. Applicable only for short-term protection.	Moderate costs.	Retained for use in specific locations along Coldwater Creek and drainage ditches from sites.
	• Encase in Pipe	Construction of pipe will not address the contaminated sediments.	Construction of pipe will involve removal of sediment.	High.	Eliminated due to high variations in creek flow.
	• Levees and Floodwalls	No general restrictions on effectiveness.	Not applicable for areas with open floodways.	Moderate.	Eliminated, since there are no areas prone to flooding consisting of open floodways.

Table 2-5. (continued)

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screening Status
4. Collection	<u>Pumping</u>				
	• Extraction Wells	Potentially effective, but removal times can be long.	Implementable, but care must be taken for proper placement of wells. Installation of wells would require locating underground utilities. This is not expected to be a problem.	Moderate capital; moderate O&M costs.	Retained.
	• Extraction/ Injection Wells	Potentially effective, but injection wells are proven to have operational problems.	Implementable, but "dead spots" of water movement can occur if injection wells are not placed properly. Installation of wells would require locating underground utilities. This is not expected to be a problem.	Moderate capital; moderate O&M costs.	Retained.
	<u>Subsurface Drains</u>				
	• Interceptor Trenches	Will not be effective since permeability of soils at the site are not suitable.	May not be easily implementable with the clayey nature of soils. Existing structures, land use, and presence of utilities may restrict use.	Moderate capital; low O&M costs.	Eliminated.
5. Treatment	<u>Physical Processes</u>				
	• Air Stripping	Effective and proven method for removal of radon and VOCs. Inorganics would require pretreatment to avoid scaling or fouling of tower. Off gas may require further treatment for organics and radon.	Readily implementable.	Low capital; low O&M costs.	Retained.

Table 2-5. (continued)

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screening Status
5. Treatment (continued)	Physical Processes (continued)				
	• Steam Stripping	Effective for removal of radon and VOCs. Inorganics would require pretreatment to avoid scaling or fouling of the tower. Condensate would require further treatment.	Energy source required for stream generation.	High.	Eliminated due to intensive energy requirements and little benefit beyond that obtained by air stripping.
	• Carbon Adsorption	Effective for attaining good removal and low effluent levels for organics and radionuclides. Suspended solids may require removal prior to treatment to avoid clogging of carbon bed.	Readily implementable.	Moderate capital; high O&M costs.	Retained as a polishing step to follow other treatment and for treatment of radionuclides.
	• Thin Film Evaporation	Volume of water to be concentrated would be excessive. Not proven effective for radionuclides in surface water/groundwater.	Implementable.	High costs.	Eliminated.
	• Reverse Osmosis	Effective for achieving low concentration of subject chemicals. Suspended solids and inorganics may foul or clog membrane. Process produces a concentrated waste stream requiring further treatment.	Readily implementable.	Moderate capital; high O&M costs.	Eliminated since ion exchange would achieve the same objectives.
	• Resin Adsorption	Effective for achieving low concentration of subject chemicals. Process requires concentrated stream.	Readily implementable.	Moderate capital; high O&M costs.	Eliminated in favor of ion exchange.

Table 2-5. (continued)

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screening Status
5. Treatment (continued)	Physical Processes (continued)				
	• Ion Exchange	Effective for achieving low concentration of subject chemicals. Effective for removal of radionuclides. Often used in conjunction with ppt/flocculation as a method to reduce sludge production.	Readily implementable.	Moderate capital; high O&M costs.	Retained for treatment of radionuclides.
	• Evaporative Recovery	Effective in producing concentrated waste stream.	Implementable, but high energy requirements.	Moderate capital; high O&M costs.	Retained for treatment of radionuclides.
	• Electrodialyses	Effective for removal of radionuclides.	Implementable but process requires a concentrated waste stream.	High.	Eliminated.
	• Ultrafiltration	Effective for removal of radionuclides.	Implementable but process requires a concentrated waste stream.	High.	Eliminated.
	Chemical Processes				
	• UV/Photolysis	Effective as a polishing step in removing hard to treat organics. Color and suspended solids must be reduced to ensure effective treatment of organics. Not effective for treatment of inorganics.	Implementable, but will need energy source for lights.	Moderate capital; high O&M costs.	Eliminated. Concentration of organics is minimal. Carbon adsorption will be just as effective for site conditions.
	• Wet Air Oxidation	Not economical for dilute organic waste streams (<1%). Current applications include wastewater and wastewater sludges to reduce COD and destroy dilute organics.	Energy source required to produce heat.	High capital. High O&M costs.	Eliminated. Effectiveness at full-scale operations not proven, other oxidation methods available.

Table 2-5. (continued)

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screening Status
5. Treatment (continued)	<u>Chemical Processes (continued)</u>				
	• Supercritical Water Oxidation	Not economical for dilute organic waste streams (<1%). Current applications include wastewater and wastewater sludges to reduce COD and destroy dilute organics.	Energy source required to produce heat.	High capital. High O&M costs.	Eliminated. Effectiveness at full-scale operations not proven.
6. Disposal/Discharge	<u>Onsite Discharge/ Disposal</u>				
	• Surface Water Discharge	Effective and reliable discharge method. NPDES discharge limits must be met.	NPDES permit required.	Low capital; Low O&M costs.	Retained.
	• Reinjection	None.	Cannot be implemented in the State of Missouri.		Eliminated.
	<u>Offsite Discharge/ Disposal</u>				
	• 11(e)(2) Landfill or Mixed Waste (MW) Landfill	Effective for disposal of treatment residuals. considered hazardous. Must comply with land disposal restrictions; MW Landfill cannot accept low level radioactive wastes unless it is classified mixed.	Implementable, but must comply with land disposal restrictions.	High cost.	Retained for sludge disposal.
	• POTW	Pretreatment may be required.	Permission to discharge will have to be obtained first.	High capital. Low O&M.	Retained.
	• Incineration	Presence of radionuclides may impact permitting process.	Presence of radionuclides may impact permitting process.	High cost.	Eliminated.

2.6.2.3 Containment of Surface Water and Groundwater

Potential remedial technologies identified for this response action included horizontal and vertical hydraulic barriers, and surface water controls such as grading, revegetation and diversion controls. Based on available information on the site hydrology, hydraulic barriers for groundwater control were determined to be applicable st SLDS and potentially at Coldwater Creek. The primary objectives of the barriers at SLDS would be to prevent contact of the water with the contaminated soils and control migration of the water towards the Mississippi River. Slurry walls was retained as a vertical barrier option. Grout injection to seal groundwater from the source area especially under buildings was chosen as an option for horizontal barriers.

Slurry walls are the most common subsurface barriers because they are relatively inexpensive compared to other subsurface barriers. They are constructed in a vertical trench that is excavated under a slurry. The slurry acts essentially like a drilling fluid by hydraulically shoring the trench to prevent collapse, and, at the same time forming a filter cake on the trench walls to prevent high fluid losses into the surrounding ground. Grout injection involves emplacement of a bottom seal by grouting. It involves drilling through the site or specific directional drilling from the site perimeter, and injecting grout to form a curved or horizontal barrier.

Slurry walls have been shown to be effective at several NPL sites. Pilot testing would have to be done at the St. Louis site to determine the slurry wall construction materials that would be compatible with the contaminants present in the soils. Grout injection can be used as a horizontal barrier under buildings at SLDS and Futura Coatings. Costs for a slurry wall can be estimated as moderately high.

Grading is the general term for techniques used to reshape the surface of areas in order to manage surface water infiltration and runoff while controlling erosion. These techniques are effective when used with other management methods such as capping and vegetation. Certain portions can be implemented at the stream and areas at the site adjacent to the stream where runoff could enter Coldwater Creek.

Scarification and contour furrowing is used for stabilizing the stream bank to prevent erosion of stream sediments and diversion of the surface water stream from contaminated areas. This is a grading process and consists of excavation (along a contour), size separation, mixing, and compacting of soils.

The establishment of a vegetative cover through planting of shrubs, bushes, and trees is a cost effective method to stabilize a disposal surface, especially when preceded by capping and grading. It is easily implementable and costs are generally low.

For diversion of surface water flow, dikes and berms were retained for further evaluation. As mentioned earlier, surface water does not require treatment. The diversion system implemented in the creek would serve as an interim measure until dredging of contaminated sediments can be completed. Levees and floodwalls are principally constructed to serve as flood protection structures in areas subject to flooding. Levees and floodwalls were screened out because of their limited applicability. Encasing flow in a pipe is not required at the sites. The flow in the creek is generally low near the sites and the potential for redeposition of sediments due to stream flow is minimal. In addition, providing pipeflow is much more expensive and accompanying costs could be as much as one order of magnitude higher than dikes and berms.

Dikes and berms are well-compacted earthen ridges or ledges constructed immediately upslope from or along the perimeter of contaminated areas. These structures are generally designed to provide short-term protection (no more than a year) of critical areas by intercepting runoff and diverting water flow. It can be implemented in Coldwater Creek in the short-term until contaminated sediments are dredged from the site. It can also be implemented at the drainage ditches emanating from the site and leading to Coldwater Creek or the Mississippi River (at SLDS).

2.6.2.4 Collection of Groundwater

Extraction wells and a combination of extraction/injection wells were retained as remedial options for groundwater extraction. Extraction wells are effective and easily implemented. However, care must be taken in determining the location of the wells. The injection wells can be used to inject treated groundwater for plume control. Interceptor trenches were screened out in favor of extraction wells for collection of groundwater at the St. Louis site. Extraction wells will be more effective at the site than interceptor trenches considering the low permeability soils present at the sites.

2.6.2.5 Treatment of Surface Water and Groundwater

Process options considered for remediation of surface water/groundwater included air stripping, steam stripping, carbon adsorption, thin film evaporation, reverse osmosis, resin adsorption, ion exchange, evaporative recovery, electrodialysis, ultrafiltration, UV/photolysis, wet air oxidation, and supercritical water oxidation. Air stripping, carbon adsorption, ion exchange, and evaporative recovery, were retained for further evaluation.

