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Feasibility Study for Management of the Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri

February 1990

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

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prepared by

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prepared for

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NOTATION

The following is a list of the acronyms, initialisms, and abbreviations (including units of measure) used in this document.

ACRONYMS, INITIALISMS, AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AEC	U.S. Atomic Energy Commission
ARAR	applicable or relevant and appropriate requirement
BRA	baseline risk assessment
BRE	baseline risk evaluation
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended
CFR	Code of Federal Regulations
CSR	Code of State Regulations
DAC	derived air concentration
DCG	derived concentration guide
DNT	dinitrotoluene
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EE/CA	engineering evaluation/cost analysis
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FONSI	finding of no significant impact
FS	feasibility study
HEPA	high-efficiency-particulate-air (filter)
ICRP	International Commission on Radiological Protection
LSA	low specific activity
MKT	Missouri-Kansas-Texas (railroad)
MSL	mean sea level
NAAQS	National Ambient Air Quality Standards
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act of 1969, as amended
NIOSH	National Institute of Occupational Safety and Health
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEL	permissible exposure limit
PL	Public Law
REL	recommended exposure limit
RI	remedial investigation
ROD	record of decision

RSMo.	Revised Statutes of Missouri
SARA	Superfund Amendments and Reauthorization Act of 1986
SFMP	Surplus Facilities Management Program
SPHEM	*Superfund Public Health Evaluation Manual*
SHPO	State Historic Preservation Office
SOU	separate operable unit
Stat.	Statute
TDS	total dissolved solids
TLV	threshold limit value
TNT	trinitrotoluene
TSA	temporary storage area
TWA	time-weighted average
USC	United States Code

UNITS OF MEASURE

°C	degrees Celsius
°F	degrees Fahrenheit
Ci	curie(s)
cm	centimeter(s)
cm^3	cubic centimeter(s)
d	day(s)
dBA	decibel(s), A-weighted
ft	foot (feet)
ft^2	square foot (feet)
g	gram(s)
gal	gallon(s)
h	hour(s)
ha	hectare(s)
in.	inch(es)
kg	kilogram(s)
km	kilometer(s)
L	liter(s)
lb	pound(s)
µCi	microcurie(s)
µg	microgram(s)
µm	micrometer(s)
µR	microroentgen(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
MeV	million electron volts
mg	milligram(s)
mi	mile(s)
min	minute(s)
mL	milliliter(s)
mph	mile(s) per hour
mR	milliroentgen(s)
mrem	millirem(s)
pCi	picocurie(s)
ppm	part(s) per million
rem	roentgen equivalent man
s	second(s)
t	metric ton(s)
WL	working level(s)
WLM	working level month(s)
WLR	working level ratio
yd^3	cubic yard(s)
yr	year(s)

FOREWORD

The U.S. Department of Energy (DOE), under its Surplus Facilities Management Program, is responsible for cleanup activities at the Weldon Spring site in St. Charles County, Missouri. This currently inactive site was contaminated as a result of disposal activities and processing of uranium, thorium, and other materials during the 1940s through the 1960s. The Weldon Spring site consists of two noncontiguous areas: (1) a chemical plant area and (2) a quarry. The quarry was used for disposal of various chemically and radioactively contaminated wastes between 1942 and 1969. Monitoring results have indicated that contaminants are being released from these wastes into groundwater and air at the quarry. The DOE is proposing to (1) respond to potential threats associated with contaminant releases and (2) support overall cleanup decisions for the Weldon Spring site by conducting an interim remedial action at the quarry to address the bulk wastes therein, i.e., those solid materials that can be managed using standard technologies.

The three primary documents that support the proposed management of the quarry bulk wastes are the remedial investigation (RI), the baseline risk evaluation (BRE), and this feasibility study (FS). The RI presents information on the environmental setting of the quarry and the physical, chemical, and radioactive characteristics of the bulk wastes. The BRE assesses the risks associated with current conditions at the quarry in the short term (i.e., the next several years). The FS develops, screens, and evaluates alternatives for managing the quarry bulk wastes. The contents of these documents were developed in consultation with EPA Region VII and the state of Missouri and reflect the focused scope defined for this interim action.

Based on the analyses in this document, the currently preferred alternative for managing the quarry bulk wastes is to remove them from the quarry and transport them to a temporary storage facility at the chemical plant area. This interim action would (1) eliminate the primary source of radioactively and chemically contaminated materials from the quarry, (2) facilitate subsequent characterization of the quarry and its vicinity, and (3) support disposal decisions for the bulk wastes and other contaminated materials from the Weldon Spring site. A comprehensive assessment of the need for additional remedial action at the quarry will be performed following bulk waste removal and detailed characterization activities. Site characterization data are continuing to be collected in support of the overall Weldon Spring Site Remedial Action Project. The analyses of potential impacts to human health and the environment in this FS are based on environmental data available as of May 1989.

FEASIBILITY STUDY FOR MANAGEMENT OF THE BULK WASTES AT THE WELDON SPRING QUARRY, WELDON SPRING, MISSOURI

SUMMARY

The U.S. Department of Energy (DOE), under its Surplus Facilities Management Program, is responsible for conducting remedial actions at the Weldon Spring site in St. Charles County, Missouri. The Weldon Spring site, which is listed on the National Priorities List of the U.S. Environmental Protection Agency (EPA), became contaminated as a result of processing and disposal activities that took place from the 1940s through the 1960s. The site consists of a quarry and a chemical plant area located about 6.4 km (4 mi) northeast of the quarry. The quarry is surrounded by the Weldon Spring Wildlife Area and is near a well field that constitutes a major source of potable water for St. Charles County; the nearest supply well is located about 0.8 km (0.5 mi) southeast of the quarry. From 1942 to 1969, the quarry was used for the disposal of various radioactively and chemically contaminated materials. Bulk wastes in the quarry consist of contaminated soils and sediments, rubble, metal debris, and equipment. As part of overall site remediation, DOE is proposing to conduct an interim remedial action at the quarry to manage the radioactively and chemically contaminated bulk wastes contained therein.

Potential remedial alternatives for managing the quarry bulk wastes have been developed, screened, and analyzed consistent with EPA guidance for conducting remedial actions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act. Based on the analysis in this document, the final alternatives selected for bulk waste management are (1) no action, (2) expedited removal of the bulk wastes from the quarry, with temporary storage at the chemical plant area, and (3) delayed action pending the overall record of decision for the Weldon Spring site. The DOE's currently preferred alternative is expedited removal of the wastes for the following reasons:

- Removal of the bulk wastes is responsive to ongoing releases of contaminants into the environment, which occur via uncontrolled airborne emissions and leaching to soil and groundwater. This action would initiate permanent source control for the potential threats associated with these releases at the quarry (i.e., by eliminating the primary source of groundwater contamination in this area and reducing atmospheric levels of contaminants, specifically radon gas, at the quarry to background levels); hence, the proposed action is consistent with the overall intent of CERCLA.

- Releases from the bulk wastes (which have exceeded DOE limits for radon gas) can be much more effectively controlled if the materials are stored in an engineered facility at the chemical plant area.

- Removal of the bulk wastes will permit detailed characterization of the quarry subsurface to evaluate the need for follow-on remediation of this area (i.e., to address residual materials remaining in the quarry fissures, contaminated groundwater, and contaminated vicinity properties such as Femme Osage Slough).

- Removal of the bulk wastes will permit detailed characterization of these wastes, which is currently very difficult because of the types of wastes and their placement in the quarry (i.e., the wastes are a heterogeneous mixture of contaminated soils and sediments, rubble, metal debris, and equipment that is distributed over 3.6 ha [9 acres] to depths of 12 m [40 ft]); this characterization is important as a basis to support comprehensive decisions on both the disposition of these wastes and ultimate site remediation.

Expedited removal of the bulk wastes from the quarry with temporary storage at the chemical plant area is protective of human health and the environment, can be implemented in a timely manner, and is cost-effective. Although most impacts from the action are expected to be beneficial, limited adverse environmental impacts would occur. Activities related to waste removal would destroy about 15 ha (37 acres) of vegetation at the quarry, at the temporary storage area in the chemical plant area, and along a road that would be constructed to haul the bulk wastes to temporary storage. Some small, relatively immobile wildlife would be lost, and other wildlife would be disturbed, displaced, and possibly lost during construction and operations. However, removal of the bulk wastes would be expected to reduce any negative effects on biota that might result from the presence of these wastes in the quarry. No adverse impacts to any federal- or state-listed threatened or endangered species are expected. During construction and operation activities, airborne concentrations of particulates would increase near the quarry, haul road, and temporary storage area. However, the remedial action would be conducted in a manner consistent with all applicable air quality requirements.

Potential health effects to the general public from exposure to radioactive and chemical contaminants as a result of this action would be small. The maximum radiological risk to a member of the general public as a result of this action (i.e., the increased likelihood of contracting a fatal cancer) is estimated to be 1.1×10^{-6}, which is approximately 1 in 1 million; this represents the risk to a hypothetical individual who would walk by the quarry on a daily basis during the entire period of bulk waste excavation. The radiological risk to a student at the Francis Howell High School is estimated to be 2.1×10^{-8}. For comparison, the annual risk from background radiation is estimated to be about 5×10^{-5}/yr. Hence, the radiological risk to the general public associated with the bulk waste remedial action is considerably lower than that from background sources of radiation. The maximum chemical carcinogenic risk (i.e., the risk of developing a cancer) would also be low. This risk to a hypothetical passerby at the quarry is estimated to be 1.7×10^{-8}, or about 1 in 50 million; the risk to a student at the high school would be much lower. (In comparison, about 30% of Americans will eventually develop cancer, and it is estimated that 60% of all cancers are fatal [American Cancer Society 1988].) The maximum noncarcinogenic chemical hazard index for the passerby and student are estimated to be less than 0.001, which is considerably below the level of concern identified by the EPA, i.e., a hazard index of one.

Potential health effects to workers from exposure to radioactive and chemical contaminants as a result of this action would also be small. Potential occupational risks would be minimal provided that appropriate protective equipment was used and proper work procedures were followed to ensure that contaminants were not inhaled or ingested in concentrations that could adversely impact worker health. The occupational dose from external gamma radiation is estimated to be 29 person-rem for the entire work force implementing the bulk waste remedial action. The dose received by an individual worker in the quarry during the 1.25-year excavation period is estimated to be 0.65 rem. This dose is considerably below the DOE occupational limit of 5 rem/yr. Occupational accidents could occur during this action. The total number of occupational fatalities is estimated to be 0.02, and the total number of occupational injuries is estimated to be 14.6, with 6.2 of these injuries expected to result in lost workdays.

1 INTRODUCTION

1.1 ENVIRONMENTAL COMPLIANCE PROCESS

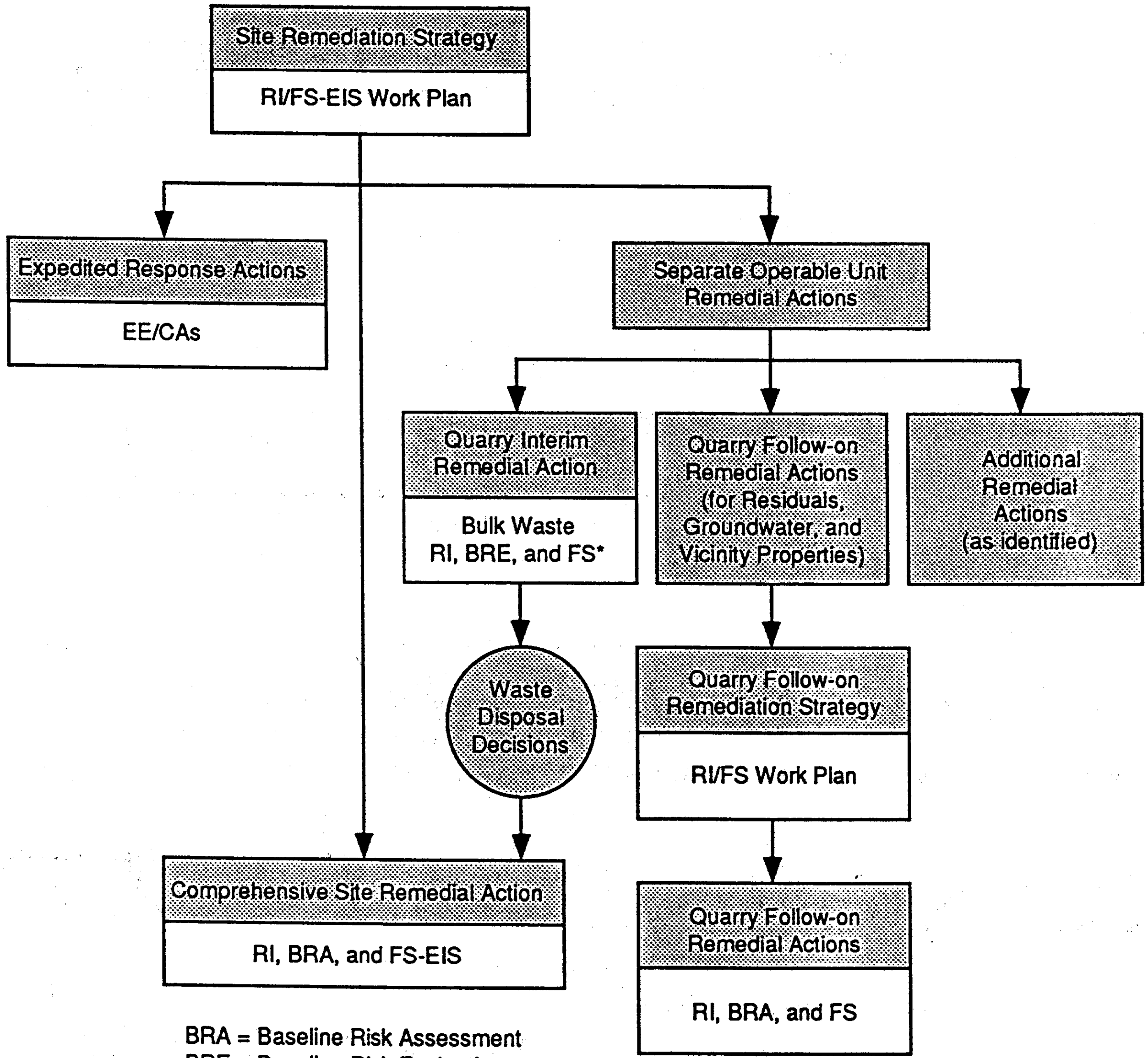
1.1.1 Background

The U.S. Department of Energy (DOE) is responsible for conducting remedial actions at the Weldon Spring site under its Surplus Facilities Management Program (SFMP). Because the site is listed on the National Priorities List (NPL) of the U.S. Environmental Protection Agency (EPA), these remedial actions are being carried out consistent with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. The DOE is also responsible for complying with the National Environmental Policy Act (NEPA) of 1969, which requires federal agencies to consider the environmental consequences of a proposed action during the planning process. It is DOE policy to integrate the requirements of the NEPA and CERCLA processes in order to minimize the preparation of duplicate documentation, avoid unnecessary expenditures, and facilitate implementation of environmentally responsive cleanup activities.

The DOE issued a draft environmental impact statement (EIS) in February 1987 to assess the environmental impacts of alternatives for long-term management of contaminated materials associated with remedial actions at the Weldon Spring site (DOE 1987a). The draft EIS was prepared in accordance with the requirements of NEPA, as implemented according to regulations promulgated by the Council on Environmental Quality (CEQ) and DOE's implementing guidelines. Following publication of the draft EIS, significant new information became available that was relevant to environmental concerns at the Weldon Spring site, i.e., information indicating that the groundwater beneath the chemical plant area contained elevated concentrations of nitrates and nitroaromatic compounds.

In response to this development, DOE announced in June 1987 its intent to issue for public comment a revised draft EIS that would incorporate the new information. Subsequent to this decision, EPA Region VII formally requested that DOE prepare a remedial investigation/feasibility study (RI/FS) for the Weldon Spring site, pursuant to the requirements of CERCLA. The DOE has agreed to prepare an RI/FS concurrently with the revised draft EIS. An overview of the environmental compliance strategy for the Weldon Spring site is shown in Figure 1.1. This strategy is described in detail in the RI/FS-EIS work plan (Peterson et al. 1988). The overall remedial action for the Weldon Spring site will be addressed in the RI/FS-EIS, which is currently being prepared.

As identified in Figure 1.1, various interim actions (both expedited response actions and interim remedial actions) will be performed prior to completion of the RI/FS-EIS to mitigate actual or potential uncontrolled releases of radioactively or chemically hazardous substances into the environment (see Peterson et al. 1988). Of these actions, the most significant is management of the bulk wastes in the quarry. All interim actions for the project must adhere to CEQ regulations for NEPA compliance, as



BRA = Baseline Risk Assessment
BRE = Baseline Risk Evaluation
EE/CA = Engineering Evaluation/Cost Analysis
EIS = Environmental Impact Statement
FS = Feasibility Study
RI = Remedial Investigation

*This document

FIGURE 1.1 Major Environmental Compliance Activities and Related Documents for the Weldon Spring Site Remedial Action Project

identified in 40 CFR 1506.1. The currently preferred alternative for managing the quarry bulk wastes is expedited removal of the wastes with transport to the chemical plant area for temporary storage, pending a decision on the ultimate disposition of all contaminated materials from the Weldon Spring site. This alternative satisfies the criteria given in 40 CFR 1506.1.

1.1.2 Quarry

The quarry can be divided into five components for the purpose of environmental response actions: (1) bulk wastes, (2) contaminated surface water in the quarry pond, (3) contaminated groundwater, (4) contaminated vicinity properties, and (5) residual materials remaining after removal of the bulk wastes. These components are shown in Figure 1.2.

The first action being considered for the quarry is management of the surface water currently in the quarry, which is radioactively and chemically contaminated as a result of leaching from the bulk wastes. This pond water is providing a gradient for contaminant migration into the local groundwater because the pond surface is higher than the surrounding groundwater table. An engineering evaluation/cost analysis (EE/CA) report for CERCLA compliance was prepared to evaluate alternatives for managing this water (MacDonell et al. 1989); the EE/CA has been adopted as an environmental assessment for NEPA compliance, and a FONSI has been prepared. The response alternative selected as a result of the EE/CA process, which included public review and comment, was to treat the contaminated water and discharge it to the Missouri River in compliance with a permit issued to DOE by the Missouri Department of Natural Resources. The planned action constitutes a temporary response to the ongoing groundwater contamination problem at the quarry. This migration control measure is expected to be initiated in 1991 and will continue until source control decisions for a permanent solution are finalized and implemented. Although this action is independent of bulk waste management, the removal of surface water and of some interstitial water

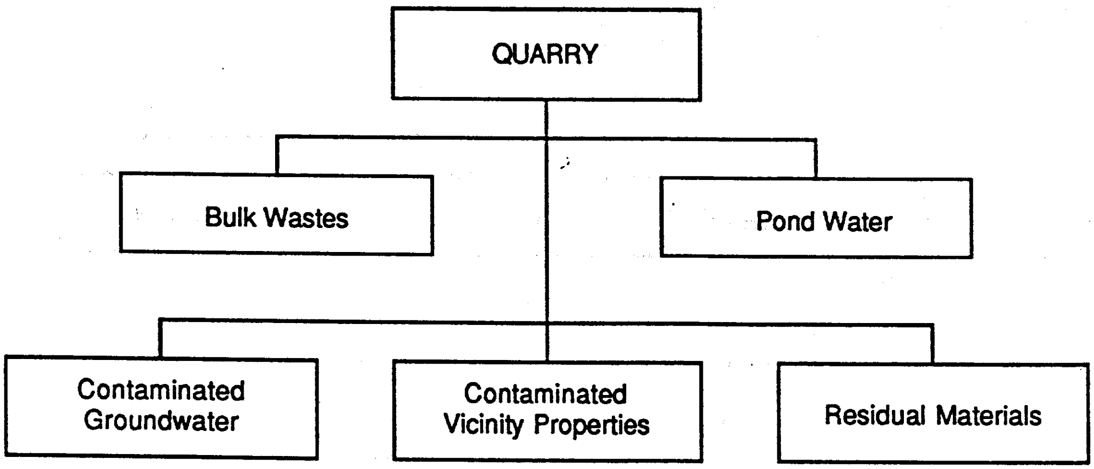


FIGURE 1.2 Environmental Compliance Components for the Weldon Spring Quarry

currently in the bulk wastes will facilitate implementation of the bulk waste remedial action. Because the pond action will precede the bulk waste remedial action, the baseline conditions for evaluating management alternatives for the quarry bulk wastes in this FS are (1) the quarry water treatment plant is operational, (2) the quarry pond water has been removed and treated and the bulk wastes have been partially dewatered, and (3) all water inflows into the quarry are being removed and treated as they occur.

The DOE is proposing to address the quarry bulk wastes as a separate operable unit (SOU) of the overall remedial action at the Weldon Spring site. The two general types of remedial actions that can be addressed as SOUs are (1) final actions that completely remediate a discrete area of a site or (2) interim actions taken to facilitate cleanup and to mitigate an ongoing release or threat of a release or limit a potential pathway of exposure. Remedial action for the quarry bulk wastes falls into the second category. The implementation of a response action as an SOU must be consistent with the permanent remedy for the entire site, even though the action might be implemented prior to selection of the final remedy. Defining the bulk wastes as an SOU of the Weldon Spring site makes it possible to expedite management of these wastes.

The three primary documents that support the bulk waste remedial action are the RI, the baseline risk evaluation (BRE), and this FS. The contents of these documents were developed in consultation with EPA Region VII and the state of Missouri and reflect the focused scope defined for the proposed action. The RI and BRE have been published as separate reports (MK-Ferguson Company and Jacobs Engineering Group [1989a] and Haroun et al. [1990], respectively).

The RI presents information on the environmental setting of the quarry and the physical, chemical, and radioactive characteristics of the bulk wastes. Because removing the bulk wastes from the quarry is an interim step in the overall remedial action for the quarry, the RI report focuses on quarry data pertinent to that removal. The scope of the BRE was developed with a similar focus, and it assesses the risks associated with current conditions at the quarry in the short term (i.e., the next several years). The risk evaluation, which was constrained by data availability (as described in the RI report), does not (1) evaluate the potential loss of institutional control, (2) project future contaminant concentrations, or (3) assess the risks to potential receptors over the long term. These issues will be addressed in a comprehensive baseline risk assessment (BRA) that will be prepared following the decision on managing the bulk wastes and the completion of detailed characterization of the quarry and surrounding area. The BRA will incorporate all potential exposure pathways for current and future scenarios to support the decision on final quarry remediation.

This report constitutes the FS portion of the RI/FS for managing the quarry bulk wastes. The RI/FS is a focused RI/FS as appropriate for this SOU because the management action (1) has limited remedial alternatives, (2) allows a more simplified selection process, and (3) requires limited data gathering. An FS serves as the mechanism for the development, screening, and detailed evaluation of potential remedial technologies and alternatives. As with the RI and BRE for the quarry, the focused scope of this document is limited to the quarry bulk wastes. Following a decision on the appropriate means for managing these wastes, detailed characterization and evaluation of the contamination remaining in the quarry vicinity will be performed to address any residual materials remaining within the quarry fissures, contaminated groundwater, and contaminated vicinity properties. The scope of this follow-on evaluation, which will address quarry cleanup criteria, will be defined in consultation with EPA Region VII and the state of Missouri.

Based on the analyses in this FS, the preferred alternative for managing the quarry bulk wastes is to remove the wastes from the quarry and transport them to a temporary storage facility at the chemical plant area. A description of the temporary storage area was not included in the RI because this alternative was selected following completion of the RI. Therefore, a description of the physical setting of this area is presented in a supporting document (MK-Ferguson Company and Jacobs Engineering Group 1990c) and is summarized in this FS. The environmental impacts associated with developing the area for storage of the quarry bulk wastes are also included in this FS.

Implementation of the preferred alternative will require use of a facility to treat contaminated water generated at the chemical plant area as a result of this action. Potential sources of such water include (1) water from decontamination of trucks and equipment, (2) runoff from precipitation events, and (3) leachate generated during temporary storage of the bulk wastes. As part of an expedited response action for the chemical plant area, an EE/CA is being prepared to address (1) contaminated water in the four raffinate pits that are part of the chemical plant area and (2) other potential sources of contaminated surface water at this area, including sources associated with implementation of the preferred alternative for the quarry bulk wastes. The scope of the EE/CA, which will serve as the environmental compliance document for treatment of contaminated surface water at the chemical plant area, was developed in consultation with EPA Region VII and the state of Missouri. Because the EE/CA will contain information relevant to the treatment of water generated at the chemical plant area as a result of the quarry bulk waste remedial action, it will also be used to support the NEPA determination for the quarry action.

Analysis of the potential environmental impacts identified in the primary RI/FS documents for the bulk waste remedial action (i.e., the RI, BRE and FS) and in the EE/CA related to this action (i.e., the water treatment plant EE/CA for the chemical plant area) will support the determination of whether a FONSI can be issued. It is expected that a FONSI can be issued and that the RI/FS process will proceed through issuance of a record of decision (ROD) for bulk waste management. If it is determined that a FONSI is inappropriate, environmental compliance activities for the Weldon Spring site would proceed as follows: (1) efforts on the quarry bulk waste RI/FS process would cease, (2) documentation of the activity would be incorporated into the RI/FS-EIS currently being developed for overall remediation of the Weldon Spring site, and (3) the quarry bulk wastes would be removed from the quarry only after the comprehensive ROD for the site was issued. An overview of the environmental compliance process for managing the quarry bulk wastes is presented in Figure 1.3.

Background information on the Weldon Spring site, including site history, is presented in Sections 1.2 and 1.3. Chapter 2 describes the environmental setting of the Weldon Spring quarry, and Chapter 3 summarizes the BRE that has been prepared to

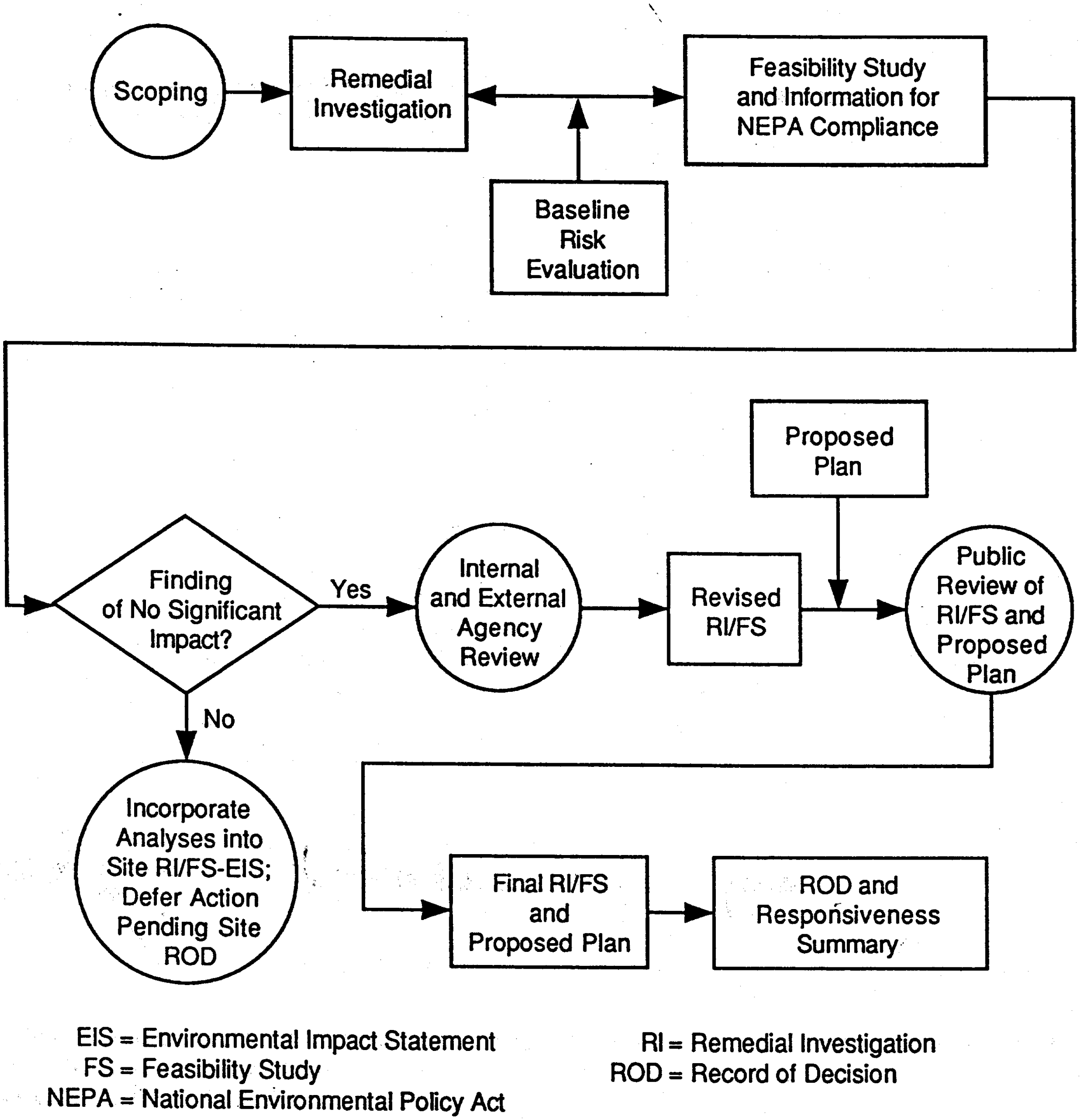


FIGURE 1.3 Overview of the Environmental Compliance Process for Managing the Quarry Bulk Wastes

address potential effects on human health and the environment in the short term due to the presence of bulk wastes in the quarry. Chapters 4 through 7 present the development, screening, and evaluation of alternatives for bulk waste management. Chapter 8 provides a detailed description of the preferred alternative to support the assessment of potential environmental effects associated with its implementation. Chapter 9 presents additional information on the specific environmental setting potentially affected by the bulk waste remedial action. The potential environmental and health effects associated with the preferred alternative are discussed in Chapters 10 and 11, respectively.

1.2 GENERAL SITE INFORMATION

The Weldon Spring site is located in St. Charles County, Missouri, near the city of Weldon Spring, about 48 km (30 mi) west of St. Louis (Figure 1.4). The site consists of two noncontiguous areas: (1) the chemical plant area, which contains the chemical plant and four raffinate pits, and (2) the quarry. The chemical plant area is about 3.2 km (2 mi) southwest of the junction of Missouri (State) Route 94 and U.S. Route 40/61. The quarry is about 6.4 km (4 mi) south-southwest of the chemical plant area and about 8 km (5 mi) southwest of the city of Weldon Spring. Both the chemical plant area and the quarry are accessible from State Route 94 and are fenced and closed to the public. The relative locations of the chemical plant area and the quarry are shown in more detail in Figure 1.5.

Portions of the chemical plant area are covered with buildings and ponds, and the remainder is covered with vegetation (predominately grasses, shrubs, and small trees), gravel, or paved surfaces. The August A. Busch Memorial Wildlife Area is located to the north, the Weldon Spring Wildlife Area to the south and east, and the U.S. Army Reserve and National Guard Training Area to the west of the chemical plant area.

The quarry was excavated into a limestone bluff that forms a valley wall at the edge of the Missouri River alluvial floodplain; prior to 1942, it was mined for limestone to support various construction activities. The quarry is about 300 m (1,000 ft) long by 140 m (450 ft) wide and covers an area of approximately 3.6 ha (9 acres). The main floor of the quarry comprises approximately 0.8 ha (2 acres) and currently contains about 11,000 m^3 (3,000,000 gal) of ponded water covering about 0.2 ha (0.5 acre). (This ponded water is being addressed under a separate environmental response action at the quarry [see MacDonell et al. 1989].) The quarry is vegetated with grasses, shrubs, and trees, and is surrounded by the Weldon Spring Wildlife Area. The general layout of the quarry is shown in Figure 1.6. A detailed description of the quarry is given in the RI report (MK-Ferguson Company and Jacobs Engineering Group 1989a).

The Missouri-Kansas-Texas (MKT) railroad line formerly passed just south of the quarry; this line was recently dismantled, and the right-of-way has been converted to a gravel-based public trail for hiking and biking (Katy Trail). A rail spur enters the quarry at its lower level from the west and extends approximately one-third of its length. The spur is overgrown with vegetation and is in a state of disrepair. The St. Charles County well field is located southeast of the quarry, between the quarry and the Missouri River (Figure 1.7). The nearest well is located about 0.8 km (0.5 mi) from the quarry.

1.3 SITE HISTORY

In April 1941, the U.S. Department of the Army acquired about 7,000 ha (17,000 acres) of land in St. Charles County, Missouri, for construction of the Weldon Spring Ordnance Works. From November 1941 through January 1944, the Atlas Powder Company operated the ordnance works for the Army to produce trinitrotoluene (TNT) and dinitrotoluene (DNT) explosives. The ordnance works was reopened during 1945 and 1946 but was closed and declared surplus to Army needs in April 1946. By 1949, all but about

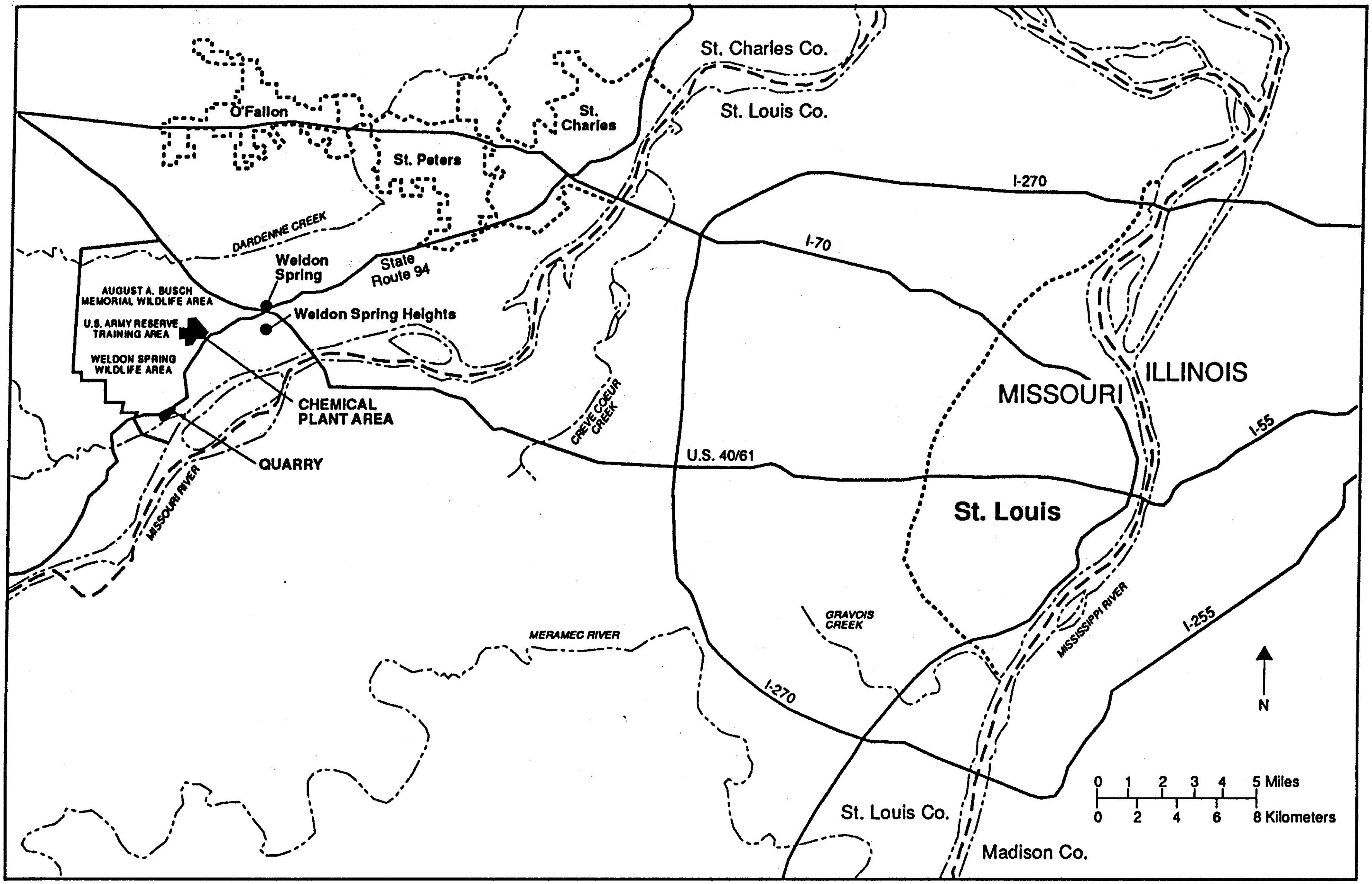


FIGURE 1.4 Location of the Weldon Spring Site, Weldon Spring Missouri

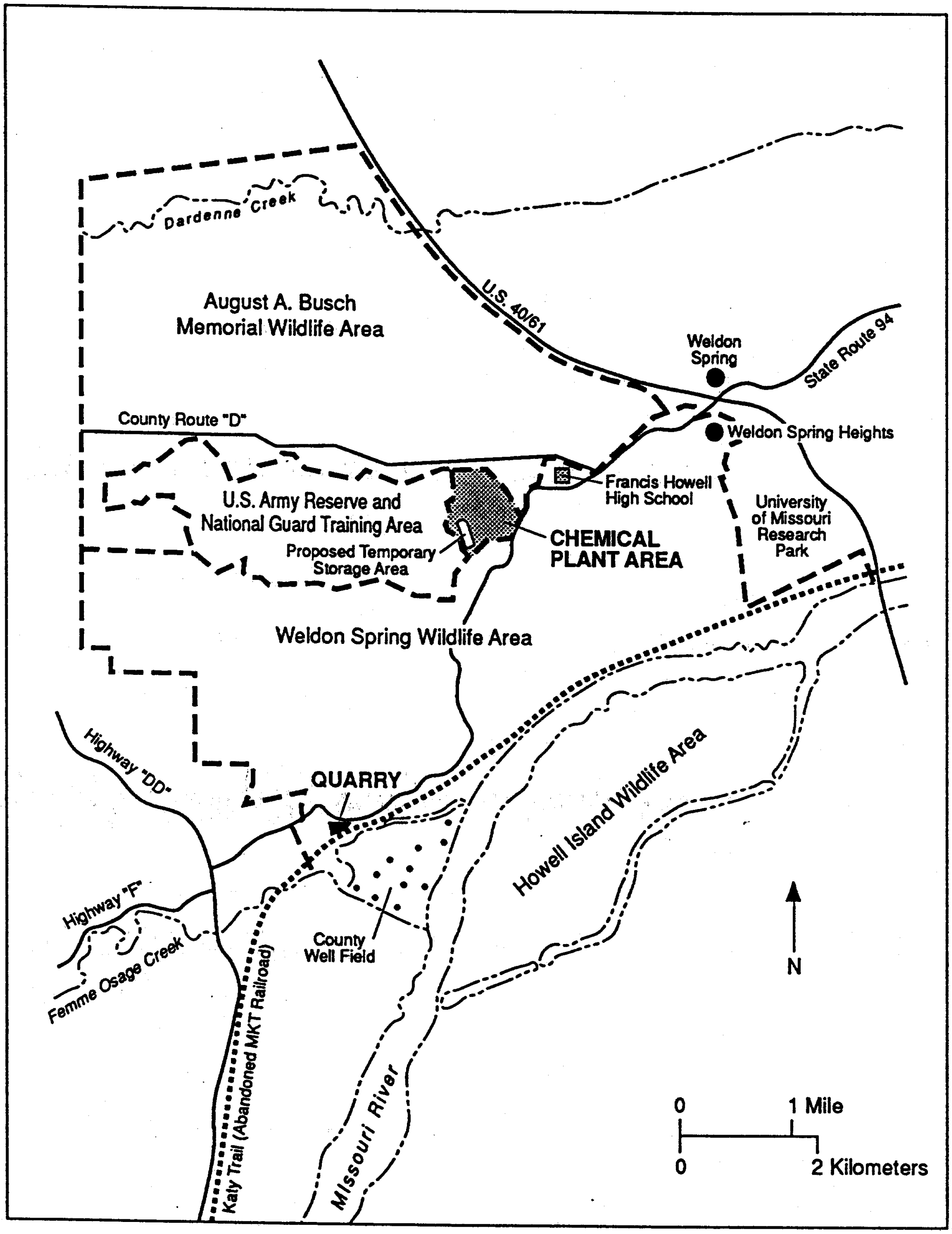


FIGURE 1.5 Map of the Weldon Spring Site and Vicinity

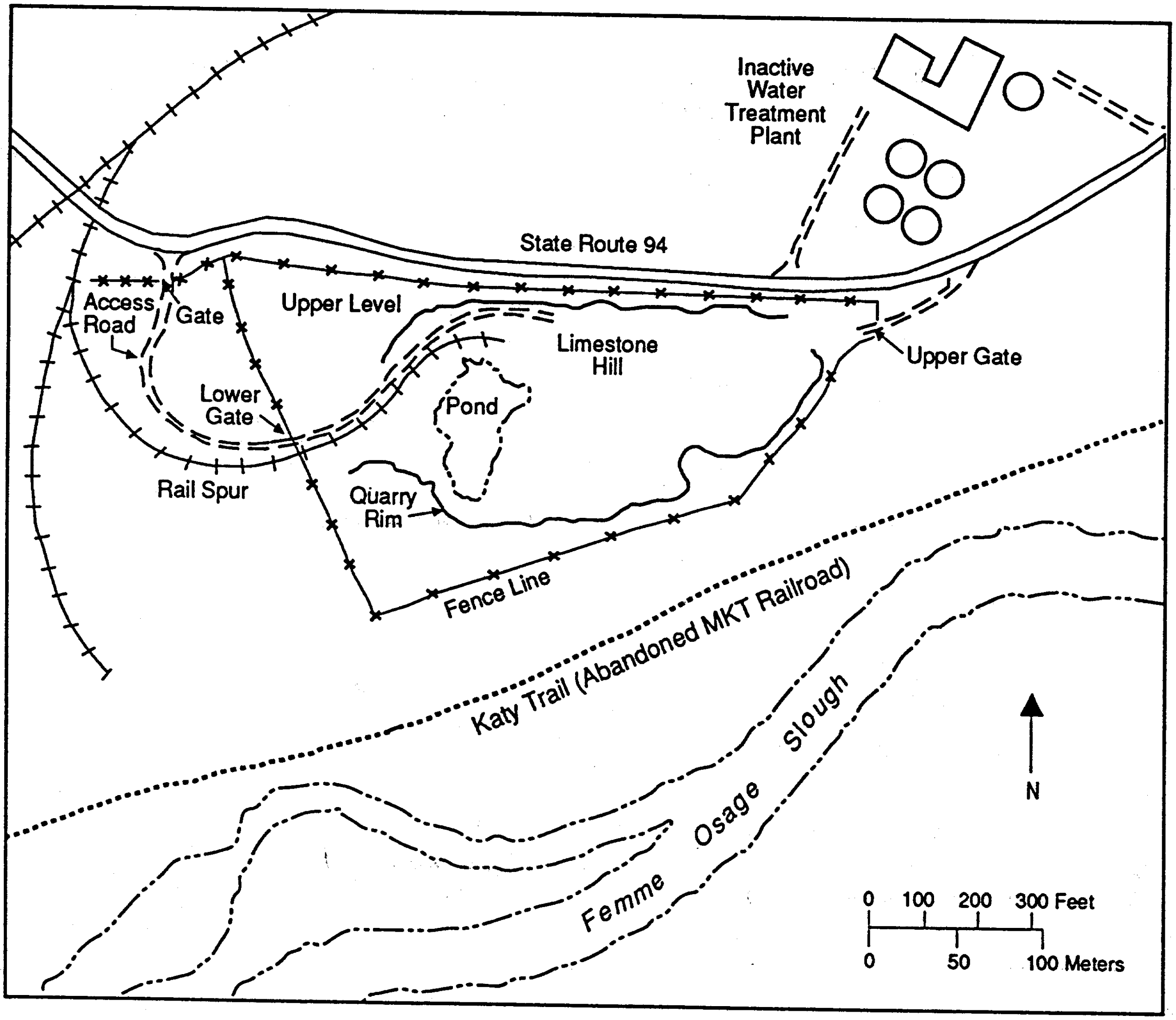


FIGURE 1.6 Layout of the Weldon Spring Quarry

810 ha (2,000 acres) had been transferred to the state of Missouri (August A. Busch Memorial Wildlife Area) and the University of Missouri (agricultural land). Much of the land transferred to the University of Missouri was subsequently developed into the Weldon Spring Wildlife Area. Except for several small parcels transferred to St. Charles County, the remaining property became the U.S. Army Reserve and National Guard Training Area.