Steam stripping requires intensive energy requirements and is not a marked improvement in treatment efficiency over air stripping and, therefore, eliminated. Thin film evaporation has not been proven to be effective for all organics in an aqueous stream. Electrodialysis, ultrafiltration, reverse osmosis, and resin adsorption provide little added benefit over ion exchange, and, therefore will not be considered further.

UV/photolysis is also effective as a polishing step for organics, but is eliminated in favor of carbon adsorption.

Air stripping effectively removes volatile organics and radon present in the water, and carbon adsorption is effective as a polishing step to treat hard-to-remove organics and radionuclides. Ion exchange and reverse osmosis (membrane filtration) were considered for removing radionuclides and concentrating the radionuclides from the aqueous stream. Ion exchange involves the interchange (or adsorption) of ions between the aqueous solution and a solid resin. Ion exchange system can comprise fixed bed, moving bed, and resin adsorption. Ion exchange is an effective and economical way to remove very fine radioactive contaminants from liquids to extremely low levels. Reverse osmosis is also effective in removing radioactive contaminants and achieving a concentrated aqueous stream, but is energy intensive and can be easily disrupted with fluctuations in influent conditions. Evaporative recovery effectively produces a concentrated waste stream and can be a pretreatment step before ion exchange.

Precipitation/flocculation/sedimentation, aeration, filtration, and sludge dewatering are all pretreatment or support technologies required to implement groundwater treatment options. Precipitation effectively removes metals and radionuclides. Aeration may be required as a pretreatment step to precipitation. Filtration effectively removes suspended solids from the precipitation process; and sludge generated will have to be dewatered prior to disposal.

2.6.2.6 Disposal/Discharge of Groundwater

Discharge of treated water to a surface water body, and disposal of sludges produced at an appropriately permitted waste disposal facility were retained for further evaluation.

Deep well injection is not permitted in Missouri. Offsite incineration will not be effective because of the presence of radionuclides in the sludge. Discharge to a POTW was retained for further evaluation. Permission to discharge will first have to be obtained.

Discharge to surface water would require compliance with effluent discharge permit limits for contaminants in addition to ensuring that the physical and chemical parameters of the treated water (e.g., temperature and pH) would not disrupt the receiving body's ecosystem. At the St. Louis site, this discharge option could be implemented by piping treated water from the treatment facility to Coldwater Creek or the Mississippi River. Disposal of sludge produced from the treatment operations will have to occur at an offsite facility meeting all pertinent regulatory requirements.

2.6.3 Preliminary Evaluation and Screening of Remedial Options for Buildings and Structures

The results of the preliminary evaluation and screening of remedial options for buildings and structures are presented in Table 2-6. Brief summaries of those results are provided in the following sections.

2.6.3.1 No Action for Buildings and Structures

This response action will remain applicable throughout the FS-EIS evaluation.

2.6.3.2 Institutional Controls/Site Management

The options of implementing site security with appropriate posting of signs and continued monitoring of the ambient air for radioactivity levels have been retained for further consideration. These are already being implemented at SLDS and Futura Coatings and will continue to be implemented. The option of deed restrictions to prevent direct contact of the public with the contaminated building areas was retained as well.

2.6.3.3 Containment of Radionuclides on Buildings and Structures

Surface sealing through paints, resins or plastics, or other impermeable materials has been retained for further evaluation. The principal objective of surface sealing is to reduce the mobility of the contaminants and reduce the further spread of contaminants into the ambient air or onto personnel working in the vicinity of the buildings. It is effective in containing the contaminants in the short-term.

2.6.3.4 Demolition of Buildings and Structures

Partial and complete demolition/dismantlement were both retained for further evaluation at the St. Louis site. An appropriate demolition/dismantlement method can be selected to effectively remove the contaminated surfaces.

2.6.3.5 Decontamination

All available physical decontamination options such as scrubbing, scraping, scrabbling, sanding, grinding sand/grit or CO_2 blasting have all been retained for further evaluation. Physical methods generally do not work well on metallic surfaces but with the proper choice of equipment can still be used. The actual method that will be employed will be addressed during the remedial design phase.

Table 2-6. Preliminary Evaluation and Initial Screening of Remedial Options for Buildings and Structures at the St. Louis Site

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screen Status
1. No Action	None	Will not be effective in reducing risk.	There are no process options.	None.	Retained; required for consideration by NCP and NEPA.
2. Institutional Controls/Site Maintenance	<u>Institutional Actions</u> • Deed Restrictions	Effectiveness depends on continued future implementation. Does not reduce contamination.	May not be implementable at non-DOE-owned properties.	Negligible costs, but could be high if DOE had to buy properties.	Retained.
	<u>Site Security</u> • Fencing/Signs	Fencing may reduce direct contact with contaminated soil to a certain extent, but will not comply with all remedial action objectives.	Fencing and site security is currently being implemented at SLDS and Futura Coatings. May be difficult to implement at properties not owned by DOE.	Low costs.	Retained.
	<u>Environmental Monitoring</u> • Monitoring of Ambient Air	Useful for documenting and evaluating conditions, but does not reduce risk by itself.	Implementable. May be difficult to implement at properties not owned by DOE	Low capital; moderate O&M costs.	Retained.
3. Containment	<u>Surface sealing</u> • Paints, resin/ plastic or other impermeable barriers	Limits dermal and inhalation exposure for a limited time. Not effective in long-term.	Implementable, but coordination with building owners will be required. May be difficult to implement at properties not owned by DOE.	Low costs.	Retained.

Table 2-6. (continued)

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screen Status
4. Collection	<u>Demolition</u>				
	• Partial Demolition	Effective on buildings where contamination is limited.	Implementable with appropriate equipment and procedures. There are no major buildings that cannot be demolished but ownership issues may present a problem.	Moderately High.	Retained.
	• Total Demolition	Effective.	Implementable. Use of buildings at SLDS and Futura Coatings is important to owners, so scheduling and sequence of demolition is important.	Moderately High.	Retained.
5. Decontamination	<u>Physical Decontamination Procedures</u>				
	• Scraping, scabbling, sanding, grinding, pelletized CO_2 blasting.	Effective on concrete, wood and masonry surfaces; not very effective on metal surfaces.	Implementable; availability of vendors may be limited.	Moderately High.	Retained.
	<u>Chemical Decontamination Procedures</u>				
	• Use of water, solvents, acids/bases, complexing agents.	Effective for contaminants that are hard to remove by physical means. Poor for porous materials. Waste must be capable of being dissolved in chemical.	Implementable. Collection of decontamination material is required.	Moderately High.	Retained.

Table 2-6. (continued)

Response Action	Remedial Option	Effectiveness	Implementability	Cost	Screen Status
5. Decontamination (continued)	Radon Control				
	• Passive or active collection systems.	Effective in collecting and controlling radon emissions from soil. Only radon emanations can be controlled. Does not address gamma radiation.	Implementable. May not be applicable at certain buildings where space is not adequate.	Low Costs.	Retained.
	• Ventilation system inside buildings.	Can be effective on a temporary basis in achieving radon reductions. Only radon emanations can be controlled. Does not address gamma radiation.	Implementable. Most buildings already have ventilation systems. Can be implemented at other buildings as well.	Low to moderate costs.	Retained.
	• Electrostatic precipitators (ESPs).	Can be effective in controlling dust particles. Only radon emanations can be controlled. Does not address gamma radiation.	Implementable. ESPs can easily be installed in rooms or enclosed areas.	Low costs.	Retained.
6. Disposal	Disposal.[1]				

1 Disposal options will be similar to that for soils and sediments and the disposal of materials in a solid waste landfill has been retained.

Chemical decontamination procedures would include the use of water, solvents, acids and bases, and complexing agents. Chemical procedures work best on metal surfaces. The choice of chemical to be used will be site- and material-specific and will depend on the contaminants to be removed, the surface that needs to be decontaminated and the physical location of the building or structure surface (i.e., whether it is located at a point where it could impact public health or the environment).

A number of physical and chemical methods have been used successfully in decontaminating buildings and equipment at other sites. At the St. Louis site, levels of radioactivity on the building surfaces are relatively low and typical decontamination procedures would be effective and implementable as well.

For radon control, the use of active or passive collection systems around the buildings or structures, and ventilation systems inside the buildings have been retained for further consideration. The option of using electrostatic precipitators (ESPs) to control dust inside the buildings has been retained as well. Buildings are currently ventilated, good construction and building management practices are followed, and the amount of dust or other suspended particulate inside the building is minimal. Therefore, ESPs are easy to install and effective in controlling dust emissions, but do not control radon generation.

Radon control methods such as active and passive collection systems around buildings and structures, ventilation systems inside buildings, and ESPs are simple, effective, and relatively inexpensive. They are considered temporary alternatives while long-term solutions for the source material in the soils are being considered and implemented.

2.6.3.6 Disposal/Discharge

For disposal of decontaminated building materials, those options considered for soils and sediments will be applicable for building materials as well. In addition, disposal of materials in a solid waste landfill has been retained for further evaluation.

2.7 SUMMARY OF SCREENING AND EVALUATION, AND LIST OF POTENTIALLY APPLICABLE REMEDIAL OPTIONS

The process of preliminary evaluation and initial screening of remedial options is schematically represented in Figures 2-1, 2-2, 2-3 for soils and sediments, surface water and groundwater, and buildings and structures, respectively. The list of remedial options that were determined to be potentially applicable after preliminary screening and evaluation, for remediation of soils and sediments, surface water and groundwater, and buildings and structures are summarized in Tables 2-7, 2-8, and 2-9 respectively. As evidenced in the tables, the list of potential technologies are arranged under each response action. These remedial options will be used to develop alternatives that address remediation of the site as a whole. The development of remedial alternatives is discussed in Section 3.

RESPONSE ACTION	REMEDIAL OPTIONS	SCREENING STATUS	
		Retained	Eliminated
No Action	None	X	
Institutional Controls/ Site Maintenance	Fencing/Signs	X	
	Soils/Sediments Monitoring	X	
	Deed Restrictions	X	
Collection	Excavation	X	

Figure 2-1. Summary of Initial Screening of Remedial Options for Soils/Sediments at the St. Louis Site

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RESPONSE ACTION	REMEDIAL OPTIONS	SCREENING STATUS	
		Retained	Eliminated
Containment	Clay Cap	X	
	Asphalt		X
	Concrete		X
	Multimedia Cap	X	
	Topsoil & Vegetative Cover	X	

Figure 2-1. Summary of Initial Screening of Remedial Options for Soils/Sediments at the St. Louis Site (cont'd)

RESPONSE ACTION	REMEDIAL OPTIONS	SCREENING STATUS	
		Retained	Eliminated
Disposal/Discharge *			
Onsite	Land Encapsulation	X	
Offsite	Federally Managed Facility **	X	
	FUSRAP Dedicated Facility	X	
	Commercially-Licensed Facility	X	
	Land Spreading		X
	Geologic Repositories		X
	Ocean Disposal		X
	Beneficial Reuse	X	
	Land Encapsulation at a Dedicated In-State Facility	X	

* The disposal/discharge remedial option will include supporting operations such as interim storage (if required), transportation and containerization. Interim Storage can be onsite in covered piles or indoors under a covered building, or can be offsite at a Federally-managed facility. Contaminated soil is expected to be transported in bulk via trucks or railcars.

** Federal Facility could be either at an existing site or could be created specifically for the St. Louis waste at a Federally-owned property.

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Figure 2-1. Summary of Initial Screening of Remedial Options for Soils/Sediments at the St. Louis Site (cont'd).

RESPONSE ACTION	REMEDIAL OPTIONS	SCREENING STATUS	
		Retained	Eliminated
Treatment *			
Volume Reduction Processes	Soil Washing	X	
	Organic Solvent Extraction	X	
	Classification	X	
	Flotation		X
	Screening	X	
	Gravity Separation	X	
Immobilization Processes	Solidification	X	
	Vitrification Thermal Treatment	X	

* Includes any ancillary treatment technologies such as filtration, precipitation/flocculation/sedimentation, and ion exchange.

Figure 2-1. Summary of Initial Screening of Remedial Options for Soils/Sediments at the St. Louis Site (cont'd).

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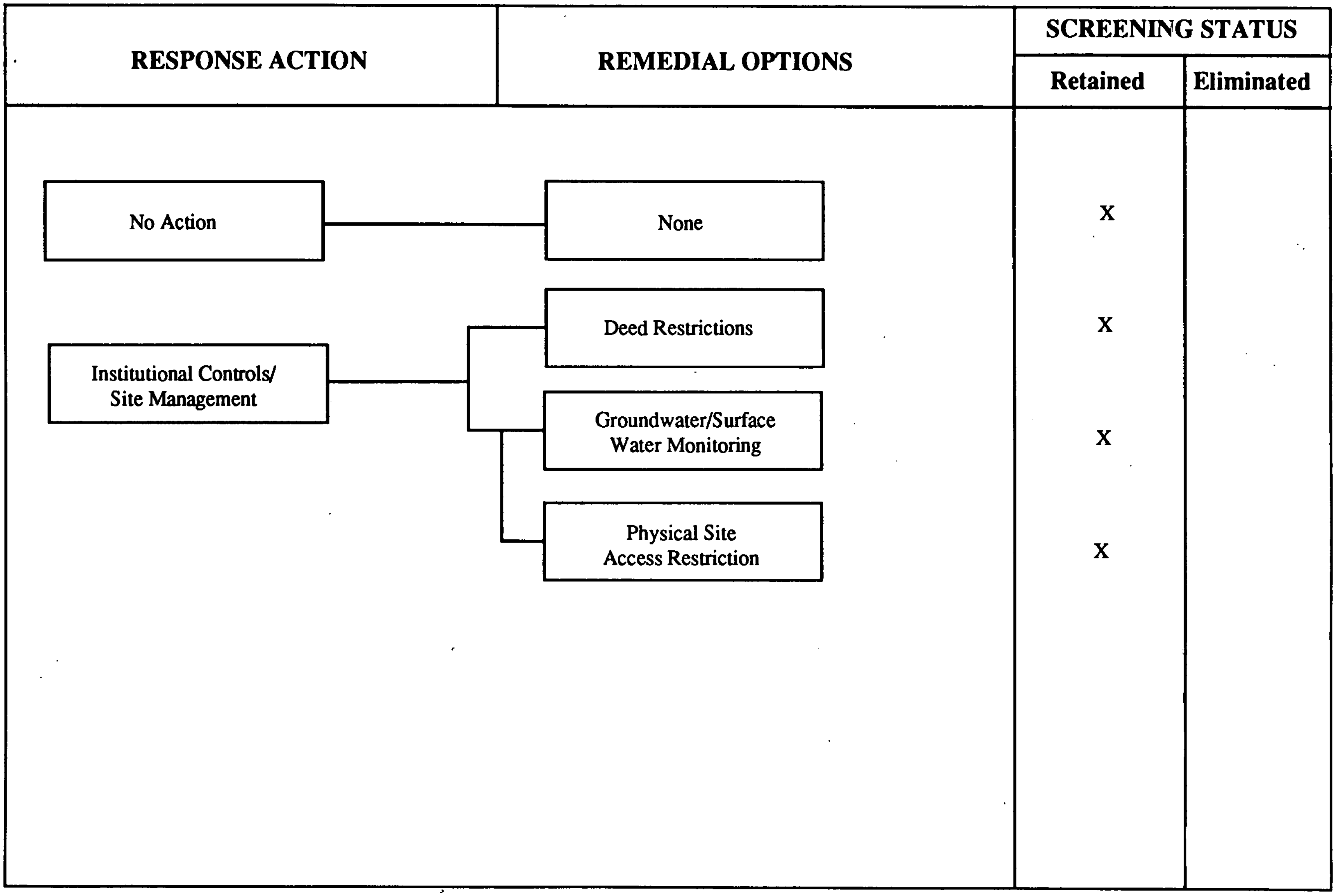

Figure 2-2. Summary of Initial Screening of Remedial Options for Surface Water/Groundwater at the St. Louis Site.

RESPONSE ACTION		REMEDIAL OPTIONS	SCREENING STATUS	
			Retained	Eliminated
Containment & Surface Water Controls				
	Vertical Barriers	Slurry Walls	X	
		Grout Curtains		X
		Vibrating Beams		X
		Steel Sheet Piling		X
	Horizontal Barriers	Grout Injection	X	
		Block Displacement		X

Figure 2-2. Summary of Initial Screening of Remedial Options for Surface Water/Groundwater at the St. Louis Site (cont'd)

RESPONSE ACTION	REMEDIAL OPTIONS	SCREENING STATUS	
		Retained	Eliminated
Containment & Surface Water Controls			
Revegetation	Grasses, Shrubs & Trees	X	
Grading	Scarification, Contour Furrowing	X	
Diversion Systems	Dikes and Berms	X	
	Levees and Floodwalls		X
	Encase in Pipeflow		X

Figure 2-2. Summary of Initial Screening of Remedial Options for Surface Water/Groundwater at the St. Louis Site (cont'd)

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RESPONSE ACTION	REMEDIAL OPTIONS	SCREENING STATUS: Retained	SCREENING STATUS: Eliminated
Collection			
Pumping	Extraction Wells	X	
	Extraction/Injection	X	
Subsurface Drains	Interceptor Trenches		X

Figure 2-2. Summary of Initial Screening of Remedial Options for Surface Water/Groundwater at the St. Louis Site (cont'd)

RESPONSE ACTION	REMEDIAL OPTIONS	SCREENING STATUS	
		Retained	Eliminated
Treatment *			
Physical Processes	Air Stripping	X	
	Steam Stripping		X
	Carbon Adsorbtion	X	
	Thin Film Evaporation		X
	Reverse Osmosis		X
	Resin Adsorbtion		X
	Ion Exchange	X	

* The treatment response action includes ancillary treatment technologies such as aeration and filtration required to support the primary treatment options.

Figure 2-2. Summary of Initial Screening of Remedial Options for Surface Water/Groundwater at the St. Louis Site (cont'd)

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RESPONSE ACTION	REMEDIAL OPTIONS	SCREENING STATUS	
		Retained	Eliminated
Treatment (cont'd)			
Physical Processes	Evaporative Recovery	X	
	Electrodialysis		X
	Ultrafiltration		X
	UV/Photolysis		X
Chemical Processes	Wet-Air Oxidation		X
	Supercritical Water Oxidation		X

Figure 2-2. Summary of Initial Screening of Remedial Options for Surface Water/Groundwater at the St. Louis Site (cont'd)

RESPONSE ACTION	REMEDIAL OPTIONS	SCREENING STATUS	
		Retained	Eliminated
Disposal/Discharge			
Onsite Discharge	Discharge to Surface Water	X	
	Deep Well Injection		X
Offsite Disposal/Discharge	Offsite Waste Disposal Facility	X	
	Offsite Incineration		X
	POTW Discharge	X	

Figure 2-2. Summary of Initial Screening of Remedial Options for Surface Water/Groundwater at the St. Louis Site (cont'd)

RESPONSE ACTION	REMEDIAL OPTIONS	SCREENING STATUS	
		Retained	Eliminated
No Action	None	X	
Institutional Controls/ Site Management			
Site Security	Fencing/Signs	X	
Environmental Monitoring	Ambient Air Monitoring	X	
Access Restrictions	Deed Restrictions	X	

Figure 2-3. Summary of Initial Screening of Remedial Options for Buildings and Structures at the St. Louis Site