The U.S. Atomic Energy Commission (AEC, a predecessor of DOE) acquired 83 ha (205 acres) of the former ordnance works property from the Army by permit in May 1955, and the property transfer was approved by Congress in August 1956. An additional 6 ha (15 acres) was later transferred to the AEC for expansion of waste storage capacity. The AEC constructed a feed materials plant -- now referred to as the chemical plant -- on the property for the purpose of processing uranium and thorium ore concentrates. The quarry, which had been used by the Army since the early 1940s for disposal of chemically

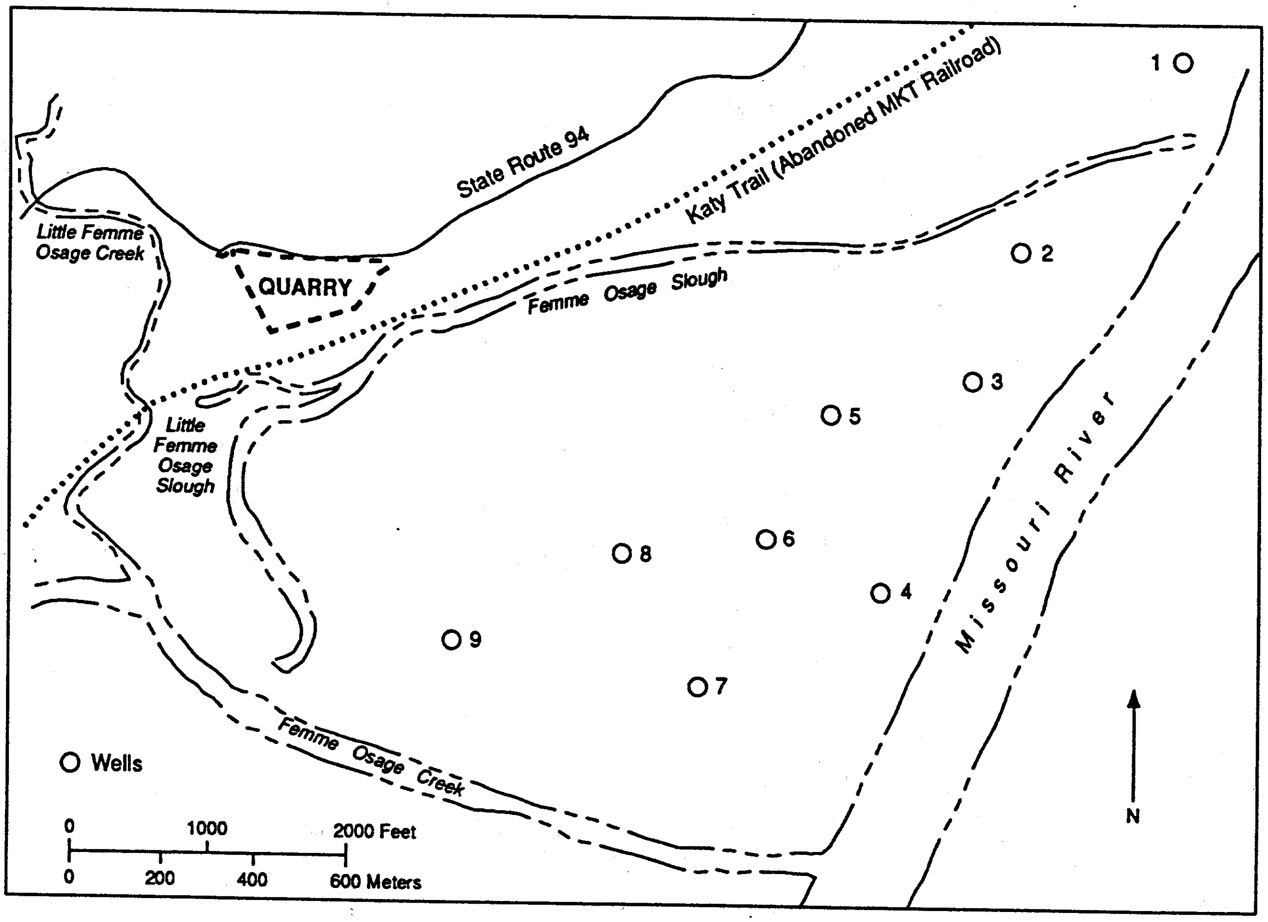


FIGURE 1.7 Surface Hydrological Features in the Vicinity of the Quarry and Location of Production Wells in the St. Charles County Well Field

contaminated (explosive) materials, was transferred to the AEC in July 1960 for use as a disposal site for radioactively contaminated materials (Niedermeyer 1976).

The feed materials plant was operated for the AEC by the Uranium Division of Mallinckrodt Chemical Works from 1957 to 1966. During this period, the AEC used the quarry to dispose of uranium and thorium residues (drummed and uncontained), radioactively contaminated building rubble and process equipment, and TNT and DNT residues from cleanup of the former ordnance works. Following closure by the AEC, the Army reacquired the chemical plant site in 1967 and began converting the facility for herbicide production. The buildings were partially decontaminated, and some equipment was dismantled. Contaminated rubble and equipment from some buildings were placed in the quarry. In 1969, prior to becoming operational, the herbicide project was canceled. Since that time, the plant has remained essentially unused and in caretaker status.

The last instance of waste disposal at the quarry was planned for 1969, when the AEC contracted to use it for the disposal of contaminated barium sulfate residues from the St. Louis Airport Site (Niedermeyer 1976). However, these residues were deposited instead in a local landfill (U.S. Nuclear Regulatory Commission 1988). A summary of disposal activities at the quarry is presented in Table 1.1. The approximate location of

TABLE 1.1 History of Disposal Activities at the Weldon Spring Quarry

Time Period	Waste Type	Estimated Volume[a] m^3	Estimated Volume[a] yd^3
1942-1945	TNT and DNT process waste (burn areas)	-	-
1946	TNT and DNT process waste (burn areas)	b	b
1946-1957	TNT and DNT residues and contaminated rubble from cleanup of the ordnance works (in deepest part and in northeast corner of quarry)	-	-
1959	3.8% thorium residues (drummed, currently below water level)	150	200
1960-1963	Uranium- and radium-contaminated rubble from demolition of the St. Louis Destrehan Street feed plant (covering 0.4 ha [1 acre] to a 9-m [30-ft] depth in deepest part of quarry)	38,000	50,000
1963-1965	High-thorium-content waste (in northeast corner of quarry)[c]	760	1,000
1963-1966	Uranium and thorium residues from the chemical plant and off-site facilities; building rubble and process equipment (both drummed and uncontained)	-	-
1966	3.0% thorium residues (drummed, placed above water level in northeast corner of quarry); TNT residues from cleanup of the ordnance works (placed to cover the drums)	460	600
1968-1969	Uranium- and thorium-contaminated rubble and equipment from interiors of some chemical plant buildings (101, 103, and 105)	4,600	6,000

[a]A hyphen indicates that the waste volume estimate is not available.

[b]An estimated 90 tons of TNT/DNT waste was burned in 1946.

[c]This was a portion of the waste originally stored at the Army Arsenal in Granite City, Illinois; most of this material was subsequently removed from the quarry for the purpose of recovering rare earth elements.

Sources: Data from MK-Ferguson Company and Jacobs Engineering Group (1989a), Lenhard et al. (1967); Pennak (1975); Weidner and Boback (1982); Bechtel National (1983); Berkeley Geosciences Associates (1984); Kleeschulte and Emmett (1986); U.S. Nuclear Regulatory Commission (1988).

these waste materials in the quarry is shown in Figure 4.1 of the RI report (MK-Ferguson Company and Jacobs Engineering Group 1989a). Based on historical data and characterization results, an estimated 73,000 m^3 (95,000 yd^3) of contaminated materials is present in the quarry; of this, approximately 31,000 m^3 (40,000 yd^3) is rubble, 39,000 m^3 (51,000 yd^3) is soil and clay, and 3,000 m^3 (4,000 yd^3) is pond sediment (MK-Ferguson Company and Jacobs Engineering Group 1989a).

In 1971, the Army returned the 21-ha (51-acre) portion of the property containing the raffinate pits to the AEC but retained control of the rest of the chemical plant area. As successor to the AEC, DOE assumed responsibility for the raffinate pits. During 1984, the Army repaired several of the buildings; decontaminated some of the floors, walls, and ceilings; and removed some contaminated equipment to areas outside of the buildings. In May 1985, DOE designated the control and decontamination of the Weldon Spring site as a major federal project under SFMP. In May 1988, DOE redesignated the project as a major system acquisition.

On October 1, 1985, custody of the Army portion of the chemical plant area was transferred to DOE. On October 15, 1985, the EPA proposed to include the Weldon Spring quarry on its NPL; this listing occurred on July 22, 1987 (EPA 1987b). On June 24, 1988, the EPA proposed to expand the listing to include the chemical plant area. This proposal was finalized on March 13, 1989 (EPA 1989b), and the expanded site was placed on the NPL under the name "Weldon Spring Quarry/Plant/Pits (USDOE/Army)." The balance of the former Weldon Spring Ordnance Works property -- which is adjacent to the DOE portion and for which the Army has responsibility -- was proposed for NPL listing on July 14, 1989 (EPA 1989g).

2 PHYSICAL CHARACTERISTICS OF THE QUARRY AREA

2.1 SETTING

The environmental setting in the vicinity of the quarry is summarized in this chapter. Additional details are provided in the RI report (MK-Ferguson Company and Jacobs Engineering Group 1989a).

2.1.1 Topography

The Weldon Spring site is located in the southwest portion of St. Charles County, Missouri. The county is bordered by the Mississippi River on the north and east and the Missouri River on the south. Approximately half of the county land is floodplain and half is uplands characterized by gently rolling topography. The site is in the southwest uplands, which are dissected by small stream valleys. The topography of the Weldon Spring site is shown in Figure 2.1.

The quarry borders the Missouri River alluvial floodplain. The surrounding topography, except for the floodplain area to the south, is rugged, heavily wooded, and characterized by deep ravines. The quarry floor and rim are at elevations of about 145 and 170 m (480 and 550 ft) above mean sea level (MSL), respectively. A pyramid-shaped limestone hill rises from the quarry floor to an elevation of about 158 m (518 ft) MSL. The topography of the quarry and vicinity is illustrated in Figure 2.2.

2.1.2 Soils

The original soils at the quarry were removed during limestone excavation. Menfro Silt Loam and Goss Cherty Silt Loam soils are present in the vicinity of the quarry. The characteristics of the soils in the quarry area are summarized in Table 2.1.

2.1.3 Geology

The Weldon Spring quarry is located in low limestone hills near the western bank of the Missouri River. The mid-Ordovician bedrock of the quarry area is predominantly limestone and dolomite. The uppermost geological stratum at the quarry is the Kimmswick Limestone Formation, and the quarry floor is the Decorah Formation (Figure 2.3). Near the quarry, the carbonate rocks dip to the northeast at a gradient of 11 to 15 m/km (58 to 79 ft/mi) (Berkeley Geosciences Associates 1984).

Bedrock near the quarry is overlain in the upland areas by wind-deposited glacial debris. In the Missouri River bottomland areas, the bedrock is overlain by up to 30 m (100 ft) of alluvial material. The sides of the quarry expose the Ordovician Kimmswick Limestone Formation whereas the bedrock floor of the quarry, currently covered with waste materials, lies in the upper portion of the Decorah Formation (see Figure 2.3). The

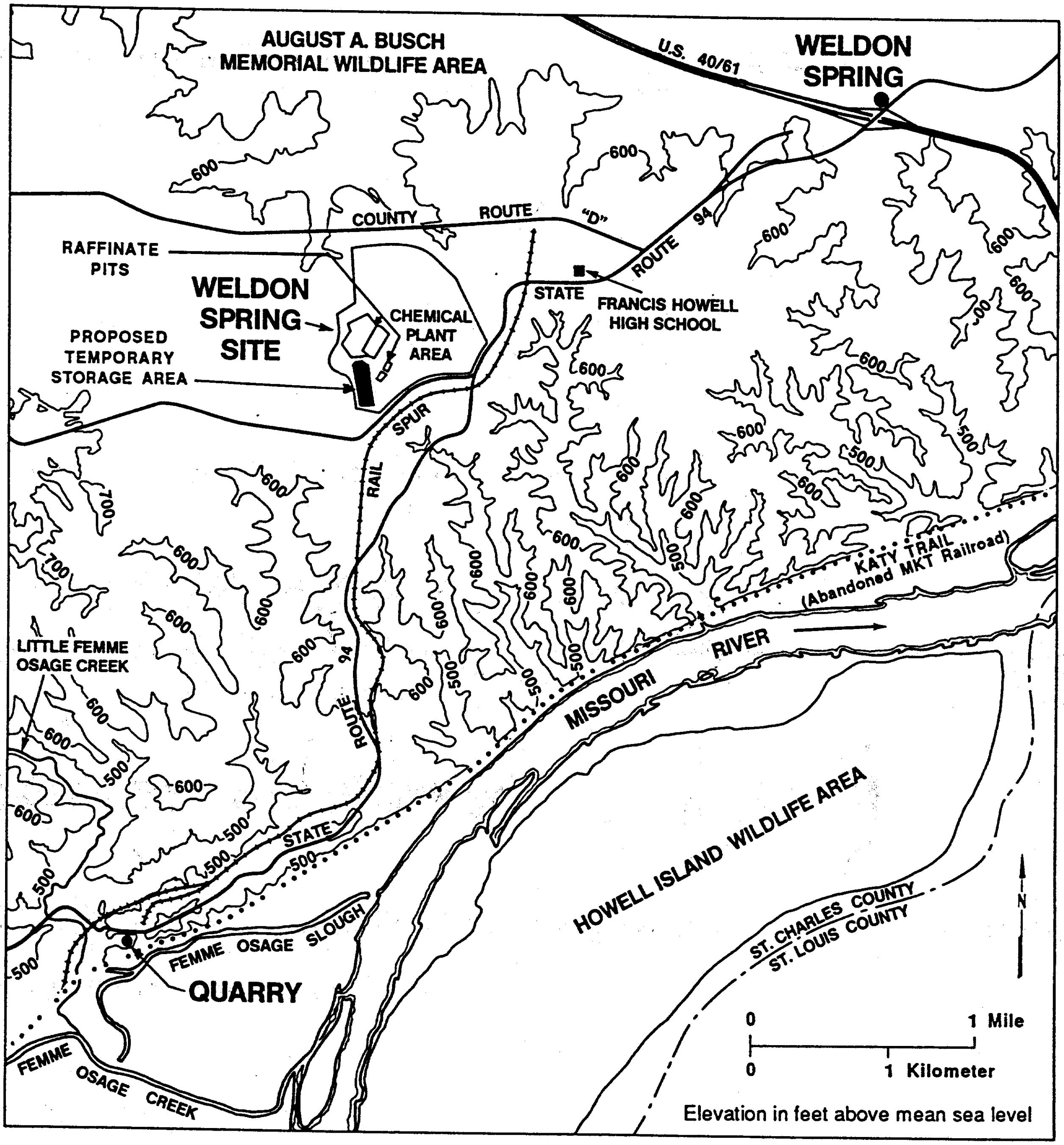


FIGURE 2.1 Topographic Map of the Weldon Spring Area

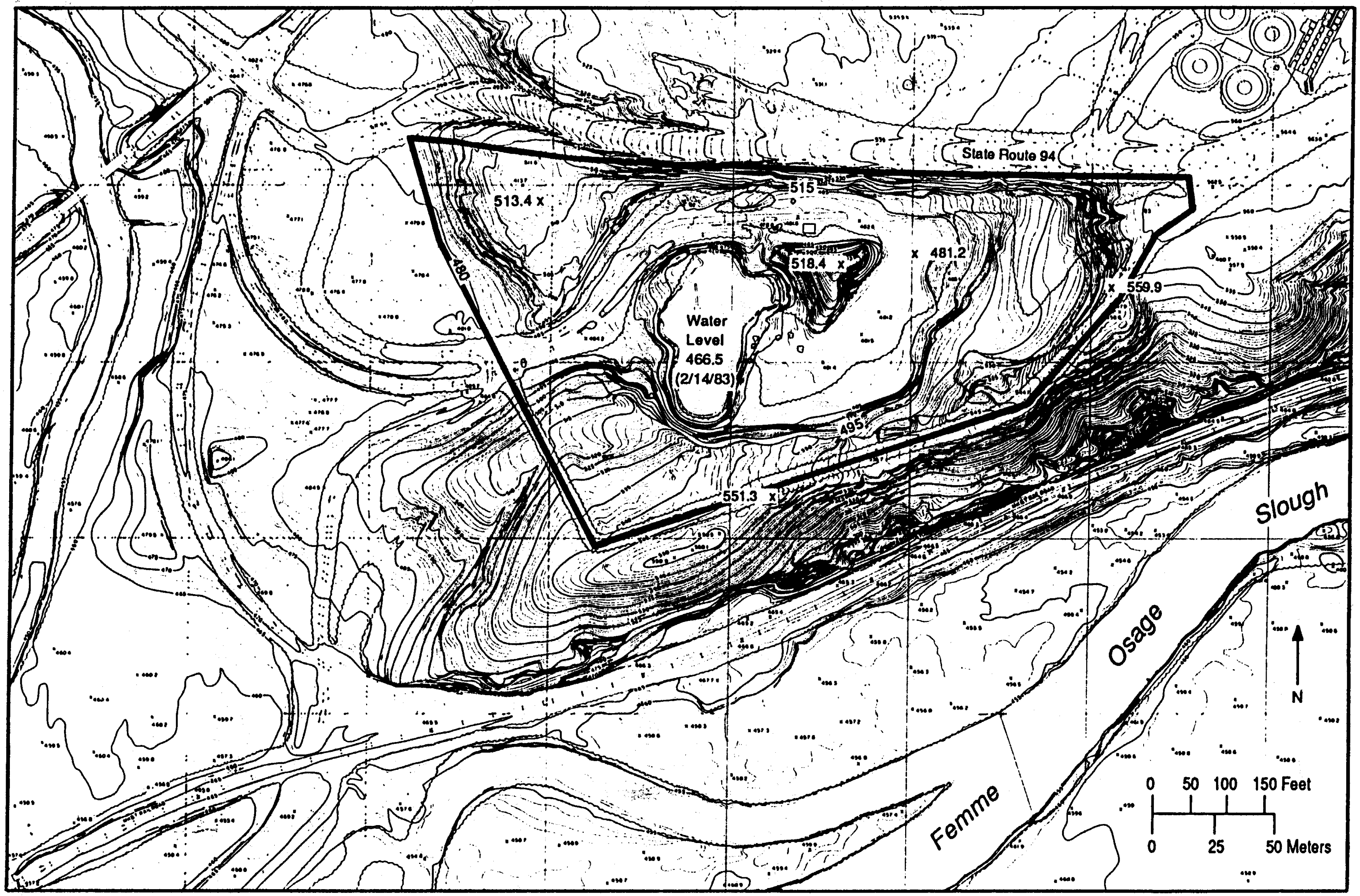


FIGURE 2.2 Topographic Map of the Weldon Spring Quarry and Vicinity

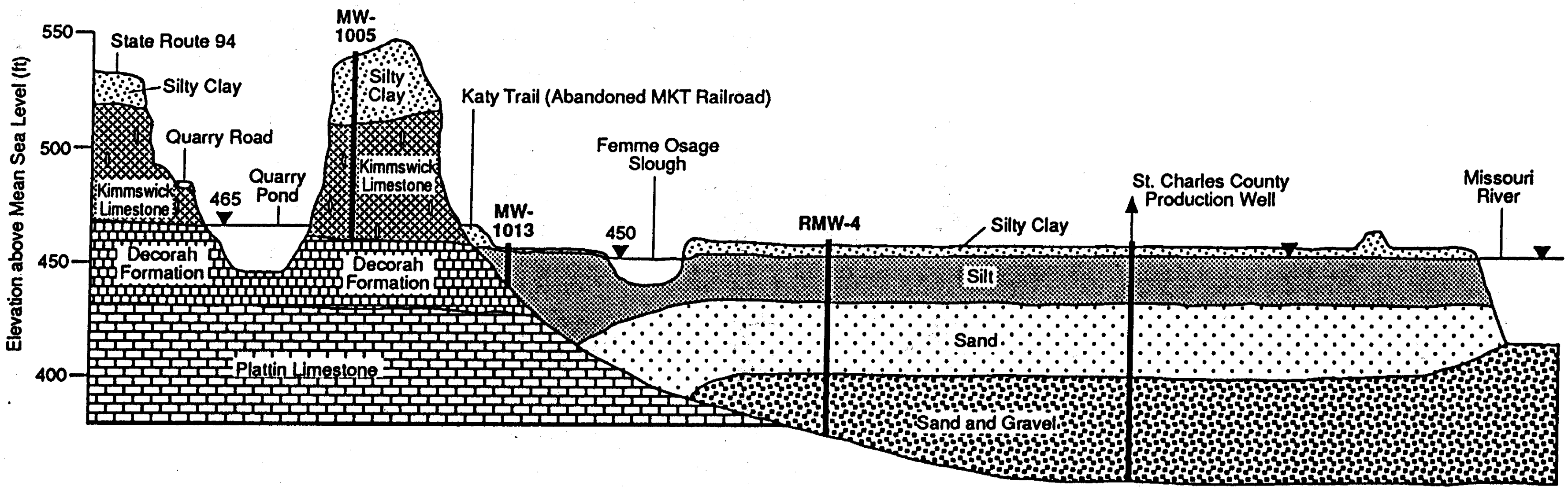


FIGURE 2.3 Idealized Geologic Cross Section through the Quarry Area (Source: Modified from U.S. Department of Energy 1987b; details regarding the cross section between the quarry and Femme Osage Slough are provided in Figures 3.6 and 3.7 of MK-Ferguson Company and Jacobs Engineering Group 1989a)

TABLE 2.1 Summary of Soil Characteristics at the Quarry and Vicinity

Location	Soil Type	Comments
Quarry proper	–[a]	–[a]
Quarry (nearby)	Menfro Silt Loam	Dark brown silt loam. Well drained, moderate permeability, high water capacity, moderate runoff, moderate shrinking and swelling. When cultivated, subject to erosion.
Quarry (general vicinity)	Goss Cherty Silt Loam	Brown cherty silt loam. Well drained, moderate permeability, low water capacity, rapid runoff, moderate shrinking and swelling. Low erosion due to high chert content.

[a]The original soils in the quarry were removed during mining. Some soils are currently in the quarry because windblown soil has reached the quarry, contaminated soil was placed in the quarry, and cover soil was placed in the quarry after disposal of wastes.

Source: Based on information from U.S. Department of Agriculture (1982).

Decorah Formation is 6 to 12 m (20 to 40 ft) thick, and the upper portion is predominantly fossiliferous limestone with shale partings (Berkeley Geosciences Associates 1984). The Kimmswick Limestone Formation, mined during quarry operations, is predominantly a crystalline limestone about 20 m (66 ft) thick. It is characterized by solution-enlarged features associated with the intersection of vertical joints and bedding planes.

East and south of the quarry, the Plattin, Decorah, and Kimmswick limestones and shales are replaced by bottomland alluvium, consisting mainly of sands and gravels. Locally, the alluvium is composed of a surficial layer of 3 m (10 ft) or more of silt underlain by about 6 m (20 ft) of sand. The thickness of the silt layer increases toward the river. Beneath the sand is a layer of approximately 20 m (66 ft) of sand and gravel. This water-bearing alluvium is a major contributor to the domestic water supply of nearby towns.

2.2 HYDROLOGY AND WATER QUALITY

2.2.1 Surface Water

Surface water drainages at the Weldon Spring site are shown in Figure 2.4. Drainage in the quarry area occurs primarily through the subsurface, with limited surface drainage along the southern and western portions of the rim. Surface drainage from the quarry rim flows to the Missouri River, located about 1.6 km (1 mi) to the east, along Little Femme Osage Creek and Femme Osage Creek (Figure 2.1). About 150 m (500 ft) south of the quarry is a 2.4-km (1.5-mi) section of the original Femme Osage Creek and a smaller section of the original Little Femme Osage Creek; these sections were cut off from their natural channels by a levee constructed by the University of Missouri during 1959 and 1960 (Kleeschulte and Emmett 1986). Flows in both Femme Osage Creek and Little Femme Osage Creek were diverted outside the levee system to prevent annual flooding of the farmland and well field located inside the levee system. The isolated body of water that resulted from the channel modifications is now called Femme Osage Slough (the northwest branch of the slough is called Little Femme Osage Slough). Water levels in the slough are influenced by levels of the Missouri River and by groundwater; the average water level in the slough is 140 m (450 ft) MSL (DOE 1987a).

The quarry currently contains ponded water; however, the water will be removed under a separate environmental response action proposed for the quarry (MacDonell et al. 1989), and its management is not part of the proposed management of the quarry bulk wastes. Although there is seasonal variation, the pond holds an estimated 11,000 m^3 (3,000,000 gal) of water when it is full, with an average surface elevation of about 142 m (465 ft) MSL and a maximum depth of about 6.1 m (20 ft) (DOE 1987a). A wooden pier extends into the pond, which is the only surface water body within the quarry.

The bottom of the Missouri River near the quarry (river mile 49 from the confluence with the Mississippi River) is at an elevation of about 129 m (422 ft) MSL. The elevations for 100-year and 500-year floods on the Missouri at river mile 49 are 144.1 and 144.7 m (472.8 and 474.6 ft) MSL, respectively (U.S. Army Corps of Engineers 1988). The elevation of the 100-year flood on Femme Osage Creek is 144.5 m (474 ft) MSL from its mouth to the confluence with Little Femme Osage Creek (Federal Insurance Administration, undated). Although the floodplain area below the quarry is partially behind a levee, the area floods every 3 to 5 years and requires 1 to 2 months to dry (DOE 1987a).

Water in both the Missouri and Mississippi rivers is of a calcium-bicarbonate type and is characterized as hard due to its natural levels of calcium and magnesium. The Missouri River has relatively high turbidity levels whereas the Mississippi River has relatively low turbidity levels upstream of its confluence with the Missouri.

Femme Osage Slough contains elevated levels of uranium; the annual averages for three locations near the quarry sampled in 1987 were 28 to 34 pCi/L of total

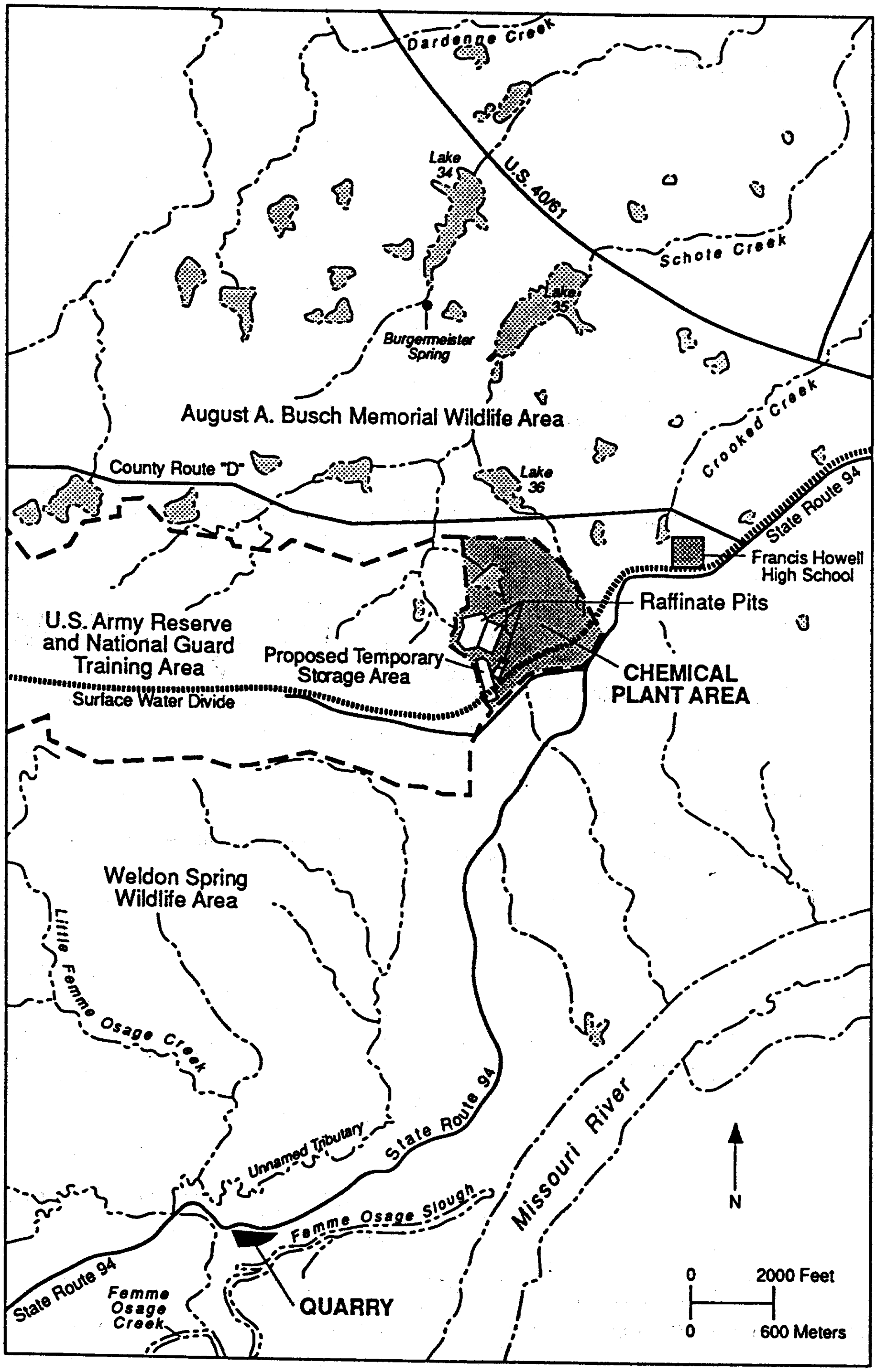


FIGURE 2.4 Surface Water Drainages at the Weldon Spring Site (Source: Modified from DOE 1988a)

uranium,* compared with the background level of about 3 pCi/L (DOE 1988a). Uranium concentrations in slough sediments are also elevated compared with background levels (Berkeley Geosciences Associates 1984). The contamination may be the result of subsurface migration of uranium from north of the slough and/or of past pumping tests on the quarry pond (during the pumping tests, water from the pond was discharged directly into Little Femme Osage Creek which then flowed into Femme Osage Creek and discharged into the Missouri River through what is now Femme Osage Slough). Concentrations of radium-226, thorium-230, and thorium-232 in slough water have been below detection limits (less than 1 pCi/L) (DOE 1988a). Measured concentrations of radium-226 and thorium-232 in slough sediments have been near background levels (DOE 1987a). Nitroaromatics were not detected in slough water sampled in the spring of 1989 but were detected in slough sediments (Meyer 1989). The annual average concentration of uranium in Little Femme Osage Creek is near the background level of about 3 pCi/L (DOE 1988a). Concentrations of radium-226 in the creek are below the average background level in this area of about 3 pCi/L, and thorium-230 and thorium-232 concentrations in the creek are below detection limits (DOE 1988a). Concentrations of total uranium in water currently ponded in the quarry are considerably above background (e.g., averaging more than 2,000 pCi/L), and the water contains various organic contaminants, including certain nitroaromatics (MK-Ferguson Company and Jacobs Engineering Group 1989a). Contamination in the quarry pond sediments is discussed in Sections 2.7 and 2.8 of this document.

2.2.2 Groundwater

In the area of the quarry, two lithologically distinct aquifers comprise the near-surface groundwater regime (MK-Ferguson Company and Jacobs Engineering Group 1989a). The first is a predominantly limestone bedrock aquifer beneath the quarry and the second is an alluvial aquifer located generally between the quarry bluff and the Missouri River (Figure 2.3).

The limestones, shales, and dolomites located below the quarry are part of a regional leaky confining layer that is about 100 m (330 ft) thick and extends down to the Joachim Dolomite. Near-surface groundwater occurs at the quarry in the Kimmswick Limestone, Decorah, and Plattin Limestone formations. Due to the proximity of the quarry wastes, there is a potential for groundwater contamination within these underlying formations.

Groundwater flow within the bedrock aquifer occurs primarily through secondary porosity, i.e., through fractures, joints, and bedding planes. The hydraulic properties of the bedrock aquifer in the Kimmswick Limestone Formation are as follows: transmissivity, 2.3×10^{-5} m^2/s (2.5×10^{-4} ft^2/s); effective porosity, 0.001 to 0.002; storativity, 0.0001; and natural groundwater velocity as determined from point dilution tests, 0.06 m/d (0.2 ft/d) (MK-Ferguson Company and Jacobs Engineering Group 1989a). These hydraulic properties are influenced by fracture interconnection and frequency, which can vary widely with location.

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*Uranium as it exists in nature consists of uranium-238, uranium-234, and uranium-235 in an activity ratio of 1:1:0.046.

The Decorah Formation, located below the Kimmswick (Figure 2.3), is considered to be a leaky confining layer on a regional scale (MK-Ferguson Company and Jacobs Engineering Group 1989a). The effectiveness of the confining properties of the Decorah is reduced by vertical fractures and by the quarry itself, which was excavated 5 m (16 ft) into the Decorah, providing a direct connection between the upper and lower strata. No precise measurements have been made of the hydraulic properties of the Decorah Formation.

A vadose (unsaturated) zone overlies the saturated, unconfined aquifer below the quarry. At the quarry rim, this zone generally consists of a few feet of silty clay loess deposits and the weathered portion of the underlying limestone (MK-Ferguson Company and Jacobs Engineering Group 1989a). Solution-enlarged features in the vadose zone promote recharge of the underlying aquifer. Surface recharge to the quarry bedrock is limited to contributions from precipitation and storm runoff (MK-Ferguson Company and Jacobs Engineering Group 1989a). Discharge may occur as springs, seeps, evapotranspiration, underflow, flow to pumping wells, flow to gaining streams, and flow to the Missouri River alluvium.

Near the Missouri River, floodplain alluvium provides intergranular porosity for a second unconfined aquifer. This aquifer is located within about 3 m (10 ft) of the ground surface, although the depth to water varies with season and pumping demands in the nearby St. Charles County well field. The thickness of the alluvium in the St. Charles County area ranges from 8 to 35 m (27 to 120 ft) along the Missouri River (DOE 1987a). The transmissivity at various locations in the alluvium, estimated from pumping tests, ranges from 0.001 to 0.07 m^2/s (0.01 to 0.7 ft^2/s) and averages 0.003 m^2/s (0.03 ft^2/s) (DOE 1987a). The effective porosity of the alluvium, estimated using the results of a two-well tracer test, ranges from 0.27 to 0.32 (Berkeley Geosciences Associates 1984). A vadose zone exists in the silts above the water table of the unconfined aquifer. The aquifer is readily recharged by water from the Missouri River as well as by infiltration from precipitation and intermittent river flooding.