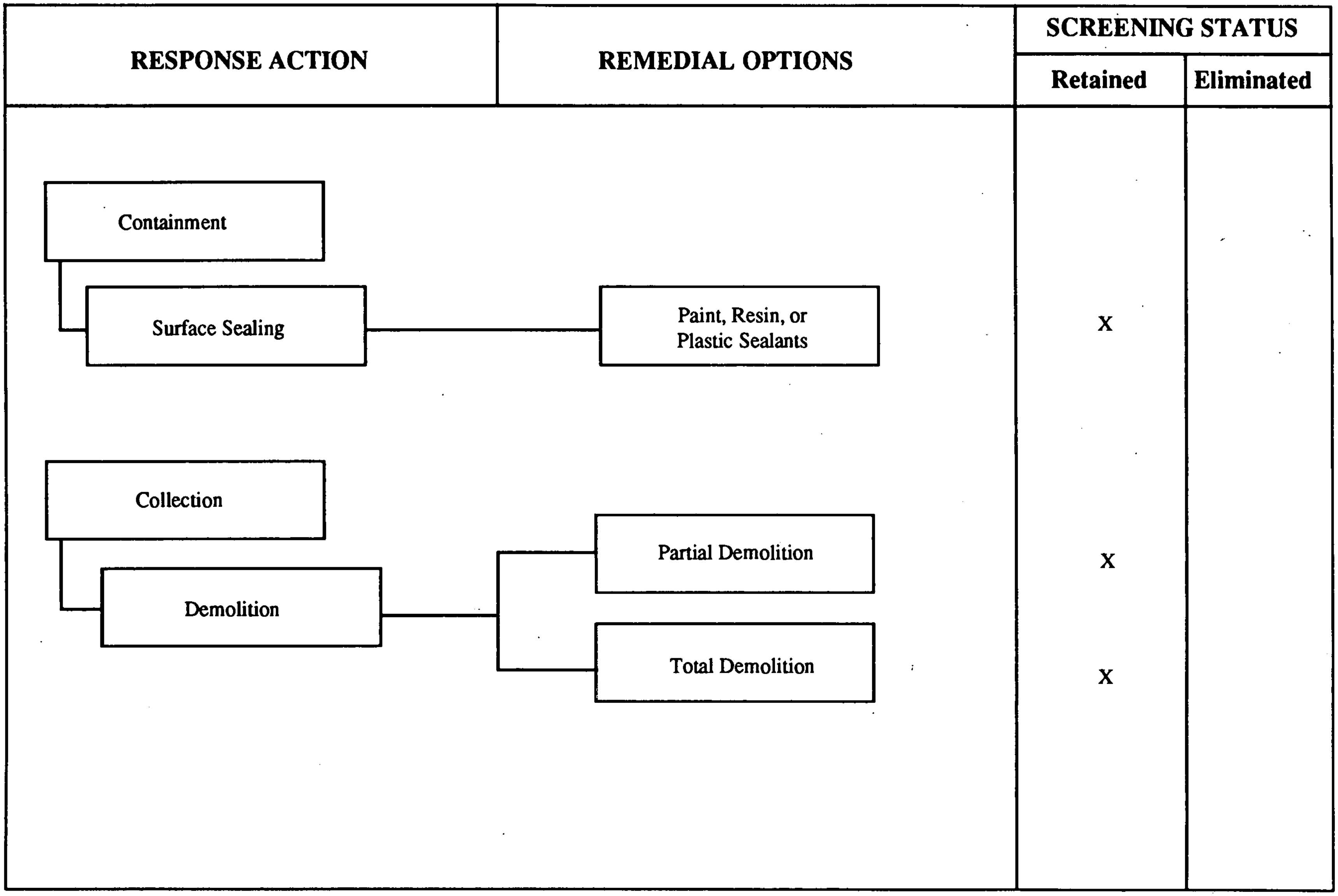

Figure 2-3. Summary of Initial Screening of Remedial Options for Buildings and Structures at the St. Louis Site (cont'd)

RESPONSE ACTION	REMEDIAL OPTIONS	SCREENING STATUS	
		Retained	Eliminated
Decontamination			
Physical Procedures	Various	X	
Chemical Procedures	Use of Various Chemicals	X	
Radon Control	Passive or Active Collection Systems	X	
	Ventilation System Inside Building	X	
	Electrostatic Precipitations	X	
Disposal *		X	

* Disposal options will be similar to that for soils and sediments, and the disposal of materials in a solid waste landfill has been retained.

Figure 2-3. Summary of Initial Screening of Remedial Options for Buildings and Structures at the St. Louis Site (cont'd)

92-020M/070192

Table 2-7. List of Potential Remedial Options Retained for Soils and Sediments at the St. Louis Site

INSTITUTIONAL CONTROLS/SITE MAINTENANCE

- Deed Restrictions
- Site Security
- Environmental Monitoring

CONTAINMENT

- Clay Cap
- Multimedia Cap
- Soil Cover

COLLECTION

- Excavation

TREATMENT (including ancillary operations)

- Soil Washing
- Screening
- Gravity Separation
- Organic Solvent Extraction
- Classification
- Solidification } Immobilization Processes
- Vitrification } Immobilization Processes

Table 2-7. (continued)

DISPOSAL
• Onsite Land Encapsulation
• Federal Facility
• FUSRAP Dedicated Facility
• Disposal at a Commercially Licensed Facility
• Beneficial Reuse
• Offsite Land Encapsulation in a Dedicated In-state Facility
(Will include interim storage, containerization, and transportation options

Table 2-8. List of Potential Remedial Options Retained for Surface Water and Groundwater at the St. Louis Site

INSTITUTIONAL CONTROLS/SITE MAINTENANCE

- Deed Restrictions/Access Restrictions
- Monitoring of Surface Water and Groundwater

CONTAINMENT

- Slurry Walls
- Grout Injection
- Revegetation (with grasses, shrubs, and trees)
- Grading of Stream Bank
- Dikes and Berms

COLLECTION

- Excavation Wells
- Extraction/Injection Wells

TREATMENT *

- Air Stripping
- Carbon Adsorption
- Ion Exchange
- Evaporative Recovery

DISPOSAL/DISCHARGE

- Surface Water Discharge
- Offsite Waste Disposal Facility
- POTW Discharge

* Includes ancillary treatment processes such as aeration, filtration, precipitation, flocculation/sedimentation, and dewatering.

Table 2-9. List of Potential Remedial Options Retained for Buildings and Structures at the St. Louis Site

INSTITUTIONAL CONTROLS/SITE MAINTENANCE

- Deed Restrictions
- Fencing/Signs
- Ambient Air Monitoring

CONTAINMENT

- Surface Sealing

COLLECTION

- Partial Demolition
- Complete Demolition

DECONTAMINATION

- Physical Procedures
- Chemical Procedures
- Radon Controls
    - passive or active collection systems
    - ventilation inside buildings
    - electrostatic precipitators

DISPOSAL

- Onsite Land Encapsulation
- Federal Facility
- FUSRAP Dedicated Facility
- Disposal at a Commercially Licensed Facility
- Beneficial Reuse
- Offsite Land Encapsulation in Dedicated In-state Facility

3. DEVELOPMENT AND SCREENING OF ALTERNATIVES

3.1 INTRODUCTION

In this section, the remedial options that were retained following preliminary screening and evaluation in Section 2 were combined to form remedial action alternatives. During development of alternatives for the St. Louis site, emphasis was placed on developing alternatives that permanently and significantly treat wastes to reduce the volume, toxicity, or mobility of the waste. Furthermore, alternatives were developed to comply with the limited remedial action objectives described in Section 1. In developing these alternatives, the following requirements for remedy selection were considered:

- The alternative adequately protects public health and the environment.
- The alternative can attain chemical-specific ARARs and can be implemented in a fashion consistent with location and action-specific ARARs.
- The alternative uses permanent solutions and alternate treatment technologies to the maximum extent possible.
- The alternative is capable of achieving a remedy in a cost effective manner, taking short- and long-term costs into consideration.
- Alternatives that permanently and significantly reduce the mobility, toxicity, or volume of hazardous substances will be selected to the maximum extent possible.

From a remediation perspective, there are five basic remedial units present at the St. Louis site. Each unit requires independent evaluation because of the unique factors that govern the disposition of the contamination. Because of these unique factors, remedial alternatives will be developed separately for each of the remedial units. Alternatives for each unit will be analyzed and evaluated separately. Finally the most appropriate alternative for each unit will be combined to yield remediation of the site as a whole. Even though the unique factors permit addressing each remedial unit separately, it is important to note that alternatives developed for each unit will be compatible with each other towards remediating the contamination at the entire site.

Accordingly, the five remedial units are as follows:

- accessible soils,
- "access restricted" soils,
- Coldwater Creek sediments,
- buildings/structures, and
- groundwater.

Accessible soils include soils that can be easily excavated without impacting buildings or structures, residential or commercial properties, and the people living or working near the vicinity properties. Soils at SLAPS, HISS, and some residential and vicinity properties would fall under this remedial unit. In addition, soils at SLDS that are not covered by buildings or permanent structures can be termed as accessible soils as well.

"Access restricted" soils are those that exceed the cleanup levels for radionuclides but, access to these soils is currently constrained. Soils present under buildings, man-made structures, railroads, stormwater and sanitary sewers and other permanent structures would fall under this category. Any attempts to excavate these soils will require demolishing buildings or structures that are now used. Access to soils will remain constrained only so long as the buildings or structures remain. In the event buildings or structures are decommissioned and demolished, the soils will become accessible.

Other remedial units are Coldwater Creek, which includes sediments and surface water in the creek, building and structures predominantly at SLDS and Futura Coatings, and groundwater that is present beneath each of the sites.

3.2 IDENTIFICATION OF PRELIMINARY REMEDIAL ALTERNATIVES

Preliminary remedial alternatives have been identified for each remedial unit and are described below.

3.2.1 Accessible Soils

As discussed in Sections 1 and 2, the waste soils at the site are contaminated predominantly with radionuclides in the U-238, Th-232, and U-235 decay series. Some organic compounds have also been detected at low concentrations. Currently, the risks due to exposure to the contaminants are minimal. Remedial alternatives developed will focus on reducing impacts to human health and the environment from future exposures. In addition, it is assumed that alternatives involving removal will generally comply with DOE's 5/15 pCi/g criteria for radium and thorium, and the level of 50 pCi/g for uranium. The volume of soils exceeding these guidelines has been conservatively estimated at 635,000 m^3 (830,000 yd^3). The alternatives developed for the accessible soils include:

- no action,
- institutional controls/site maintenance,
- containment,
- excavation followed by treatment and disposal, and
- excavation followed by disposal.

Disposal options include:

- onsite land encapsulation,
- existing federal facility,
- FUSRAP dedicated facility,
- commercially licensed facility,
- offsite land encapsulation in dedicated in-state facility, and
- beneficial reuse.

No Action

This alternative consists of performing no remedial actions and maintaining a "status quo" at the site. Periodic monitoring of contaminant levels through collection and analyses of samples is incorporated in this alternative.

Institutional Controls/Site Maintenance

This option considers implementing deed restrictions, site security, and conducting environmental monitoring. SLDS, SLAPS, and HISS including the Futura Coatings building, are already enclosed by a fence that prevents direct access to the site. Security also is maintained at these sites. This may be difficult to implement at the vicinity properties; however, warning signs could be posted, if required, at appropriate locations at the vicinity properties.

Future use of the sites could be restricted through land use restrictions. Notation would be made to record the presence of radionuclide contamination and restrict future development and use of the site. In some areas this may require purchase of the property by DOE. In other areas such as SLDS, it may not be implementable.

The objective of environmental monitoring is to evaluate whether the contaminant levels are changing and if the contaminants are migrating offsite. Environmental monitoring would involve routine, periodic sampling of the soils at the site. Details of the monitoring program will be described and evaluated in the FS-EIS.

Containment

This alternative incorporates capping of the site to prevent direct contact of contaminants in the soil with the public and reduce further spread of contaminants. This alternative will have to be implemented along with institutional controls that incorporate deed restrictions to prevent unrestricted use of the site. Environmental monitoring of the media also will be an important element of the alternative to ensure that contaminants are not migrating offsite.

Excavation Followed by Disposal

Any soils that exceed the cleanup guidelines for radium, thorium, and uranium would be excavated. Soils within 15 cm (6 in.) of the ground surface would be considered contaminated if radium and thorium concentrations are above 5 pCi/g, and deeper soils would be considered contaminated if radium and thorium concentrations are above 15 pCi/g. This option would assure eliminating adverse health effects, and assure the elimination of contamination. Standard techniques for excavation would be used at the sites. Dust control, soil erosion and sediment control, and other health and safety precautions would be taken during excavation.

Excavation Followed by Treatment and Disposal

After excavation, soils are treated onsite using volume reduction procedures such as soil washing, screening, or gravity separation. After processing, clean soils can be utilized for roadbed construction, airport expansion, or similar projects. The remaining residues would then be disposed of appropriately, as discussed below.

Disposal Options

The following six options selected for disposal involve a combination of onsite and offsite disposal options. Offsite disposal options include disposal in a designed encapsulation cell at a generic location within the state of Missouri. Solidification and vitrification have been retained as potential pretreatment options prior to transportation and/or disposal. The two technologies can be applicable with any of the six disposal options.

A. Onsite Disposal in a Designed Encapsulation Cell at SLAPS

The contaminated materials would be excavated and disposed in an encapsulation cell at SLAPS. The cell would have a liner that prevents upward migration of water into the cells and minimizes potential buildup of water within the cell. Infiltration of surface water into the cell would be minimized and release of radon gas would be mitigated. Erosion preventative measures and protection against burrowing rodents would be incorporated. The cell should be constructed so that it is above the groundwater table. Monitoring wells would be installed around the cell to detect any breaks in the cell. Air monitoring equipment and adequate lighting should be provided for the duration of the life of the cell.

B. Offsite Disposal in an In-state Land Encapsulation Cell, but In-state (Generic Location)

This option involves disposal of the waste materials at a facility within the state of Missouri. The design requirements for an encapsulation cell offsite will be similar to that for an onsite cell. The development of a disposal facility within the state of Missouri to handle the St. Louis waste is a technically viable possibility. It is, however, more likely that the state and EPA would require DOE build and maintain any cells dedicated to the St. Louis waste.

C. Offsite Disposal at a Commercially-Licensed Disposal Facility

Under this option, the contaminated materials would be excavated and transported offsite to a commercially licensed waste disposal facility for permanent disposal. Contaminated materials may be transported in bulk via trucks or rail or may require containerization. Strict compliance with all federal and state regulations regarding the transportation of the waste would be maintained. All truck or rail cars utilized to haul contaminated materials would be inspected prior to use. The route of transportation will be established and an emergency response program will be established to respond to accidents. Several disposal sites are potentially applicable as discussed earlier in Section 2. The effectiveness and implementability of each disposal site will be evaluated in detail in the FS-EIS.

D. Offsite Disposal at an Existing Federal Facility

This option would be similar to Disposal Option C. Several federal facilities could be used for disposal as discussed earlier in Section 2. The effectiveness and implementability of each federal facility will be evaluated in detail in the FS-EIS.

E. Permanent Disposal at a FUSRAP-Dedicated Disposal Facility Located at an Existing DOE Facility

This option involves disposal at a dedicated newly designed, and constructed encapsulation cell at an existing DOE facility. The design requirements for an encapsulation cell offsite will be similar to that for an onsite cell. This land encapsulation facility could be dedicated to the disposal of not only St. Louis waste, but other FUSRAP wastes as well.

F. Beneficial Reuse

This option involves the disposal of select soils as fill material during the construction of a new runway at the Lambert Airport located adjacent to SLAPS. An appropriate model should be set up to predict the fate of the contaminants in the runway subsoils. The results of this modeling effort can then be used to develop levels of contaminants in the soils that can be safely used as fill material for runway construction. Much of the siting and design criteria required for a land encapsulation cell would be applicable for disposal of soils as fill material under runways.

3.2.2 "Access Restricted" Soils

"Access restricted" soils are those that exceed the cleanup levels for radionuclides, but where access to these soils is currently constrained. These soils are subject to the same set of remedial options that were discussed earlier in Section 3.2.1. However, for purposes of analysis, these soils are being evaluated independently to better identify differences, e.g., additional cost required as a result of building demolition and possible stormwater and sanitary sewer system remediation. In addition, a phased approach is being considered which provides for short-term controls until the soils become accessible. Accordingly, the following short-term alternatives were identified for the "Access Restricted" soils.

No Action

This alternative consists of performing no remedial actions and maintaining a "status quo" at the site. Periodic monitoring of contaminant levels through collection and analyses of samples is incorporated in this alternative.

Institutional Controls/Site Maintenance

The institutional controls and site maintenance activities will be similar to that for "Access Restricted" soils.

Radon Controls

The containment option will be as described for the accessible soils. Radon control measures can include passive or active collection systems, ventilation inside buildings, and use of electronic precipitators. These are described under options for remediation of buildings and structures.

3.2.3 Coldwater Creek

Contamination in the creek is mainly in the sediments lining the banks and the bottom of the creek bed. Surface water is not contaminated and will not be addressed. Development of remedial alternatives at Coldwater Creek consisted of diverting surface water flow at specific locations along the creek to permit partial excavation of contaminated sediments, and grading the stream embankments at specific locations to reduce erosion and resuspension of stream sediments. After excavation of sediments at Coldwater Creek, further treatment and disposal options for sediments would be similar to that for waste soils at the site. The remedial alternatives for Coldwater Creek are as follows:

No Action

Under this alternative no remedial actions will be conducted at the site and "status quo" will be maintained.

Institutional Control/Site Management

This alternative consists of implementing land use restrictions, site security where applicable, and environmental monitoring of surface water and sediments. Areas of the creek located close to the site where contaminated sediments are located could be cordoned off by a fence to prevent direct contact with the contamination. Warning signs could be posted notifying the public of the potential hazards. The portion of the creek where contamination is located could be restricted for future use. Environmental monitoring would be conducted by collecting samples of sediments and surface water. The sampling results would show if contamination in the sediments is migrating downstream and contamination is being transferred to surface water.

Diversion of Flow Through Dikes and Berms Followed by Partial Excavation of Sediments

This allows for the removal of hot spots of contamination from the creek. Any excavation in the creek will result in significant environmental impacts. Therefore, if excavation is required, it should focus on areas of contamination with high radioactivity levels. Dikes and berms can be constructed at appropriate locations to divert surface water flow until excavation of sediments is complete. Construction of dikes and berms is straightforward, and can be implemented easily. Since dikes and berms will only be interim measures, materials of construction and techniques of construction would be such that the diversion structures can be completed easily and quickly.

Grading of Embankment Along With Revegetation at Specific Locations

A potential concern due to the presence of contaminated sediments in the creek is the gradual erosion of the sediments along the embankment and migration downstream. Erosion control measures can be implemented by grading the creek bank at appropriate locations and revegetating the graded area to hold the sediments together.

3.2.4 Buildings and Structures

Remediation of buildings and structures should be coordinated in a manner that results in minimal disruption of activities ongoing at the sites. Old buildings are renovated at SLDS periodically by either demolition of the buildings or through modifications of the specific portions that require repair or renovation. The alternatives developed cover a range of options and can be applied towards remediation of buildings that have recently been renovated and will be renovated now only after an extended period of time, or buildings that are in a deteriorated condition and must be renovated in a short period of time. The alternatives developed for remediation of buildings and structures include:

No Action

This alternative consists of performing no remedial actions and maintaining a "status quo" at the site. Periodic monitoring of contaminated areas through collection and analysis of samples is incorporated in this alternative.

Institutional Controls

This alternative will consist of implementing site security, where applicable, posting of signs indicating potential for exposure, where appropriate, and continued monitoring of air for external gamma radiation from the contaminated surfaces of buildings and structures. Adequate security already exists at SLDS and in particular at the buildings where the surfaces are contaminated, such that the public is not impacted. Some signs have been posted at buildings where the surfaces are believed to be contaminated. This allows workers to take precautions before entering the buildings. Restriction on future development would be incorporated into the property deed to limit land use should the Mallinckrodt Chemical Plant be decommissioned.