The ponded quarry water is hydraulically connected to the underlying fractured bedrock and, as shown in Figure 2.5, its elevation appears to be a hydrologically high elevation for the vicinity. A majority of the groundwater flow from the quarry is transported by the local gradient toward the alluvium of the Missouri River floodplain. The connection of the fractured limestone aquifer beneath the quarry with the unconfined alluvial aquifer near Femme Osage Slough is not clearly understood. Although it is certain that groundwater flows toward the Missouri River from the quarry, the influence of Femme Osage Slough on this flow and the associated solute transport are uncertain. Studies reported by MK-Ferguson Company and Jacobs Engineering Group (1989a) indicate that the clay and silty alluvium at the slough may act as a groundwater barrier. This hypothesis is based on three observations: (1) groundwater velocities in the vicinity of the slough are very low to almost stagnant, (2) water levels in the alluvium south of the slough are approximately 2 to 3 m (5 to 8 ft) lower than water levels in the slough, and (3) the alluvial aquifer south of Femme Osage Slough is not radioactively contaminated. These observations are indicative of a poor hydraulic connection between the bedrock and the alluvial aquifers. Although no indication currently exists of groundwater flow through the alluvial material below the slough to the alluvial aquifer, groundwater

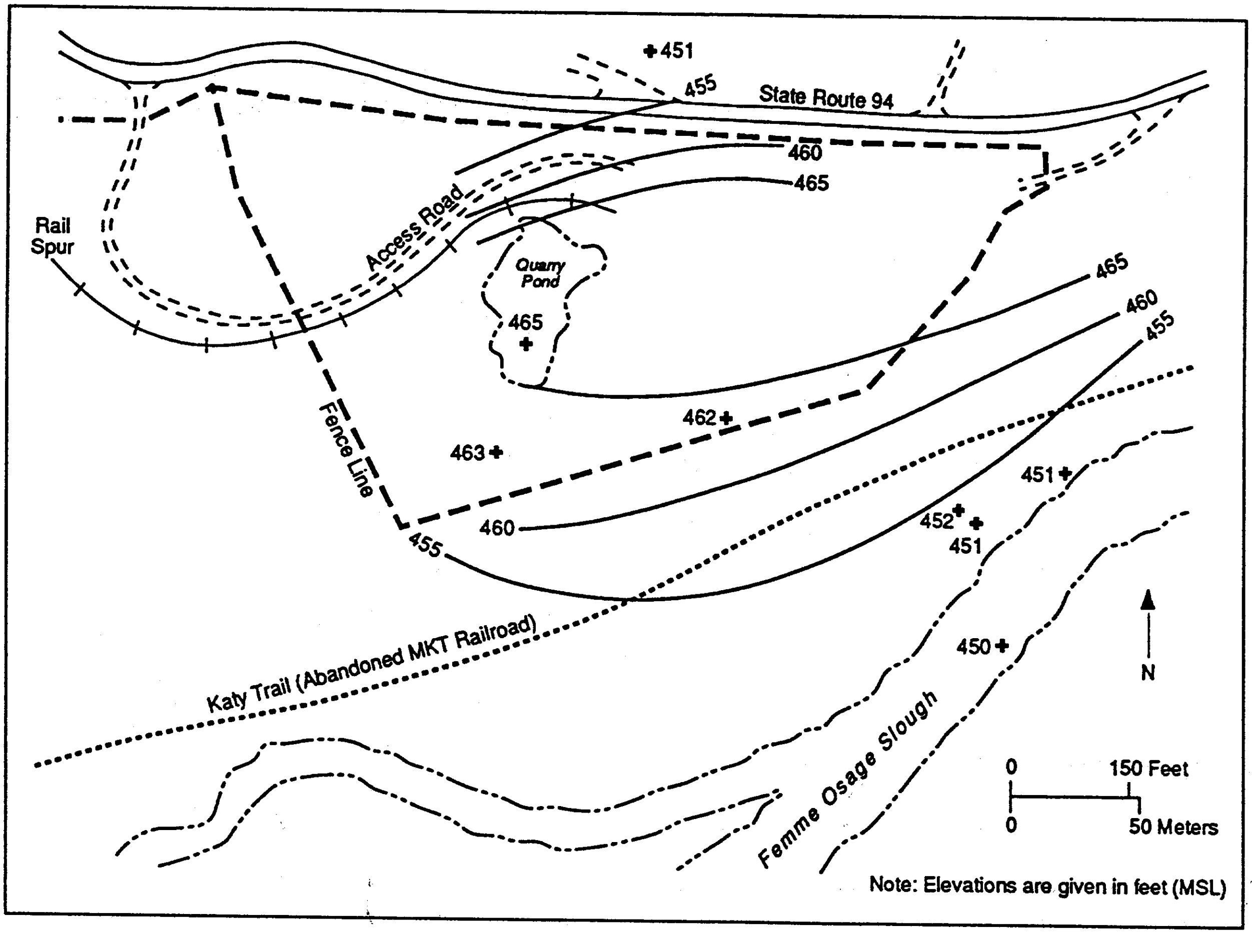

FIGURE 2.5 Groundwater Elevations at the Quarry Area

may flow underneath the clay and silty material through fractured bedrock. Groundwater velocity in the bedrock below the alluvium is not known. Also, the relationship is not fully understood of (1) pumping in the county well field (nine production wells completed in the unconfined alluvial aquifer pump at a total rate of about 130 L/s [2,000 gal/min]) and (2) the varying water levels in the Missouri River and the groundwater flow system.

Bedrock groundwater at the quarry is enriched in calcium, magnesium, carbonate, sulfate, and nitrate, but it contains low levels of iron (MK-Ferguson Company and Jacobs Engineering Group 1989a). Radiological and chemical analyses of groundwater from the quarry bedrock have identified contamination with nitroaromatics and uranium (MK-Ferguson Company and Jacobs Engineering Group 1989a). The highest concentrations of total uranium (up to 18,700 pCi/L) were detected in the eastern region of the quarry. Although levels of radium-226 and thorium-230 have been detected above background, the concentrations have all been below respective DOE derived concentration guides (DCGs). Neither the vertical flow of groundwater nor the extent of vertical contamination have been defined for the bedrock aquifer, although the contamination is known to extend from the lower portion of the Kimmswick Limestone Formation to the Decorah Formation. The upper Plattin Limestone Formation (Figure 2.3) below the alluvium north of Femme Osage Slough may also be contaminated (MK-Ferguson Company and Jacobs Engineering Group 1989a). Groundwater contamination below the Plattin has not yet been investigated.

Groundwater in the unconfined alluvial aquifer south of Femme Osage Slough is not radioactively contaminated; concentrations of radioactive constituents in samples from this aquifer are within the typical background range for this region (MK-Ferguson Company and Jacobs Engineering Group 1989a). However, nitroaromatic compounds have been detected at low levels (less than 1 μg/L) in groundwater south of the slough (Meier 1989). These compounds have been detected sporadically in 5 of the 10 DOE monitoring wells located south of the slough. No nitroaromatic compounds have been detected in the county well field or in county monitoring wells located between the DOE wells and the county well field. Nitroaromatic compounds detected south of the slough may be the result of contamination in slough sediments due to discharges of nitroaromatically contaminated wastes into Little Femme Osage Creek during World War II, past pumping tests on the quarry pond (see Section 2.2.1), or transport via the groundwater pathway. Although the alluvial aquifer south of Femme Osage Slough appears to be uncontaminated with uranium, measurements have not yet been made to establish solute concentrations or groundwater flow directions in the bedrock aquifer.

2.3 ECOLOGY

2.3.1 Terrestrial

The Weldon Spring site is located along the boundary between two physiographic provinces (Johnson 1987; Thom and Wilson 1980). The chemical plant area occurs within the southern portion of the Glaciated Plains physiographic province. Although the area is characterized by rolling hills and broad flat valleys, some limestone bluffs and steep hills occur at the eastern edge of the province along the Mississippi River. Marshes, native prairies, and upland deciduous forests were the dominant plant communities in presettlement times; much of the region has since been altered by agricultural activities.

The quarry area is situated in the northern portion of the Ozark Border physiographic province. This region occurs in a band along the lower Missouri River and the eastern edge of the state of Missouri along the Mississippi River. The area is characterized by hills and bluffs, deciduous forests, and wide river valleys.

Much of the land immediately surrounding and adjacent to the Weldon Spring site is state-owned wildlife areas that are actively managed for wildlife and support a diverse biota -- i.e., Weldon Spring Wildlife Area (2,900 ha [7,200 acres]), Howell Island Wildlife Area (1,100 ha [2,600 acres]), and August A. Busch Memorial Wildlife Area (2,800 ha [7,000 acres]). Habitat types include open fields and pastures; slope, upland, and bottomland forests; and cultivated farmlands. Plant species common to the open fields and pastures include Indian Mallow, crabgrass, ragweed, aster, thistles, goldenrod, and a variety of grass and herbaceous species. The forested habitats contain a variety of tree species such as shagbark hickory; red, white, post, and black oaks; pawpaw; Kentucky coffeetree; black walnut; and eastern cottonwood.

The 3.6-ha (9-acre) quarry area is surrounded by the Weldon Spring Wildlife Area and consists primarily of forest with some old-field habitat. Although extensively affected by past human activities, little human disturbance currently occurs in this area and vegetation has reestablished. Much of the quarry floor is old-field habitat and contains a variety of grasses, herbs, and shrubs. The rim and upper portions of the quarry consist primarily of slope and upland forest; tree species include cottonwood, sycamore, and oak.

The area south of the quarry is within the 100-year floodplain of Little Femme Osage Creek and the Missouri River. Vegetation in this area consists primarily of herbaceous species and crops or grass. Trees are generally restricted to the numerous levees throughout the area and to the banks of Little Femme Osage Creek, Femme Osage Slough, and the Missouri River.

The Missouri Department of Conservation has identified 25 species of amphibians, 47 species of reptiles, and 29 species of mammals as occurring in St. Charles County (Dickneite 1988). Mammalian species in the area may include fox and gray squirrel, white-tailed deer, fox, opossum, raccoon, skunk, eastern cottontail, and a variety of mice and other rodents. Amphibian and reptilian species include bullfrog, spring peeper, slimy and eastern tiger salamanders, Fowler's toad, softshell and map turtles, and a variety of snakes. Three venomous snake species may also be present: the Osage copperhead, the eastern massasauga, and the timber rattlesnake.

More than 295 avian species have been reported from St. Charles County (Dickneite 1988) and could occur at the Weldon Spring site. More than 100 of these species are known to breed in the area, and many are common throughout much of the year. In addition, the many ponds and small lakes at the Busch Wildlife Area provide important habitat for migrating birds in spring and autumn (Missouri Department of Conservation 1976). Common birds that may occur at the quarry include a variety of warblers, sparrows, hawks, owls, thrushes, and woodpeckers. Surface water in the area -- including the ponds, lakes, and streams of the wildlife areas and possibly the quarry pond -- provide habitat for waterfowl and shorebirds, including Canada goose, mallard, wood duck, sandpipers, herons, and gulls.

2.3.2 Aquatic

The principal aquatic habitats in the immediate vicinity of the quarry include the Missouri River (approximately 1.6 km [1 mi] southeast of the quarry), Little Femme Osage Creek (150 m [500 ft] west of the quarry), Femme Osage Creek (610 m [2,000 ft] south-southwest of the quarry), and Femme Osage Slough (150 m [500 ft] south of the quarry). Other aquatic habitats include the 0.2-ha (0.5-acre) quarry pond and numerous small, unnamed creeks, drainages, springs, and ponds located throughout the Weldon Spring Wildlife Area.

The Missouri Department of Conservation reports that 105 species of fish are present in St. Charles County (Dickneite 1988), some of which may be found in the various aquatic habitats in the Weldon Spring area. Common species in the numerous ponds, lakes, and small streams of the area include carp, black bullhead, bluegill, crappie, gizzard shad, bass, and a variety of chubs, shiners, darters, and minnows. Species in the Mississippi and Missouri rivers include gar, paddlefish, sturgeon, sucker, buffalo, freshwater drum, white bass, and catfish. Many of the aquatic habitats in the area support recreational fishing activities, and numerous ponds in the Busch Wildlife Area are stocked and/or managed for channel catfish, bass, crappie, and other species (Missouri Department of Conservation 1978).

In 1988, the quarry pond was sampled for fish using electrofishing equipment (MK-Ferguson Company and Jacobs Engineering Group 1988); no fish were found in the pond during this sampling. The quarry pond could provide habitat for amphibians, reptiles, and waterfowl, although the extent of use by these species is not known and none were observed in a 1989 site visit. During this visit, some aquatic and semiaquatic insects, such as dragonflies and damselflies, were observed. As currently planned, the pond water will be treated and discharged to the Missouri River under a separate action (see Section 1.1).

2.3.3 Threatened and Endangered Species and High-Quality Natural Communities

Based on consultation with the U.S. Fish and Wildlife Service (Nash 1988; Tieger 1988), the only federally listed threatened or endangered species that occurs in the Weldon Spring area is the bald eagle (*Haliaeetus leucocephalus*) -- except for possible transient occurrences by such species as the peregrine falcon (*Falco peregrinus*). A night roost for bald eagles overwintering in the area occurs at the Howell Island Wildlife Area (Gaines 1988). However, no critical habitat for this species exists either at the quarry or the chemical plant area. In addition, there are records of the sturgeon chub (*Hybopsis gelida*) and the sicklefin chub (*Hybopsis meeki*), both Category 2 species,* for the Missouri River at the Howell Island and Weldon Spring wildlife areas -- i.e., at Daniel Boone Bridge on U.S. Route 40/61 (Gaines 1988). These species, however, are restricted to the open channels of large turbid rivers and do not enter tributary streams (Pflieger 1975). Thus, with the exception of the Missouri River proper, these species will not occur in the aquatic habitats that are present throughout the Weldon Spring area. Three additional Category 2 species and two former Category 2 species (see Table 2.2) are also reported to occur in St. Charles County (Gaines 1988); none of these species, however, are known to occur in the immediate vicinity of the Weldon Spring site.

The Missouri Department of Conservation (Gaines 1988) has identified 17 state endangered and 17 state rare species from St. Charles County; eight additional species that are considered by the state to be of special concern are also reported from the county (Table 2.2). However, except for the bald eagle and the sturgeon and sicklefin chubs, only two state-listed rare or endangered species and one state species of concern are known to occur in the immediate vicinity of the Weldon Spring site (Gaines 1988). Although some of the other state-listed species may also be present, the Missouri Department of Conservation has no related data at this time.

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*Federal candidate for listing as a threatened or endangered species.

TABLE 2.2 Threatened, Endangered, or Special Concern Species Reported from St. Charles County, Missouri, and Potentially Occurring in the Weldon Spring Quarry Area

Species	Status	
	Federal[a]	State[b]
__Plants__		
Starwort (variety)	C2	Endangered
Forbes saxifrage	C3	Watch list
Rose turtlehead	C3	Endangered
Arrow arum	-	Rare
Star duckweed	-	Rare
Bugseed (variety)	-	Watch list
Adder's tongue fern (variety)	-	Undetermined
Salt meadow grass (variety)	-	Undetermined
__Fish__		
Pallid sturgeon	C2	Endangered
Pugnose minnow	-	Endangered
Sturgeon chub	C2	Rare
Sicklefin chub	C2	Rare
Alligator gar	-	Rare
Brown bullhead	-	Rare
Alabama shad	-	Rare
Starhead topminnow	-	Watch list
Western sand darter	-	Watch list
__Reptiles and Amphibians__		
Western fox snake	-	Endangered
Rattlesnake	-	Endangered
Western smooth green snake	-	Endangered
Wood frog	-	Rare
Northern crawfish frog	-	Watch list
__Birds__		
Bald eagle	Endangered	Endangered
Peregrine falcon	Endangered	Endangered
Least tern	C2	Endangered
Cooper's hawk	-	Endangered
Northern harrier	-	Endangered

TABLE 2.2 (Cont'd)

Species	Status Federal[a]	Status State[b]
Birds (Cont'd)		
Sharp-shinned hawk	-	Endangered
Osprey	-	Endangered
Barn owl	-	Endangered
Double-crested cormorant	-	Endangered
Snowy egret	-	Endangered
Bachman's sparrow	-	Endangered
American bittern	-	Rare
Yellow-headed blackbird	-	Rare
Red-shouldered hawk	-	Rare
Black-crowned night heron	-	Rare
Little blue heron	-	Rare
Mississippi kite	-	Rare
Upland sandpiper	-	Rare
Henslow's sparrow	-	Rare
Sedge wren	-	Watch list
Mammals		
Long-tailed weasel	-	Rare

[a]C2 = federal candidate for listing as a threatened or endangered species.

C3 = former federal candidate species.

[b]Special concern species include those classified by the state as rare, on the watch list, or status undetermined.

Watch list = species of possible concern for which the Missouri Department of Conservation is seeking further information; this listing does not imply that these species are imperiled.

Undetermined = possibly rare or endangered but insufficient information is available to determine the proper status.

Sources: Dickneite (1988); Gaines (1988).

The Cooper's hawk (*Accipiter cooperii*), a state endangered species, is reported to occur at the Weldon Spring Wildlife Area. This species nests in large trees, 7 to 14 m (25 to 45 ft) in height (Bent 1937), and such trees are found in the quarry area. The wood frog (*Rana sylvatica*) is classified by the state as rare and is known to occur at the Weldon Spring Wildlife Area (Saladin 1989). In Missouri, the wood frog is generally associated with wooded hillsides and breeds in small, fishless woodland ponds and pools; thus, the quarry pond area may currently provide suitable breeding habitat for this species.

Amphibians are very sensitive to water quality conditions for reproduction, larval growth, and metamorphosis, and several studies have examined the importance of water quality to the reproduction, physiology, habitat selection, and distribution of the wood frog (Dale et al. 1985; Gascon and Planas 1986). Some of the water quality characteristics reported for the quarry pond -- including aluminum, chloride, and magnesium concentrations and pH (MacDonell et al. 1989) -- are within the range of values reported from known wood frog habitats. Other chemicals -- such as sulfate, potassium, and calcium -- have been detected in the quarry pond at concentrations greater than those reported from wood frog habitats. However, the effects of these higher concentrations on wood frogs are not known. Similarly, little is known regarding the effects on the wood frog of other chemical constituents in the quarry pond water (such as toluene, 2,4-DNT, and uranium).

The sedge wren (*Cistothorus platensis*), a species on the state's watch list, has been reported from old-field habitat in the vicinity of the Weldon Spring site. No legal status is associated with this listing; watch list status is given to species of possible concern for which the Missouri Department of Conservation is seeking further information (see Table 2.2).

The Missouri Department of Conservation has also identified several high-quality natural communities in the area of the Weldon Spring site (Gaines 1988). A mesic forest/dry-mesic chert forest of approximately 51 ha (125 acres) and containing very good old growth is located within the Weldon Spring Wildlife Area, south of State Route 94 near the chemical plant area. (Approximately 33 ha [81 acres] of this forest community lies within the Department of Conservation's Weldon Spring Natural Area, which is a very old-growth, mesic forest.) In addition, very-high-quality dry chert forest and chert savannah communities are located in the Weldon Spring Wildlife Area northwest of the quarry. These communities contain old-growth vegetation, and the dominant trees (primarily oaks) often exceed 50 cm (20 in.) in diameter at breastheight. The chert savannah community, which contains very old-growth black and post oaks and some unusual plants, is essentially undisturbed and has been classified as rare by the Missouri Department of Conservation (Gaines 1988).

2.4 CLIMATE, METEOROLOGY, AND AIR QUALITY

2.4.1 Climate and Meteorology

The area of the Weldon Spring site has a modified continental climate, with moderately cold winters and warm summers. The average daily maximum temperature for the St. Louis area ranges from 3°C (38°F) in January to 32°C (89°F) in July. The average daily minimum ranges from -7°C (20°F) in January to 20°C (69°F) in July (National Climatic Data Center 1987). South of the site is the warm, moist air of the Gulf of Mexico, and to the north in Canada is a region of cold air masses. The alternate invasion of the Weldon Spring area by these air masses and the conflict along their frontal zones produce a variety of weather conditions, none of which typically persists for any length of time (National Climatic Data Center 1987).

The prevailing winds are from the south at about 4 m/s (10 mph). Winds in the St. Louis area occur most often from the south during late spring through late fall and from the northwest during the remainder of the year. A peak gust of 30 m/s (66 mph) was reported in March 1984, based on a 4-year period of record (1984 through 1987) for Lambert-St. Louis International Airport (National Climatic Data Center 1987).

Normal annual precipitation in the area is about 86 cm (34 in.), of which about 28 cm (11 in.) occurs in spring. Winter is the driest season, averaging about 15 cm (6 in.) of total precipitation. Summer rains are frequently in the form of thunderstorms that often include hail and high winds. Thunderstorms usually occur in the area between 40 and 50 times per year (National Climatic Data Center 1987). Tornadoes may occur in the St. Louis area once or twice per year, most often in April and May, but they usually have a narrow path and often dissipate after a few kilometers. From 1918 to 1986, the numbers of tornadoes observed to have touched down in nearby counties were: St. Louis city and county, 38; Jefferson, 20; Franklin, 16; Warren, 5; Montgomery, 9; and Lincoln, 10. From 1918 to 1989, 20 tornadoes were observed in St. Charles County (Tucker 1989). Only a limited number of the tornadoes observed in these counties were associated with extensive damage and/or loss of life.

Meteorological data specific to the quarry area are not available. Therefore, representative data from a nearby source were selected. The selection and application of these data are discussed in Section 10.2.

2.4.2 Air Quality

The Weldon Spring site is located in the St. Louis Air Quality Control Region. Measurements taken in 1984 at the closest state monitoring location (Queeny Park, 22 km [14 mi] southeast of site) indicate that the area is in compliance with federal and state air quality standards for carbon monoxide, nitrogen dioxide, total suspended particulates, and lead (Missouri Department of Natural Resources, undated). Measurements taken in 1984 at the state monitoring site in Weldon Spring indicate that the standard for sulfur oxides is also being met. However, the Queeny Park location has recorded violations of the ozone standard, as have the majority of such stations in the

St. Louis area. As a result, all of St. Charles County -- which includes the Weldon Spring site -- is a nonattainment area for ozone. Measured values and air quality standards for these parameters are shown in Table 2.3.

Concentrations of radon gas* have been measured at the quarry fence line since 1980 as part of the ongoing environmental monitoring program. The background concentration of radon in the Weldon Spring area is about 0.3 pCi/L. In 1987, the annual average concentration of radon (including background) for the six monitoring locations along the quarry fence was 1.2 pCi/L; the maximum concentration was measured near the upper gate in the northeastern corner of the quarry. At that location, quarterly average concentrations ranged from 0.7 to 4.0 pCi/L, with an annual average of 2.6 pCi/L (DOE 1988a). The highest radon concentrations measured in 1988 were also at this location, with an annual average of 4.3 pCi/L. The DOE maximum permissible value for annual average concentration of radon-222 above background in uncontrolled areas is 3 pCi/L (DOE 1988a). (See Appendix C for additional discussion of radon limits.) Atmospheric radon concentrations measured within the quarry have ranged from 0.8 to 18 pCi/L, with an average of 14 pCi/L (Berkeley Geosciences Associates 1984). Atmospheric radon and radon decay product concentrations are currently being monitored both within the quarry and at the fence line.

Gamma exposure rates have also been measured along the quarry fence as part of the environmental monitoring program. Annual average values ranged from 62 to 158 mR/yr for the period 1982-1987 (MK-Ferguson Company and Jacobs Engineering Group 1989a). The average exposure rate for the Weldon Spring area measured in 1987 was 85 mR/yr, with a range of 78 to 96 mR/yr (DOE 1988a).

In general, no information is available on existing levels of chemical contaminants in the atmosphere at the Weldon Spring site (except for asbestos at the chemical plant area).

2.5 LAND USE AND DEMOGRAPHY

The quarry is adjacent to State Route 94 and is surrounded by the Weldon Spring Wildlife Area. The St. Charles County well field lies between the quarry and the Missouri River (Figure 1.5). State Route 94 is the main transportation artery past the site, with an estimated traffic flow of 1,820 vehicles per day near the quarry (Rankin 1989). Employees of St. Charles County and the Missouri Cities Water Company service the county well field via a dirt road to the east of the quarry. The dirt road also provides recreational access to the Missouri River. A major land use in the area is recreation, with activity centered on the Weldon Spring and Busch wildlife areas. Much of the land south of the quarry, along the Missouri River floodplain, is used for agriculture.

Public access to the quarry is prohibited by fences and locked gates. The adjacent well field provides water for a number of nearby communities. St. Charles

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*In this report, the term *radon* refers to all isotopes of radon.

TABLE 2.3 Air Quality Measurements near the Weldon Spring Site

Pollutant	Averaging Period	Maximum Concentration[a] ($\mu g/m^3$)	Most Restrictive Standard ($\mu g/m^3$)
Carbon monoxide	1 hour	7,700	40,000
	8 hours	6,600	10,000
Nitrogen dioxide	1 year[b]	27	100
Total suspended particulates[c]	24 hours	175[d]	150
	1 year[e]	37	75
Lead	3-month calendar quarter	0.29	1.5
Sulfur oxides[f]	3 hours	1,007	1,300
	24 hours	260	365
	1 year[b]	22	80
Ozone	1 hour	–[g]	235

[a]Except for sulfur oxides, all data are 1984 measurements taken at Queeny Park; sulfur dioxide was measured at Weldon Spring. Source: Missouri Department of Natural Resources (undated).

[b]Arithmetic mean.

[c]This pollutant is no longer regulated as such (see Appendix C for current particulate regulations).

[d]Second highest value was 124 $\mu g/m^3$, which met the standard.

[e]Geometric mean.

[f]Expressed as sulfur dioxide.

[g]18.6 expected exceedances from 1982 through 1984 violates the allowable number of three exceedances of standard.

County Water Plant Number 1, located on State Route 94 about 1.2 km (0.8 mi) east of the quarry, treats water from this well field. The water treatment plant supplies water to Missouri Cities Water Company and Public Water and Sewer District Number 2, as well as to its own distribution system. Overall, about 21,000 customers use water from the well field (Aaron 1989). These users include various commercial and industrial facilities, as well as residences. Assuming about 3 persons per customer site, the well field serves over 60,000 persons.

The Weldon Spring site is located in the western part of the St. Louis metropolitan area. The population of this area has been growing rapidly over the last three decades. St. Charles County had 52,970 residents in 1960, 92,954 in 1970, and 144,107 in 1980 (U.S. Bureau of the Census 1970, 1980). Rapid population growth has continued since then, and the growth rate is projected to remain high in the future. The community nearest the quarry is Defiance, which is about 5 km (3 mi) to the west and has a population of about 100. The nearest residence is about 0.8 km (0.5 mi) west of the quarry.

2.6 CULTURAL RESOURCES

2.6.1 Regional Prehistory and History

Archeological remains from all periods of the regional prehistoric record in the vicinity of the Weldon Spring site have been recovered in northeastern Missouri (Chapman 1975, 1980; Donham 1982; O'Brien and Warren 1983). These data have contributed to research concerning a variety of issues in regional prehistory (e.g., O'Brien et al. 1982). Euro-American settlers first penetrated the region near the Weldon Spring site in the 1600s and encountered Algonquin-speaking Native American groups. Although St. Louis was founded in 1764, widespread Euro-American settlement did not begin until after the Louisiana Purchase in 1803. Overviews of Missouri history have been presented by Meyer (1963), March (1967), and others.

2.6.2 Inventory and Evaluation of Cultural Resources

The DOE conducted a literature/file search for local cultural resources, which produced information on four previously recorded archeological sites in the area of the Weldon Spring quarry (Walters 1988). Two of these sites (23SC21 and 23SC178) are located immediately adjacent to the quarry, and two (23SC80 and 23SC90) are located several hundred meters west of the quarry. (The precise locations of the sites are confidential and cannot be identified in a public document.)

In 1986, the Missouri State Historic Preservation Officer (SHPO) determined that an archeological survey of the quarry and the chemical plant area was not required on the basis of prior disturbance, low potential for archeological remains, and possible health risks (Weichman 1986). However, because areas outside of the immediate quarry area could contain significant archeological remains, DOE undertook an archeological survey of areas surrounding the quarry that could be affected by remedial actions (Walters 1988).

The survey area, totaling about 28 ha (70 acres), was subjected to pedestrian reconnaissance and, where ground visibility was poor (less than 10%) due to thick vegetative cover, shovel tests were conducted in locales with high potential for archeological remains (Walters 1988). The shovel tests (25 cm × 25 cm × 25 cm) were excavated at 25-m intervals with a shovel and/or trowel, and the excavated sediment was visually examined for artifacts but not sieved. Shovel testing was conducted at selected locales throughout most of the survey area; ground visibility was high (51-75%) only in the westernmost 20% of the area. The methods employed in the survey were approved by the Missouri SHPO (Weichman 1988). This survey relocated the four previously recorded sites and discovered two new sites (23SC708 and 23SC709) several hundred meters southwest of the quarry. These six sites are briefly described in Table 2.4.

Archeological sites and historic structures that meet the criteria established for eligibility to the *National Register of Historic Places* would require mitigative action if subjected to adverse effects resulting from remedial actions at the quarry. Data recovered from four of the archeological sites indicated that they were unlikely to meet eligibility criteria, due primarily to prior disturbance; however, sites 23SC21 and 23SC80 were determined to require further testing (Walters 1988). A follow-up field survey was conducted at the quarry area during the fall of 1989. This survey indicated that sites 23SC21 and 23SC80 are potentially eligible for inclusion in the *National Register*. In addition, two new sites were identified west of the quarry, sites 23SC81 and 23SC83, and these sites were also determined to be potentially eligible (Walters 1989). This new information will be used in planning support activities at the quarry area, in consultation with the Missouri SHPO, to ensure that no adverse impacts to significant cultural resources would result from implementing remedial actions.

2.7 RADIOLOGICAL CHARACTERIZATION

The radioactive materials disposed of in the quarry consist of wastes from the Weldon Spring chemical plant as well as wastes brought in from other areas, including (1) materials associated with the processing of uranium and thorium concentrates, (2) uranium- and radium-contaminated rubble, (3) high-thorium-content materials (most of which were subsequently removed from the quarry for the purpose of recovering rare earth elements), and (4) 3.0% thorium residues. Of the estimated 73,000 m^3 (95,000 yd^3) of bulk wastes in the quarry, a majority is radioactively contaminated. The radioactive contaminants of concern are those associated with the uranium-238 and thorium-232 decay series (Figures 2.6 and 2.7).

Radioactive contamination on the main floor of the quarry covers an area of almost 5,600 m^2 (60,000 ft^2) and extends to depths of about 12 m (40 ft); radioactive contamination in the entire quarry covers an area of about 15,900 m^2 (171,000 ft^2) and extends to an average depth of about 4 m (13 ft). The locations and depths of radioactive contamination at the quarry are shown in Figures 2.8 and 2.9.

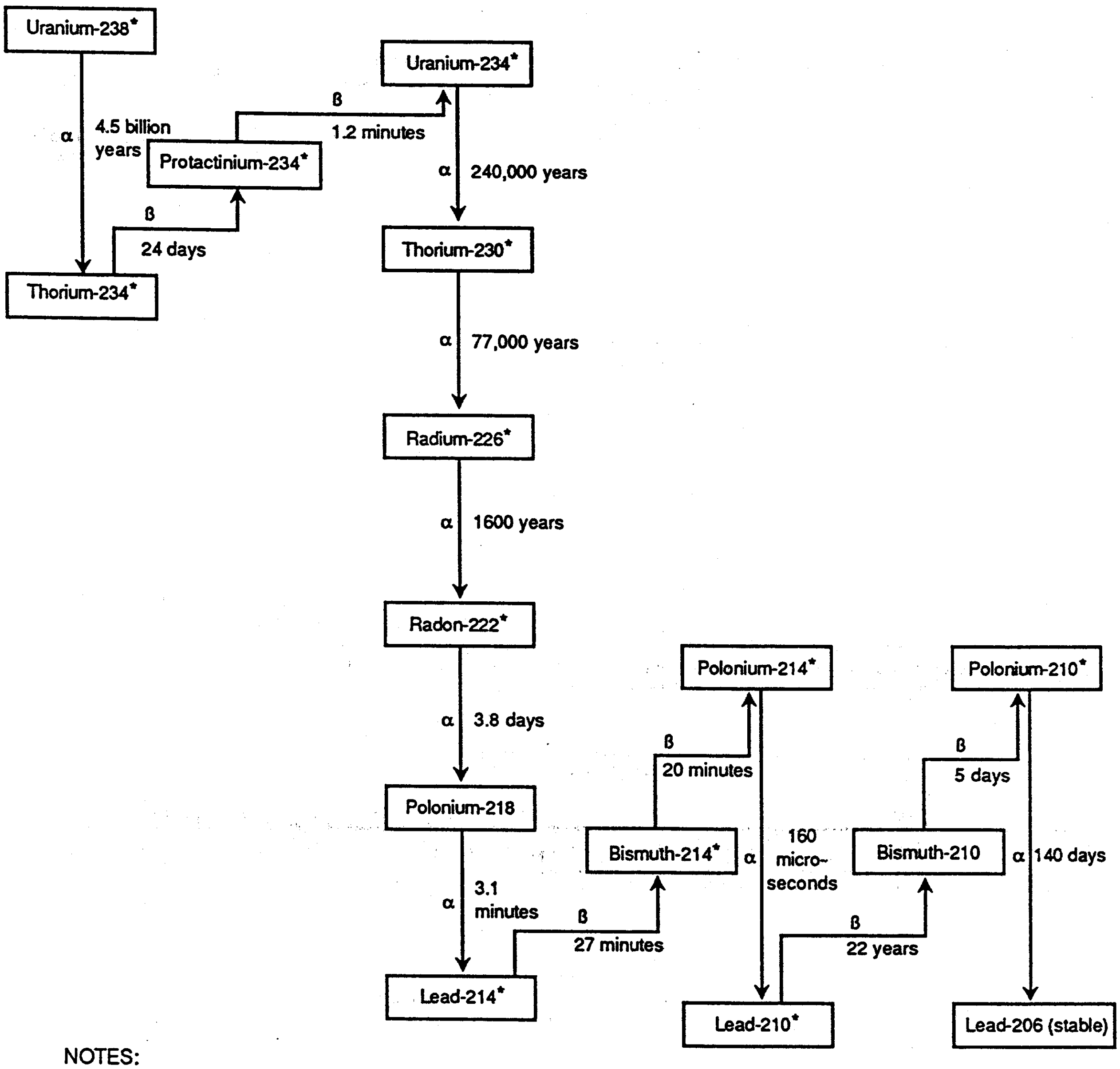
TABLE 2.4 Archeological Sites in the Vicinity of the Quarry

Site No.	Estimated Size (m × m)	Contents	Period	*National Register* Status
23SC21	100 × 50	3-4 burial mounds, artifacts (cores, flakes, tools) deposited in situ at depths of up to 25 cm	Middle Woodland	Conduct further testing
23SC80	475 × 100	Artifacts (cores, flakes, tools) deposited on the surface; some artifacts deposited in situ below modern plowzone	Woodland/ Mississippian	Conduct further testing
23SC90	150 × 75	Artifacts (cores, flakes, possibly tools) deposited on the surface	Archaic/ Woodland	Probably not eligible
23SC178	350 × 50	Artifacts (flakes) deposited below the surface in disturbed sediment (mixed with road construction debris)	Unknown	Probably not eligible
23SC708	100 × 25	Artifacts (flakes) deposited in uppermost 15 cm of surficial sediment (possibly disturbed by railroad construction)	Unknown	Probably not eligible
23SC709	75 × 50	Artifacts (flakes) deposited in uppermost 15 cm of surficial sediment (possibly disturbed by railroad construction)	Unknown	Probably not eligible

Source: Based on data in Walters (1988).

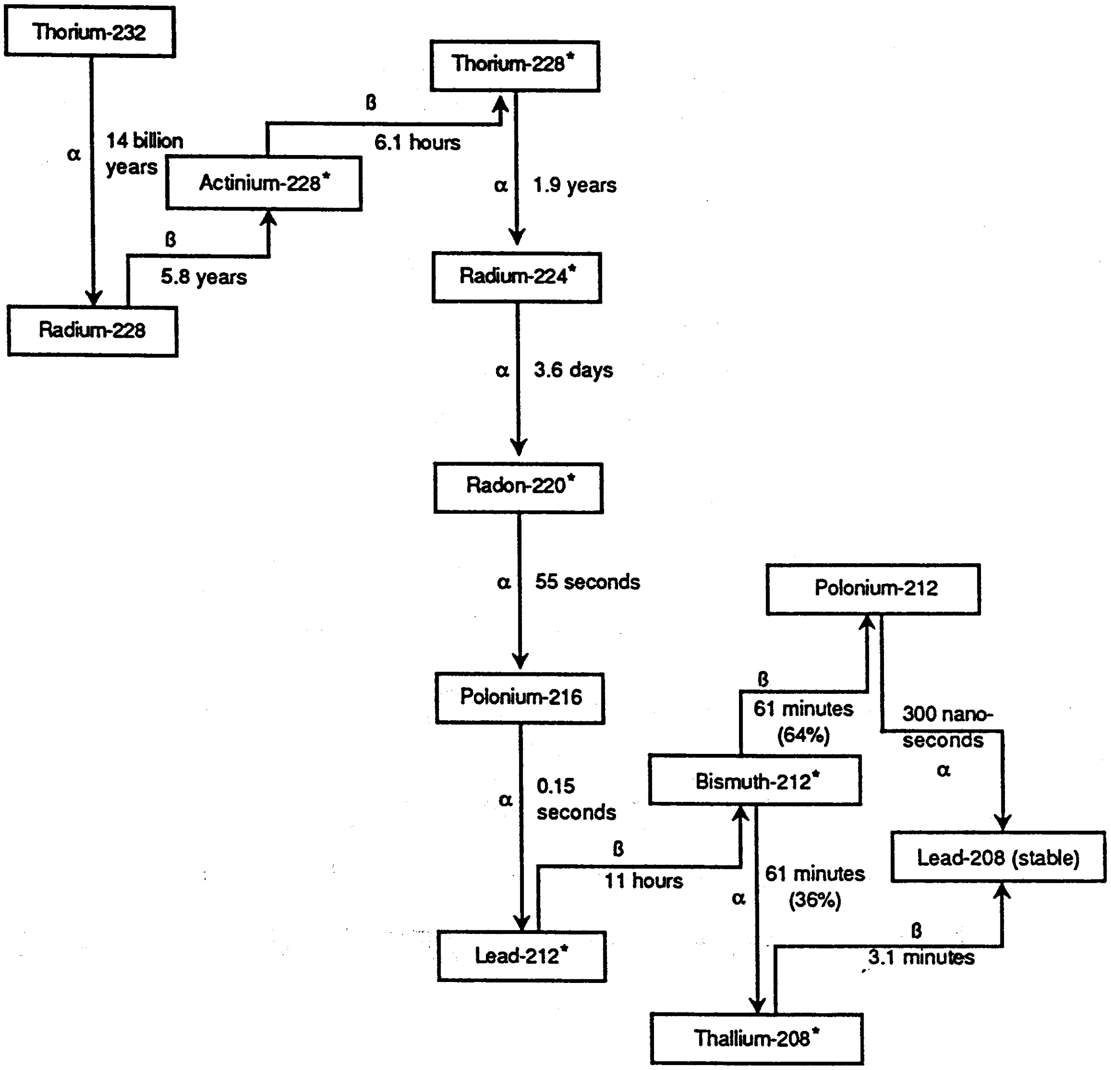
Two studies have evaluated the radiological characteristics of the quarry wastes. Berkeley Geosciences Associates (1984) performed a radiological survey intermittently from 1979 through 1981, and Bechtel National (1985) performed an additional survey during 1984 and 1985. The concentrations of radionuclides in the quarry wastes as determined from these studies are summarized in Table 2.5, and they provide the basis for the radiological evaluations presented in this document. The results of these studies are evaluated in detail in the RI report (MK-Ferguson Company and Jacobs Engineering Group 1989a).