Surface Encapsulation of Contamination on Surfaces of Buildings and Structures

This alternative involves using an appropriate material such as resin or paint to seal the contaminants on the surfaces. This alternative would reduce exposure to external gamma radiation.

Physical or Chemical Decontamination Procedures Followed by Surface Restoration

This alternative involves using a combination of physical and/or chemical decontamination procedures to remove the contamination from the surfaces to acceptable levels. Physical decontamination procedures can include scrubbing, scraping, scabbling, sanding, grinding, pelletized CO_2, or sand blasting. Chemical decontamination procedures can include using water, solvents, acids and bases, and complexing agents to dissolve contaminants present on the surface. After decontamination is complete, the surfaces will be restored to the original condition, and the buildings can be released for unrestricted use. Waste streams that would be generated from the decontamination operations would have to be collected and treated to remove radionuclide contaminants.

Demolition and Subsequent Disposal of Building Materials

This alternative involves the demolition of buildings and structures without decontamination being performed on the surfaces. It is expected that, in at least some portion of the demolished debris, the overall activity levels will be below the 5/15 pCi/g criteria that is being employed for the cleanup of the soils. It is expected that this material can be transported to a permitted demolition landfill for disposal. The remainder of the building debris that does not comply with the 5/15 pCi/g criteria must be addressed along with the contaminated soils.

Physical or Chemical Decontamination Followed by Demolition and Disposal

This alternative involves decontaminating the surfaces of the buildings and structures prior to demolition. It is expected that, since the decontamination would reduce contamination to acceptable levels and thereby reduce exposure to external gamma radiation, the building debris can be transported to a permitted solid waste landfill for disposal.

3.2.5 Groundwater

Remediation of groundwater from the St. Louis site addresses both radionuclides and other organic and inorganic chemicals detected in the water. Additional data required on the characteristics of contamination in the groundwater and the extent of contamination at each site is being obtained. This information will be used to determine the number of extraction wells that may be needed and the locations where they would be placed. The alternatives that were identified for groundwater remediation are as follows:

No Action

This alternative consists of performing no remedial actions and maintaining a "status quo" at the site.

Institutional Controls

This alternative will consist of implementing deed restrictions to limit groundwater and land use and continued monitoring of groundwater to assess the potential migration of containments in groundwater.

Containment Through Emplacement of Slurry Walls and In situ Grouting for Horizontal Barriers

This alternative consists of installing a subsurface barrier to divert groundwater flow around the source material (subsurface soils). This alternative will be implemented along with the construction of a cap (addressed under containment of accessible soils). The cap will reduce infiltration of water through the waste and result in reduction of further containment of groundwater. Geotechnical borings drilled prior to design would supplement information obtained from the RI studies to determine the actual location of the slurry walls.

Extraction Followed by Treatment and Disposal

This alternative involves installing extraction wells to collect contaminated groundwater from beneath the site and then treating the water to remove contamination to acceptable levels.

Options for Treatment and Disposal

A. Precipitation/Flocculation/Filtration Followed by Air Stripping and Activated Carbon Adsorption and Discharge to a Surface Water Body

   This alternative uses a precipitation/flocculation/filtration system to precipitate and remove suspended solids, dissolved metals, and radionuclides from the groundwater. It is followed by air stripping and activated carbon adsorption to remove residual radionuclides and organic contaminants from the groundwater. The treated water is then discharged to a surface water body.

B. Precipitation/Flocculation/Filtration Followed by Air Stripping and Activated Carbon Adsorption and Disposal to a POTW

   This is similar to the above alternative except that discharge would be to a POTW.

C. Air Stripping Followed by Activated Carbon Adsorption, Evaporative Recovery to Concentrate Aqueous Stream, Ion Exchange and Disposal to a Surface Water Body

This alternative uses air stripping and carbon adsorption to remove organic contaminants from the groundwater. It is followed by concentration and ion exchange to remove inorganics, including radionuclides, from the groundwater. The treated water is then discharged to a surface water body.

D. Air Stripping Followed by Activated Carbon Adsorption, Evaporative Recovery to Concentrate Aqueous Stream, Ion Exchange and Disposal to a POTW

This is similar to Alternative C., but disposal will be to a POTW.

E. Precipitation/Flocculation Followed by Air Stripping, Evaporative Recovery to Concentrate Aqueous Stream, Ion Exchange and Disposal to a Surface Water Body

Here, a precipitation/flocculation system is used to remove suspended solids and dissolved metals from the groundwater. This process is followed by air stripping and activated carbon adsorption to remove volatile organic contaminants from the groundwater. The waste stream is concentrated and passed through an ion exchange unit to remove radionuclides. The treated water is then discharged to a surface water body.

For all treatment options, it is assumed that sludge generated from treatment operations will be transported to a permitted demolition landfill for disposal. The alternatives developed for each contamination scenario are summarized in Tables 3-1 through 3-5.

Table 3-1. Summary of Selected Remedial Alternatives for Accessible Soils at the St. Louis Site

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Alternative No. 1 - No Action

This alternative consists of performing no remedial actions and maintaining a "status quo" at the site. Periodic monitoring of contaminant levels through collection and analyses of samples is incorporated in this alternative.

Alternative No. 2 - Containment

This alternative incorporates capping of the site to prevent direct contact of contaminants in the soil with the public and reduce further spread of contaminants.

Alternative No. 3 - Excavation, Treatment, and Disposal

Excavation to remove all contamination above guidelines. After excavation, soils could be treated using volume reduction procedures such as soil washing, screening, or gravity separation or immobilization treatment technologies.

Alternative No. 4 - Excavation and Disposal

Excavation to remove all contamination above guidelines.

Disposal Options

Option 4A - Onsite disposal in a designed land encapsulated cell at SLAPS

Option 4B - Permanent disposal in an offsite, but in-state (generic location) land encapsulation cell

Option 4C - Permanent disposal at an offsite commercially licensed facility

Option 4D - Permanent disposal at an existing offsite federal disposal facility

Option 4E - Permanent disposal at a created/dedicated FUSRAP disposal facility located at an existing DOE facility

Option 4F - Permanent disposal of select soils through beneficial reuse

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Table 3-2. Summary of Selected Remedial Alternatives for "Access Restricted" Soils at the St. Louis Site

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Alternative No. 1 - No Action

This alternative consists of performing no remedial actions and maintaining a "status quo" at the site. Periodic monitoring of contaminant levels through collection and analyses of samples is incorporated in this alternative.

Alternative No. 2 - Institutional Controls

This option will consider the use of deed restrictions, site security and other means to prevent direct contact of the public with the contaminants. Environmental monitoring is also incorporated.

Alternative No. 3 - Containment and Radon Controls

This alternative involves the use of a soil cover, where appropriate, to cap the site to prevent direct contact of contaminants in the soil with the public and reduce further spread of contaminants, and implement radon controls to capture and control radon emissions from the soils.

Note: The alternatives that were identified for Accessible Soils will be technically feasible for "Access Restricted" soils as well.

Table 3-3. Summary of Selected Remedial Alternatives for Coldwater Creek at the St. Louis Site

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Alternative No. 1 - No Action

This alternative consists of performing no remedial actions and maintaining a "status quo" at the site. Periodic monitoring of contaminant levels through collection and analyses of samples is incorporated in this alternative.

Alternative No. 2 - Institutional Controls

This option will consider the use of deed restrictions, site security and other means to prevent direct contact of the public with the contaminants at the creek. Environmental monitoring is incorporated as well.

Alternative No. 3 - Diversion of Flow through Dikes and Berms Followed by Partial Excavation of Sediments

This alternative considers diverting the flow of water in the creek to allow the excavation of contaminated sediments in the creek. The diversion measures would be temporary until the excavation can be completed.

Alternative No. 4 - Grading of Embankment Along with Revegetation at Specific Locations

This alternative involves stabilizing the banks of the creek to prevent further resuspension of the sediments in the surface water flow.

Table 3-4. Summary of Selected Alternatives for Buildings and Structures at the St. Louis Site

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Alternative No. 1 - No Action

This alternative consists of performing no remedial actions and maintaining a "status quo" at the site.

Alternative No. 2 - Institutional Controls

This option considers the use of site security, deed restrictions, and other means to prevent direct contact of the public with the contaminants.

Alternative No. 3 - Surface Encapsulation of Contamination Surfaces

This alternative involves using an appropriate material such as resin or paint to seal the contaminants on the surfaces.

Alternative No. 4 - Physical and/or Chemical Decontamination Procedures Followed by Surface Restoration

This alternative involves using a combination of physical and/or chemical decontamination procedures to remove the contamination from the surfaces to acceptable levels. After decontamination is complete the surfaces will be restored to the original condition, and the buildings released for unrestricted use.

Alternative No. 5 - Demolition and Disposal

This alternative involves the demolition of buildings and structures without decontamination being performed on the surfaces.

Alternative No. 6 - Physical and/or Chemical Decontamination Followed by Demolition and Disposal

This alternative involves decontaminating the surfaces of buildings and structures prior to demolition.

Table 3-5. Summary of Selected Remedial Alternatives for Groundwater at the St. Louis Site

Alternative No. 1 - No Action

This alternative consists of performing no remedial actions and maintaining a "status quo" at the site.

Alternative No. 2 - Institutional Controls

This option will consider the usc of deed restrictions, site security and other means to prevent the public from using groundwater. Environmental monitoring is also incorporated.

Alternative No. 3 - Containment

This involves capping and emplacement of slurry walls and in situ grouting for horizontal barriers to contain groundwater within the zone of influence at the site.

Alternative No. 4 - Extraction and Treatment/Disposal

Extraction of the water can be accomplished through the installation of extraction or a combination of extraction and injection wells. The wells will be strategically placed to capture predominantly radionuclides in the water.