In nature, the radionuclides in the uranium-238 and thorium-232 decay series are in a state of secular equilibrium in which the activities of all radionuclides in each series



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

FIGURE 2.6 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 2.7 Thorium-232 Radioactive Decay Series

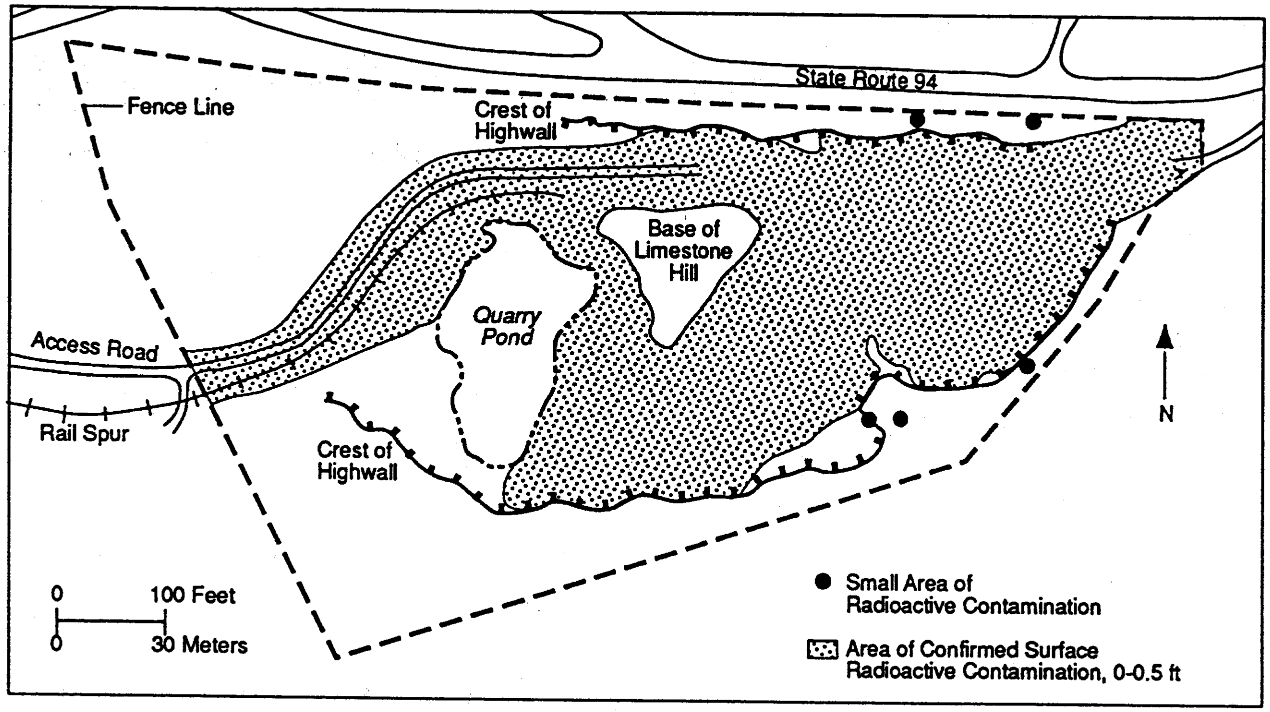


FIGURE 2.8 Surface Radioactive Contamination at the Quarry (Source: Data from MK-Ferguson Company and Jacobs Engineering Group 1989a)

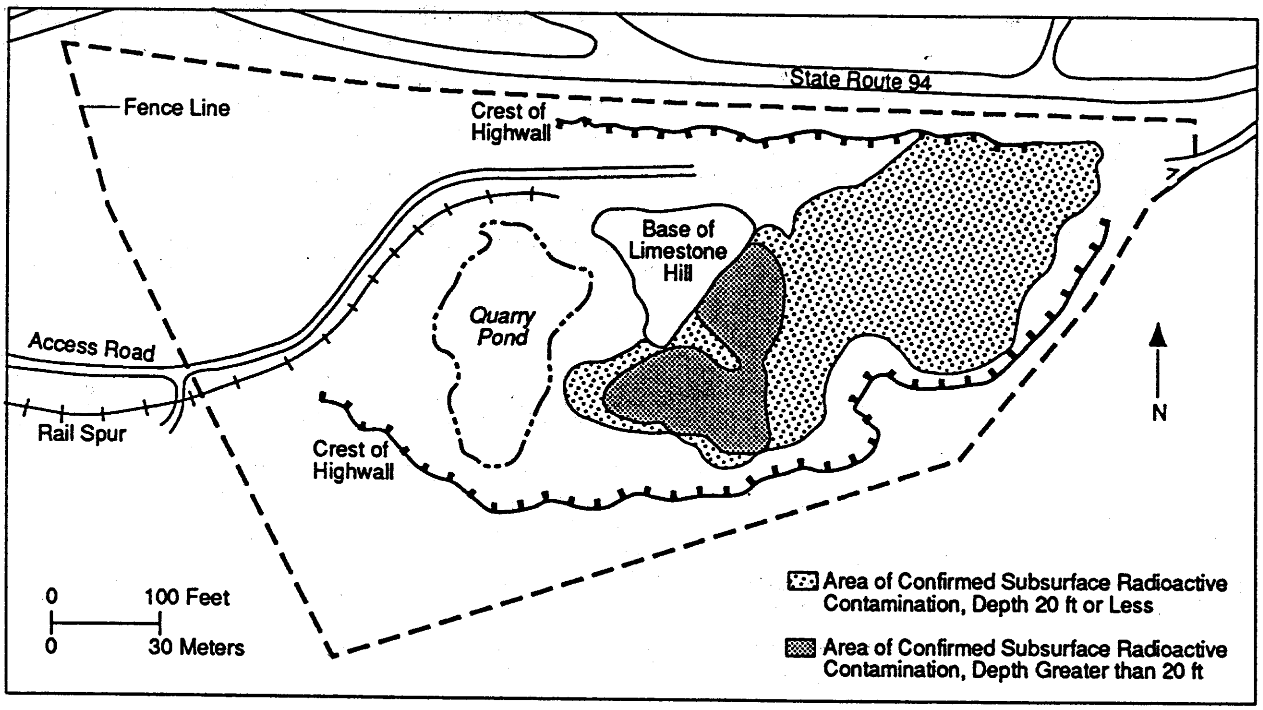


FIGURE 2.9 Subsurface Radioactive Contamination at the Quarry (Source: Data from MK-Ferguson Company and Jacobs Engineering Group 1989a)

TABLE 2.5 Concentrations of Radionuclides in the Quarry Bulk Wastes

Radionuclide	Average Surficial Concentration[a] (pCi/g)	Average Bulk Waste Concentration[b] (pCi/g)
Uranium-238	170	200
Thorium-232	–[c]	26
Thorium-230	150	330
Radium-228	20	96
Radium-226	110	110

[a]Samples obtained from the top 15 cm (6 in.) of the quarry bulk wastes.

[b]Average concentration for all bulk wastes in the quarry.

[c]No data available.

Source: Data from MK-Ferguson Company and Jacobs Engineering Group (1989a); all data rounded to two significant figures.

are equal. However, this natural state is altered during the processing of uranium and thorium ores. The rate at which equilibrium conditions are reestablished depends on the half-lives of the decay products. All radionuclides in the thorium-232 decay series from thorium-228 through lead-208 can be assumed to be in secular equilibrium because the radionuclides from radium-224 through lead-208 all have half-lives that are much shorter than the half-life of thorium-228. Because thorium-228 and radium-228 have similar half-lives, these radionuclides are in transient equilibrium in which the activity ratio is constant (but the activities are not necessarily the same) with time. The intermediate radionuclide actinium-228 is in secular equilibrium with radium-228. Thus, the radiological hazards of the thorium-232 decay series can be described by the activity concentrations of thorium-232 and radium-228.

Similarly, the radiological hazards of the various radionuclides in the uranium-238 decay series can be determined from the activity concentrations of uranium-238, thorium-230, and radium-226. Activities of the radionuclides from uranium-238 through uranium-234 can be assumed to be equal to that of uranium-238 because the activities of uranium-238 and uranium-234 are equal in nature and thorium-234 and protactinium-234 have short half-lives. Also, the activities of the radionuclides from radium-226 through lead-206 can be assumed to be equal to that of radium-226. The latter assumption is supported by measured subsurface concentrations of lead-210 reported by Bechtel National (1985); although these concentrations are higher than those of radium-226 in some samples, the concentrations of the two radionuclides are generally comparable.

In both the uranium-238 and thorium-232 decay series, one member of the series is a gas (radon-222 and radon-220, respectively). Characterization activities do not generally include surveying for these gases. Rather, the contaminated materials are typically analyzed for radium-226 and radium-228, and these values are used to estimate the concentrations of radon-222 and radon-220 in the atmosphere. However, radon gas concentrations have been measured within the quarry and at the quarry fence, and radon-222 and radon-220 decay product concentrations have been measured within the quarry; these measured values have been used in this document. Additional measurements are currently being taken.

As radionuclides decay, they emit various types of radiation; certain of these can traverse environmental media and penetrate human skin. Hence, close proximity to radioactive materials can pose hazards to individuals without actual uptake by the body (i.e., through ingestion or inhalation). The most energetic form of electromagnetic radiation emitted by radionuclides is the gamma ray. Gamma exposure rates have been measured regularly at the quarry fence as part of the annual environmental monitoring program (see Section 2.4); measured gamma levels within the quarry have been presented in the two previous radiological characterization studies (Berkeley Geosciences Associates 1984; Bechtel National 1985). The doses from gamma radiation exposure are included in the radiological risk assessment presented in this document.

The quarry bulk wastes could contain small amounts of fission products and/or enriched uranium. Records indicate that scrap metal was processed at the chemical plant, but the source of this metal is not known with certainty. The chemical plant was never used for nuclear fuel reprocessing and does not contain the facilities necessary for such an operation (e.g., shielded hot cells having equipment for remote operations). However, this scrap metal could have originated from DOE fuel-processing facilities and, if so, could have contained slightly enriched uranium as well as trace levels of fission products. In addition, much of the waste originated from sources other than the chemical plant.

Radiological investigations of the quarry bulk wastes indicate that, compared with uranium as it occurs in nature, some of the bulk wastes contain slightly elevated concentrations of uranium-235 and its decay products (e.g., thorium-227, actinium-227, and possibly protactinium-231). The concentration of uranium-235 in natural uranium is 0.72 percent by weight. Of the 42 samples radiochemically analyzed for uranium-238, uranium-234, and uranium-235 by Bechtel National (1985), 15 had concentrations of uranium-235 greater than 0.72 weight percent -- ranging up to 2.3 weight percent of the total uranium present in the samples. Ten of these 15 samples were from two closely spaced boreholes, indicating that the areas of slightly enriched uranium contamination are very localized. However, 21 of the 42 samples had uranium-235 concentrations below those in natural uranium. These data indicate that enriched uranium, if it is present in the bulk wastes, is present in only small amounts. Soil samples collected by Bechtel National during its quarry characterization activities were archived and are available for additional analyses. The samples that potentially contain enriched uranium will be reanalyzed for uranium-235 and cesium-137, a relatively long-lived fission product (with a 30-year half-life) that would still be present if placed in the quarry during disposal operations.

The radiological hazards of natural uranium are dominated by radionuclides in the uranium-238 decay series. The existence of slightly enriched uranium in a relatively small portion of the quarry wastes poses no significant additional hazard beyond that of natural uranium at the same concentration. Trace amounts of fission products in the bulk wastes, if present, would also pose no significant additional threat to workers or the public compared with that already associated with the uranium-238 and thorium-232 decay-series radionuclides and would not appreciably increase external gamma exposure rates. Hence, the evaluation of hazards associated with radioactive contamination in the quarry bulk wastes is limited to those hazards associated with the uranium-238 and thorium-232 decay series.

Three sediment samples from the quarry pond were collected by Bechtel National in 1985 for radiological analysis. The major contaminants were identified as uranium isotopes and thorium-230. The average concentrations were about 900 pCi/g for both uranium-234 and uranium-238, 110 pCi/g for uranium-235, and 320 pCi/g for thorium-230 (MK-Ferguson Company and Jacobs Engineering Group 1989a). Four samples from mud and organic sediments were analyzed for uranium-238 by Berkeley Geosciences Associates (1984). These samples had lower concentrations of uranium activity; the concentrations were about 25 and 63 pCi/g in mud sediments and about 130 and 200 pCi/g in organic sediments (MK-Ferguson Company and Jacobs Engineering Group 1989a). These contaminant levels are comparable to those estimated for the bulk wastes (see Table 2.5).

2.8 NONRADIOLOGICAL CHARACTERIZATION

Nonradioactive contaminants in the quarry bulk wastes are consistent with those expected from the quarry's disposal history (see Table 1.1). Both the type of waste material present and the contaminant concentrations in this material are highly variable. As part of the radiological characterization conducted in 1984 and 1985, one surface and six subsurface samples were collected at the quarry for nonradiological analysis (Bechtel National 1985). These samples were analyzed for priority pollutant metals and organic compounds, cyanide, and other selected compounds.* Some organic contaminants and elevated levels of some metals were detected. Results for contaminants that were measured above detection limits are summarized in Table 2.6.

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*A list of "priority pollutants" was established by EPA in response to a June 7, 1978, court settlement to implement portions of the Federal Water Pollution Control Act. The list consists of 129 priority pollutants and includes organic compounds, metals, pesticides and polychlorinated biphenyls, asbestos, and cyanide. A target compound list was subsequently developed by EPA for use in remediation of hazardous waste sites.

TABLE 2.6 Concentrations of Chemicals Detected in the Quarry Bulk Wastes in the 1984-1985 Characterization Study and Background Concentrations in Missouri Soils

Chemical[a]	Composite Borehole Sample Concentration (mg/kg)		Number of Boreholes in which Chemical Detected	Surface Sample Concentration (mg/kg)	Average Background Concentration[c] (mg/kg)
	Range[b]	Average[b]			
Priority Pollutant Metals and Cyanide					
Antimony	<20[d]		0	71	<200[d]
Arsenic	73-120	100	6	100	8.7
Beryllium	0.45-0.83	0.62	6	0.61	0.8
Cadmium	1.8-98	19	6	2.0	<1
Chromium	19-49	30	6	24	54
Copper	38-160	100	6	140	13
Lead	130-410	280	6	950	20
Mercury	0.18-6.3	2.0	6	0.7	0.039
Nickel	19-120	43	6	300	14
Selenium	17-28	23	6	22	0.28
Silver	5.8-8.3	7.0	3	7.5	<0.7
Thallium	3.0-6.2	4.7	6	5.1	<50[d]
Zinc	68-870	340	6	39	49
Cyanide	0.2-0.6	0.38	5	0.2	NA[e]
Organic Priority Pollutants[f]					
α-Benzene hexachloride	0.0051-0.0053	0.0052[g]	2	-	NA
δ-Benzene hexachloride	0.019-0.095	0.045[g]	3	0.0035	NA
γ-Benzene hexachloride (lindane)	0.0013	0.0013[g]	1	-	NA
PCBs (Aroclor 1254)	0.56-46	12	5	1.0	NA
PCBs (Aroclor 1260)	9.0	9.0	1	-	NA

TABLE 2.6 (Cont'd)

Chemical[a]	Composite Borehole Sample Concentration (mg/kg)		Number of Boreholes in which Chemical Detected	Surface Sample Concentration (mg/kg)	Average Background Concentration[c] (mg/kg)
	Range[b]	Average[b]			
Other Organic Pollutants					
2-Pentanone-4-hydroxy-4-methyl (diacetone alcohol)	2-6[h]	4.6[h]	5	14[h]	NA
2-Methylnaphthalene	0.67	0.67	1	<0.06[d]	NA

[a]All compounds that had one or more positive results above detection limits are listed; concentrations are rounded to two significant figures. Samples were taken from six boreholes in the bulk wastes and from a surface waste pile.

[b]Ranges and averages are for detected values only and do not necessarily indicate the average concentration for the entire waste material.

[c]Concentration in Missouri agricultural soils (Tidball 1984).

[d]Lower limit of detection.

[e]NA means data not available.

[f]The 29 volatile priority pollutants measured for were not detected at a sensitivity level of 20 μg/kg. Thirteen semivolatile organic compounds were detected in one borehole; these compounds are indicated in Table 2.7 (identified by footnote f). The presence of PCBs prevented the detection of most pesticides.

[g]Concentrations of α-, δ-, and γ-benzene hexachloride, were reported for only 2, 3, and 1 of the borehole samples, respectively.

[h]Estimated concentrations.

Sources: Data from Bechtel National (1985), except as noted.

A more extensive chemical characterization study was conducted at the quarry in 1986, with samples taken from 17 boreholes (Kaye and Davis 1987). Selection of the borehole locations was based on historical data for waste disposal at the quarry. Nitroaromatic compounds, polychlorinated biphenyls (PCBs), and polynuclear aromatic hydrocarbons (PAHs) were detected in the borehole samples. (Although various volatile organic compounds were detected as well, these compounds were also generally present in method and field blanks, suggesting inadvertent contamination of the samples.) The results of this study are summarized in Table 2.7. Because of the heterogeneous nature of the wastes and the limited number of samples taken, the results are expected to be indicative of, rather than representative of, the wastes present in the quarry.

During the 1986 study, five sediment samples were also taken from the quarry pond (Kaye and Davis 1987). Trinitrotoluene and PCBs were detected in the sediment, along with a number of semivolatile compounds that are consistent with those found in samples taken from the bulk waste boreholes.

Three surface samples were collected in May 1987 from an area in the northeastern corner of the quarry where surficial discoloration suggested the presence of nitroaromatic compounds (Meyer 1988). Various nitroaromatic compounds were detected in the samples. The compound 2,4,6-TNT was detected at an average concentration of 13,000 mg/kg. The results of the analyses for nitroaromatic compounds are summarized in Table 2.8.

These characterization results indicate that chemical contamination is present throughout much of the quarry bulk wastes and that distribution of the contaminants is highly heterogeneous. However, general locations of various waste types can be defined in some cases. For example, combustion products are generally found near the pond whereas nitroaromatic compounds are in the eastern end of the quarry, which is consistent with the disposal history. The PCBs do not show a defined pattern of distribution but are typically limited to near-surface depths (0 to 1.8 m [0 to 6 ft]). Most chemical contaminants are found at depths of less than 3.6 m (12 ft) (Kaye and Davis 1987).

TABLE 2.7 Concentrations of Chemicals Detected in the Quarry Bulk Wastes in the 1986 Characterization Study

Chemical[a]	Concentration (mg/kg) Range[b]	Concentration (mg/kg) Average[b]	Number of Boreholes in which Chemical Detected[c]
Volatile Compounds[d,e]			
Acetone	1.4-52	13	6
2-Butanone	0.86-1.7	1.4	2
Ethylbenzene	0.68-1.8	0.99	8
Methylene chloride	0.79-6.4	2.9	8
Toluene	0.75	0.75	1
Total xylenes	0.66-1.4	0.95	2
Trichloroethene	0.9	0.9	1
Semivolatile Compounds[e]			
Acenaphthene	1.7-18	7.6	4
Dibenzofuran[f]	1.4-3.6	2.5	2
Fluorene[f]	6.6-19	13	2
Phenanthrene[f]	0.73-150	26	6
Anthracene[f]	0.34-37	9.7	6
Fluoranthene[f]	0.78-190	24	6
Pyrene[f]	0.68-170	23	6
Benz(a)anthracene[f]	0.53-86	15	6
Chrysene[f]	0.46-89	13	6
Benzo(b)fluoranthene[f]	0.62-110	17	6
Benzo(k)fluoranthene[f]	0.78-0.98	0.88	2
Benzo(a)pyrene[f]	0.46-68	11	6
Indeno(1,2,3-cd)pyrene	0.45-49	9.3	6
Dibenz(a,h)anthracene	0.33-17	2.9	4
Benzo(g,h,i)perylene	0.41-50	10	6
2,4-DNT[g]	1.7-10	6.3	1
2,6-DNT[g]	0.53-3.7	1.6	1
Di-n-butylphthalate[f]	0.47-0.58	0.53	2
Bis(2-ethylhexyl)phthalate	0.66-1.6	1.0	3
Naphthalene[f]	1.3	1.3	1
PCBs[e]			
Aroclor 1254[f]	0.46-120	21	9
Aroclor 1260[f]	9.1-12	11	1

TABLE 2.7 (Cont'd)

Chemical[a]	Concentration (mg/kg) Range[b]	Average[b]	Number of Boreholes in which Chemical Detected[c]
Nitroaromatic Compounds[h]			
2,6-Diamino-4-nitrotoluene	0.33-0.58	0.47	3
2,4,6-TNT	0.38-1600	260	6
2,4-DNT[i]	0.46-33	8.1	3
2,6-DNT[i]	0.36-68	9.5	3
2,4-Diamino-6-nitrotoluene	1.3-7.3	4.8	2

[a]All compounds that had one or more positive results above detection limits are listed; concentrations are rounded to two significant figures. Samples were taken in the last quarter of 1986 from 17 boreholes in the bulk wastes.

[b]Ranges and averages are for detected values only and do not necessarily indicate the average concentration for the entire waste material.

[c]Detection of a chemical indicates that the species was detected in at least one incremental sample from a borehole. Each incremental sample was not necessarily tested for all chemical species.

[d]Except for trichloroethene, all of the volatile compounds detected in the samples were also detected in method and field blanks.

[e]Analyses for volatile organics, semivolatile organics, and PCBs were performed in accordance with the EPA Contract Laboratory Program.

[f]This compound was also detected in the 1984-1985 study by Bechtel National (1985).

[g]This compound is also listed in this table under nitroaromatic compounds (see footnote i).

[h]Analyses for nitroaromatic compounds were performed according to Method 4B of the U.S. Army Toxic and Hazardous Materials Agency using high-pressure liquid chromatography.

[i]This compound is also listed in this table under semivolatile compounds. Split samples were analyzed in accordance with the EPA Contract Laboratory Program and Method 4B of the U.S. Army Toxic and Hazardous Materials Agency. Information is not provided in the Kaye and Davis (1987) report to explain the discrepancy in results or in the number of boreholes in which these compounds were detected based on the two methods.

Source: Data from Kaye and Davis (1987).

TABLE 2.8 Concentrations of Nitroaromatic Compounds in Surface Soils at the Quarry[a]

Nitroaromatic Compound	Concentration (mg/kg)	
	Range	Average
2,4,6-TNT	4,900-20,000	13,000
2,4-DNT	6.6-29	18
2,6-DNT	<1.2-8.6	5.0
Nitrobenzene	8.4-130	78
1,3,5-Trinitrobenzene	18-280	140
1,3-Dinitrobenzene	<0.8[b]	-

[a]Three surface samples were taken from the exposed slope in the northeastern corner of the quarry.

[b]Lower limit of detection.

Source: Data from Meyer (1988); concentrations rounded to two significant figures.

3 SUMMARY OF THE BASELINE RISK EVALUATION

As part of the environmental compliance process at the Weldon Spring site, a baseline risk evaluation (BRE) was prepared to assess the potential risks associated with the contamination present at the quarry. Risk assessment is a key component of the RI process and is typically conducted for the baseline (no-action) case to (1) determine potential impacts to human health and the environment, (2) support the determination of appropriate cleanup criteria, and (3) provide a basis for evaluating the effectiveness of proposed remedial action alternatives. However, because management of the bulk wastes is a focused interim action of the overall remedial action for the quarry, the scope and purpose of this assessment was less comprehensive than that generally identified in guidance from the EPA. For this reason, the assessment was referred to as a baseline risk "evaluation," to distinguish it from the more comprehensive baseline risk "assessment." Limited availability of site characterization data regarding the nature and extent of contamination and the pathways and mechanisms for contaminant migration from the quarry precluded preparation of a comprehensive baseline risk assessment. Hence, the analyses in the risk evaluation were carried out to meet, within the limits of available data, the first of the three objectives of a risk assessment, i.e., to assess the potential impacts to human health and the environment. The scope of the risk evaluation was limited to an assessment of the potential risks associated with the bulk wastes and addressed exposures that could occur in the short term under existing site conditions.

The BRE was published as a separate report (Haroun et al. 1990). Although limited in scope, the evaluation was conducted -- to the extent possible -- using guidance given in the *Superfund Public Health Evaluation Manual* (EPA 1986) and the *Superfund Exposure Assessment Manual* (EPA 1988a). A summary of the analyses is presented in Sections 3.1, 3.2, and 3.3 of this document. Potential health effects to the general public and to workers resulting from exposures to site releases during implementation of the preferred remedial action alternative at the quarry are assessed in Chapter 11.

3.1 CONTAMINANTS OF CONCERN

The BRE identified those radionuclides and chemicals present in the quarry bulk wastes that pose the greatest potential risk to human health. The radioactive contaminants of concern (i.e., indicator radionuclides) at the quarry are those associated with the uranium-238 and thorium-232 decay series (see Table 2.5 and Figures 2.6 and 2.7). The radiological hazards of the various radionuclides in these series were determined from the activity concentrations of uranium-238, thorium-232, thorium-230, radium-228, and radium-226 and from measured values of radon-222, radon-220, and their short-lived decay products. The risks associated with gamma radiation were also assessed.

The indicator chemicals were selected from contaminants detected in the quarry bulk wastes (see Tables 2.5, 2.6, 2.7, and 2.8). They were selected mainly on the basis of their toxicological properties and their concentrations in surface soils at the quarry. (Under current site conditions, the only complete exposure pathways at the quarry result from surface soil contamination.) With the exception of volatile organic compounds, the chemical contaminants selected represent the major chemical classes present at the quarry. Volatile organic compounds were not selected as indicator chemicals because the presence of six of the seven compounds detected in method and field blanks suggests that all but trichloroethene were laboratory contaminants. Trichloroethene was not selected because it was detected in only one subsurface sample. The indicator contaminants for the BRE were nitroaromatic compounds (2,4,6-TNT, 2,4-DNT, 2,6-DNT, and 1,3,5-trinitrobenzene), metals (arsenic, lead, nickel, selenium, and uranium), PCBs, and PAHs. Of these compounds, TNT, DNT, arsenic, lead, nickel, PCBs, and PAHs are considered to be potential carcinogens.

3.2 EXPOSURE ASSESSMENT

The key factors considered in developing the exposure pathways at the quarry included (1) the quarry is fenced, closed to the public, and surrounded by wildlife areas; (2) the nearest residence is 0.8 km (0.5 mi) west of the quarry on State Route 94; and (3) no remedial action activities are currently taking place at the quarry. The exposure assessment in the BRE was based on current land-use conditions and contaminant concentrations.

The main source of contamination within the quarry is the bulk wastes, and the exposure pathways considered in the risk evaluation are those directly associated with these wastes. Groundwater at the quarry has been shown to contain elevated concentrations of chemical and radioactive contaminants, but it is not used as a drinking water source. The groundwater south of the quarry and at the nearby St. Charles County well field is monitored routinely, and mitigative measures would be taken if elevated concentrations were detected in the well field. Thus, because there are no known or indicated points of current exposure, the groundwater pathway is incomplete and was not considered in the BRE.

Based on an evaluation of waste characteristics and potential release mechanisms, the BRE identified the principal contaminants at the Weldon Spring quarry to which individuals could be exposed and the potential routes of human exposure to these contaminants as:

- Inhalation of radon-222, radon-220, and their short-lived decay products;
- Exposure to external gamma radiation;
- Inhalation of radioactively and chemically contaminated airborne dusts;
- Dermal contact with chemically contaminated surface soils; and
- Ingestion of radioactively and chemically contaminated surface soils.

No private residences or other structures are currently located within the area that was determined to be potentially impacted by releases, i.e., within 0.5 km (0.3 mi) of the quarry. This area was defined on the basis of the major contaminant and dispersion considerations for the quarry. The major airborne contaminant for current conditions at the quarry is radon gas. The distance from the edge of the quarry, at which radon concentrations resulting from bulk waste emissions would be about 10% of ambient levels, was estimated based on dispersion modeling. This distance was estimated to be 0.5 km (0.3 mi) using the MILDOS Gaussian plume dispersion model (Strenge and Bander 1981), which was modified to more accurately assess airborne concentrations resulting from releases from large areas (Yuan et al. 1989).

Scenarios of human activities that could result in exposures by these pathways were developed for individuals temporarily occupying the impacted area. "Passerby" and "trespasser" scenarios were evaluated that were considered to be realistic, but conservative, descriptions of possible human activities resulting in exposures to quarry contaminants. Under both scenarios, two "cases" were developed to estimate "representative" exposure and "plausible maximum" exposure. The passerby scenario considered potential exposures to an individual who routinely walks by the northern boundary of the quarry along State Route 94. For the representative exposure case, it was assumed that the individual walks by the quarry twice per day, 250 days per year over a period of 5 years; for the plausible maximum exposure case, the exposure period was increased to 365 days per year over a period of 10 years. The exposure pathways evaluated for this scenario were inhalation of radon-222 and radon-220 and their short-lived decay products, exposure to external gamma radiation, and inhalation of dusts contaminated with nitroaromatic compounds and uranium. (Nitroaromatic compounds and uranium are the only contaminants found in exposed areas in the quarry that are subject to fugitive dust emissions.)

The trespasser scenario considered exposures to an individual (presumably a youth) who enters the quarry several times per year. For the representative exposure case, it was assumed that the individual (11 to 15 years old) enters the quarry, remains there for a period of 2 hours, and repeats this activity 12 times per year over a period of 5 years. For the plausible maximum exposure case, it was assumed that the individual (9 to 18 years old) enters the quarry once per week for a period of 4 hours, 50 weeks per year over a period of 10 years. The exposure pathways evaluated for the trespasser scenario included the same pathways considered for the passerby as well as direct contact with contaminated soils, which could result in dermal absorption of the organic indicator chemicals and incidental ingestion of all compounds.

The conditions of the passerby scenario were selected to represent (1) the exposure occurring at the location of highest off-site radon and airborne particulate concentrations (i.e., along State Route 94) and (2) a frequency and duration of exposure (i.e., daily, for a total duration of 24 minutes) that, over the long term, would not be exceeded by an individual routinely entering any area impacted by contaminant releases from the quarry. Thus, although other potential receptors were identified (e.g., individuals driving by the quarry on State Route 94 or a hiker on Katy Trail), they were not explicitly evaluated because their exposures would be similar to or less than the exposures estimated for the passerby. Although access to the quarry is restricted by a chain-link fence, the area is not guarded, and hence it is reasonable to assume that a trespasser could enter the contaminated area. The trespasser scenario is considered to be a conservative estimate of potential exposures to any individual coming into direct contact with the contamination in the quarry.

3.3 SUMMARY OF HEALTH RISKS AND ENVIRONMENTAL IMPACTS

The BRE assessed the radiological and chemical health risks resulting from potential exposures to the quarry contaminants under current site conditions. Health effects resulting from radiation exposure were evaluated in terms of the increased likelihood of inducing fatal cancers and serious genetic effects in future generations. The potential for the occurrence of adverse health effects (other than cancer) from exposure to chemical contaminants was assessed by dividing the average daily exposure estimates (intakes) by established reference doses* to determine the "hazard index." A hazard index of less than one is considered to indicate a nonhazardous situation or, conversely, a hazard index of greater than one is considered to indicate a potential for adverse health effects. (Derivation of the hazard index is described in detail in Section 11.3.2.)

The estimated carcinogenic risks and hazard indexes for the passerby and trespasser scenarios are summarized in Table 3.1. The carcinogenic risks from radiation exposures range from 4.2×10^{-6} for the passerby representative exposure case to 8.7×10^{-5} for the trespasser plausible maximum exposure case, and the carcinogenic risks from chemical exposures range from 1.0×10^{-9} to 3.6×10^{-5}, respectively. The risk from radiation exposure exceeds that from chemical exposure for both scenarios. The major exposure pathway for the radiological risk in all cases is inhalation of radon-222 and its short-lived decay products. The major contributor to the chemical carcinogenic risk for the trespasser is 2,4,6-TNT, which accounts for approximately 40% of the risk; arsenic, PCBs, and PAHs account for the remaining 60%.

The very low hazard indexes estimated for the passerby scenario (less than 2×10^{-3}) indicate that there is little potential for noncarcinogenic health impacts to individuals outside the quarry. However, for the trespasser, the hazard index is 2.0 for the representative exposure case and 8.5 for the plausible maximum exposure case. (A hazard index greater than one indicates a potential for adverse health effects.) For both cases, the major contributor to the noncarcinogenic hazard is exposure to 2,4,6-TNT. This is not unexpected given the presence of this contaminant at concentrations greater than 1% in surface soils at the quarry. The estimated hazard indexes for 2,4,6-TNT are 1.7 and 7.2 for the representative and plausible maximum trespasser exposure cases, respectively. These results indicate the potential for the occurrence of adverse health effects to an unprotected individual frequently entering the quarry; however, under current site conditions in which access to the quarry is restricted, it is unlikely that an individual would routinely enter the quarry.

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*A reference dose is the average daily dose that can be incurred by individuals without likely adverse effects.

TABLE 3.1 Carcinogenic Risks and Health Hazard Indexes for the Passerby and Trespasser Scenarios

Exposure Scenario/Case	Carcinogenic Risks: Radiological[a]	Carcinogenic Risks: Chemical[b]	Health Hazard Index for Noncarcinogenic Effects[c]
Passerby			
Representative	4.2×10^{-6}	1.0×10^{-9}	1.0×10^{-3}
Plausible maximum	1.2×10^{-5}	3.0×10^{-9}	1.6×10^{-3}
Trespasser			
Representative	6.0×10^{-6}	4.3×10^{-6}	2.0
Plausible maximum	8.7×10^{-5}	3.6×10^{-5}	8.5

[a]Risk of a fatal cancer; the rate of cancer induction will be higher.

[b]Rate of cancer induction. The EPA has recommended a range of 1×10^{-4} to 1×10^{-7} for exposure to carcinogenic chemicals.

[c]The health hazard index is a measure of the potential for adverse chronic health effects other than cancer. A value greater than one is considered to indicate a potential for adverse health effects.

Source: Haroun et al. (1990).

The potential risks to the environment considered in this BRE were impacts on water resources, soil resources, air quality, vegetation, and wildlife. This assessment was prepared prior to issuance of recent EPA guidance on performance of environmental risk assessments at NPL sites (EPA 1989e). Consistent with the scope of the human health evaluation, the environmental assessment was narrowly defined because comprehensive environmental data are not available. Additional information on the environmental setting and ecological resources at the quarry are given in Chapter 2 of this document.

No adverse impacts have been observed for soil resources, air quality, or vegetation and wildlife as a result of the bulk wastes in the quarry. The major impact that could result from gaseous releases, i.e., radon, is addressed in the human health assessment portion of the BRE. Water resources have been impacted by the presence of the bulk wastes in the quarry. Ponded water within the quarry has already been contaminated as a result of contact with the bulk wastes, but incremental contamination from continued contact, e.g., future surface runoff, is not expected to significantly alter the existing water quality. Similarly, Femme Osage Slough south of the quarry already contains radioactive and chemical contaminants. This contamination may have resulted from subsurface migration from areas north of the slough and/or from past discharges into Little Femme Osage Creek (see Sections 2.2.1 and 2.2.2). Groundwater in the vicinity of the quarry has been contaminated as a result of contaminant migration from the bulk wastes (MK-Ferguson Company and Jacobs Engineering Group 1989a). If the bulk wastes remain in the quarry, contaminants could migrate farther into the surrounding environment via the fractured limestone of the Kimmswick Limestone Formation, and contaminant concentrations might increase in the vicinity of Femme Osage Slough.

4 IDENTIFICATION OF REMEDIAL TECHNOLOGIES

The proposed management of quarry bulk wastes is being conducted as a separate operable unit (SOU) of the Weldon Spring Site Remedial Action Project. This action has been separated from the overall remedial action for the site to facilitate cleanup and expedite a response to the potential threat to human health and the environment that is associated with the presence of bulk wastes in the quarry. The decision-making process for the bulk waste SOU is summarized in Section 1.1 of this focused FS report. The following steps were carried out: (1) potential response technologies were identified and screened for applicability to the bulk wastes, (2) preliminary alternatives were assembled from the screened technologies, (3) the preliminary alternatives were screened to identify final alternatives, and (4) the final alternatives were evaluated in detail to identify the most appropriate response for managing the bulk wastes. The initial step of the FS process is presented in Sections 4.1 through 4.3 of this report; the three remaining steps are presented in Chapters 5, 6, and 7.

4.1 REMEDIAL ACTION GOALS

The overall goal of comprehensive remedial action at the Weldon Spring site is to stabilize contaminated materials to protect human health and the environment and bring the site into compliance with regulatory requirements. The primary objectives of the proposed management of bulk wastes in the quarry are to (1) support the overall site goal by removing the source of contaminant migration from the quarry and controlling the wastes to limit human exposure and (2) conduct the action in a manner that is consistent with future site cleanup activities.

4.2 GENERAL REMEDIAL ACTION TECHNOLOGIES

The following discussion summarizes the procedures and rationale for developing alternative remedial actions by identifying technologies that are applicable to the quarry bulk wastes. The number of suitable and practicable treatment technologies that can be applied to managing the bulk wastes is limited, due to the focused nature of this action. The technologies considered in selecting remedial action alternatives included those identified in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Additional technologies addressed in the following discussion are based on experience and information gained as a result of remedial action planning and implementation at similar sites.

Section 121 of SARA identifies a strong statutory preference for remedies that are reliable and provide long-term protection. The primary requirements for a final remedy are that it be both protective of human health and the environment and cost-effective. Additional selection criteria include the following:

- Preferred remedies are those in which the principal element is treatment to permanently or significantly reduce the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants;

- Where practical treatment technologies are available, off-site transport and disposal without treatment is the least preferred alternative; and

- Permanent solutions and alternative treatment technologies or resource recovery technologies should be assessed and used to the maximum extent practicable.

These criteria for final remedies have been considered, as appropriate, for the interim action that is being proposed. The decisions regarding remediation of the chemical plant area and follow-on quarry remediation will fully consider these selection criteria (see Section 7.1). Protection of human health and the environment at the quarry was the primary consideration for determining how the bulk wastes should be managed. Available treatment technologies potentially applicable to the chemically and radioactively contaminated materials present in the quarry were considered in developing alternatives for managing the bulk wastes (see Chapter 5).

A broad overview of response technologies that could be implemented to protect human health and the environment, based on the current understanding of contaminants in the quarry bulk wastes and on the potential for population exposure, is presented in Sections 4.2.1 and 4.2.2. The following discussion is divided into two general categories as prescribed in the NCP: source-control response actions and migration-control response actions.

4.2.1 Source Control

The objective of source-control response actions is to protect human health and the environment by altering the nature of a waste source (i.e., the radioactively or chemically hazardous constituents) to reduce contaminant toxicity, mobility, and/or volume. Source-control response actions that are potentially applicable to management of the quarry bulk wastes include institutional controls, removal, treatment, temporary storage, and disposal.

Institutional Controls. Institutional controls involve (1) monitoring, (2) access restrictions such as physical barriers (e.g., fences), and (3) use or deed restrictions. These controls may reduce the potential for exposure to contaminated materials, but they do not reduce contaminant toxicity, mobility, or volume. Institutional controls currently in place at the quarry include an extensive monitoring program, which assesses contaminant migration, and fences and DOE ownership, which limit entry and use. The improvement of existing barriers and continued control of property use would be relatively easy to implement. However, such controls generally serve as a reliable means of protecting human health and the environment only when used as support for primary actions. Therefore, institutional controls are considered applicable only as a support component for managing the quarry bulk wastes.

Removal. Removal of the quarry bulk wastes would involve their excavation from the quarry using standard equipment and practices. Excavation is a reliable technology and would be an effective means of reducing contaminant toxicity, mobility, and volume at the quarry. After removal from the quarry, the materials could be treated, stored, and/or disposed of, as appropriate. These activities would require planning and operational controls. Removal technologies are considered potentially applicable to management of the quarry bulk wastes.

Treatment. Treatment encompasses a wide range of chemical, physical, and/or biological technologies that address various types of contamination in various media. Only a limited number of technologies are effective when radioactive contamination is present. Treatment technologies for radioactive wastes can be divided into two general categories:

- Those that remove radioactive constituents from the waste matrix, and

- Those that change the form of the waste, thereby reducing contaminant toxicity, mobility, and/or volume.

The first category of treatment technologies generally consists of chemical processes (although there are exceptions, such as physical separation techniques), whereas the second category generally consists of physical processes. Biological processes are typically used to treat organic wastes rather than radioactive wastes.

Chemical treatment technologies are typically used to alter the nature of hazardous chemical constituents and can reduce the toxicity, mobility, and/or volume of contaminated liquids, sludges, or solids. When radioactive contaminants are also present, a chemical extraction or leaching process can be used to remove the radioactive components from a waste matrix to reduce contaminant volume and/or mobility. The liquid leachate can then be reprocessed to isolate the radioactive components. The quarry bulk wastes consist of sludges and mixed solid materials. A sludge or solid waste can be chemically treated either in situ (e.g., with a lixiviant wash) or following excavation (e.g., in an engineered system).

Stabilization/fixation could involve the addition of cementitious materials to contaminated soils and sludges in situ to produce a solid monolith. (Although physical processes also play a role, stabilization is discussed under chemical treatment because it results from the addition of chemicals.) This technique would reduce contaminant mobility and could reduce toxicity, but the final waste volume would increase. Stabilization/fixation can also be implemented following removal by placing contaminated materials in an engineered system.

Physical treatment technologies are used to alter the structure of waste constituents to facilitate stabilization and handling. Physical treatment can reduce the toxicity, mobility, and/or volume of contaminated sludges or solids and can be implemented in situ or following excavation. Contaminated sludges can be physically treated by dewatering technologies such as pumping and gravity drainage trenches in situ or by other methods such as centrifugation, pressure or vacuum filtration, horizontal belt filtration, screening, drying beds, or gravity thickening following excavation. Two classes of physical treatment technologies that could be considered for dewatered sludges and soils are thermal treatment (e.g., vitrification or incineration) and solids separation.

In the vitrification process, contaminated material is solidified by passing an electrical current through the material to create temperatures high enough to melt it. The molten volume cools after power to the system is turned off, and a block of glass-like material resembling natural obsidian is produced. This innovative technology can be implemented in situ to reduce the toxicity, mobility, and volume of a solid waste but has not yet been used on a large-scale basis. Thermal treatment technologies can also be implemented following removal and placement in an engineered system (e.g., an incinerator).

Several solids separation techniques have been identified for reducing the volume of contaminated materials following excavation. These techniques, which separate the radioactive constituents from a waste matrix (e.g., soil containing relatively high concentrations of radionuclides), have been used in the mining industry but are developmental for waste treatment applications. The techniques include sand sifting, paramagnetic separation, soil sorting, and selective mineral separation.

Biological treatment technologies can be used to alter the nature of a waste and to remove contaminants (typically organics) from a waste matrix; they can be implemented in situ or following the removal of contaminated sludges and soils. Biological processes are routinely employed in conventional wastewater treatment systems and can reduce contaminant toxicity, mobility, and/or volume. Such processes include activated sludge treatment, trickling filters, and surface impoundments such as aerated lagoons.

Based on the general characteristics of the sludges and solids that comprise the quarry bulk wastes, certain treatment technologies are not considered applicable to their management, including biological treatment, solids separation following excavation, thermal treatment following excavation, chemical stabilization/fixation following excavation, and chemical leaching in situ. Biological treatment would be generally ineffective in treating the inorganic contaminants (e.g., radionuclides and heavy metals) that constitute a major portion of the quarry contamination. Solids separation following excavation would be generally ineffective in treating the widely variable solids (e.g., equipment, drums, and large pieces of structural debris) that constitute a considerable portion of the bulk wastes. At this interim stage of the project, thermal treatment following excavation could bias the decision for overall site remediation and decrease the efficiency of its implementation. An informed decision on the permanent treatment of exhumed materials can be made only as part of the comprehensive waste management decision for the Weldon Spring site; this decision will be documented in the ROD following completion of the RI/FS-EIS process. Furthermore, no on-site or off-site facility would be available within the appropriate time period (i.e., to coincide with the proposed initiation of bulk waste management in an environmentally responsive manner). Chemical stabilization/fixation following excavation is not considered applicable for the same reasons identified for thermal treatment following excavation. Chemical leaching in situ is not considered applicable primarily because this process would be ineffective in treating the widely variable wastes but also because the affected area and fractured subsurface at the quarry would hinder the control of contaminated leachate that could migrate from the quarry.

Treatment technologies that are considered potentially applicable to managing the quarry bulk wastes include vitrification and stabilization/fixation in situ. Additional technologies that could be used as support processes to improve the manageability of the wastes are also considered potentially applicable. For example, dewatering could be used following excavation to facilitate transportation of the wastes to, and control at, a temporary storage facility. Dewatering could also be considered as a support process in situ, e.g., to facilitate waste excavation.

Temporary Storage. Temporary storage consists of isolating contaminated materials in a manner that protects human health and the environment in the short term until the ultimate disposition of the materials can be determined. Temporary storage can involve the placement of contaminated materials on an engineered pad and covering them with a synthetic-membrane liner, clay cap, or other protective layer. Temporary storage can also be achieved by placing the contaminated materials in an existing engineered structure or in a structure newly constructed for containment purposes. This technology would not reduce contaminant toxicity or volume but would reduce contaminant mobility and the associated potential for population exposure. An off-site facility is neither currently available nor expected to become available within an appropriate time frame. Thus, only on-site temporary storage can be considered potentially applicable to management of the quarry bulk wastes.

Disposal. Disposal involves the permanent placement of contaminated materials in a manner that protects human health and the environment for the long term. This technology can effectively reduce contaminant mobility and the associated potential for population exposure. Disposal options for the bulk wastes include (1) on-site disposal, i.e., either within the quarry or at the chemical plant area; (2) off-site disposal in a land-based facility; or (3) disposal in the ocean. Use of the quarry for permanent disposal would bias the decision for overall site remediation and would not reliably ensure long-term protection. Neither an on-site facility nor an off-site facility is currently available for disposal of the bulk wastes, and no such facility is expected to become available within the near future. Ocean disposal is not currently available as an option and is not expected to become available because of regulatory restrictions, transportation considerations, costs, and public concern. In addition, disposal decisions are beyond the scope of this focused action because of the potential for adversely impacting site cleanup decisions. Therefore, although the ultimate management of the quarry bulk wastes will involve disposal, this option is not available during the short term.

4.2.2 Migration Control

Migration-control response actions are designed to limit the release of contaminants from a waste site, thereby minimizing the potential for population exposure. An additional objective of migration-control measures is to limit human activity that could result in the migration of contaminated materials. Migration-control response actions that are potentially applicable to management of the quarry bulk wastes include institutional controls and containment/treatment.

Institutional Controls. Institutional controls, which are described in Section 4.2.1, are currently in place at the quarry. Improvements could be made in the existing physical barriers, e.g., by closing gaps in the fence and posting additional signs. Such improvements could reduce the potential for contaminant migration by human activities and could limit contact with areas to which contaminants have already migrated. Site ownership will continue, but use or deed restrictions are not generally effective in preventing contact with contaminants that have already migrated outside a controlled area, nor do they limit the effect of natural forces (e.g., wind and precipitation) on contaminant migration. Thus, institutional controls are retained as an option for managing the quarry bulk wastes only as support for other response activities.

Containment/Treatment. The purpose of containment is to reduce contaminant mobility and the associated potential for migration and population exposure. Containment technologies, in and of themselves, do not typically reduce contaminant toxicity or volume. Potential technologies for migration control of the contaminated bulk wastes include isolation with a surface cap and subsurface grout or slurry seals.

When used alone or in conjunction with containment technologies, treatment technologies for migration control can reduce contaminant volume and toxicity as well as mobility. Containment with treatment can be achieved by media-specific, in-situ stabilization techniques such as dewatering and stabilization/fixation. Containment/treatment is considered potentially applicable to management of the quarry bulk wastes.

4.3 SUMMARY OF POTENTIALLY APPLICABLE TECHNOLOGIES

The identification and preliminary screening of the broad categories of potential source-control and migration-control technologies for this action are summarized in Tables 4.1 and 4.2, respectively. The following general response technologies are considered potentially applicable to management of the quarry bulk wastes: (1) institutional controls (as support for primary responses), (2) removal, (3) physical treatment, (4) temporary storage on-site, and (5) in-situ containment/treatment.

TABLE 4.1 Summary of General Response Technology Screening: Source Control

Source Control Technology	Evaluation Result	Comments
Institutional Controls		
Physical barriers	Retained	Temporarily limits on-site exposure to contaminants; may be effective when used in conjunction with other technologies.
Use or deed restrictions	Retained	Temporarily limits on-site exposure to contaminants; may be effective when used in conjunction with other technologies.
Monitoring	Retained	Provides data for assessing source-control measures; may be effective when used in conjunction with other technologies.
Removal		
Excavation	Retained	Reduces contaminant mobility by minimizing potential future migration; requires receiving facility for the wastes.
Treatment		
Chemical treatment		
Leaching/extraction (in situ)	Rejected	Infeasible due to areal and control constraints.
Leaching/extraction (post excavation)	Rejected	Infeasible due to the unavailability of a treatment facility in the appropriate time frame and the potential for adversely affecting waste management decisions for the project.
Stabilization/ fixation (in situ)	Retained	Reduces contaminant mobility; may affect waste management decisions for the project.
Stabilization/ fixation (post excavation)	Rejected	Infeasible due to the unavailability of a treatment facility in the appropriate time frame and the potential for adversely affecting waste management decisions for the project.

TABLE 4.1 (Cont'd)

Source Control Technology	Evaluation Result	Comments
Physical treatment		
Vitrification (in situ)	Retained	Reduces contaminant mobility and possibly toxicity; may affect waste management decisions for the project.
Thermal treatment (post excavation)	Rejected	Infeasible due to the unavailability of a treatment facility in the appropriate time frame and the potential for adversely affecting waste management decisions for the project.
Dewatering (in situ and post excavation)	Retained	May reduce mobility and/or volume of contaminated materials with high moisture content (e.g., sludges).
Solids separation (post excavation)	Rejected	Not suitable for bulk wastes that include a wide variety of structural debris and drums.
Biological treatment (in situ and post excavation)	Rejected	Not suitable for bulk wastes that include a wide variety of inorganic structural debris and drums.
Temporary Storage		
On-site	Retained	Reduces contaminant mobility and exposure to contaminants while a permanent remedy is being developed; requires engineered facility.
Off-site	Rejected	Not currently available and not expected to become available within an appropriate time frame due to technical and institutional concerns.

TABLE 4.1 (Cont'd)

Source Control Technology	Evaluation Result	Comments
Disposal		
Land-based facility		
On-site	Rejected	Infeasible due to the unavailability of a disposal facility in the appropriate time frame and the potential for adversely affecting waste management decisions for the project.
Off-site	Rejected	Infeasible due to the unavailability of a disposal facility in the appropriate time frame and the potential for adversely affecting waste management decisions for the project.
Ocean disposal	Rejected	Infeasible due to unavailability and the potential for adversely affecting waste management decisions for the project.

TABLE 4.2 Summary of General Response Technology Screening: Migration Control

Migration Control Technology	Evaluation Result	Comments
Institutional Controls		
Physical barriers	Retained	Temporarily limits exposure to contaminants; may be effective when used in conjunction with other technologies.
Use or deed restrictions	Retained	Temporarily limits exposure to contaminants; may be effective when used in conjunction with other technologies.
Monitoring	Retained	Provides data for assessing contaminant migration; may be effective when used in conjunction with other technologies.
Containment/Treatment		
In-situ system	Retained	Reduces contaminant mobility; when containment is used in conjunction with treatment (e.g., dewatering), may also reduce contaminant toxicity and/or volume.

5 DEVELOPMENT OF PRELIMINARY ALTERNATIVES

5.1 GENERAL CRITERIA

Preliminary alternatives for managing the quarry bulk wastes were developed and assessed, as appropriate for this interim action, according to the following categories specified for final remedial actions in the current NCP:

- No action;
- Alternatives for treatment or disposal at an off-site facility, as appropriate;
- Alternatives that attain applicable or relevant and appropriate requirements (ARARs) for protecting human health and the environment;
- Alternatives that exceed ARARs; and
- Alternatives that do not attain ARARs but will reduce the likelihood of present or future threats from the hazardous substances and will provide significant protection to human health and welfare and the environment. This must include an alternative that closely approaches the level of protection provided by those alternatives that attain the ARARs.

Section 105 of SARA required the President (who subsequently delegated this responsibility to the EPA) to propose amendments to the NCP. The EPA is currently revising the NCP, and publication is expected within the next few months. In the interest of addressing those requirements that will likely be promulgated before this action has been completed, categories of final remedial action alternatives that are recommended in the proposed NCP revisions and in EPA's RI/FS guidance were also considered in the current evaluation. These categories are:

- No action (or no further action);
- Containment (migration control) -- involving little or no treatment, but protective of human health and the environment by reducing contaminant mobility and related exposure risks; and
- Treatment (source control) -- ranging from (a) treatment as the principal element of the alternative to reduce the primary threat(s) posed by a site (i.e., may not involve the highest degree of treatment or the treatment of all wastes) to (b) treatment that will minimize the need for long-term management of the wastes, including monitoring.

Compliance with ARARs is not required if one of six waiver conditions is met. These conditions are identified in Section 121(d)(4) of SARA, as follows:

1. The remedial action is only part of a total remedial action that will attain the ARAR(s) when completed;

2. Compliance with the ARAR(s) will result in a greater risk to human health and the environment than alternative options;

3. Compliance with the ARAR(s) is technically impracticable from an engineering perspective;

4. The remedial action will attain a standard of performance that is equivalent to that required under the otherwise applicable ARAR(s) through use of another method or approach;

5. For state requirements, the state has not consistently applied the ARAR(s) (or demonstrated the intention to do so) in similar circumstances at other remedial actions within the state; or

6. For Superfund-financed actions only, compliance with the ARAR(s) will not permit a balance between achieving protectiveness at one facility and retaining sufficient funds for responses at other sites. (This condition is not relevant to the Weldon Spring site because Superfund money is not being used to finance the cleanup.)

The first waiver condition directly applies to the interim remedial action that is being proposed for the quarry. Management of the bulk wastes is only part of the overall remedial action for the project (see Section 1.1). Cleanup criteria for quarry remediation are not being established as part of this focused SOU; these criteria can be determined only after a decision on bulk waste management is reached, detailed characterization of the quarry area is completed, and a comprehensive baseline risk assessment for the quarry is prepared. Hence, ARARs for final remediation are not part of this stage of the remedial action process. Rather, they will be fully addressed in the follow-on activities at the quarry. However, those ARARs related to implementing the selected alternative for managing the quarry bulk wastes would be met unless a waiver condition applies. An overview of potential ARARs for this SOU is presented in Appendix C, pursuant to identification of the currently preferred alternative in Section 7.4.

5.2 ASSEMBLY OF TECHNOLOGIES INTO ALTERNATIVES

The general technologies discussed in Sections 4.2.1 and 4.2.2 have been screened for applicability to the proposed management of quarry bulk wastes (see Tables 4.1 and 4.2). This preliminary screening has identified various control technologies as potential components of alternatives for managing the wastes. The primary considerations for a remedial action at the level appropriate for this interim action are long-term protection, permanence, and compliance with ARARs, as appropriate (see Section 5.1); cost-effectiveness; and consistency with overall site remediation. Based on these considerations, the technologies have been grouped into the following preliminary alternatives:

- Alternative 1: No action;
- Alternative 2: Surface containment;
- Alternative 3: Surface and subsurface containment;
- Alternative 4: In-situ treatment;
- Alternative 5: Expedited excavation with temporary storage at the chemical plant area; and
- Alternative 6: Delayed action pending the ROD for the site.

5.3 DESCRIPTION OF ALTERNATIVES

The six preliminary alternatives identified in Section 5.2 are described in Sections 5.3.1 through 5.3.6. Migration control at the quarry (via containment) is the primary emphasis of Alternatives 2 and 3, whereas source control at the quarry (via excavation and/or treatment) is the primary emphasis of Alternatives 4 and 5. Alternative 6 (delayed action) is essentially the same as Alternative 1 (no action) in the short term and is expected to be similar to one of the action alternatives (i.e., Alternatives 2 through 5) in the long term, depending upon the action selected following the delay.

Each of the action alternatives would require various support activities prior to implementation. These activities include (1) design and construction of staging and support areas, (2) procurement of appropriate equipment, and (3) development of planning and operational controls to minimize contaminant releases. In addition, the institutional controls that now exist at the quarry -- i.e., DOE ownership, fences and locked gates, and monitoring -- are implicitly included as support activities for the alternatives, as appropriate. Under the action alternatives, these controls would be upgraded as needed. For example, certain portions of the fence and gates would be repaired, additional signs would be posted, and monitoring would increase.

5.3.1 Alternative 1: No Action

Under Alternative 1, no further action would be taken at the quarry, and the bulk wastes would remain in their current condition. The no-action alternative is included in the preliminary list of alternatives as a baseline for comparison with the other alternatives. As part of this baseline condition, the water treatment plant would be in operation at the quarry under a previous response action (documented in MacDonell et al. 1989).

5.3.2 Alternative 2: Surface Containment

Under Alternative 2, a surface containment layer would be installed at the quarry. As part of site preparation for emplacement of this layer, all surface vegetation would be removed. This activity would also be included in Alternatives 3 through 5. After the quarry was cleared, a surface containment layer -- e.g., soil cap or synthetic geotextile fabric -- would be installed over the entire area. Surface containment at the quarry would reduce the release of contaminants via surface pathways (e.g., wind dispersal) and could limit percolation of water through contaminated materials therein (and subsequent contaminant migration into the groundwater). However, lateral flow through the wastes would still be possible because the wastes would be in contact with the groundwater.

5.3.3 Alternative 3: Surface and Subsurface Containment

The components of Alternative 3 are the same as those of Alternative 2, with the addition of subsurface containment. The containment system for Alternative 3 would consist of an underlying confinement layer and lateral cutoff walls in addition to the surface cover or cap. Under this alternative, the quarry bulk wastes would be isolated in place by installing a surface layer as described for Alternative 2 and by emplacing a natural or polymeric grouting material around the periphery of the quarry and beneath the entire area at a depth greater than that of the buried wastes. A contiguous surface and subsurface containment system at the quarry would minimize surface releases of contaminants and could limit percolation and lateral and downward migration.

5.3.4 Alternative 4: In-Situ Treatment

Under Alternative 4, the contaminated materials would be solidified in situ at the quarry by mixing them with a cementitious material to form a solid mass or by vitrifying them with an electrical current to form a glass-like matrix. The resultant waste form would limit surface releases, percolation, and lateral and downward migration of contaminants.

5.3.5 Alternative 5: Expedited Excavation with Temporary Storage at the Chemical Plant Area

Under Alternative 5, the bulk wastes would be excavated from the quarry and transported along a haul road to the chemical plant area of the Weldon Spring site. At the chemical plant area, they would be segregated according to physical properties and stored temporarily in an engineered facility, pending a final decision on management of the entire site. Transportation activities and construction and maintenance of the temporary storage facility would be carried out in a manner that would minimize potential releases of contaminants to the environment. (Haul route options and details regarding the storage facility are discussed in Chapter 8.) Limited treatment would be conducted, as appropriate, to facilitate implementation (e.g., post-excavation dewatering to facilitate waste transport and storage control). The subsequent treatment and/or disposal of the bulk wastes would be addressed in conjunction with that of other on-site materials after completion of the RI/FS-EIS process and approval of the ROD for the Weldon Spring site.

A variation of this alternative could be identified, i.e., excavation with replacement for temporary storage in the quarry after chemical sealant or liner emplacement. However, technical difficulties associated with cover and seal emplacement would compromise the effectiveness of this option, such that protection of human health and the environment could not be ensured (see Sections 6.2.2 and 6.2.3). In addition, the availability of land at the quarry for staging is extremely limited due to ownership and topography constraints; therefore, storage of the required volume of material pending preparation of the quarry for waste emplacement would be infeasible. Thus, this variation was not considered further.

5.3.6 Alternative 6: Delayed Action Pending the Record of Decision for the Site

Under Alternative 6, a decision on the appropriate response action for the quarry bulk wastes would be delayed until the ROD was approved for the Weldon Spring site. Thus, response actions at the quarry would not be expedited, and the bulk wastes would remain in their current condition for the short term.

6 SCREENING OF PRELIMINARY ALTERNATIVES

The six preliminary alternatives identified and described in Sections 5.2 and 5.3 were screened for applicability to the proposed management of bulk wastes in the quarry according to the three general criteria described in EPA's RI/FS guidance: (1) effectiveness, (2) implementability, and (3) cost (EPA 1988b). These criteria are defined in Section 6.1. Following this screening, which is discussed in Section 6.2, the final alternatives (i.e., those that survived the screening process) were considered in greater detail. The detailed evaluation of final alternatives is presented in Chapter 7.

6.1 SCREENING CRITERIA

The effectiveness of an alternative is defined by its ability to protect human health and the environment from contaminant-associated risks in both the short term and the long term. The ability of an alternative to reduce contaminant toxicity, mobility, and volume is considered a measure of effectiveness.

The implementability of an alternative is defined by its technical feasibility, availability, and administrative feasibility. Technical feasibility addresses the construction, operation, maintenance, replacement, and monitoring of an alternative's technical components, as appropriate. Availability addresses the resources required to implement specific components of an alternative and the ability to obtain them. Administrative feasibility addresses the acceptability of an alternative by other agencies and interested parties, and it can be affected by the permanence of the solution.

The cost of an alternative is considered only in a comparative manner, e.g., to determine if the cost of one alternative is much greater than that of another alternative of similar effectiveness. General estimates of potential costs for each alternative can be compared to permit screening according to relative costs. Potential future costs, capital costs, and operation and maintenance costs are considered where appropriate, but indirect costs are not rigorously addressed during the screening stage.

6.2 SCREENING OF ALTERNATIVES

6.2.1 Alternative 1: No Action

The no-action alternative provides a baseline for comparison with the other alternatives. Under Alternative 1, the bulk wastes would remain in their current condition. Implementability and cost do not apply to this alternative.

In terms of effectiveness, Alternative 1 would not reduce the toxicity, mobility, or volume of contaminated materials in the quarry. The potential for human exposure to contaminants released from the quarry (e.g., radon gas) would continue in the short term and could increase over time. To mitigate groundwater migration, a water treatment plant has been proposed to treat the ponded water currently in the quarry. However, this constitutes only a temporary measure pending implementation of a permanent solution for source control at the quarry, i.e., management of the bulk wastes. Until a permanent solution is implemented, protection of human health and the environment at the quarry cannot be ensured for the long term.

6.2.2 Alternative 2: Surface Containment

Alternative 2 consists of placing a surface layer (e.g., a soil cap or synthetic geotextile fabric) over the quarry bulk wastes. To support this action, existing institutional controls would be continued, and the quarry vegetation would be removed so that a continuous surface layer could be emplaced. (Continuation of institutional controls would also be included in the other action alternatives.)

In terms of effectiveness, Alternative 2 would reduce the mobility of the contaminated materials but would not reduce their toxicity or volume. The potential for human exposure under this alternative could be reduced in the short term. A surface containment system would decrease gamma exposure rates and emissions of radon gas at the quarry. Additionally, an effective surface cover would limit water infiltration into the bulk wastes, thereby lowering the rate at which contaminants could migrate into the local environment. However, this cover would not preclude lateral migration, and the potential for human exposure in the long term would remain. In addition, the long-term effectiveness of such a containment system would be difficult to ensure. If the uppermost layer of the cover were vegetated for erosion control, the release of radon gas from the underlying bulk wastes might be reduced initially but could increase over time due to root channeling and radon exhalation by plants into the atmosphere via the transpiration stream. Furthermore, this alternative would adversely impact the subsequent evaluation of groundwater at the quarry because the wastes would remain therein.

More importantly, the topography of the quarry essentially precludes the emplacement of a surface containment system that could effectively limit infiltration of the bulk wastes by precipitation or snowmelt over the long term. Nearly all of the precipitation falling within the quarry rim would remain therein because the only surface runoff away from the quarry occurs in a very limited area outside the quarry wall. In addition, although the net amount of water retained annually at the quarry (i.e., precipitation minus evapotranspiration) is low under current conditions, this amount would increase after the quarry was cleared of vegetation and covered. Finally, large volumes of surface water could be present in the quarry at certain times e.g., during heavy thunderstorms and spring snowmelt. Thus, although effective runoff capacity and infiltration control would represent design criteria for a surface containment system at the quarry, they would be generally infeasible to sustain for the long term.

The implementation of Alternative 2 with regard to availability of resources would be relatively straightforward. Improvement of institutional controls at the quarry, e.g., fence repair, could be achieved using standard equipment and materials that are readily available. (Implementation of this activity would be similarly straightforward for the other action alternatives.) The emplacement of a surface containment system could also be achieved using standard equipment and materials, but system performance is expected to be poor.

A single-layer containment system is generally acceptable as a temporary cover for areas where evapotranspiration exceeds rainfall and groundwater contamination is not an issue or where the integrity of containment can be ensured. However, the proposed surface containment at the quarry is not intended as a short-term measure, local climatic and hydrogeologic conditions are not conducive to a single-layer system, and the integrity of such a system could not be ensured because of a variety of factors (including disturbance by volunteer vegetation and small animals). Hence, only a multilayer system is considered appropriate for surface containment at the quarry.

A multilayer surface containment system typically consists of (1) an upper layer of vegetated soil to provide erosion control; (2) a middle layer of sand to provide drainage; and (3) a bottom layer of low permeability, e.g., a synthetic fixed-membrane liner and/or compacted soil, to limit percolation of water into the underlying bulk wastes. Monitoring and maintenance of the cover would be required. Performance standards for the system would include adequate drainage and minimal vertical migration (which would be extremely difficult to achieve due to site-specific factors), efficient erosion control, resistance to damage by settling or subsidence, and limited maintenance requirements. However, the actual installation of a surface containment system at the quarry that could perform as designed would be essentially infeasible. The quarry terrain (i.e., concave, with uneven surfaces and fairly steep slopes in certain portions) would impede installation of a natural or synthetic cover, and concerns regarding design life, surface ponding, and the nature of the quarry subsurface would preclude the ensurance of long-term system integrity. The performance of this otherwise fairly standard system would be questionable under such conditions, even in the short term.

The administrative feasibility of Alternative 2 would be similarly complex. Acceptability would be affected by the technical difficulties of implementation and the inability to ensure effectiveness. This alternative does not represent a permanent solution because the bulk wastes would remain in the quarry as a source of subsurface contaminant migration. Therefore, administrative acceptability could be low.

The cost of Alternative 2 could be relatively small in the short term compared with certain other alternatives. Installing a flexible-membrane liner as part of a cover system is estimated to cost $\$32/m^2$ ($\$3/ft^2$), not including surface preparation costs. For the quarry, liner installation alone could cost about \$2 million; the addition of clay soil and sand/gravel layers would increase emplacement costs to over \$3 million. Long-term monitoring and maintenance requirements would significantly increase total costs. In addition, containment effectiveness would be questionable. Hence, long-term costs could be significant due to contaminant migration onto properties that are not currently contaminated, such that greater cleanup efforts and expenditures would be required in the future. Remedial actions would also cost more in the future due to inflation.

6.2.3 Alternative 3: Surface and Subsurface Containment

Alternative 3 includes the surface containment system of Alternative 2 but adds the installation of a subsurface containment system. This system could consist of cutoff walls around the periphery of the quarry to limit the lateral migration of contaminants and an underlying layer to limit vertical migration. That is, grouting material could be injected around and beneath the bulk wastes to isolate them from the environment.

In terms of effectiveness, Alternative 3 could reduce the mobility of the contaminated materials to a greater extent than Alternative 2 but would not reduce their toxicity or volume. The potential spread of contamination into the local environment and subsequent human exposure would be reduced by this alternative in the short term. However, although it may appear to be much more effective than Alternative 2, the long-term protection of human health and the environment would be similarly difficult to ensure under Alternative 3 because of (1) concerns similar to those identified for the surface containment system of Alternative 2 and (2) concerns regarding the subsurface containment system, i.e., the difficulty in achieving isolation in a fractured geological setting that provides numerous potential pathways for contaminant migration. The limestone geology underlying the quarry contains solution-enlarged channels through which contaminants are known to be migrating into the groundwater. A complete containment system in such an environment would be extremely difficult to construct, verify, or maintain. For example, grout injected into the subsurface could move directly into discrete limestone fractures and would therefore fail to create a quarry seal. Based on geology, topography, and the considerable size of the affected area, the actual movement of grout following placement could not be controlled. Hence, waste isolation could not be verified under Alternative 3, nor could the extent of maintenance requirements be identified. Although a number of potential pathways for contaminant migration might be sealed initially, failure of the confining layer to block even a fraction of the fissures would be sufficient to significantly compromise the containment. Furthermore, this alternative would adversely impact the subsequent evaluation of groundwater at the quarry because the wastes would remain therein. For these reasons, the effectiveness of Alternative 3 is not expected to differ significantly from that of Alternative 2 in the long term.

The implementation of Alternative 3 with regard to availability of resources would be fairly straightforward. The surface and subsurface containment systems would be constructed using standard equipment and materials that are readily available. Maintenance of the system and monitoring of its integrity would be required. However, the technical feasibility of this alternative would be quite low. The difficulties associated with the surface containment system would be the same as those identified for Alternative 2. To install the subsurface system, drilling through the wastes and injecting a confining layer around and beneath the entire quarry would be very difficult due to (1) the extent of the affected area, (2) the nature and depth of the buried wastes (i.e., a heterogeneous mixture that includes metal debris and equipment extending to depths of 12 m [40 ft]), and (3) the fractured nature of the bedrock. The ability of the containment system to perform as designed could not be ensured because of these serious limitations. Thus, isolation of the bulk wastes from the environment by placing a confining layer around the quarry periphery would be questionable at best; placing such a layer beneath the quarry is effectively infeasible.

The administrative feasibility of Alternative 3 would be similar to that identified for Alternative 2, although Alternative 3 might encounter less resistance because the containment system would be more extensive and might therefore *appear* to be more effective. However, the acceptability of Alternative 3 would probably be affected by the technical difficulties of implementation. In addition, as for Alternative 2, Alternative 3 does not represent a long-term solution to the potential risks associated with the bulk wastes at the quarry because the wastes would remain therein and the containment system could be breached at some time in the future. Therefore, implementation of Alternative 3 in terms of administrative feasibility is expected to be fairly difficult.

The cost of Alternative 3 would be significantly greater than that of Alternative 2. The attempted placement of a confining layer to a considerable depth around and beneath the entire quarry and the associated increased efforts to ensure system integrity would be very expensive. Installing grout curtains around the perimeter of the quarry is estimated to cost about $4 million. Considering only the cost of materials and equipment, attempting to grout beneath the quarry would increase the cost by an order of magnitude. Therefore, the partial costs of grouting and cover emplacement could reach $50 million, excluding the costs of drilling and injection for the underlying grout layer. Additional costs would significantly increase the total estimate due to preparation requirements and complicating factors that have been identified previously, including the extent, topography, and fractured geology of the affected area and the nature of the buried wastes. Because the likelihood of achieving a contiguous containment system is low, the incremental cost of attempted maintenance would be very high.

6.2.4 Alternative 4: In-Situ Treatment

Under Alternative 4, the bulk wastes would be solidified in place at the quarry. Solidification could be achieved by either (1) stabilization/fixation, whereby a cementitious material would be added to the wastes to form a solidified mass, or (2) in-situ vitrification, whereby the wastes would be solidified in a glass-like matrix following the application of intense heat over a long period of time.

In terms of effectiveness, Alternative 4 could be more protective of human health and the environment than any of the previous alternatives, depending on the selected method of solidification. However, this alternative would adversely impact the subsequent evaluation of groundwater at the quarry because the wastes would remain therein. The reduction in contaminant toxicity, mobility, and volume and the long-term effectiveness of the solution would also depend on the method of solidification. If cementation were used, Alternative 4 would reduce the mobility but not the toxicity or volume of the contaminated materials in the quarry. In fact, the volume would increase due to the incorporation of uncontaminated material (e.g., soil and chemical additives) in the solidified mass. This option would not reliably protect human health and the environment in the long term because the contaminated materials could potentially leach from the cement matrix in the future.

If in-situ vitrification were used, contaminant toxicity and mobility would be significantly reduced, as would the net waste volume (the reduction in pore volume would be expected to offset increases that could result from incorporation of uncontaminated materials in the solidified mass). In-situ vitrification could constitute a long-term solution because its projected lifetime is considerable and leachability under optimized conditions is expected to be low. However, the actual effectiveness of this innovative process over time is unknown due to the unavailability of relevant field data and the nature and considerable volume of contaminated materials requiring treatment.

The implementation of Alternative 4 in terms of technical feasibility and availability would be affected by the specific solidification method. If the method were cementation, implementation would be technically difficult. Although standard equipment and resources could be used, a very intensive effort would be required. Complete mixing and stabilization would be effectively impossible to achieve because the bulk wastes extend over a significant area and depth and include process equipment and other unwieldy debris.

If in-situ vitrification were used to stabilize the bulk wastes, technical implementation would be similarly difficult due to (1) limited availability of equipment, (2) time and energy requirements, and (3) content and placement of the bulk wastes. Because in-situ vitrification is a developing technology, the availability of necessary process equipment is extremely limited. If its implementation were in fact feasible at the quarry, extensive time and power commitments would be required due to (1) the considerable size of the affected area (3.6 ha [9 acres], extending to depths of 12 m [40 ft]), and (2) the volume of materials to be treated (73,000 m^3 [95,000 yd^3]). For example, for a low-moisture-content waste block about 6 m (20 ft) per side, the cooling time alone (i.e., following melt time) can exceed one year. If in-situ vitrification were feasible at the quarry, it would take many years to complete. Furthermore, the depth of the contaminated materials and the moisture and metal contents would seriously hinder implementation. The maximum depth to which electrodes have been extended to date (i.e., about 8 m [26 ft]) is significantly less than that required at the quarry. In addition, because moisture content can impede treatment (interstitial water must be evaporated before solidification can begin, and inflows -- e.g., from precipitation and groundwater recharge -- must be controlled), the local climate and hydrogeology at the quarry would adversely affect implementation. Finally, the presence of metal wastes can effectively preclude the use of in-situ vitrification. The process is generally feasible only if the wastes contain less than 5% metal by weight and if less than 90% of the linear separation between electrodes is occupied by metal; otherwise, the electrodes may be short-circuited. Because of the metal debris scattered throughout the quarry -- e.g., as drums, process equipment, and building rubble -- these constraints could not be met. Hence, unless these materials were excavated and segregated or redistributed, implementation would be essentially infeasible. However, the variation of excavating the bulk wastes for treatment and replacement at the quarry was not considered for reasons given in Section 5.3.5 for similar activities. Excavation with treatment away from the quarry was not considered because it is inconsistent with the technology screening and the scope of this alternative (see Section 6.2.5 for discussion of Alternative 5, which includes excavation as a component). Therefore, in-situ vitrification would be technically impracticable for the quarry bulk wastes.

The administrative feasibility of in-situ treatment would depend on the selected method of treatment. The acceptability of cementation could be affected by technical difficulties similar to those for Alternative 3. Although in-situ vitrification might be preferred to the injection of a confining layer because of potential long-term protection, considerable institutional barriers to implementation could result from both the innovative nature of this technology and considerations of technical feasibility, implementation time, and cost.

The cost of Alternative 4 would depend on the specific method of stabilization; however, because of the volume, nature, and depth of the bulk wastes, it is expected that either cementation or vitrification would be prohibitively expensive relative to certain other alternatives that could provide at least the same measure of protection at the quarry. The implementation of in-situ vitrification in straightforward applications (e.g., for an area of confined surface contamination) is estimated to cost about $\$330/m^3$ ($\$250/yd^3$). Applicability of the vitrification process to contaminated materials at the Weldon Spring site was recently assessed by Pacific Northwest Laboratory (Koegler et al. 1989). Based on this analysis, in-situ vitrification of the quarry bulk wastes was not considered because of technical difficulties associated with its implementation. Thus, costs were estimated only for vitrifying the wastes after they were excavated. Although treatment following excavation was eliminated during the technology screening stage (see Chapter 4), the related estimate can be used to frame potential costs for an attempted in-situ application. Vitrification following removal would cost about $36 million; if in-situ vitrification were attempted, this value would increase severalfold due to severe technical constraints and extensive, long-term energy requirements. Additional costs (e.g., for monitoring and maintenance) could also be significant because of questionable treatment effectiveness.

In-situ stabilization by chemical addition could cost more than $60 million, excluding preparation costs and scaleup factors associated with attempting to drill, inject, and mix the stabilizing agent under adverse physical conditions at the quarry. As for in-situ vitrification, additional costs (e.g., for monitoring and maintenance) would be substantial based on the questionable effectiveness of this option.

6.2.5 Alternative 5: Expedited Excavation with Temporary Storage at the Chemical Plant Area

The bulk wastes would be removed from the quarry under Alternative 5, which would constitute source control for current contaminant migration. The excavated wastes would be transported about 6.4 km (4 mi) to the chemical plant area for consolidation with other site wastes; the quarry wastes would be stored temporarily in a facility designed and operated to control contaminant migration. Following completion of the RI/FS-EIS process for the Weldon Spring site, these wastes would be managed in conjunction with all other site wastes, i.e., using treatment and/or disposal technologies, as appropriate. Thus, Alternative 5 would expedite action at the quarry without biasing comprehensive waste management decisions for the entire site.

In terms of effectiveness, Alternative 5 would reduce contaminant mobility but not toxicity. The volume of contaminated materials would probably increase because a certain amount of uncontaminated materials would be excavated along with the bulk wastes. The potential for human exposure to contaminants migrating from the quarry would be reduced in both the short term and the long term under Alternative 5 because the source of this contamination would be removed from the quarry. The potential for exposure to contaminants migrating from the temporary storage facility would be low because releases would be controlled by engineered measures (e.g., covers, liners, and a runoff collection system).

In addition to its direct effectiveness for protecting human health and the environment from potential adverse impacts associated with the bulk wastes in the quarry, Alternative 5 would also have a positive indirect impact on the effectiveness of comprehensive remediation of the quarry area. Implementation of this alternative would permit the efficient performance of subsequent activities at the quarry that are essential to the ultimate goal of quarry remediation (see Section 1.1). Furthermore, Alternative 5 would permit comprehensive characterization of the quarry bulk wastes, which is infeasible as long as the wastes remain in place (i.e., under Alternatives 1, 2, 3, and 4, and under Alternative 6 in the short term); this characterization is essential to an informed evaluation of treatment technologies for these and other site wastes. Thus, Alternative 5 would strongly support the goal of long-term protection through comprehensive remediation, utilizing treatment technologies to the maximum extent practicable to provide a permanent solution. Under Alternative 5, monitoring requirements at the quarry would decrease over time; monitoring at the chemical plant area would continue as part of the ongoing program.

The implementation of Alternative 5 in terms of technical feasibility and availability would be relatively straightforward. Although removal of the bulk wastes from the quarry would not constitute a standard excavation activity, the wastes would be excavated and transported with readily available equipment in accordance with standard practices. Similarly, the temporary storage facility at the chemical plant area would be constructed and operated with standard equipment and procedures. (Details on the transportation route and temporary storage area are provided in Chapter 8.) The administrative feasibility of Alternative 5 is also expected to be straightforward, based on the initiation of a permanent solution at the quarry and the consolidation and control of contaminated materials at the chemical plant area. In addition, Alternative 5 supports the overall goal of the Weldon Spring project -- i.e., the consistent management of all site-related wastes, with expedited responses as appropriate, such that overall waste management decisions are not adversely affected.

The cost of Alternative 5 is expected to be reasonable relative to certain other alternatives that would be equally or less effective (e.g., Alternatives 3 and 4). Excavation costs are estimated to be about $5 million, as are costs for support activities -- including construction of the haul road and temporary storage facility. Alternative 5 could be implemented in a straightforward and timely manner, and long-term monitoring and maintenance costs at the quarry would decrease because the wastes would be permanently removed from this location. Under Alternative 5, the ultimate waste management decisions for the Weldon Spring site could be identified for the majority of contaminated materials at the same location and at the same time. Therefore, a considerable savings could be realized relative to the potential for unreasonable costs incurred by treating substantial volumes of materials at separate locations (i.e., the quarry and the chemical plant area) and at different times (i.e., at least twice -- once, if a decision on the ultimate disposition of the quarry wastes were made at this time; and a second time in the future, after the ROD was approved for the entire site, if it was eventually determined that the bulk wastes must be removed from the quarry).

6.2.6 Alternative 6: Delayed Action Pending the Record of Decision for the Site

Under Alternative 6, no action would be taken with respect to the quarry bulk wastes until a decision was made regarding the ultimate disposition of the entire Weldon Spring site, i.e., for management of all site-related wastes. Hence, Alternative 6 is similar to Alternative 1 (no action) in the short term and would probably be similar to one of the action alternatives in the long term (i.e., if a similar action were selected following the delay). Remedial action would not be expedited at the quarry but would be implemented following issuance of the ROD for the site.

In terms of effectiveness, Alternative 6 would not reduce the toxicity, mobility, or volume of the contaminated bulk wastes in the short term. The potential for human exposure to these wastes at the quarry and to contaminants that might migrate into the local environment would continue for the short term, as for Alternative 1. However, the delay period is expected to be limited to about 2 to 5 years. Following the ROD, remedial action would be undertaken at the quarry to control potential risks to human health and the environment that are associated with the bulk wastes. Thus, the potential impacts identified for Alternative 1 over the long term would not apply to Alternative 6. Current environmental monitoring at the quarry would continue during the delay period, and expedited response actions would be taken if an imminent and substantial endangerment of human health or the environment were identified. Irrespective of timing, if the alternative eventually selected for the bulk wastes involved removing the wastes from the quarry, a staging area would be required to permit waste segregation and characterization following excavation. This staging area would also serve as a temporary storage area because waste management decisions for the quarry bulk wastes could not be finalized prior to waste characterization. Therefore, the potential advantage related to closer sequencing of excavation and disposal is not expected to be significant.

Implementability does not apply to Alternative 6 in the short term and is expected to be similar to one of the action alternatives in the long term. Alternative 6 would cost nothing in the short term, but the long-term costs for this alternative could be greater than the total costs for certain other alternatives because of inflation. These costs could increase substantially if failure to control contaminant migration resulted in extension onto properties that are not currently contaminated, which would require greater cleanup efforts and expenditures in the future. In addition, monitoring costs under this alternative would continue during the delay period.

A more detailed discussion of potential long-term impacts regarding effectiveness, implementability, and cost is not possible at this time because no specific action has been identified for implementation following the ROD and these impacts are strongly dependent on the ultimate response.

6.2.7 Summary

The screening of the six preliminary alternatives for managing the quarry bulk wastes is summarized in Table 6.1. This summary presents information for each alternative in a relative manner, according to EPA's screening criteria of effectiveness, implementability, and cost.

6.3 IDENTIFICATION OF FINAL ALTERNATIVES

Based on the screening of preliminary alternatives in Section 6.2, the following alternatives were eliminated from further consideration for managing the quarry bulk wastes:

- Alternative 2: Surface containment;
- Alternative 3: Surface and subsurface containment; and
- Alternative 4: In-situ treatment.

The no-action alternative (Alternative 1) was retained through this screening step to provide a basis for comparison with the remaining action alternatives during their subsequent evaluation. The elimination of Alternatives 2, 3, and 4 from further consideration was based on (1) ineffectiveness, i.e., the inability of the alternatives to ensure long-term protection of human health and the environment at the quarry, (2) difficulties in implementation, i.e., the technical and administrative infeasibility of specific components of the alternatives, and (3) the potential for adversely affecting overall remediation decisions for the Weldon Spring Site Remedial Action Project.

Alternatives 2, 3, and 4 would adversely impact overall project effectiveness because bulk waste characterization and subsurface studies at the quarry that are essential to comprehensive remediation decisions would be very difficult if the wastes remained in the quarry. Drilling through the wastes would be extremely difficult and could result in adverse worker impacts in terms of both accidents and exposures. Furthermore, representative sampling is infeasible because comprehensive records of past disposal activities were not maintained and the actual nature and location of each waste placement is unknown. Therefore, because characterization results would not be representative, they could not serve as reliable input to comprehensive, informed decisions on waste disposition for the Weldon Spring site. In addition, the effectiveness of subsurface remediation, if appropriate, could be seriously compromised.

In summary, long-term source control at the quarry and treatment options that could reduce the toxicity, mobility, and/or volume of contaminated bulk wastes over the long term cannot be adequately considered with the wastes in place. Thus, Alternatives 2, 3, and 4 are inconsistent with the overall remedial action goals of the Weldon Spring project, which include (1) the reliable protection of human health and the environment over the long term and (2) the support of comprehensive site remediation.