Options for Treatment and Disposal

Option 4A - Precipitation/flocculation/filtration followed by air stripping and activated carbon adsorption and discharge to a surface water body

Option 4B - Precipitation/flocculation/filtration followed by air stripping and activated carbon adsorption and discharge to a POTW

Option 4C - Air stripping followed by activated carbon adsorption, evaporative recovery to concentrate aqueous stream, ion exchange and discharge to a surface water body

Option 4D - Air stripping followed by activated carbon adsorption, evaporative recovery to concentrate aqueous stream, ion exchange, and discharge to a POTW

Option 4E - Precipitation/flocculation followed by air stripping, evaporative recovery to concentrate aqueous stream, ion exchange and discharge to a surface water body.

4. ADDITIONAL STUDIES RECOMMENDATIONS

Additional studies will be required before some of the remedial alternatives can be implemented at the St. Louis site. The data needs are especially important for contaminated soils treatment (immobilization and/or volume reduction technologies), onsite disposal, groundwater remediation, and remediation of buildings and structures.

Treatability Studies for Contaminated Soils and Sediments

Treatability studies would be necessary to provide specific information if treatment were selected as the preferred alternative.

Bench- or pilot-scale studies may be required to optimize the effectiveness of immobilization and/or volume reduction treatment technologies. EPA guidance (EPA 1988) outlines the rationale for deciding when treatability studies are and are not required. A summary from this guidance is provided below.

Certain technologies have been demonstrated sufficiently so that site-specific information collected during the site characterization is adequate to evaluate and cost those technologies without conducting treatability testing. Examples when treatability testing may not be necessary include:

- a developed technology is well proven on similar applications;
- substantial experience exists with a technology employing treatment of well-documented waste materials; (for example, air stripping or carbon adsorption of groundwater containing organic compounds for which treatment has previously proven effective); and
- relatively low removal efficiencies are required (e.g., 50 to 90 percent), and data are already available.

Frequently, technologies have been insufficiently demonstrated or characterization of the waste alone is insufficient to predict treatment performance or to estimate the size and cost of appropriate treatment units. Furthermore, some treatment processes are insufficiently understood for performance to be predicted, even with a complete characterization of the wastes. For example, often it is difficult to predict biological toxicity in a biological treatment plant without pilot tests. When treatment performance is difficult to predict, an actual testing of the process may be the only means of obtaining the necessary data. In fact, in some situations it may be more cost-effective to test a process on the actual waste than it would be to characterize the waste in sufficient detail to predict performance.

Treatability testing performed during an RI/FS may be used to evaluate a remedial option, including evaluating performance, determining process sizing, and estimating costs in sufficient detail to support the remedy-selection process. Some treatability testing on soils from the St. Louis site has been performed to test the effectiveness of volume reduction technologies (AWC 1987). Treatability testing in the RI/FS is not meant to be used solely to develop detailed design or operating parameters that are more appropriately developed during the remedial design phase.

For solidification, the selection of a solidifying agent and the appropriate mix ratios can be determined through treatability tests. The effectiveness of vitrification should be determined through treatability studies conducted specifically on the site soils.

A data sufficiency study was recently completed for the St. Louis site. The objective of this study was to identify data gaps that currently exist in the characterization database. At SLDS and SLAPS, additional shallow soil samples will be collected to more precisely define the perimeter of surface contamination. This will help define the extent of excavation and capping of the site, where required. To help identify an onsite location for a land encapsulation disposal cell, additional deep soil samples will be required from the ballfield area for geotechnical analyses.

Groundwater Remediation

Based on the results of the data sufficiency study, several monitoring wells will be installed at SLDS, SLAPS, and HISS to complete groundwater characterization at these sites. Additional aquifer tests will be performed at the same sites, and the ballfield area to better understand the hydrogeologic characteristics of the water bearing units. Information from these activities will be used to more accurately define where hydraulic barriers can be placed or where wells can be installed if the pump and treat option is selected.

Remediation of Buildings and Structures

Treatability studies may have to be conducted to obtain more information on the choice of decontamination agent that will be most effective on the building surfaces. Several innovative technologies (e.g., CO_2 pellet blasting) have been developed for decontaminating building surfaces. Tests should be conducted to determine the applicability of these innovative decontamination options.

Site Suitability Study

Site suitability studies for proposed in-state and newly developed out-of-state disposal site locations may need to be conducted to assess geological and geographical conditions. Geological setting would be studied with regards to tectonic stability; type, depth, and thickness of soils, bedrock and other materials underlying the site; and meeting appropriate state regulations for a radioactive waste landfill. Geographic conditions would examine wilderness areas, wetlands, 100-year flood plain, endangered species, population, surface water, groundwater, aquifers, and other pertinent factors.

5. TREATABILITY STUDIES RECOMMENDATIONS

Treatability studies would be necessary to provide specific information if treatment were selected as the preferred alternative. EPA Guidance for conducting Remedial Investigations and Feasibility studies under CERCLA (EPA 1988) outlines the rationale for deciding when treatability studies are and are not required. An excerpt from this guidance is provided below.

Certain technologies have been demonstrated sufficiently so that site-specific information collected during the site characterization is adequate to evaluate and cost those technologies without conducting treatability testing. Examples of when treatability testing may not be necessary include:

- a developed technology is well proven on similar applications;
- substantial experience exists with a technology employing treatment of well-documented waste materials; (For example, air stripping or carbon adsorption of groundwater containing organic compounds for which treatment has previously proven effective); and
- relatively low removal efficiencies are required (e.g., 50 to 90 percent), and data are already available.

Frequently, technologies have been insufficiently demonstrated or characterization of the waste alone is insufficient to predict treatment performance or to estimate the size and cost of appropriate treatment units. Furthermore, some treatment processes are insufficiently understood for performance to be predicted, even with a complete characterization of the wastes. For example, often it is difficult to predict biological toxicity in a biological treatment plant without pilot tests. When treatment performance is difficult to predict, an actual testing of the process may be the only means of obtaining the necessary data. In fact, in some situations it may be more cost-effective to test a process on the actual waste than it would be to characterize the waste in sufficient detail to predict performance.

Treatability testing performed during an RI/FS may be used to evaluate a specific technology, including evaluating performance, determining process sizing, and estimating costs in sufficient detail to support the remedy-selection process. Treatability testing in the RI/FS is not meant to be used solely to develop detailed design or operating parameters that are more appropriately developed during the remedial design phase.

The technologies that may require treatability studies can be grouped under soil and groundwater studies.

Soil treatability studies may include:

- Volume Reduction Processes
  - soil washing
  - wet screening
  - gravity separation process
  - organic solvent extraction
  - classification

- Immobilization Technologies
  - vitrification thermal treatment
  - stabilization/solidification

Groundwater treatment and containment treatability studies may include:

- ion exchange,
- sulfide precipitation, and
- slurry wall construction materials.

Before treatability studies for screening can be implemented, the following information must be obtained and established through laboratory analyses:

- particle size distribution of the feed soil,
- radionuclide distribution with particle size,
- moisture content,
- mineralogical composition,
- dust control requirement, and
- throughput requirement for full-scale remediation.

Liquid to solid ratio, and optimum time required for leaching are the two major parameters that influence the effectiveness of soil washing. Both these technical parameters will have to be determined through treatability studies.

Before treatability studies for gravity separation can be conducted, the following information must be obtained through laboratory analyses:

- throughput required for full-scale remediation;

- feed preparation procedures that will be used during remediation (natural, classified, hydraulically etc.);

- characteristics of the soil-sand, clay humus, or silt;

- particle size and shape distribution of the feed soil; and

- specific gravity and chemical analyses of the soil.

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APPENDIX A

GENERAL WASTE TRANSPORTATION REQUIREMENTS

DOT is the federal agency primarily responsible for the regulation of hazardous materials transport. DOT exercises this responsibility partly through SUBCHAPTER C HAZARDOUS MATERIALS REGULATIONS in Title 49 of the Code of Federal Regulations (49 CFR). The DOT definition of "Radioactive Material" is any material having a specific activity greater than 0.002 microcuries per gram, which is the equivalent of 2,000 pCi/g. This minimum specific activity number includes all uranium, radium, and thorium daughter products. Radionuclides that exceed this minimum are DOT regulated Low Specific Activity (LSA) materials. Title 49 CFR Part 172 also contains the Hazardous Materials Table, requirements for shipping papers, and details on the proper marking and labeling of packages, placarding of vehicles, and requirements for emergency response information.

The St. Louis site radioactive waste generally has a cumulative specific activity that is less than 2,000 pCi/g, and there, is not expected to fall under the DOT definition of radioactive materials. For the small volumes of soil which may exceed this activity level, all applicable DOT shipping requirements will be met.

LOW-LEVEL RADIOACTIVE WASTE DISPOSAL OPTIONS
PRIVATELY-OWNED COMMERCIAL FACILITIES

ENVIROCARE OF UTAH, INC. - CLIVE, UTAH

Contacts

Curt Higgens, Marketing Rep	(801) 532-1330
Dan Owens, Site Manager	(801) 580-6078

Location

The Envirocare Facility is located approximately 80 miles west of Salt Lake City in western Tooele County. The site covers approximately 550 acres encircling a 100-acre Vitro UMTRA cell. It is accessible to Interstate 80 and to a Union Pacific main line via a short rail spur. The facility has a rail-dump system to accommodate bulk shipments, a decontamination facility, and onsite laboratory.

License Restrictions

The site is currently licensed to receive a variety of radioactive wastes. Although Envirocare cannot currently accept 11 (e)(2) materials, it has applied for the license to accept this material. The facility is also permitted to accept mixed waste. The mixed waste cell is currently under construction.

Volume Limits

Expansion capabilities of the current cell could increase capacity to as much as 14 million yd^3.

Costs

Currently the radioactive waste disposal cost is estimated to range between \$8 to \$10 per ft^3, while the disposal cost for mixed waste could be as high as \$18 to \$120 per ft^3.