TABLE 6.1 Screening of Preliminary Alternatives

Alternative	Effectiveness	Implementability	Cost
Alternative 1: No action	Continued migration of contaminants from the bulk wastes could increase exposures of human, animal, and plant populations to chemicals and radionuclides over time. Contaminant toxicity, mobility, and volume would not be reduced.	Not applicable.	Not applicable.
Alternative 2: Surface containment	Exposures could be reduced in the short term but are not expected to be effectively reduced over the long term due to the potential for subsurface migration. Contaminant mobility would be somewhat reduced, but toxicity and volume would not be reduced.	Very difficult due to the topography and extent of the contaminated area.	Lower than other action alternatives in the short term but expected to be higher than those alternatives over time due to monitoring and maintenance and questionable effectiveness (i.e., the eventual need for a more effective response), which would increase costs due inflation and the potential increased extent of contamination.

TABLE 6.1 (Cont'd)

Alternative	Effectiveness	Implementability	Cost
Alternative 3: Surface and subsurface containment	Reduction of potential exposures could be greater than for Alternative 2 in the short term, but effectiveness over the long term is doubtful due to difficulties in ensuring and maintaining containment in a fractured setting. Reduction of contaminant mobility would be greater than for Alternative 2 in the short term, but toxicity and volume would not be reduced.	Essentially infeasible due to difficulties associated with surface containment (as for Alternative 2) and with subsurface containment due to the extent of the affected area, depth and type of waste material, and fractured nature of the bedrock.	Significantly greater than Alternatives 2 and 5 due to serious difficulties associated with attempting to drill and grout under existing waste conditions, the fractured subsurface, and questionable effectiveness.
Alternative 4: In-situ treatment	More protective than Alternatives 1, 2, or 3, but effectiveness over the long term is questionable due to uncertainties associated with verifying treatment success and ensuring the integrity of the solidified waste form over time. Contaminant mobility would be reduced, but not toxicity; the volume might increase or decrease depending on the treatment method.	Essentially infeasible due to the nature and extent of the bulk wastes.	Significantly greater than Alternatives 2 and 5 and could be greater than Alternative 3 due to the type and placement of the wastes, the extensive resource requirements, the need to control moisture content, and questionable effectiveness.

TABLE 6.1 (Cont'd)

Alternative	Effectiveness	Implementability	Cost
Alternative 5: Expedited excavation	Most protective of all the alternatives; initiates a permanent solution at the quarry and supports follow-on comprehensive quarry remediation and waste management decisions for the entire project. Contaminant mobility would be reduced, but not toxicity; the total volume of materials would increase due to the inclusion of some uncontaminated materials.	Relatively straightforward, using standard equipment and procedures.	Low relative to other alternatives that would be equally or less effective; costs of monitoring and maintenance at the quarry would decrease over time; total project costs could be minimized due to the coordination of decisions for waste disposition.
Alternative 6: Delayed action	Similar to Alternative 1 in the short term and expected to be similar to one of the action alternatives in the long term (i.e., if a similar response was selected following the delay).	Not applicable during the short term and expected to be similar to one of the action alternatives in the long term.	Expected to be higher than certain action alternatives in the long term due to the costs associated with monitoring until action is eventually taken and with inflation and the potential increased scope of the cleanup effort due to contaminant migration.

The preliminary alternatives that were retained for subsequent evaluation are:

- Alternative 1: No action;
- Alternative 5: Expedited excavation with temporary storage at the chemical plant area; and
- Alternative 6: Delayed action pending the ROD for the site.

7 DETAILED EVALUATION OF FINAL ALTERNATIVES

7.1 EVALUATION CRITERIA

The EPA guidance for RI/FS preparation (EPA 1988b) and the proposed revisions to the NCP identify nine criteria for evaluating final alternatives for a remedial action. These nine criteria can be grouped into three general categories: threshold criteria, primary balancing criteria, and modifying criteria.

The threshold criteria category includes two criteria that must be satisfied by the selected alternative:

1. Overall protection of human health and the environment and

2. Compliance with ARARs, unless a waiver condition is met.

One of the waiver conditions for compliance with ARARs addresses the case where the remedial action being selected is only part of a total remedial action; in such a case, compliance with ARARs is required only when the entire project is completed rather than during the interim action (see Section 5.1). This condition directly applies to the quarry bulk waste SOU. Further actions will be taken at both the quarry and the chemical plant area following completion of the RI/FS-EIS currently being prepared for the site. Compliance with standards and guidelines related to cleanup criteria and residual risks will be evaluated for these actions in consultation with EPA Region VII and the state of Missouri as part of the follow-on quarry documentation and the site RI/FS-EIS. Therefore, compliance with ARARs will only be discussed as appropriate during the detailed evaluation of final alternatives for bulk waste management (e.g., as related to implementation of this interim action).

The primary balancing criteria category contains five criteria that must be considered during the detailed evaluation of alternatives to determine an optimum combination:

1. Short-term effectiveness -- which addresses protecting human health and the environment during implementation as well as timeliness, or the time required to achieve protectiveness;

2. Long-term effectiveness and permanence -- which addresses minimizing residual risks and the adequacy and reliability of institutional/engineering controls;

3. Reduction of contaminant toxicity, mobility, and volume -- which addresses the magnitude, significance, and irreversibility of such reductions;

4. Implementability -- which addresses technical and administrative feasibility, including the availability of resources, seasonal limitations, and permit requirements; and

5. Cost — which addresses the cost-effectiveness of construction and operation and maintenance, such that the overall effectiveness is at least proportional to total costs (on a present worth basis).

The modifying criteria category consists of two criteria:

1. State acceptance and

2. Community acceptance.

These two criteria can be effectively considered only after the public has had an opportunity to comment on a proposed action. The proposed management of quarry bulk wastes is being developed in consultation with EPA Region VII and the state of Missouri.

The alternatives for the proposed management of quarry bulk wastes that were retained through the screening process (see Section 6.3) are analyzed in detail in Section 7.2 according to the three general categories of evaluation criteria. The final alternatives are:

- Alternative 1: No action,
- Alternative 5: Expedited excavation with temporary storage at the chemical plant area, and
- Alternative 6: Delayed action pending the ROD for the site.

7.2 EVALUATION OF ALTERNATIVES

7.2.1 Alternative 1: No Action

The no-action alternative is included in the list of final alternatives as a baseline for comparison with the remaining two alternatives. This alternative would not be protective of human health and the environment. In addition, this alternative would not be responsive to contaminant-specific requirements because releases of radon gas at the quarry have exceeded DOE limits. Therefore, Alternative 1 does not satisfy the threshold criteria and was rejected from further detailed consideration.

7.2.2 Alternative 5: Expedited Excavation with Temporary Storage at the Chemical Plant Area

Alternative 5 satisfies the threshold criteria for remedial action alternatives. This alternative would protect human health and the environment at the quarry by removing the source of ongoing contaminant migration. In addition, this alternative would be implemented in a manner consistent with regulatory requirements (see Appendix C).

Alternative 5 would provide a positive balance among the five criteria of the primary balancing criteria category. The action would be effective in the short term (first criterion) because it would be conducted in a manner to ensure that the overall short-term impacts of implementation on the public and workers would be low (see Chapter 11); it would also be timely (first criterion) because the time to remove the bulk wastes from the quarry is estimated to be less than 2 years. Long-term effectiveness and permanence (second criterion) would be achieved at the quarry by removing the major source of contamination. Standard equipment and practices would be used, and institutional controls would be maintained. This alternative would also minimize residual risks over the long term by expediting subsequent characterization of the quarry, which would include a full-scope risk assessment and evaluation of the need for additional remediation (see Section 1.1). The toxicity, mobility, and volume of contamination in the quarry would be significantly reduced by removing the bulk wastes to a separate area of the site where storage could be controlled (third criterion). The stored wastes would be subsequently treated and/or disposed of pursuant to the decisions made in the RI/FS-EIS currently being developed for the Weldon Spring site.

Alternative 5 is both technically and administratively feasible (fourth criterion). Resources are readily available to excavate the bulk wastes and transport them to a temporary storage facility at the chemical plant area and to construct and maintain the storage facility. Details on transportation activities and on the temporary storage facility are provided in Chapter 8. Alternative 5 would also be cost-effective (fifth criterion) because it would expedite a beneficial response to ensure protection of human health and the environment at the quarry and would preclude both inflationary effects and the potential for increased cleanup costs in the future if action were delayed (e.g., due to the potential spread of contamination to a greater area and more extensive cross-media involvement). In addition, this alternative could minimize total project costs because it would (1) permit the bulk wastes and quarry subsurface to be characterized in a timely manner and (2) facilitate the coordination of comprehensive decisions for waste treatment and disposal. The total cost of implementing Alternative 5 is estimated to be $11 million, about half of which is related to support activities that include preparation of the quarry and temporary storage area.

The modifying criteria cannot be adequately assessed until after the public has had an opportunity to comment on the proposed management of the quarry bulk wastes. However, Alternative 5 is expected to be generally acceptable relative to the other alternatives because it provides short-term and long-term effectiveness at the quarry and facilitates comprehensive site cleanup.

7.2.3 Alternative 6: Delayed Action Pending the Record of Decision for the Site

Alternative 6 would satisfy the threshold criteria after action was taken, but this alternative could not ensure protection of human health and the environment at the quarry in the short term. Releases of radon gas at the quarry have exceeded DOE limits. Thus, Alternative 6 does not adequately satisfy the threshold criteria during the delay period.

Alternative 6 would not adequately satisfy and balance the five primary balancing criteria. For short-term effectiveness (first criterion), the timeliness of this alternative could be inadequate because of the delay period -- which is expected to last 2 to 5 years. The human health and environmental risks associated with the action period of this alternative are expected to be similar to those identified for one of the other action alternatives (see Sections 6.2.2 through 6.2.5) because the eventual response under Alternative 6 would probably be based on a similar alternative. However, incremental risks could be incurred during the delay period due to the continued, uncontrolled presence of contaminated materials in the quarry during that time. For example, radon gas releases from the bulk wastes in the quarry have exceeded DOE limits for health protection. In addition, this alternative would delay the initiation of (1) long-term effectiveness and a permanent solution at the quarry and (2) the characterization of bulk wastes and the quarry subsurface that are essential to comprehensive remediation and risk management decisions (second criterion). The delay in excavating the wastes would also postpone any reduction of contaminant toxicity, mobility, and/or volume (third criterion).

Technical and administrative feasibility considerations (fourth criterion) would not apply to the delay period of Alternative 6 but would probably be similar to those for one of the other action alternatives during the subsequent action period. Finally, the costs (fifth criterion) of Alternative 6 would include those associated with the alternative selected following the delay and any incremental costs that might result from inflation and increased cleanup due to contaminant releases that occurred during the delay. In addition, delaying necessary characterization activities and comprehensive waste management decisions could adversely impact total project costs. Thus, cost-effectiveness is expected to decrease due to the delay.

Although the modifying criteria cannot be adequately assessed until after the public has had an opportunity to comment, Alternative 6 is not expected to be accepted as fully as Alternative 5 because of the associated delay both in ensuring protection of human health and the environment at the quarry and in the ability to conduct characterization activities that are needed for comprehensive cleanup decisions.

7.3 SUMMARY AND COMPARATIVE ANALYSIS

Alternative 1 fails the threshold criteria and was therefore not carried forward through the second and third categories of detailed evaluation. In contrast, Alternative 5 satisfies both the threshold criteria and the primary balancing criteria. Alternative 6 does not adequately satisfy either the threshold criteria or the primary balancing criteria in the short term, i.e., during the delay period, but this alternative would probably be similar to one of the action alternatives (see Section 6.2) following the delay. Finally, Alternative 5 is expected to better satisfy the two modifying criteria.

The potential environmental impacts of Alternative 5 are described in Chapter 10. The potential adverse impacts of Alternative 6 are expected to be greater than those of Alternative 5 due to impacts that could occur because the contaminant source would remain in the quarry during the delay. During the action period, the impacts associated with Alternative 6 would depend on the action eventually selected (e.g., the impacts would be similar to those for Alternative 5 if the bulk wastes were eventually removed).

The potential health impacts on workers and the general public associated with Alternative 5 are described in Chapter 11. Potential impacts associated with Alternative 6 could be greater than those for Alternative 5 because contaminant releases could impact human health during the delay period. Alternative 5 is expected to be more protective than Alternative 6 in both the short term and the long term because it would expedite control of the quarry bulk wastes. As the more timely alternative, Alternative 5 would reduce contaminant toxicity, mobility, and volume at the quarry whereas this reduction would be postponed under Alternative 6. Furthermore, Alternative 5 would expedite the implementation of follow-on quarry activities such that monitoring requirements at the quarry would decrease in the long term. If the excavation alternative were selected following the delay for Alternative 6, a potential advantage would be the possibility of reducing the size of the staging/storage area required for the bulk wastes following excavation and prior to disposal (to permit segregation and characterization). However, based on the timing of these activities, this advantage is not expected to be significant and, in fact, the area needed might actually increase if the volume of contaminated materials increased relative to Alternative 5 during the delay.

Alternative 6 would postpone the attainment of remedial action objectives at the quarry (e.g., reduction of contaminant toxicity, mobility, and volume and initiation of follow-on activities). Alternative 5 could be implemented with standard equipment and procedures. Implementability does not apply to Alternative 6 during the delay period and would depend on the action selected following the delay. If the excavation alternative were eventually selected, implementation during the action period of Alternative 6 would be similar to that for Alternative 5.

Alternative 5 would be more cost-effective than Alternative 6 because it would preclude incremental costs due to inflation and the increased cleanup effort that would be required if the extent of contamination increased during the time the wastes remained in the quarry.

Finally, Alternative 5 is expected to be more acceptable to the state and community than Alternative 6 because it would expedite protection of human health and the environment at the quarry and would facilitate comprehensive cleanup of the Weldon Spring site.

7.4 IDENTIFICATION OF THE PREFERRED ALTERNATIVE

Based on an evaluation of the three final alternatives, Alternative 5 -- expedited excavation with temporary storage at the chemical plant area -- has been identified as the preferred alternative for managing the quarry bulk wastes. Under this alternative, the wastes would be excavated and transported from the quarry to a controlled storage facility at the chemical plant area, pending a decision on the ultimate disposition of the Weldon Spring site. Alternative 5 could be implemented in a straightforward manner, it would be cost-effective, and it would minimize the potential risks to human health and the environment associated with the bulk wastes in the quarry. Finally, Alternative 5 is consistent with and would contribute to the efficient performance of overall remedial actions being planned for the Weldon Spring site. Detailed discussions of specific components of this action are provided in Chapter 8.

8 DESCRIPTION OF THE PREFERRED ALTERNATIVE

Under the preferred alternative, DOE proposes to remove the bulk wastes from the quarry and transport them by truck to a temporary storage area (TSA) at the chemical plant area of the Weldon Spring site. This action would involve the construction and use of a support area at the quarry (e.g., for equipment decontamination and parking) and construction and use of the TSA. A haul road would be constructed between the quarry and the TSA for use in transporting the wastes. As part of a separate response action, DOE plans to build and operate a water treatment plant at the quarry to treat contaminated water from the quarry pond.

Prior to bulk waste excavation, the quarry pond and bulk wastes would have been substantially dewatered by the quarry water treatment plant (MacDonell et al. 1989); dewatering would continue during the excavation effort. Based on available information, it is expected that pumping from the quarry pond would be adequate for dewatering the wastes. However, additional measures might be employed to support this action, such as drilling dewatering wells or excavating a drainage trench along the limestone pyramid wall.

8.1 SUPPORT FACILITIES

The support area constructed at the quarry would include decontamination facilities, roads, showers, a potable water supply, portable sanitary facilities, fencing, security facilities, electrical power facilities, and offices for the on-site construction management staff and the environmental, safety, and health staff. The proposed location of the support area is shown in Figure 8.1; more detail is provided in Figure 8.2. (The water treatment plant that has been separately documented would be located adjacent to and south of the proposed support area, as indicated in Figure 8.1.) The support area would be cleared and grubbed and the topsoil removed; if any contaminated vegetation were identified during presurvey sampling, it would be placed inside the quarry fence. All other vegetation would be chipped, shredded, and made available for use by the Missouri Department of Conservation. Uncontaminated topsoil could be used locally for construction purposes; contaminated materials would be placed inside the quarry fence. Preparation of the support area (clearing and grubbing, grading, and excavation) would require about 9 weeks.

8.2 BULK WASTE EXCAVATION

An estimated 73,000 m^3 (95,000 yd^3) of radioactively and chemically contaminated bulk wastes are proposed to be removed and transported from the quarry (DOE 1987a). These wastes include drums, uncontained wastes, steel and concrete rubble, machinery, process residues, and contaminated soils and sediments. The bulk wastes are therefore heterogeneous, and densities may vary from 1,800 to 2,600 kg/m^3 (3,000 to 4,400 lb/yd^3). The history of waste disposal at the quarry, including types and quantities of materials present, is summarized in Table 1.1. In addition, materials resulting from

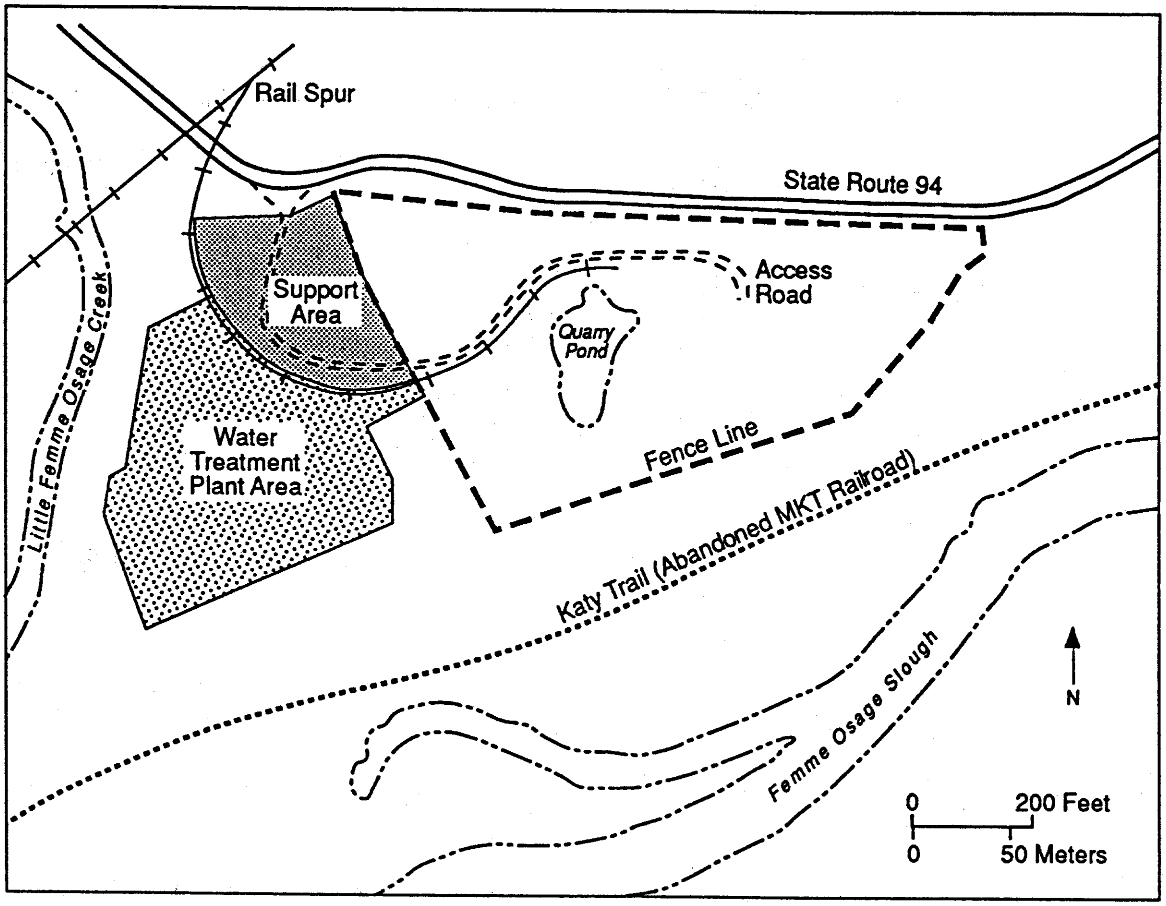

FIGURE 8.1 Proposed Layout of Support and Water Treatment Plant Areas at the Quarry

clearing and grubbing the quarry area and materials produced by overexcavation of the wastes (e.g., some uncontaminated materials from below or adjacent to the wastes) would be removed and transported to the TSA. The sequencing of activities at the quarry would consist of removing vegetation and then excavating the bulk wastes, including pond sediments. Vegetation would be chipped and shredded and then hauled in covered, tightly sealed, leakproof trucks to the TSA for storage.

The nature of the quarry bulk wastes and the difficulties associated with in-place characterization would result in uncertainties during excavation. These uncertainties would be managed utilizing an observational method. This method provides a structured approach whereby planning is based on available data and realistic assumptions concerning field conditions, and adjustments are made in the field as work proceeds. Reasonably conceivable deviations from expected conditions and mechanisms by which to identify their occurrence are defined, and plans are developed to address or mitigate adverse effects that result from these deviations. This approach ensures responsiveness to actual field conditions.

For example, one of the uncertainties being addressed for the bulk waste remedial action is the adequacy of the dewatering effort. If the quarry water treatment

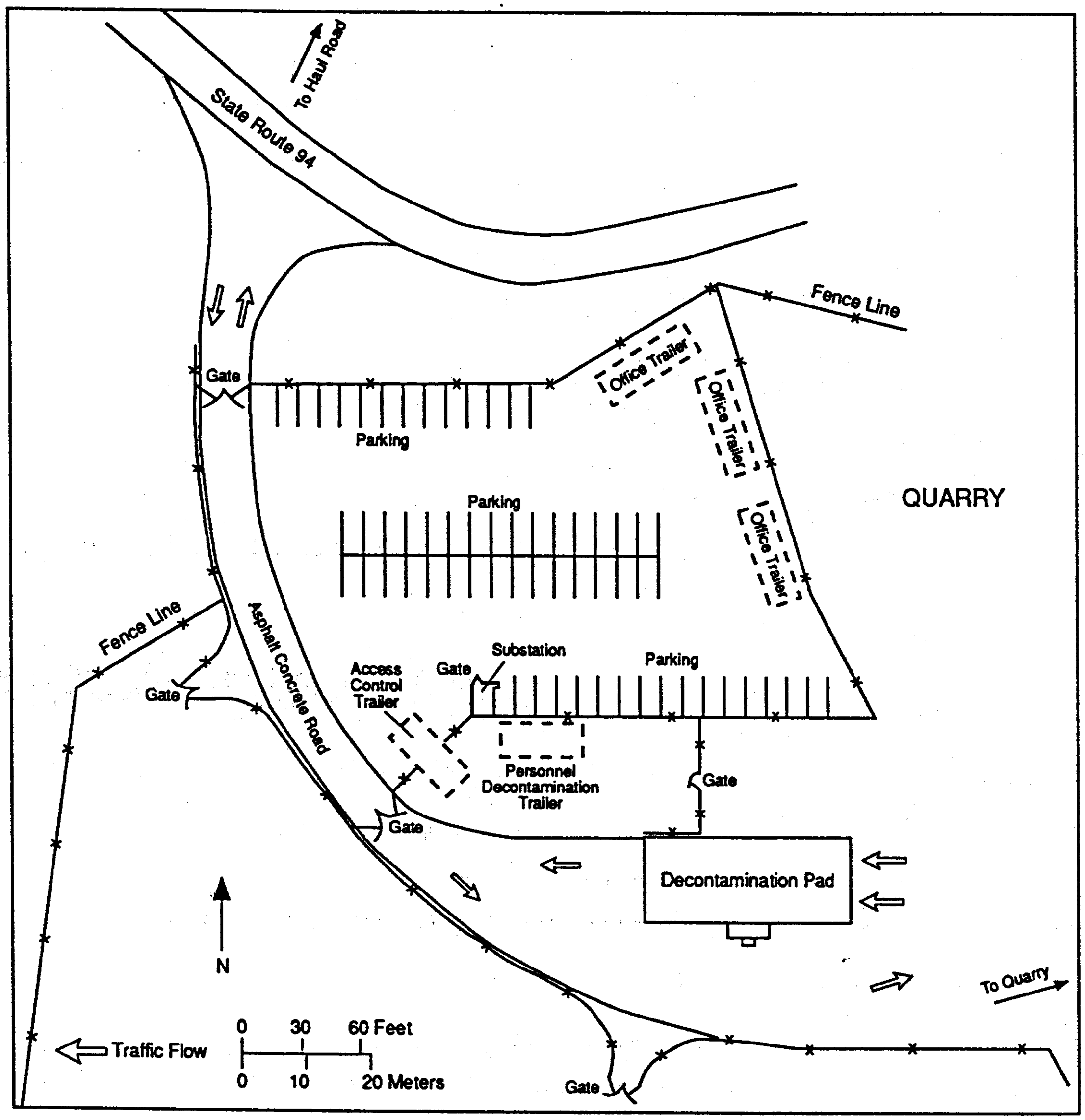

FIGURE 8.2 Details of the Proposed Support Area at the Quarry (Source: Modified from MK-Ferguson Company and Jacobs Engineering Group 1990b)

plant lowers the water level to the quarry floor, as expected, the preferred excavation method would be to utilize a backhoe capable of removing the bulk wastes in a single pass. Approximately 90% of the excavation would be conducted in cuts varying from 3 to 12 m (10 to 40 ft) in depth. A large hydraulic backhoe excavator would be used to remove wastes from depths of 12 m (40 ft) using a 19-m (61-ft) hoe reach, sufficient power, and a large bucket. It is anticipated that the wastes would be excavated to bedrock in three phases, as shown in Figure 8.3. The excavated wastes would be cast directly behind the excavator, where more room would be available for gross sorting, based on physical characteristics, and loading on haul trucks. Two front-end loaders of 2.3- to 3.8-m^3 (3- to 5-yd^3) capacity would be used for sorting, a 3.8-m^3 (5-yd^3) front-end loader would be used for truck loading, and a hydraulic crane of 9- to 14-t (10- to 15-ton) capacity would be used for removing, stacking, and loading structural plates and

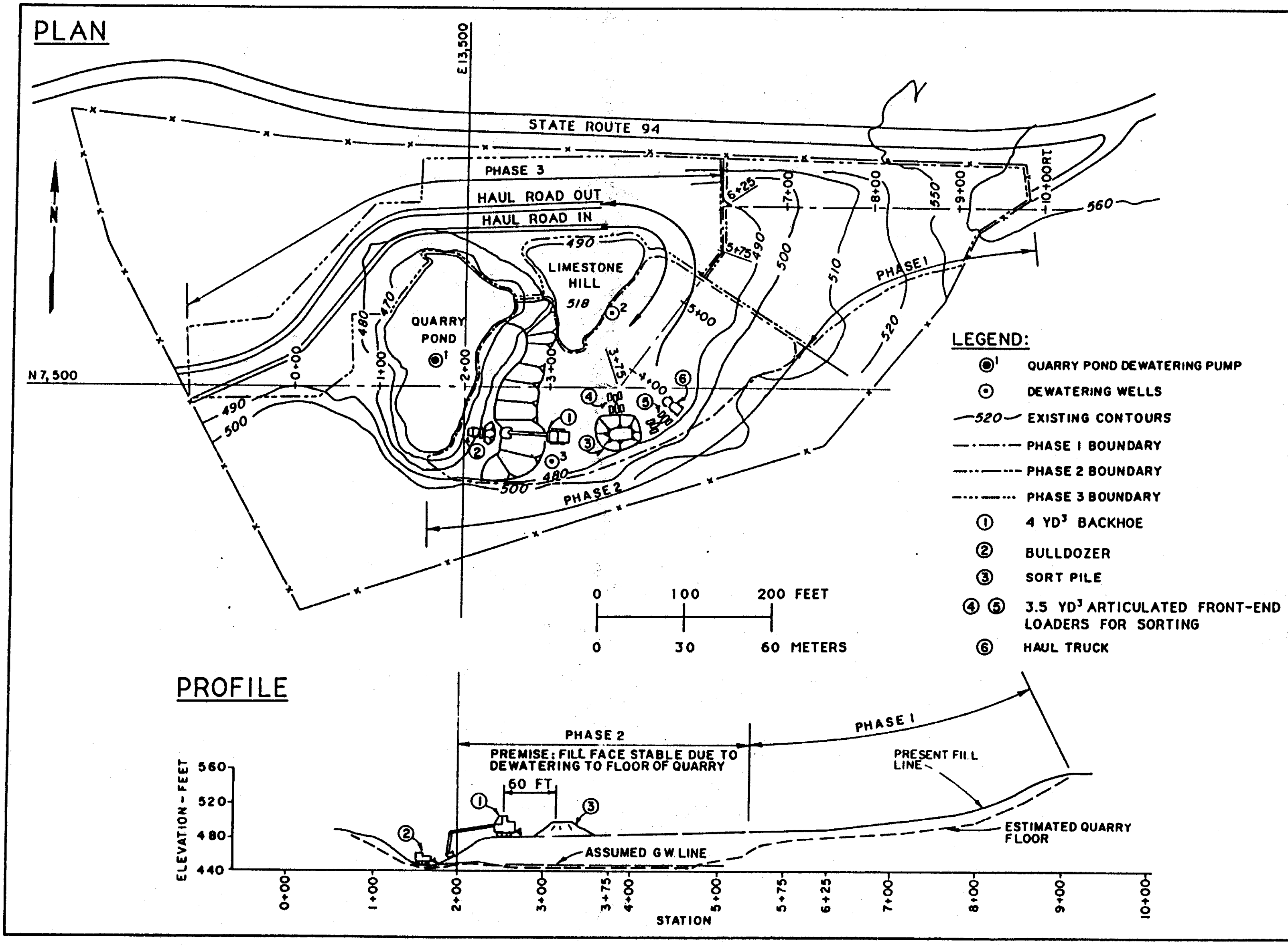

FIGURE 8.3 Proposed Approach for Bulk Waste Excavation (Source: Modified from MK-Ferguson Company and Jacobs Engineering Group 1990b)

pieces. Also, a bulldozer would be operated on the quarry floor to feed wastes to the backhoe (see Figure 8.3). Preliminary gross sorting of wastes and a rough washdown of metal and structural debris would be carried out at the quarry, as space and logistics allowed. After transport to the TSA, the wastes would be further segregated, as necessary.

If the water table was only partially or slowly lowered, a second excavation option would be implemented using a two-or-more-stage program with bench development. This variation would allow excavation along the upper bench as the lower bench continued to be dewatered. In this case, equipment with less reach and power than the large, long-reach backhoe could be employed. Lifts of approximately 6 m (20 ft) maximum could be excavated using a hydraulic backhoe excavator equipped with a hoe capable of digging to a depth of 11 m (35 ft).

As a third option, a dragline approach would be implemented if dewatering of the quarry was inadequate. The dragline equipment would work the face to its full depth in one pass but would remain approximately 27 m (90 ft) back from the toe of the face. A dragline excavator equipped with a 38-m (125-ft) boom and a 3.8-m^3 (5-yd^3) bucket would be used for this excavation method.

These excavation options illustrate how the bulk wastes could be removed with conventional equipment, using the observational method. Details on removal and specific equipment selection will be provided in technical support documents for this action, including the conceptual design and final design reports.

If necessary, the floor of the quarry could be trenched to promote drainage to the quarry pond; collected water would be treated in the quarry water treatment plant. It is anticipated that the drainage trenches could be excavated, without blasting, using a small backhoe in the shale and limestone quarry floor and benches. Easily removable, quick-setting impervious grout bridges could be placed on the surface of the fractured areas to direct drainage to the dewatering sump. All loose materials on the quarry floor that could be removed using conventional equipment would be removed. Some loose materials would be removed manually from cracks and crevices (i.e., with smaller excavation tools). As the bulk wastes were removed, initial cleanup of the walls would be limited to scraping by the excavation equipment. The walls would then be washed with high-pressure water to remove any remaining loose materials.

Exposure of the quarry walls and floor during and after bulk waste removal could result in contaminant migration into the subsurface. Activities such as continuous dewatering (by operating the water treatment plant) and selected surface grouting would minimize any potential for contaminants to migrate from the quarry via groundwater. Additional mitigative measures would be implemented, as appropriate. For example, if significant groundwater contamination was detected in monitoring wells, a control strategy such as capture wells or interceptor trenches could be used.

Groundwater, surface water, and air would be monitored in and adjacent to the quarry during bulk waste excavation activities. Monitoring locations are shown in Figures 8.4 through 8.6. Groundwater would be monitored for total uranium and nitroaromatic compounds, every other month north of the slough and quarterly south of the

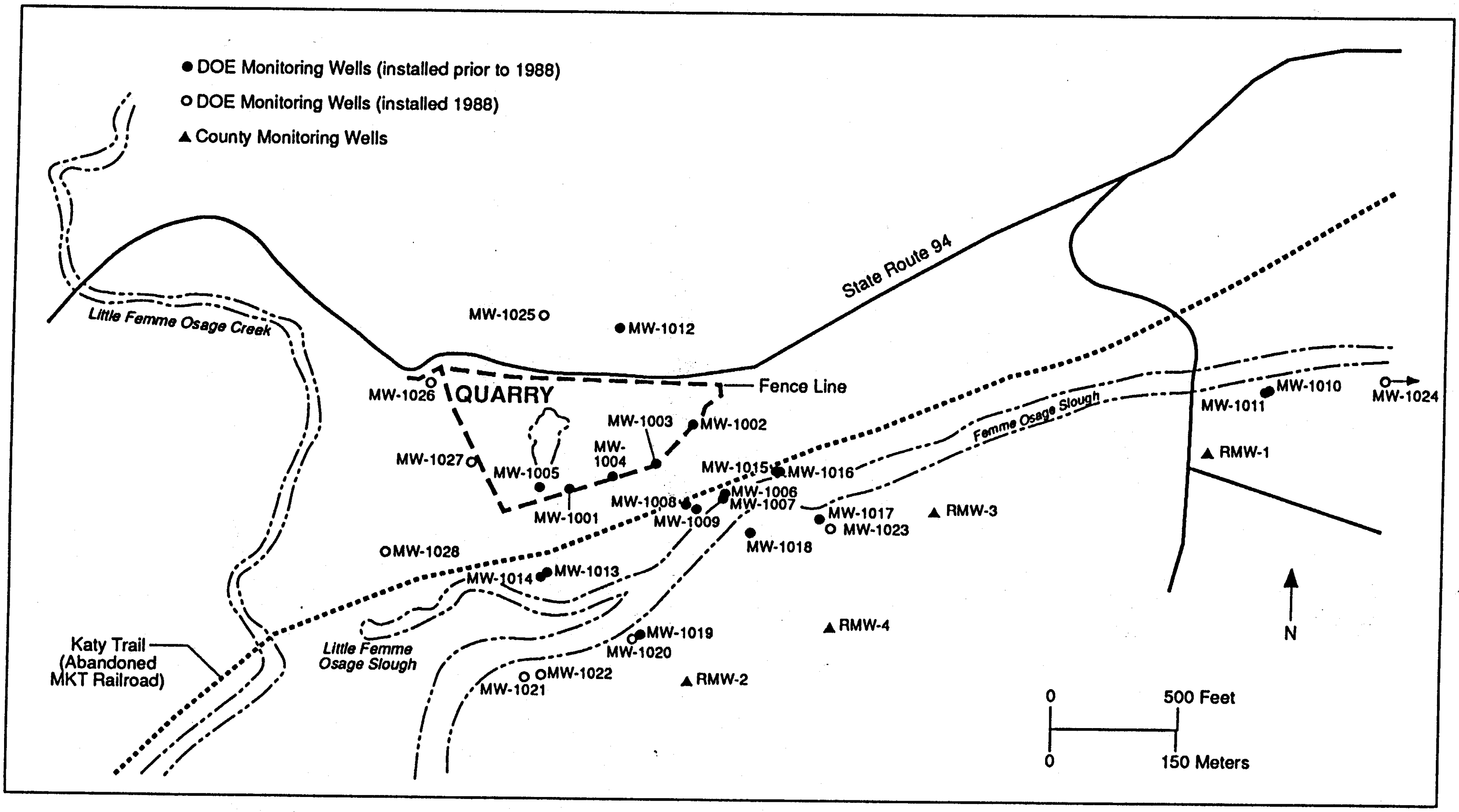

FIGURE 8.4 Groundwater Monitoring Locations at the Quarry (Source: Modified from DOE 1988a)

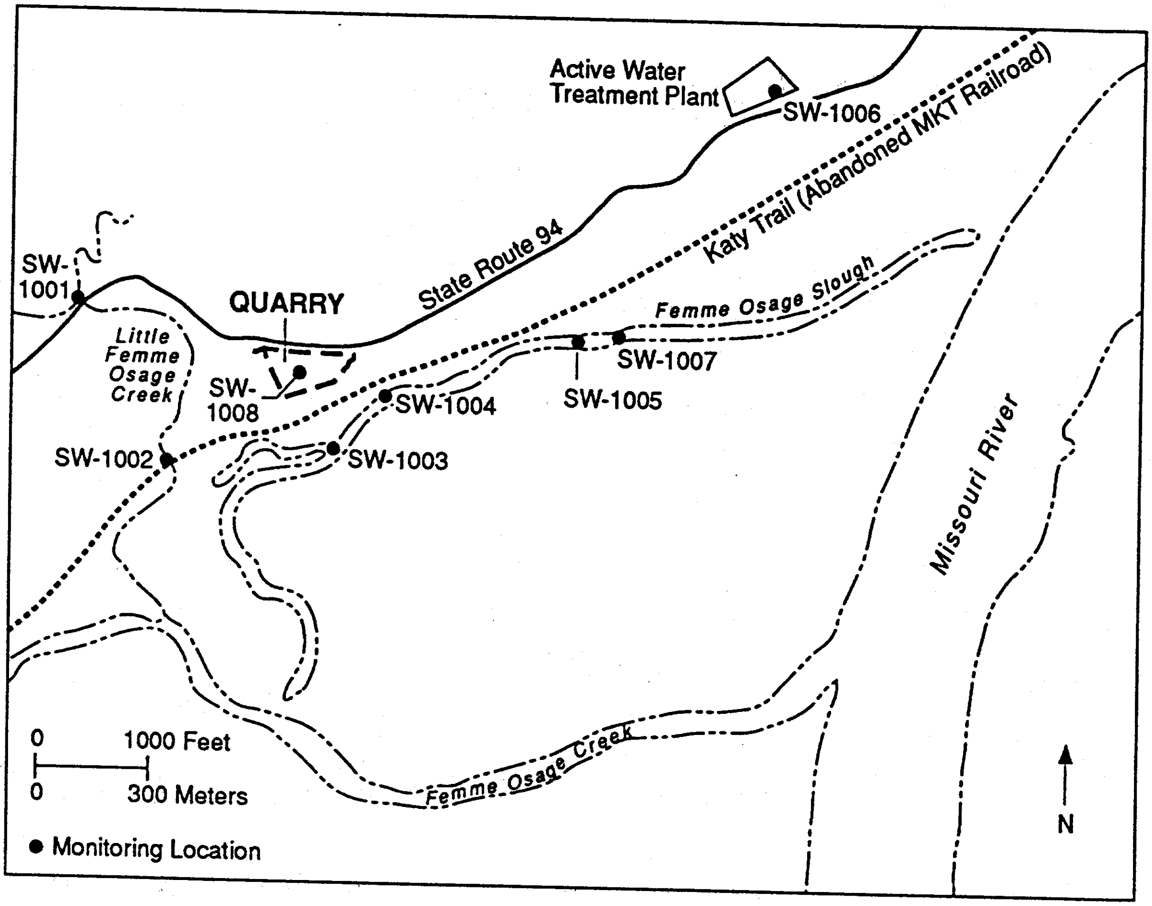

FIGURE 8.5 Surface Water Monitoring Locations near the Quarry (location SW-1008 would not exist following removal of water from the quarry pond)

slough, to detect any movement of contaminants away from the quarry. In addition, groundwater would be sampled annually for thorium-232, thorium-230, radium-226, volatile organic compounds, PCBs, and metals. Groundwater levels would be measured monthly. Surface water would be monitored quarterly for total uranium. Air would be monitored continuously to detect contaminants released from the quarry and during work hours to permit identification of the need to control worker exposures. Airborne particulates would be sampled at the working face in the quarry. Particulate samples would be analyzed routinely for gross alpha activity and periodically for uranium-238, uranium-234, thorium-232, thorium-230, thorium-228, radium-226, radium-224, and polonium-210. In addition to the the fixed air monitoring locations shown in Figure 8.6, several mobile units would be used to monitor airborne contaminants as the excavation proceeded. Monitoring at the working face would include sampling for volatile organic compounds and explosive gases. Samples would be analyzed for nitroaromatic compounds during excavation of areas suspected of containing nitroaromatics, e.g., at the northeast corner of the quarry. If asbestos-containing material was suspected or identified, the working face would be monitored daily. Additional fence-line monitoring would be performed if excessive levels of any contaminants were detected in the work area. Radon and radon decay product concentrations would be measured hourly at the quarry fence and in the work area. Additional details on the monitoring program, including

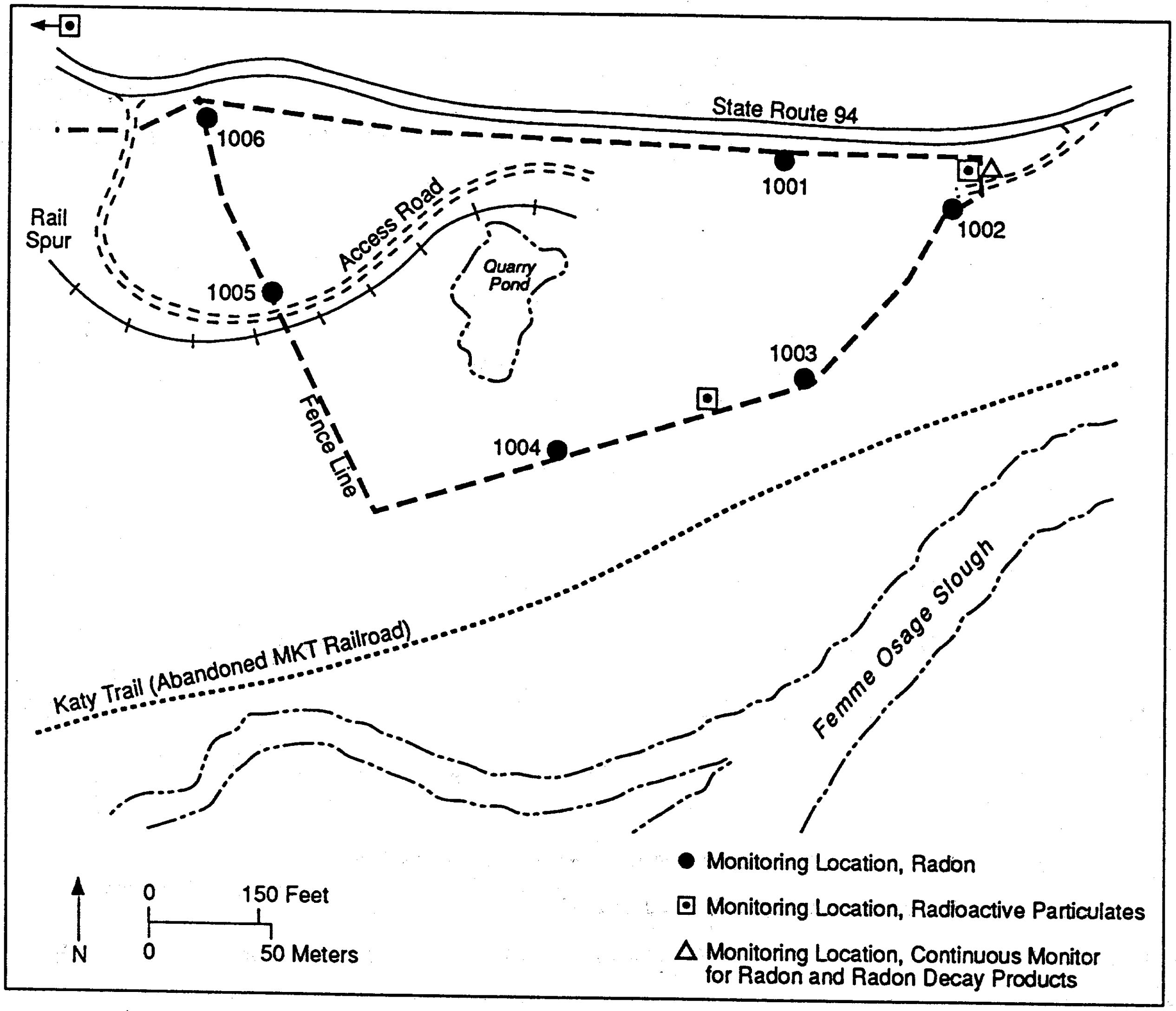

FIGURE 8.6 Air Monitoring Locations at the Quarry

frequencies and techniques, are provided in the operational environmental, safety, and health plan being prepared for the bulk waste remedial action.

During bulk waste removal activities, mitigative measures would be implemented to ensure compliance with DOE's process for keeping exposures of workers and the general public to levels that are as low as reasonably achievable. For example, to minimize the potential for temporary increases in the amounts of radioactive and chemical contaminants released to the environment, the extent of the exposed work area would be limited and dust generation would be mitigated by wetting and covering surfaces, as appropriate. Radon releases would be controlled, as necessary, by covering radium-contaminated areas with flexible-membrane liners, which have been demonstrated to be very effective in such applications. Even without covers, the rate of radon release is expected to decrease as the source is removed from the quarry (MK-Ferguson Company and Jacobs Engineering Group 1990a). Workers within the quarry would use respiratory protective equipment, as appropriate, to minimize the potential for inhaling contaminants during excavation activities.

8.3 BULK WASTE HAULING

The bulk wastes would be transported from the quarry to the TSA in compliance with applicable federal and state regulations. All contaminated materials would be transported in covered, tightly sealed, leakproof trucks meeting U.S. Department of Transportation (DOT) requirements for strong, tight containers to transport low-specific-activity (LSA) materials (see Appendix C). The preferred route would be a new, dedicated haul road; alternate routes are the old farm road route, the railroad easement (the railroad itself is in a state of disrepair and not usable), and State Route 94 (Figure 8.7). The proposed haul road would leave the quarry along the route of the existing rail spur. The segment of road through the support area at the quarry would be paved with asphalt; the remainder of the road would be surfaced with gravel. After crossing State Route 94, the haul road would follow the railroad easement west of Route 94. At the point at which the railroad crosses Route 94 a second time, the haul road would leave the easement and parallel the highway until the railroad crosses Route 94 a third time, where the road would again follow the railroad easement to enter the chemical plant area. The railroad easement is owned by DOE; the balance of the route belongs to the state of Missouri. Use of state-owned land is being negotiated with the state of Missouri, and agreement would be obtained prior to construction of the haul road.

The proposed haul road through the quarry support area would generally be a two-lane, two-way road (see Figure 8.2), as would the segment between the TSA and State Route 94; the balance of the road would be one lane with turnouts. The total haul distance from the quarry entrance to the TSA would be about 5.4 km (3.4 mi). Empty trucks would be decontaminated adjacent to the TSA and would then proceed to State Route 94 along the two-lane haul road segment and return to the quarry using State Route 94. Trucks would enter the quarry along the same road used for exiting vehicles. Contingency plans would be developed or modified, as necessary, for responding to any transportation-related spills or accidents. All wastes would be handled in accordance with DOE's waste management plan for the site (MK-Ferguson Company and Jacobs Engineering Group 1989b).

Prior to construction, the haul route would be cleared and grubbed to a width of 10 m (30 ft). Use of the railroad easement as a one-lane gravel haul road would require (1) removing old rails and ties, (2) repairing washed-out culverts and failed embankments, (3) removing fill material to provide an adequate width, minimum 4 m (12 ft), and (4) adding base and aggregate surface materials to construct the haul road. During road construction and operation, good management practices would be used to control erosion. Construction materials would be obtained from local sources. Gates would be placed on the haul road at the crossing of State Route 94 near the quarry so that the road could not be used by unauthorized vehicles. Traffic would be directed by flagpersons or signals where the haul road crosses Route 94. Alternatives to provide for grade separation at the crossing are currently being evaluated.

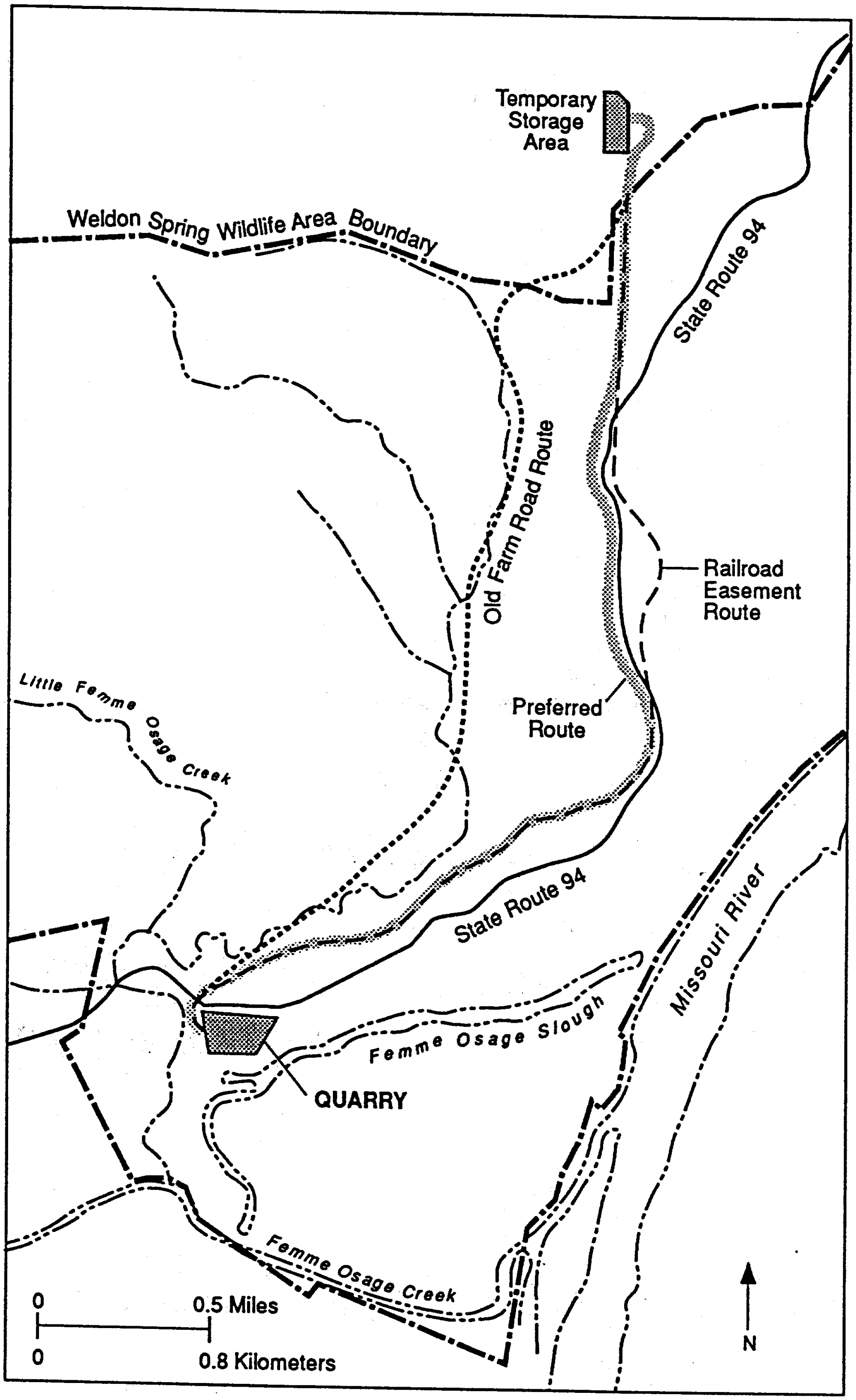

FIGURE 8.7 Preferred and Alternate Haul Routes to the TSA

Dust generated during construction and hauling activities would be controlled by either a truck-mounted water sprinkler or chemical dust suppressant. The speed of loaded haul trucks would be limited to 32 km/h (20 mph). Road construction would occur for about 16 weeks prior to bulk waste removal. While in use, the haul road would be graded regularly and repaired as needed to provide a good roadbed. During operation, the haul road and State Route 94 would be routinely surveyed for radioactive contamination using portable instruments; if any contamination was found, the contaminated areas would be decontaminated. Following completion of the bulk waste remedial action, the haul road would be surveyed for contamination, decontaminated if necessary, and then transferred to the state of Missouri for its use.

One alternative to the preferred route would be to use State Route 94 for both transporting the wastes from the quarry to the TSA and returning the empty trucks to the quarry. The one-way haul distance would be 6.0 km (3.7 mi). This alternative would require (1) constructing an access road into the quarry from State Route 94, (2) modifying Route 94 at both the quarry and chemical plant area exits to accommodate truck traffic, (3) upgrading an existing gravel road connecting Route 94 and the railroad easement at the chemical plant area, and (4) constructing a road along the railroad easement. Use of State Route 94 would require less construction activity than the preferred alternative, resulting in less environmental disruption, but is expected to involve a higher risk of accidents for trucks loaded with waste materials.

A second alternative to the preferred route would be to construct a road that would follow the existing railroad easement in its entirety; this would allow two-way use (with turnouts) or one-way use with a return on State Route 94. Use of the railroad easement would involve trucks crossing Route 94 three times between the quarry and the TSA. The total one-way haul distance would be 5.6 km (3.5 mi). Use of only the easement would result in less environmental disruption associated with construction than would use of the preferred route, but the risk of accidents would be higher because Route 94 would be crossed three times during each trip from the quarry.

As a third alternative to the preferred route, a haul road could be constructed that would generally follow the route of an existing unpaved farm road located west of State Route 94 (Figure 8.7). This route could also enter the chemical plant area along the railroad easement. The total one-way haul distance would be 5.3 km (3.3 mi). Only one crossing of State Route 94 would be required, so the potential for accidents would be similar to that for the preferred route. However, environmental impacts associated with construction on the farm road route would be considerably higher than for the preferred route. Much of the route would be located in a previously undeveloped area, and the route would require a number of stream crossings. In addition, portions of the area on or near the farm road route are currently used for agriculture.

Trucks with a capacity of 8 to 11 m^3 (10 to 15 yd^3) would be used to haul the bulk wastes. These trucks would be leakproof (including any tailgate), and would be covered and tightly sealed to meet DOT requirements for transporting LSA materials. Assuming a nominal 9-m^3 (12-yd^3) load, it is estimated that 10 trucks, each making 4 trips per day for 65 weeks (5-day week; 10% downtime for inclement weather), would be needed to transport 110,000 m^3 (140,000 yd^3) of materials from the quarry to the TSA. This estimated volume includes materials resulting from clearing and grubbing, uncontaminated materials, and the bulk wastes; it also includes an expected expansion of the wastes following removal, plus a 15% contingency factor.

After being loaded at the quarry, trucks would pass through an adjacent surveying and decontamination area. Vehicles would be inspected for leakage and washed with high-pressure water over a sloped, concrete decontamination pad (Figure 8.2) to remove any loose contamination. If high-pressure water was inadequate to decontaminate a vehicle, an alternate approach -- such as hot water or steam -- would be used. The vehicles would be surveyed for radioactive contamination prior to leaving the quarry area, and the decontamination pad would be washed after each use. The wash water would be collected and treated in the water treatment facility constructed to treat contaminated surface water from the quarry pond (see MacDonell et al. 1989). Water would be provided to the quarry from a water main located about 580 m (1,900 ft) west of the quarry; a 10-cm (4-in.) pipe would connect to the main.

8.4 BULK WASTE SEGREGATION AND TEMPORARY STORAGE

An engineered storage facility would be constructed at the chemical plant area to allow sorting, characterization, and storage of the bulk wastes excavated from the quarry. The TSA would contain a receiving pad for sorting the bulk wastes according to their physical properties. Eight separate subareas would be constructed at the TSA to store the segregated wastes (including sludges), and two double-lined collection ponds would be constructed to collect rainfall runoff from the TSA and any leachate generated by the stored wastes. Details of the TSA are provided in Section 8.4.1. A decontamination pad for cleaning haul trucks before they leave the chemical plant area would be constructed adjacent to the TSA. Temporary covers would be placed over those wastes susceptible to wind erosion both at night and as needed during operations at the TSA. After the bulk waste remedial action was completed, the stored materials would be covered and monitored pending the decision on their ultimate disposition.

The proposed action does not address final disposal of the bulk wastes after their placement in the TSA. Final disposal of these wastes will be included as part of the overall remedial action for the Weldon Spring site and will be addressed in the RI/FS-EIS for the site (currently in preparation). Use of the TSA is part of an interim remedial action to allow the consolidation, characterization, and control of wastes in one area and the initiation of activities necessary to address comprehensive quarry remediation. Thus, the bulk wastes would be handled again for final disposal. This double handling is required, independent of excavation timing, because the wastes must be sorted and characterized prior to finalizing ultimate management decisions. However, the total volume of wastes handled in the future would not increase significantly because the TSA would be lined for waste containment, which would prevent contaminants from migrating to areas away from the TSA.

The TSA would be specifically designed to contain the quarry bulk wastes and would not constitute a permanent disposal facility. It would be constructed outside the floodplain and above the seasonal high water table. The TSA would have a foundation and liner of sufficient strength and thickness to prevent failure due to pressure gradients, physical contact with wastes or leachate, climatic conditions, stress of installation, or stress of daily operations. The storage area would be constructed using conventional equipment during an estimated 12-week period prior to bulk waste removal. The TSA would be designed to meet the substantive storage facility requirements of the Solid Waste Disposal Act, as amended (see Appendix C). Design criteria are given in Table 4.1 of the preliminary engineering report (MK-Ferguson Company and Jacobs Engineering Group 1990b).

A portion of the approximately 7,600 m^3 (10,000 yd^3) of soils that would be excavated during preparation of the TSA would be radioactively and/or chemically contaminated. Residual radioactive contamination in the soils south of the raffinate pits probably resulted from equipment and debris placed there during the Army's decontamination of chemical plant buildings in the late 1960s. Chemical contamination is related to the past production of explosives and uranium processing. Uncontaminated soils excavated at the TSA could be used during preparation of the storage area, e.g., for leveling or other construction purposes, as appropriate. The contaminated materials would be placed in the TSA. The total volume of contaminated materials excavated during preparation of the TSA would be small compared with the volume of wastes from the quarry and would not significantly affect storage requirements of the TSA. Following the storage period, the quarry bulk wastes would be removed from the TSA for final disposal (i.e., pursuant to the ROD for the site RI/FS-EIS), and the TSA would be remediated with the remainder of the site.

Wastes are not expected to remain in the TSA for more than 10 years, although the storage period could be extended with minimal, if any, modifications. During the temporary storage period, the TSA would be visually inspected daily, and the facility would be maintained in good condition. The wastes would be covered, as appropriate, to minimize water infiltration, wind dispersion, and radon releases.

8.4.1 Design and Construction

The TSA would be located near the southwest corner of the chemical plant area (Figure 8.8). This location is on DOE property as far as possible from Francis Howell High School. The TSA would be located in space currently available that would not impact remedial action decisions for the site. The selected location would also provide for easy truck access, with minimum travel through the chemical plant area.

The TSA would be designed to store approximately 110,000 m^3 (140,000 yd^3) of excavated materials, which includes the quarry bulk wastes and contaminated materials from the quarry construction staging area. The design volume would also accommodate variations in the amounts of contaminated materials that might occur due to swelling upon excavation. The TSA would be composed of waste-specific subareas, and a contingency of at least 15% (based on engineering judgment) would be incorporated into the design for each subarea. The design volumes for the subareas are presented in Table 8.1. The layout and locations of the subareas are shown in Figure 8.9. Cross sections and details of the TSA are shown in Figures 8.10 through 8.14.

The storage subareas would be sized to accommodate the design volume of excavated wastes in each category. The stacking heights and the estimated requirements

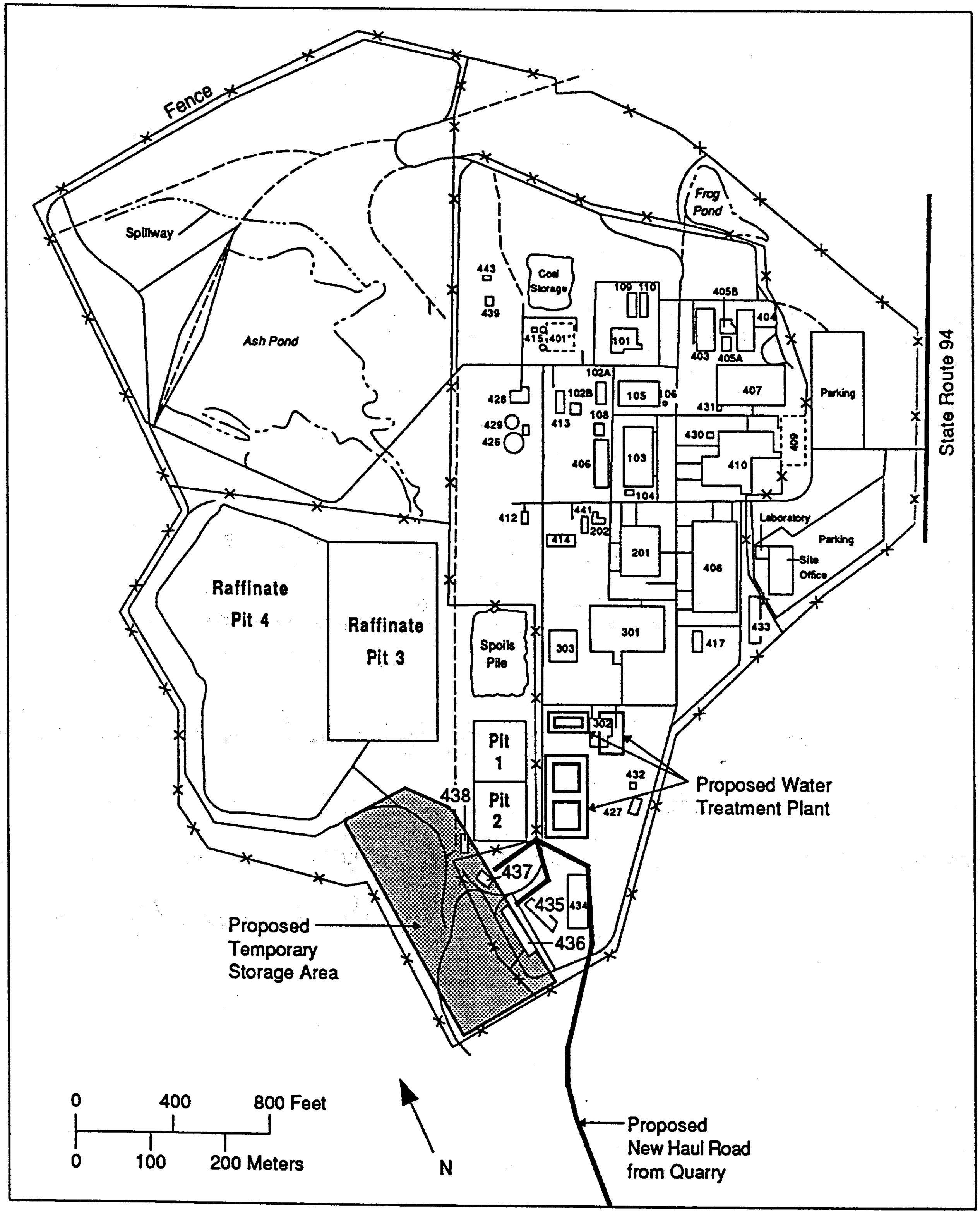

FIGURE 8.8 Proposed Location of the TSA (Source: Modified from MK-Ferguson Company and Jacobs Engineering Group 1990b)

TABLE 8.1 Segregation Scheme and Estimated Volumes of Wastes at the TSA[a]

Sub-area[b]	Category	In-Place Volume (yd^3)	Contingency Volume (yd^3)	Swell Factor (%)	Design Volume (yd^3)
A	Rock and concrete	36,200[c]	5,400	20	49,900
B	Fine-grained soils	44,700[d]	6,700	10	56,500
C	Sludge	4,100	600	2	4,800
D	Nitroaromatic-contaminated soils	7,000	1,000	10	8,800
E	Structural debris	5,000	800	20	7,000
F	Drums and miscellaneous metals (compacted)	500	80	20	700
G	Equipment and process vessels	5,000	800	10	6,400
H	Cleared and grubbed materials	5,300	800	2	6,200
Total		107,800	16,180		140,300

[a]Several thousand cubic yards of contaminated soil excavated during construction of the TSA would also be stored in the TSA. This volume is not included in the estimates in this table.

[b]See Figure 8.9 for the locations of these subareas.

[c]Includes 6,000 yd^3 for overexcavation.

[d]Includes 1,000 yd^3 for the staging area.

Source: Data from MK-Ferguson Company and Jacobs Engineering Group (1990b).

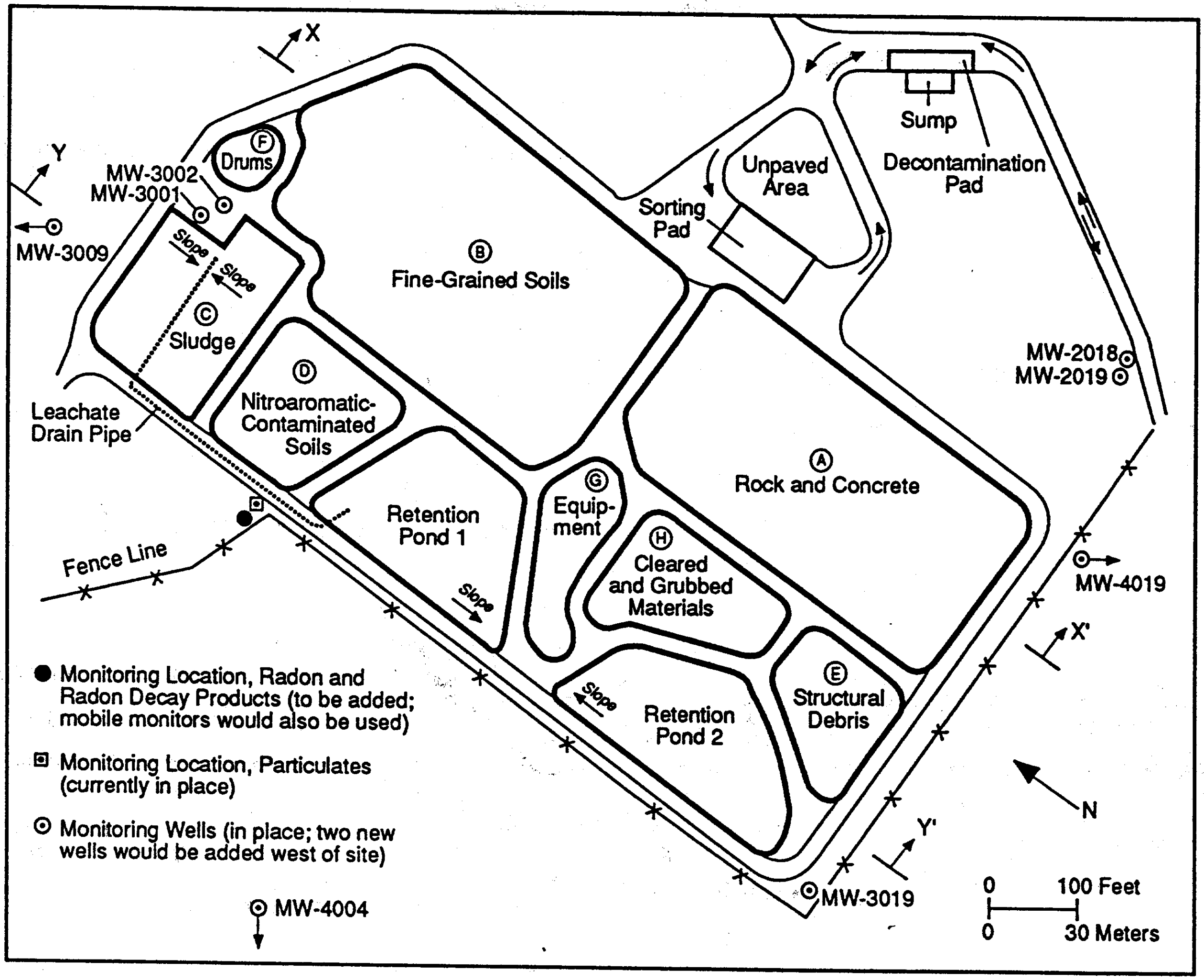

FIGURE 8.9 Conceptual Layout of the TSA (see Figures 8.10 and 8.11 for cross sections X-X' and Y-Y') (Source: Modified from MK-Ferguson Company and Jacobs Engineering Group 1990b)

for base areas based on these stacking heights are given in Table 8.2. Additional storage capacity could be obtained by stacking to a height of up to 6 m (20 ft). If the quantity of a given category exceeded the contingency, excess material would be stored in a different subarea, separated from the other wastes by geotextile fabric. All wastes would be managed in accordance with DOE's waste management plan for the site (MK-Ferguson Company and Jacobs Engineering Group 1989b).

The foundation of the TSA would consist of a 10-cm (4-in.) thick asphalt-concrete surface underlain by an aggregate base and a 30-cm (12-in.) thick layer of recompacted clay (Figure 8.14). The recompacted clay would have a maximum permeability of 1×10^{-7} cm/s. The sludge subarea would include a double liner and an underdrain/leachate collection system (Figure 8.12). Accessways to the storage areas would be 6 m (20 ft) wide and crowned to direct runoff to adjacent drainage swales (Figure 8.14). The storm-water runoff and drainage system would be designed for a 25-year, 24-hour storm of approximately 14 cm (5.7 in.) of rainfall.

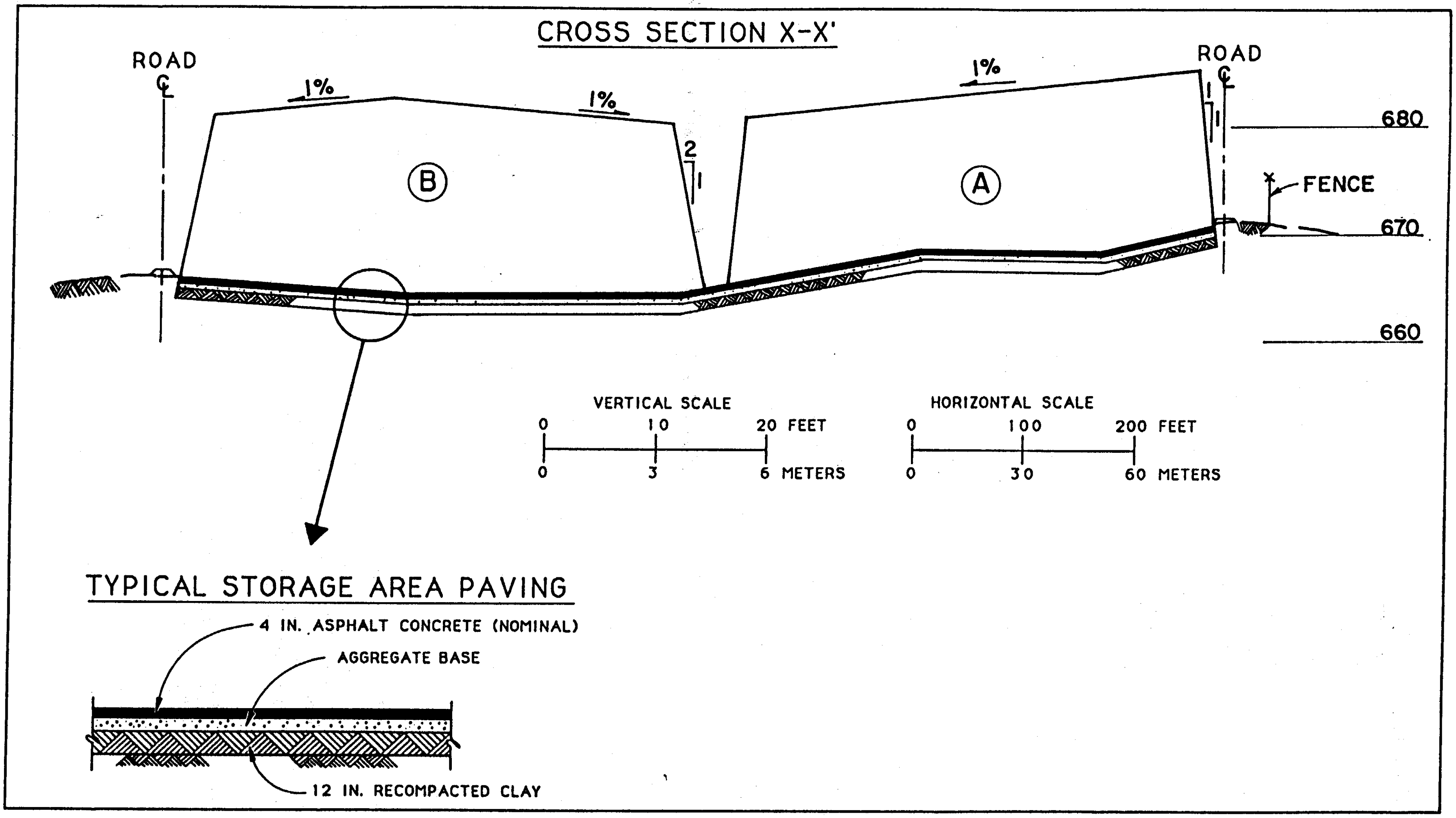

FIGURE 8.10 Cross Section X-X' of the TSA (Source: Modified from MK-Ferguson Company and Jacobs Engineering Group 1990b)

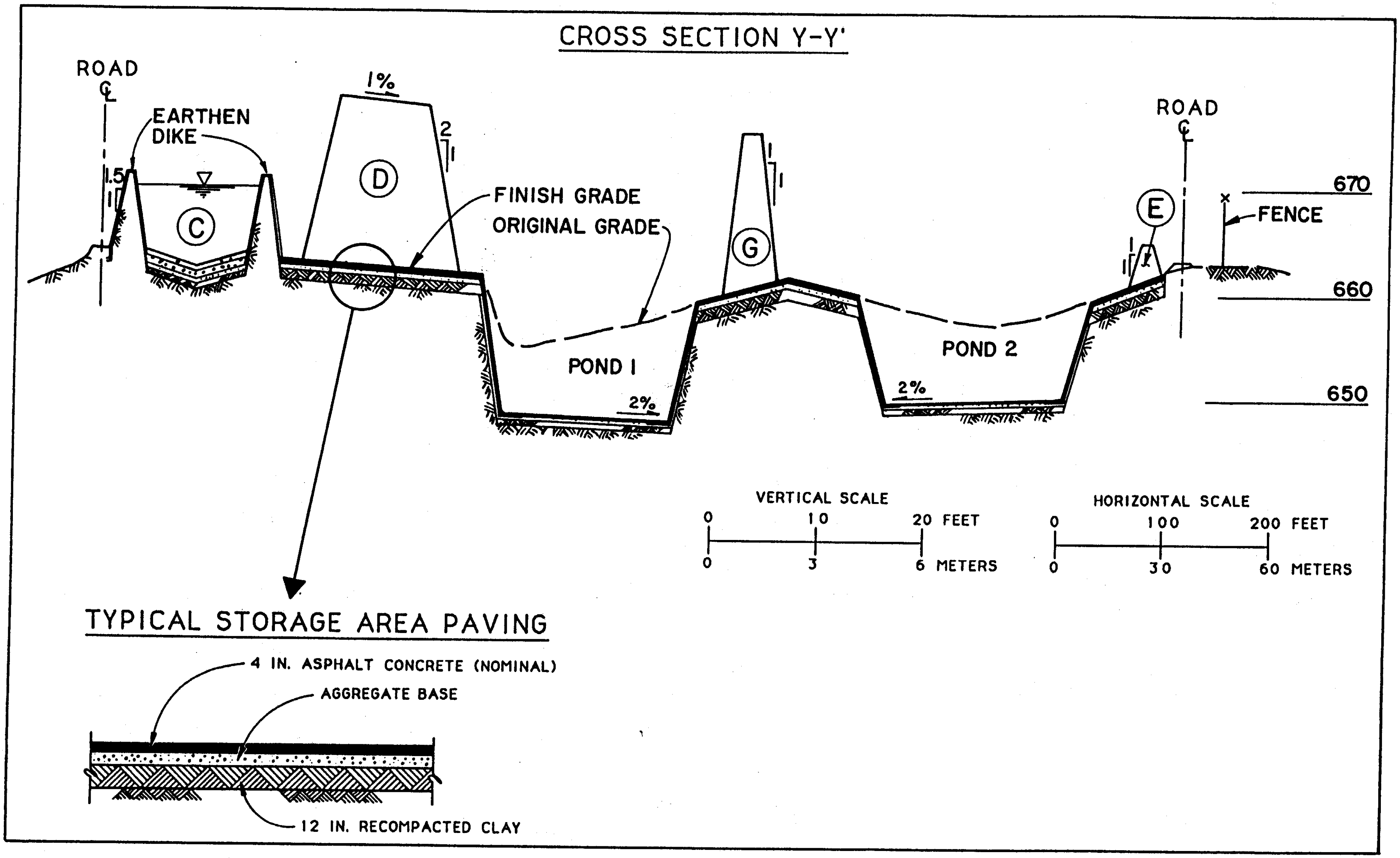

FIGURE 8.11 Cross Section Y-Y' of the TSA (see Figures 8.12 and 8.13 for cross sections of the sludge pond (C) and ponds 1 and 2) (Source: Modified from MK-Ferguson Company and Jacobs Engineering Group 1990b)

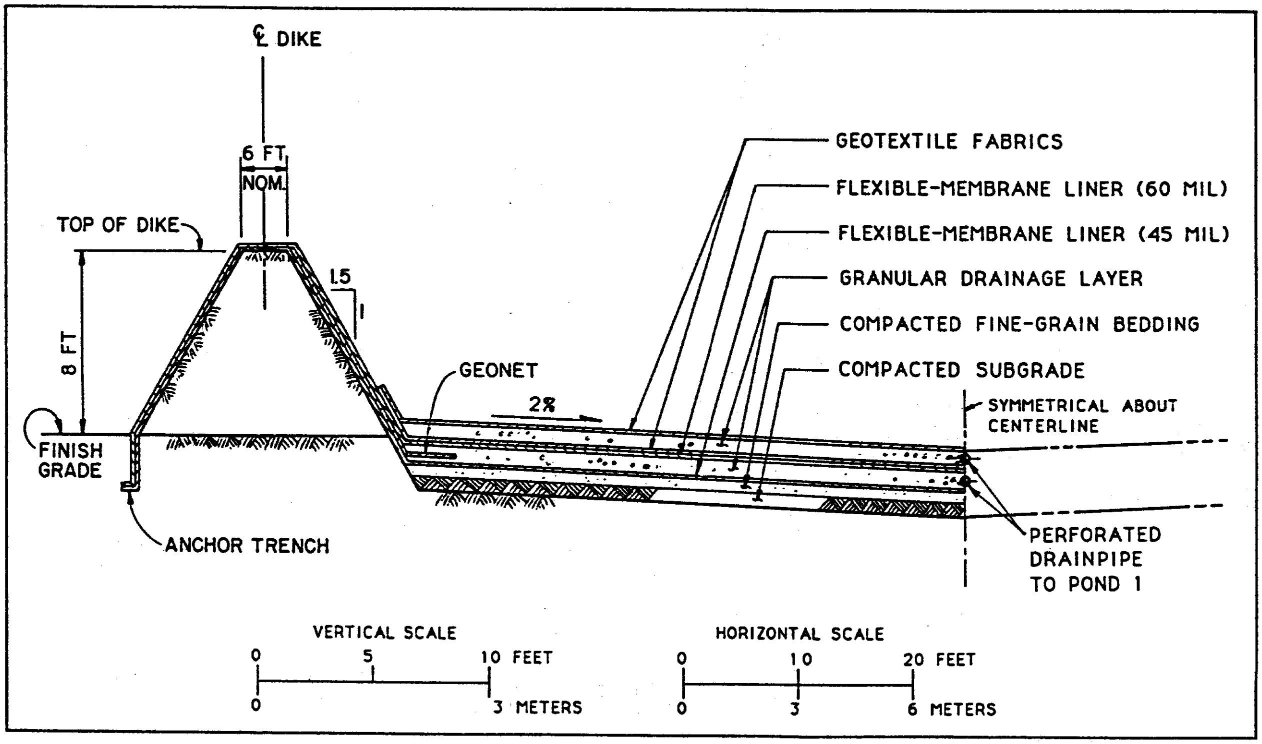

FIGURE 8.12 Typical Cross Section of the Sludge Pond (Source: Modified from MK-Ferguson Company and Jacobs Engineering Group 1990b)