US ECOLOGY - BEATTY, NEVADA

Contacts

Gary Young	(502) 426-7160
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Location

The US Ecology facility is located approximately 11 miles south of Beatty, Nevada, which is approximately 100 miles northwest of Las Vegas. The site is directly accessible to U.S. highway 95. The closest rail service to the site is Las Vegas. This facility has been cited for the Rocky Mountain Compact.

Licensing Restrictions

This facility is licensed by the State of Nevada to accept naturally occurring radioactive material (NORM), by-product, transuranic, and other low-level radioactive wastes of Classes A, B, and C per 10 CFR Part 61. The Beatty facility is currently not licensed to accept mixed waste, 11(e)(2) waste or any waste having greater than Class C rating. To satisfy DOT regulations, waste materials sent to the Beatty facility must be containerized.

Volume Limits

The facility has room to accept as much as 37,000 yd^3 of waste. The Beatty facility is scheduled to close before Jan. 1, 1993.

Costs

An estimated cost for disposal at this facility is $5 to $15 per ft^3.

US ECOLOGY - RICHLAND, WASHINGTON

Contacts

Steve Marshall	(502) 426-7160
Bob Bidstrup	(509) 377-2411

Location

This facility is located within the DOE's Hanford Operations near Richland, Washington. The site is 100 acres in size with additional property available for expansion. The property is leased from the State of Washington which leases the land from the federal government. The facility has rail access within 1.5 miles. Plans are now being made to extend the rail line directly to the facility. US Ecology has filed license applications for two new low-level radioactive waste disposal facilities, one near Needles, California, and a second near Bulte, Nevada. The facility near Needles will be a cut and bury site approximately 100 acres in size, and is scheduled to open in 1992. The facility near Bulte is a concrete vault which is scheduled to open in 1993.

Licensing Restrictions

The Richland site is similar to the US Ecology facility in Nevada and will accept NORM, by-product, transuranic, and other low-level radioactive wastes of Class A and Class B. This facility is not currently licensed to accept 11(e)(2) waste, or any waste having greater than a Class C rating. Containerization of wastes is not necessary, providing that wastes conform to DOT limits of 2,000 pCi/g.

Volume Limits

At this time, the facility has room to accept approximately 700,000 yd^3 of waste.

Costs

The present costs for disposal of low-level radioactive wastes at the Richland site begin at a base price of \$32 per ft^3 without surcharges. Disposal costs at the Needles and Buite sites are expected to range between \$110 and \$170 per ft^3.

CHEM-NUCLEAR SYSTEMS - BARNWELL, SOUTH CAROLINA

Contacts

Bill House	(803) 256-0450
Fred Gardiner	(803) 256-0450
Jim Van Vliet, Site Manager, Denver Chemical Waste Management Federal Environmental Service	(303) 234-1881 (800) 444-4167

Location

The facility is located adjacent to the Savannah River Atomic Energy Plant, and approximately 70 miles southwest of Columbia, South Carolina. The site is 235 acres in size and does not have direct access via rail line. The facility is not currently designed to handle bulk materials.

Chem-Nuclear Systems presently has filed a license application for a low-level radioactive waste disposal site near Martinsville, Illinois. This would be the facility for the Central Midwest Compact.

Also, Chem-Nuclear is apparently trying to start-up a larger disposal site to handle large-volume, bulk, radioactive wastes. The site is intended for NORM waste and may eventually include byproduct waste material. The location for this site is not determined.

Licensing Restrictions

Characterization wastes are among the low-level radioactive wastes the site is currently licensed to receive, provided they pass TCLP requirements. This site cannot currently accept waste containing radium separated and concentrated beyond its natural abundance, mixed waste, nor handle bulk materials.

Volume Limits

After 20 years of operation, the site has disposed of approximately 1 million yd^3 of waste and has not yet reached capacity.

Costs

The current base price is $40 per ft^3. Various surcharges and negotiable fees are added to the base price.

TEXCORP INDUSTRIES - SPOFFORD, TEXAS

Contact

John Salsman (512) 563-2481

Location

The proposed Texcorp Industries site is located approximately one mile southeast of Spofford, Texas. The site covers approximately 300 acres and is accessible by Farm Road 1572, and by a Southern Pacific rail line. There is not a rail spur currently at the site.

License Restrictions

The Texcorp site is currently licensed to receive, possess, store, and dispose of byproduct material as defined in Section 401.003 (3)(B) of the Texas Health and Safety Code, which includes 11 (e)(2) material. The disposed material must be in solid form as defined in their license. Any activity level is acceptable at this site except for Ra-226 which cannot exceed 8,000 pCi/g, and Ra-228 which cannot exceed 65,000 pCi/g.

Volume Limits

The facility will have room to accept approximately 10 million yd^3.

Costs

Disposal costs are not currently available, but expected to be relatively low.

AMERICAN NUCLEAR CORPORATION

Location

Site is in the Gas Hills District of Wyoming approximately 50 miles east of Riverton and 75 west-northwest of Casper. The site is a Title 1 UMTRA site where reclamation of a mill and radioactive mill tailings at the company's Gas Hills property is taking place. An undeveloped rail siding is 40 miles from the side via county-maintained dirt roads.

Licensing Restrictions

The site is licensed to accept third-party 11(e)(2) wastes; does not accept mixed waste or NORM waste which, by law, cannot be disposed of in mill tailings impoundments.

Volume Limits

The entire property consists of 1,200 acres, 200 acres which are undergoing reclamation. Pond No. 2 is full and awaiting approval of the Radon cap. Pond No. 1 is in the early fill stage, and plans include utilizing Pond No. 1 through 1995.

Costs

No information is available.

LOW-LEVEL RADIOACTIVE WASTE COMPACTS

Information: Washington State Department of Ecology

Contacts

Jerry Befley	(206) 459-6861
Executive phone line	(206) 459-6244

Appalachian Compact

Pennsylvania (host state)
Maryland
West Virginia
Delaware

Central Midwest Compact

Illinois (host state)
Kentucky

Central Interstate Compact

Nebraska (host state)
Oklahoma
Louisiana
Kansas
Arkansas

Midwest Compact

Michigan (original host state)
Minnesota
Missouri
Ohio (current host state)
Wisconsin
Iowa
Indiana

Northeast Compact

Connecticut (co-host)
New Jersey (co-host)

Northwest Compact

Washington (sited state)
Oregon
Idaho
Utah
Montana
Alaska
Hawaii

Rocky Mountain Compact

Colorado (host state)
Wyoming
Nevada (sited state)
New Mexico

Southeast Compact

Virginia
North Carolina (host state)
South Carolina (sited state)
Tennessee
Mississippi
Alabama
Georgia
Florida

Southwestern Compact

California (host state)
Arizona
North Dakota
South Dakota

States that will go-it-alone

Texas
New York
Maine
Massachusetts

Unaffiliated States

Vermont
New Hampshire
Rhode Island

LOW-LEVEL RADIOACTIVE WASTE DISPOSAL OPTION
FEDERAL FACILITIES

NEVADA TEST SITE - MERCURY, NEVADA

Contacts

Dan Blout	(702) 295-7983
Dirk Schmidhofer	(702) 295-7983
Bob Dodge, Technical Support	(702) 295-1632

Location

There are two actual sites for disposing of low-level radioactive waste at the Nevada Test Site (NTS), including Area 5 and Area 3. Both of these areas are administered under the Radioactive Waste Management site, and are located approximately 65 miles northwest of Las Vegas. There is currently no rail access at the site, all waste shipments are by truck.

Licensing Restrictions

Since this is a federal facility, there are no licensing restrictions regarding the types of radioactive waste they can accept. However, DOE has established strict acceptance criteria and waste certification requirements for the site. The site currently accepts waste from various sources, though the majority comes from DOE defense testing. The site does not currently accept mixed waste pending approval of a RCRA, Part B, permit for a mixed waste disposal cell.

Volume Limits

Disposal site in Area 5 consists of 92 acres with an additional 640 acres granted to the facility for waste disposal. In Area 3, disposal of non-mixed, low-level radioactive wastes is restricted to a number of subsidence craters of unknown total area. The facility accepts bulk shipments, however, offsite bulk shipments come in 8 ft by 8 ft by 20 ft containers that are entombed along with the waste.

Costs

The current estimated cost for disposal of low-level radioactive waste is \$10 per ft^3.

HANFORD OPERATIONS - RICHLAND, WASHINGTON

Contact

Bill Jasen (509) 376-4328
(509) 376-7411

Location

The disposal site is of unknown size, and is located within boundary of the Hanford Operation site near Richland, Washington. This site has facilities to accommodate rail, truck, and barge unloading.

Licensing Restrictions

Since this is a federal facility, there are no licensing restrictions. The site has already accepted waste from at least six FUSRAP sites. The facility also accepts and temporarily stores mixed waste. Currently the site is building a facility to treat mixed waste, as well as a facility to dispose of treated mixed waste.

Volume Limits

The facility is of unknown size, but was designed for a 50-year capacity. The facility is currently able to accept 1 million yd^3 per year. The facility does not currently accept bulk shipments.

Costs

1992 prices
$74 per ft^3 LLRW
$230 per ft^3 mixed waste
1993 prices
$100 per ft^3 LLRW

IDAHO NATIONAL ENGINEERING LABORATORY - IDAHO FALLS, IDAHO

Contacts

Dale Wells	(208) 526-2274
Dennis Wilkenson	(208) 526-2482

Location

The Radioactive Waste Management Complex is located within the boundary of the Idaho National Engineering Laboratory, approximately 50 miles west of Idaho Falls, Idaho.

Licensing Restrictions

Since this is a federal facility, there are no licensing restrictions regarding the types of waste it can accept. The State of Idaho will not currently allow offsite waste to be disposed of at the facility.

Volume Limits

It is estimated that this site can accept approximately 4,500 yd^3 of waste before capacity is reached. The facility is reported to have a volume reduction operation onsite.

Costs

Cost information is not available.

APPENDIX B

APPENDIX B. LIST OF PREPARERS

Name and Degree	Organization	Responsibility
Nand Kaushik M.S. Environmental Engineering B.S. Chemical Engineering	SAIC	Primary Author
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