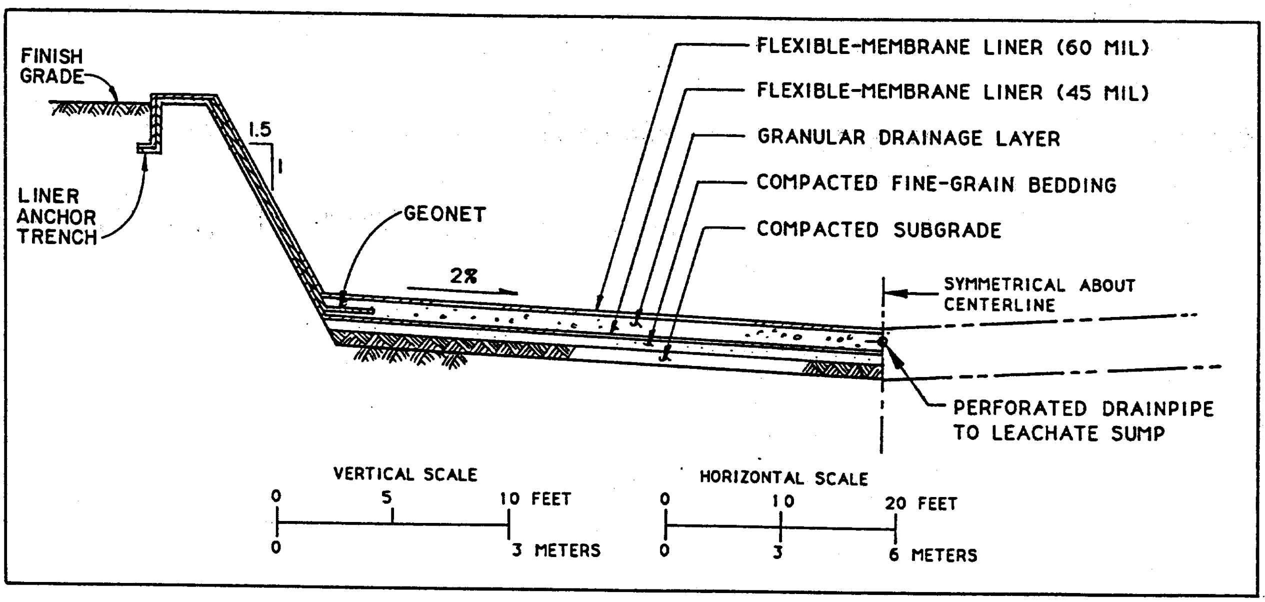

FIGURE 8.13 Typical Cross Section of Ponds 1 and 2 (Source: Modified from MK-Ferguson Company and Jacobs Engineering Group 1990b)

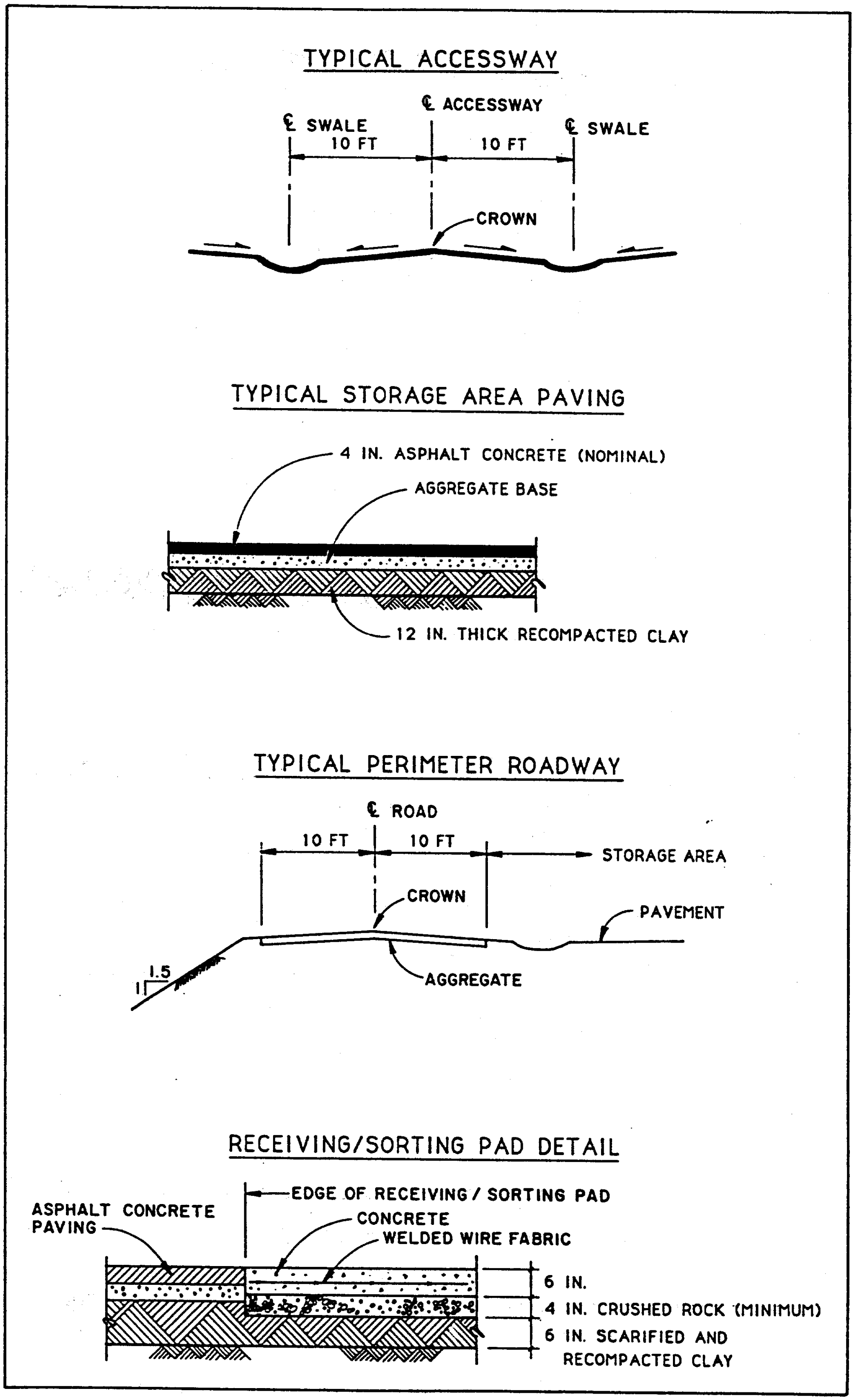

FIGURE 8.14 Details of the TSA (Source: Modified from MK-Ferguson Company and Jacobs Engineering Group 1990b)

TABLE 8.2 Waste Storage Areas at the TSA

Subarea[a]	Nominal Stack Height (ft)	Maximum Side Slope[b] (V:H)	Required Base Area (ft^2)
A	15	1:1	99,400
B	15	1:2	122,140
C[c]	8	1:1.5	25,270
D	15	1:2	23,870
E	15	1:1	16,200
F	15	1:1	2,350
G	15	1:1	14,960
H	15	1:2	17,870

[a]See Figure 8.9 for the locations of these subareas. A receiving/sorting area with a 6,000-ft^2 base area is also required.

[b]V:H = vertical to horizontal.

[c]Including a dike.

Source: Data from MK-Ferguson Company and Jacobs Engineering Group (1990b).

The TSA would be designed to utilize the natural topography of the area. Stormwater runoff and any leachate from the storage subareas would be directed to two double-lined collection ponds. The ponds would have leachate collection systems (Figure 8.13) and would be sized to accommodate the 25-year, 24-hour design storm, with 30 cm (12 in.) of freeboard. Collected water would be removed and treated at the water treatment plant for the chemical plant area, which would be located near the raffinate pits (Figure 8.8). Surface water runon would be controlled by diversion ditches.

The sorting pad at the TSA would consist of a 15-cm (6-in.) reinforced concrete pad underlain by 10 cm (4 in.) of crushed rock and at least 15 cm (6 in.) of recompacted clay. Details are provided in Figure 8.14. The decontamination pad adjacent to the TSA would be sloped to a sump, and wash water would be directed to the nearby water treatment plant. This wash water would be supplied by a nearby county water main.

Construction of the TSA would require the removal of four former chemical plant buildings that are currently used for storage -- i.e., Buildings 435, 436, 437, and 438 (see Figure 8.9). These building are described in Table 8.3. The buildings and other

TABLE 8.3 General Description of the Chemical Plant Buildings to be Removed for the TSA

Building	Structure	Past Use	Equipment Content
435	150-ft × 40-ft × 20-ft Butler building with prefabricated sheet metal panels and concrete floor	Store water-treatment chemicals and miscellaneous mechanical parts	Cabinets, work benches, tables, shelves, pallets, space heater, fume hoods, ovens, map stand, and various pieces of furniture and electrical, sampling and safety equipment
436	180-ft × 40-ft × 20-ft Butler building with steel frame and prefabricated panels and concrete floor; small restroom and enclosed office at south end	Store general items	Freezers, motors and machine parts, laboratory fixtures, pipe fittings, crates of cast metal, bins of firebrick, ladders, and various pieces of furniture
437	70-ft × 30-ft × 20-ft one-story brick structure with concrete foundation and floor and flat, built-up roof; seven rooms	Store documents (originally an ordnance works building)	Furnace, file cabinets, boxes of rock core, broken furniture, and other debris
438	100-ft × 40-ft × 16-ft Butler building, including 300-ft^2 × 10-ft office, with steel beam frame construction, prefabricated steel panels, and concrete foundation and floor	Store general items (originally a construction-support building)	Process hoppers, electrical equipment, boxed insulation, file cabinets, office furniture, and scale models of chemical plant buildings

ancillary facilities would be dismantled using standard demolition procedures similar to those used to date for other building dismantling activities at the site.

Additional items that would have to be relocated or removed are stockpiled road materials; fencing; inactive water utilities; a septic tank; a decontamination pad; abandoned sewer lines; an active electrical line; one groundwater monitoring well; and two active water lines (one 75 cm [30 in.] in diameter and one 30 cm [12 in.] in diameter). A new groundwater monitoring well would be installed adjacent to the TSA. These structures and facilities are described in the TSA characterization report (see Figure 3-2 of MK-Ferguson Company and Jacobs Engineering Group [1990c] for the locations of these items). All of the removed materials would be placed in a material staging area in the northern portion of the chemical plant area for controlled storage pending a decision on the ultimate fate of the site.

All topsoil and radioactively and chemically contaminated surface soils would be stripped and placed in a spoils area; the total volume is expected to be about 7,600 m^3 (10,000 yd^3). Following construction of the TSA, the contaminated soils would be placed inside the TSA.

The TSA would be constructed in several steps. First, the entire TSA footprint would be rough-graded; then compacted fill would be placed in 15-cm (6-in.) lifts and the lifts compacted. A preliminary grading plan is shown in Figure 8.15. Following this step, the top 30 cm (12 in.) of soil in nonfill areas would be scarified and the entire TSA would be finish-graded. Compacted earthen dikes for the sludge subarea would be constructed in 15-cm (6-in.) compacted lifts. The flexible membrane liners and leachate collection systems for the retention basins and sludge subarea would then be installed. The aggregate base for the asphalt concrete paving would be placed, and finally the TSA would be paved with plant-mix asphalt concrete. Aggregate and asphalt used for construction would be obtained from local sources. Dust generated during construction of the TSA would be controlled by either a truck-mounted water sprinkler or chemical dust suppressant. Sediment released during construction would be collected in the retention ponds.

8.4.2 Operations

Materials excavated from the quarry would be sorted and classified according to physical properties, based on visual inspection. Excavated soils would be transported directly to the TSA and stored in the appropriate subarea. Some excavated materials might be presorted at the quarry (with a rough washdown of metal and structural wastes), and trucks containing a single category of waste would be directed to the appropriate subarea at the TSA to unload. This would minimize handling of the materials at the TSA. Haul trucks would enter the southern end of the chemical plant area near the railroad easement and proceed to the TSA receiving/sorting area to unload their contents. The materials would then be sorted at the TSA, and some structural steel could be washed. Wash water would be directed to the adjacent water treatment facility. Any intact drums would be overpacked at the quarry and then placed in a designated drum storage area adjacent to the TSA. The drum storage area is located in an existing building that has been specifically modified for storage and characterization

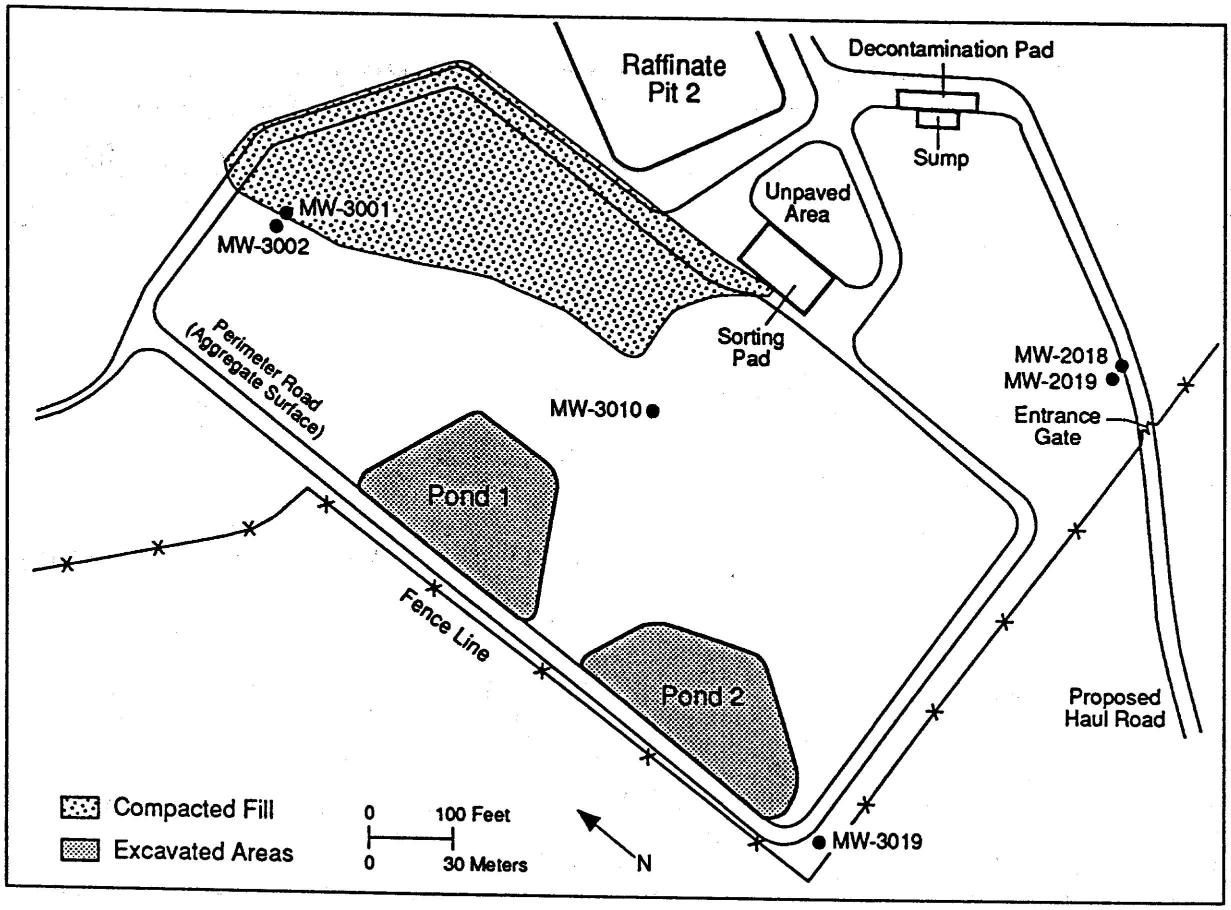

FIGURE 8.15 Grading and Paving Plan for the TSA (Source: Modified from MK-Ferguson Company and Jacobs Engineering Group 1990b)

of drummed wastes. The overpacked drums would be held at this facility pending a decision regarding their ultimate disposition. This decision will be defined in the ROD for the Weldon Spring site following completion of the RI/FS-EIS.

Prior to leaving the chemical plant area, vehicles would be cleaned on a sloped pad at the decontamination facility; truck bottoms and tires would be washed using high-pressure water supplied from an existing, nearby water main connected to the St. Charles County Water Plant Number 1. If necessary, additional measures such as hot water or steam would be used for cleaning. The trucks would be scanned for radioactive contamination before leaving the area, and the decontamination pad would be washed following each use. Wash water would be directed to the adjacent water treatment plant.

The primary equipment used to sort and transport materials at the TSA would be rubber-tired front-end loaders. This equipment is expected to be the most efficient and cause the least damage to the asphalt-concrete surface. Additional equipment would be used for stacking the various wastes to the required height in each subarea. Bulk waste piles would be constructed with stable side slopes. The fine-grained soil piles would be sloped to facilitate drainage.

During operations at the TSA, dust would be controlled by a truck-mounted water sprinkler or chemical dust suppressant. To minimize wind and water dispersal and radon emissions, a temporary weighted cover would be placed over the waste piles susceptible to wind erosion both at night and as needed, e.g., during high winds. The cover would be designed to reduce radon emissions from the wastes by at least a factor of 10 and to ensure compliance with applicable standards for radon emissions. Workers at the TSA would use respiratory protective equipment, as appropriate, to protect against inhalation of contaminated materials. When a section of a subarea pile was completed, a more permanent cover (such as a flexible-membrane liner) would be emplaced. The type of cover used could vary for different subareas. To prevent wind damage and erosion and to limit water infiltration, covers would be anchored around the edges and weighted uniformly across the surface.

Contaminants in air (i.e., particulates, radon, and radon decay products), groundwater, and surface water would be monitored while the wastes were stored at the TSA. The monitoring locations are shown in Figure 8.9. In addition to the fixed locations identified for air monitors, mobile monitors would be used for radon and radon decay products; additional permanent monitors would be added, as needed, based on monitoring results. Airborne particulates would be sampled continuously at the TSA, the U.S. Army Reserve property, and the Francis Howell High School. Samples would be analyzed routinely for gross alpha activity and periodically for uranium-238, uranium-234, thorium-232, thorium-230, thorium-228, radium-226, radium-224, and polonium-210. Radon and radon decay products would be monitored hourly at the TSA, the high school, and the Busch Wildlife Area. The TSA monitoring well locations are based on known groundwater flow directions; groundwater would be monitored every other month or quarterly for total uranium and nitroaromatics. As part of the standard surface water sampling program for the Weldon Spring project, nearby surface waters in the Busch Wildlife Area would be monitored quarterly for total uranium. Monitoring frequencies and techniques are provided in the operational environmental, safety, and health plan being prepared for the bulk waste remedial action.

After the wastes were placed in the TSA, a sampling program would be carried out to further characterize the stored wastes in order to fill data gaps associated with previous characterization. Management of the TSA would include regular inspections and periodic maintenance of engineering controls. Contaminated water from retention ponds would be treated in the adjacent water treatment plant.

8.5 MITIGATIVE MEASURES

The proposed excavation and temporary storage of the quarry bulk wastes incorporates measures that would reduce the potential for any adverse effects on human health and the environment. These measures include components of both planning and implementation. Major mitigative measures associated with this action are summarized in Table 8.4.

All activities would be carried out in compliance with the site's safety and health manual, DOE safety regulations, and other applicable requirements (see Appendix C). Radiation monitoring and protection in the work place would be provided for all

TABLE 8.4 Major Mitigative Measures for the Quarry Bulk Waste Remedial Action

Factor	Features
Haul road	Under the preferred alternative for the haul route, wastes would be hauled over a new dedicated road. Traffic would be directed by flagpersons and/or signals where the route crosses State Route 94. The haul road would be maintained in good condition and surveyed regularly for contamination.
Haul vehicles	Wastes would be transported in covered, tightly sealed, leakproof trucks. Loaded trucks would travel at low speeds.
Spill plans	Spill plans would be in place to address any spills that might occur during waste transport.
Vehicle inspection	Haul vehicles would be decontaminated and inspected before leaving the quarry and the TSA.
Temporary storage area	Wastes would be placed in a storage area constructed with a bottom liner and cover. The environment in the area would be monitored.
Quarry	Work would be staged, the work area would be limited, and the environment in the area would be monitored.
Dust control	Dust would be controlled using wet methods and/or covers at the quarry, on the haul road, and at the TSA. Chemical dust suppressant would be used if needed. At the quarry, areas not actively being worked would be covered. The TSA would be covered in stages as work progressed. Work areas at the TSA would also be covered at night and as needed, e.g., during high winds.
Erosion control	Good management practices (e.g., use of sediment barriers) would be used to minimize erosion during all activities.
Radon control	Engineering controls (reducing the working surface area and using covers, water, or chemical agents) would be applied to reduce radon emissions at the quarry and the TSA.
Noise control	Vehicle mufflers and other equipment would be checked periodically and maintained in good condition, and work would be staged.

TABLE 8.4 (Cont'd)

Factor	Features
Environmental monitoring	The air would be monitored for particulates, radon, and radon decay products at the quarry and TSA. Surface water and groundwater downgradient from the quarry and groundwater at the TSA would be monitored for chemical and radioactive contaminants. Nearby surface water would be monitored for total uranium. Appropriate responses would be taken as indicated by monitoring results.
Protection of workers	An operational environmental, safety, and health plan would be in place; the working environment would be monitored; and protective equipment would be used as needed.
Protection of the general public	Air and water would be monitored at the quarry and TSA, and appropriate responses would be taken if measured contaminant levels increased significantly above background. Access to the quarry and TSA would be restricted, as would public vehicle access to the haul road. Dust and radon controls would be applied during all activities. Decontamination methods would be used to minimize any vehicle tracking of contaminants from the quarry or TSA.

workers. An operational environmental, safety, and health plan is being prepared specifically for this action. The plan addresses (1) safe work practices, engineering controls, and worker protection equipment designed to reduce worker exposure and/or contaminant releases to the environment; (2) monitoring techniques and frequencies that would be used in the quarry, at the TSA, at the quarry and chemical plant fence lines, and at off-site locations such as Francis Howell High School and the Busch Wildlife Area; and (3) various contingencies, e.g., a transportation accident occurring during movement of the bulk wastes from the quarry to the TSA, and the anticipated responses to such contingencies.

9 PHYSICAL CHARACTERISTICS OF OTHER AFFECTED AREAS

The environmental setting of the quarry is described in Chapter 2. Additional details, as appropriate, are provided in this chapter (Chapter 9) regarding the environmental settings of the TSA, the area along the proposed haul road, and the support area at the quarry. A description of these areas is presented to support the evaluation of potential environmental impacts and potential health risks to affected individuals that could result from the proposed removal of bulk wastes from the quarry.

9.1 SETTING

9.1.1 Topography

The chemical plant area (location of the proposed TSA) straddles the watershed divide that separates the Mississippi and Missouri river valleys (Figure 2.4). The area to the north and west has gently rolling topography, whereas the terrain to the south and east is rugged, heavily wooded, and characterized by deep ravines (Figure 2.1). Elevations range from about 185 m (610 ft) MSL near the northern edge of the chemical plant area to about 205 m (670 ft) MSL near the southern edge.

The elevation of the proposed haul road would range from about 150 m (480 ft) MSL at the quarry entrance to about 200 m (650 ft) MSL at the TSA. The average slope over the approximately 5.4-km (3.4-mi) haul route would be less than 0.01; however, the route would pass near rugged areas with steep slopes.

9.1.2 Soils

A variety of soil types are present along the route of the proposed haul road. A Harvester-Urban Complex soil type is present at the location of the proposed TSA. The characteristics of these soil types are summarized in Table 9.1.

9.1.3 Geologic Setting

Six unconsolidated sedimentary units overlie bedrock at the chemical plant area (Bechtel National 1984): topsoil, modified loess (clayey silt), clay (Ferrelview Formation), clay till, basal till, and cherty clay (residual soil). A generalized description of these units is given in Table 9.2. As a result of Paleozoic structural activity, the bedrock formations of the region have been formed into arches, basins, and other structures. The chemical plant area is located on the gently dipping east flank of the northwest-trending House Springs-Eureka anticline (DOE 1987a).

The Burlington-Keokuk Limestone Formation, a cherty Paleozoic limestone approximately 50 m (160 ft) thick in the vicinity of the chemical plant area, underlies the unconsolidated sediments at the site (see the generalized stratigraphic information in

TABLE 9.1 Summary of Soil Characteristics in the Area of the Weldon Spring Site

Location	Soil Type	Comments
Proposed TSA	Harvester-Urban Complex	Silty loess materials with moderate permeability and high water content. Harvester group transported and shaped by earth-moving equipment; moderate shrinking and swelling and erodes easily. Urban group covered by streets, parking lots, buildings, and other structures.
Proposed haul road	Menfro Silt Loam	Well drained, moderate permeability, high water capacity, moderate runoff, moderate shrinking and swelling, and subject to erosion when cultivated.
	Goss Cherty Silt Loam	Well drained, moderate permeability, low water capacity, rapid runoff, moderate shrinking and swelling, and low erosion due to high chert content.
	Harvester-Urban Complex	See description above.
	Freeburg Silt Loam	Poorly drained, nearly level, moderate permeability, high water capacity, slow runoff, moderate shrinking and swelling, very friable surface, and moderate erosion.
	Sensabaugh Silt Loam	On floodplains. Well drained, moderate permeability, moderate water capacity, slow runoff, friable surface layer, and moderate erosion.
	Weller Silt Loam	Gently sloping crests of upland divides. Low permeability, high water capacity, medium runoff, high shrinking and swelling, friable surface layer, and erodes easily if bare.

Source: Based on information from U.S. Department of Agriculture (1982).

TABLE 9.2 Description of Unconsolidated Overburden Units at the Location of the Proposed TSA

Unit	Description	Thickness (ft)
Topsoil	Sandy clay; black-brown; organic	0.5 - 3.5
Modified loess	Clayey silt; mottled gray-yellow-orange; becomes dense and plastic with depth; manganese-stained	2.5 - 10
Clay (Ferrelview Formation)	Clay; mottled gray-dark yellow-orange; plastic; manganese-stained; contains weathered iron nodules	0 - 10
Clay till	Clay; yellow-brown; plastic; blocky fractures; manganese-stained; contains sand- to pebble-sized quartz, granitic, and chert grains	1 - 37
Basal till	Sandy, clayey silt; yellow-brown; abundant in broken chert nodules, loosely bound by matrix	1 - 5
Cherty clay	Clay matrix with abundant chert; multicolored in brown, red, orange and yellow; very dense	3.5 - 15

Source: Data from Bechtel National (1984).

Figure 9.1). The upper 12 m (40 ft) of the formation is gradationally weathered and exhibits an irregular rock surface. The uppermost portion of the limestone forms a 0.3- to 1.5-m (1- to 5-ft) thick zone of highly weathered residuals. This zone consists of cobbles and boulders of limestone and chert in a loose silt-sand-clay matrix. The limestone clasts often have solution features. Below the weathered zone, the Burlington-Keokuk Limestone Formation is competent; however, the upper 10 m (30 ft) is generally fractured and iron-oxide stained due to weathering.

The geologic setting of the proposed haul route is similar to that of the chemical plant area except that some of the unconsolidated units -- specifically the loess, Ferrelview Formation, clay till, and basal till -- are not present along the southern portions of the proposed route. These materials either were not deposited or have been weathered and removed by erosion. Loess may be present in the northern portion of the proposed haul route. Soils along southern portions of the route generally consist of silty clays developed in the residuum or loess, if present. This soil type varies in composition

System	Series	Stratigraphic Unit	Typical Thickness (ft)	Physical Characteristics	Aquifer
Quaternary	Holocene	Alluvium	0.5 - 4	Gravelly, silty loam	
	Pleistocene	Loess and Glacial Drift	15 - 55	Silty clay, gravelly clay, silty loam, clay, or loam over residuum from weathered bedrock	
Mississippian	Osagean	Burlington and Keokuk Limestones	100 - 200	Cherty limestone, very fine to very coarsely crystalline, fossiferous, thickly bedded to massive	Shallow Bedrock Aquifer
		Fern Glen Limestone	45 - 70	Cherty limestone, dolomitic in part, very fine to very coarsely crystalline, medium to thickly bedded	
	Kinderhookian	Chouteau Limestone	20 - 50	Dolomitic, argillaceous limestone; finely crystalline, thin to medium bedded	
Devonian	Upper	Bushberg Sandstone	40 - 55	Quartz arenite, fine to medium grained, friable	
		Lower Part of Sulfur Spring Undifferentiated		Calcareous siltstone, sandstone, oolitic limestone, and hard carbonaceous shale	
Ordovician	Cincinnatian	Maquoketa Shale	10 - 30	Calcareous to dolomitic silty shale and mudstone, thinly laminated to massive	Leaky Confining Layer
	Champlainian	Kimmswick Limestone	70 - 100	Limestone, coarsely crystalline, medium to thickly bedded, fossiliferous and cherty near base	
		Decorah Formation	30 - 60	Shale with thin interbeds of very finely crystalline limestone	
		Plattin Limestone	100 - 130	Dolomitic limestone, very finely crystalline, fossiliferous, thinly bedded	
		Joachim Dolomite	80 - 105	Interbedded very finely crystalline, thinly bedded dolomite, limestone, and shale; sandy at base	
		St. Peter Sandstone	120 - 150	Quartz arenite, fine to medium grained, massive	Deep Bedrock Aquifer
	Canadian	Powell Dolomite	50 - 60	Sandy dolomite, medium to finely crystalline, minor chert and shale	
		Cotter Dolomite	200 - 250	Agrillaceous, cherty dolomite; fine to medium crystalline; interbedded with shale	
		Jefferson City Dolomite	160 - 180	Dolomite, fine to medium crystalline	
		Roubidoux Formation	150 - 170	Dolomitic sandstone	
		Gasconade Dolomite	250	Cherty dolomite and arenaceous dolomite (Gunter Member)	
Cambrian	Upper	Eminence Dolomite	200	Dolomite, medium to coarsely crystalline, medium bedded to massive	
		Potosi Dolomite	100	Dolomite, fine to medium crystalline, thickly bedded to massive; drusy quartz common	

FIGURE 9.1 Generalized Stratigraphy in the Vicinity of the Chemical Plant Area (Source: Modified from MK-Ferguson Company and Jacobs Engineering Group 1989c)

but is generally very clayey and cherty. The amount of chert increases with depth. The lower portions of the soil profile are characteristically more porous and permeable than the upper, more clayey portion, and they typically transmit water rapidly to bedrock.

9.2 HYDROLOGY AND WATER QUALITY

9.2.1 Surface Water

The proposed TSA would be located primarily in the headwaters of Schote Creek, on the Mississippi River side of the drainage divide that traverses the chemical plant area; a small part of the proposed TSA location drains to the Missouri River (see Figure 2.4). Surface runoff from the Mississippi River side of the area flows into a nearby intermittent stream that enters Schote Creek. Schote Creek enters Dardenne Creek, a tributary of the Mississippi River, about 6 km (3.7 mi) northeast of the chemical plant area. The 500-year flood elevation for Schote Creek near the location of the proposed TSA is about 160 m (530 ft) MSL (DOE 1987a). The elevation at the proposed TSA is about 200 m (650 ft) MSL.

The unnamed tributary of Schote Creek that drains most of the southwest portion of the chemical plant area loses water to its streambed. Water flows in this stream during and after precipitation events, but some, if not all, of the flow is lost by infiltration to groundwater before reaching the main stem of Schote Creek. A dye-tracing study has shown that water lost from this stream flows underground and emerges to the north at or near Burgermeister Spring, located above Lake 34 in the Busch Wildlife Area (Kleeschulte and Emmett 1987). That spring is in an adjacent watershed and is about 2 km (1.2 mi) north of the losing reach of the unnamed tributary of Schote Creek.

In the vicinity of the chemical plant area, Lakes 34 and 35 and Burgermeister Spring, all in the Busch Wildlife Area, have elevated levels of uranium compared with background levels (DOE 1988a). Average concentrations of uranium in Dardenne Creek are within the normal background range but are slightly higher below the confluence with Schote Creek than farther upstream (DOE 1988a). Average concentrations of radium-226, thorium-230, and thorium-232 in surface waters near the chemical plant area are considerably below the average background levels for the Weldon Spring area (DOE 1988a). Based on samples taken in the fall of 1988, nitroaromatic compounds were not detected in the water or sediments of Lake 34, Lake 35, or streams near the chemical plant area (Meyer 1989).

The route of the proposed haul road would be in an area within the drainage basin of the Missouri River. This route is east of an unnamed tributary of Little Femme Osage Creek. At its closest approach, the road would be about 60 m (200 ft) from the unnamed tributary, which is a perennial stream for much of its length.

9.2.2 Groundwater

Proposed TSA. In the vicinity of the proposed TSA, groundwater occurs as perched zones in unconsolidated deposits; as a shallow, unconfined aquifer in the Mississippian limestones of the Burlington-Keokuk Formation; and as a deep, leaky aquifer in the St. Peter Sandstone (Figure 9.1).

The perched groundwater occurs in the various unconsolidated units described in Section 9.1.3. Specific information on these water-bearing lenses is generally unavailable -- such as exact delineation, character, size, and water-producing capability; however, the perched groundwater zones are prevalent in the vicinity of the raffinate pits, which suggests leakage from the pits and variable horizontal and vertical hydraulic conductivities in the overburden material. The clays underlying the location of the proposed TSA are highly impermeable, with reported hydraulic conductivities in the range of about 1×10^{-8} to 1×10^{-11} m/s (DOE 1987a). The upper few meters of overburden in the area is poorly drained, and the moisture content ranges from 15 to 30% (DOE 1987a). Unsaturated materials, combined with poor drainage, indicate that the overburden material has a low permeability. Seven soil borings were recently taken from the location of the proposed TSA. No persistent zones of perched water were identified. Evidence of perched water was found in only one boring, in which 1 cm (2 in.) of soft, saturated material was present at a depth of about 3.3 m (11 ft) (MK-Ferguson Company and Jacobs Engineering Group 1990c).

The groundwater surface of the shallow limestone aquifer in the Burlington/Keokuk Formation has been reported to be approximately 20 m (65 ft) below the bottom of the raffinate pits (DOE 1987a). This elevation exhibits both seasonal and annual variations. The water-table elevation of the shallow aquifer ranges from about 9 to 20 m (30 to 65 ft) below the ground surface (DOE 1988b). In general, the water-table elevation of the aquifer reflects local topography, and an east-west trending groundwater divide occurs to the south of the raffinate pits (DOE 1988b). To the north of the groundwater divide, flow has been reported to be generally in a northerly direction, with an average hydraulic gradient of 0.0095. Both local and seasonal variations in this gradient have also been observed. In the southeastern portion of the chemical plant area (south of the groundwater divide), groundwater flow is to the east or southeast (DOE 1988b). Groundwater flow in the Burlington-Keokuk Limestone Formation occurs in two distinct regimes: Darcian (porous-media) flow and conduit (pipe) flow. Darcian flow occurs in the fine fractures and pore channels of the limestones whereas conduit flow occurs through dendritic and trellised pathways (DOE 1988b). The hydraulic conductivity of the Burlington-Keokuk Limestone was determined based on data from slug tests performed at the chemical plant area in the spring of 1989. Hydraulic conductivities ranged from 2.44×10^{-6} to 0.81×10^{-7} m/s (8.01×10^{-6} to 2.65×10^{-7} ft/s) using the Hvorslev method and from 0.46×10^{-7} to 0.41×10^{-8} m/s (1.52×10^{-7} to 1.36×10^{-8} ft/s) using the Bouwer and Rice method (MK-Ferguson Company and Jacobs Engineering Group 1990c).

In addition to the shallow Burlington-Keokuk aquifer, a deep aquifer system occurs in the saturated rocks of the St. Peter Sandstone (Figure 9.1). The shallow and deep aquifers are separated by a leaky confining layer that extends from the base of the

Lower Sulfur Spring Unit down through the Joachim Dolomite. Flow in this aquifer is Darcian, and hydraulic conductivity is thus expected to be similar to a typical sandstone formation that has a conductivity of approximately 1×10^{-6} m/s (Freeze and Cherry 1979). Like the shallow aquifer system, the deep aquifer system has a groundwater divide. This divide is located just north of the Weldon Spring site. Flow to the north of the groundwater divide is to the northeast whereas flow to the south of the divide is to the southeast (DOE 1988b). Flow to the north of the divide eventually enters the cone of depression produced by municipal pumping wells in Wentzville and O'Fallon. The eventual discharge point of flow to the south of the groundwater divide is not currently known.

The major groundwater aquifer at the TSA that could potentially be affected by contaminant migration resulting from the proposed action is the shallow aquifer in the upper weathered layer and fracture zones of the Burlington-Keokuk Limestone Formation. Below the Burlington-Keokuk Formation, vertical migration of contaminants is impeded by shales and limestones of low hydraulic conductivity, thus minimizing potential contamination of deep, productive aquifers such as the St. Peter Sandstone (DOE 1988b).

Infiltrating water from precipitation that recharges the groundwater at the chemical plant area moves downgradient in the direction of the slope of the potentiometric surface and is discharged by either natural or artificial means. Discharge can be accomplished by evapotranspiration, springs, seeps, or pumping wells (DOE 1987a).

The water quality of the shallow bedrock aquifer in St. Charles County varies from a calcium-magnesium-bicarbonate type to a sodium-sulfate, sodium-bicarbonate, or sodium-chloride type (DOE 1988b). Total dissolved solids (TDS) and chloride concentrations increase from west to east. High sulfate concentrations are limited to areas underlain by shale, sandstone, and siltstone. Water quality data for 1984 and 1986 indicate elevated shallow groundwater concentrations of calcium, magnesium, sodium, sulfate, nitrate, lithium, strontium, and uranium in wells near the raffinate pits. Uranium concentrations in wells near the pits ranged from 6 to 86 µg/L (DOE 1988b). Nitroaromatic compounds were detected in monitoring wells throughout the chemical plant area.

During 1987, monitoring of groundwater in the shallow bedrock aquifer at the location of the proposed TSA indicated that the concentrations of radium-226, thorium-230, thorium-232, and total uranium were at background levels (DOE 1988a). Nitroaromatic compounds were detected at trace levels (µg/L). Nitrate levels (as nitrogen) at the center of the proposed TSA location were elevated, averaging 75 mg/L. These elevated nitrate levels are believed to be the result of seepage from the raffinate pits. Elevated levels of natural uranium were detected in one monitoring well (MW-3009) near the site of the proposed TSA. The above-background activity is probably also due to seepage from the nearby raffinate pits.

The water quality of the deep bedrock aquifer varies with depth and lateral location (DOE 1988b). Measured TDS values have ranged from 305 to more than 4,700 mg/L for the Joachim Formation (Figure 9.1).

Proposed Haul Road. Little specific information exists on the groundwater hydrology below the proposed haul road. However, the flow regimes are expected to be similar to those described for the TSA: a shallow, unconfined groundwater aquifer probably exists in the Burlington-Keokuk Limestone Formation, and a deep aquifer probably exists in the St. Peter Sandstone. Due to the proximity of the Missouri River and the groundwater divide near the chemical plant area, flow under the proposed route of the haul road probably occurs to the south and southeast. Water quality is expected to reflect undisturbed background concentrations for the respective formations except in very close proximity to the quarry and the chemical plant area. Prior to bulk waste removal, springs and other possible monitoring locations near the haul route would be identified for use in evaluating the spread of contamination in the event that wastes were spilled on the haul road (e.g., as the result of a transportation accident).

9.3 ECOLOGY

9.3.1 Terrestrial

The chemical plant area is bordered on the north by the Busch Wildlife Area, on the west by the U.S. Army Reserve property, and on the south and east by the Weldon Spring Wildlife Area. The chemical plant area is essentially grassland/old-field habitat containing a variety of grasses with scattered small shrubs and trees. Mowing maintains much of this area in a pasture-like condition. The location of the proposed 5.3-ha (13-acre) TSA at the chemical plant area has a gently rolling topography, most of which is actively mowed and contains little undisturbed vegetation or wildlife habitat. The area south of the proposed TSA is located within the U.S. Army Reserve property and contains a mixture of old-field and wooded habitats.

The proposed haul route is located almost exclusively within the Weldon Spring Wildlife Area and passes through a variety of habitats. The areas traversed by the railroad easement portion of this route support vegetation and wildlife habitats similar to those associated with the quarry area and include primarily bottomland, slope, and upland forests. In contrast, the proposed haul road segment that would parallel State Route 94 consists primarily of upland grassland/old-field habitat, with some agricultural areas. Trees common throughout the proposed haul road area include cottonwood, sycamore, Kentucky coffeetree, and a variety of oaks; native grasses include Indian grass, switch grass, and bluestem.

Much of the proposed haul road area would support a vertebrate fauna similar to that of the quarry area because of habitat similarity between these areas (see Section 2.3.1). Little undisturbed and/or natural habitat exists at the chemical plant area, including the proposed TSA location. The chemical plant area probably contains relatively depauperate amphibian, reptilian, and mammalian communities -- which are composed primarily of species commonly associated with urban and residential areas. Mammals might include the cottontail, opossum, raccoon, fox, deer, and a variety of small rodents; some of these mammals are associated with the numerous buildings and other structures of the chemical plant area. In contrast, the proposed TSA location contains few structures, and the mammal community is expected to consist primarily of small burrowing rodents. Few reptiles would be present at the chemical plant area (including the proposed TSA location), and most amphibians would be restricted to the raffinate pits, small ponds, drainage ditches, and intermittent and permanent streams that are located at and around the site. The area south of the proposed TSA location (in the U.S. Army Reserve property) contains a variety of habitats and would be expected to support fauna more similar to that associated with the proposed haul road area.

Common birds that may occur along the proposed haul road would be similar to those that occur at the quarry (see Section 2.3.1). The bird community at the chemical plant area, including the proposed TSA location, consists predominantly of species typically associated with grassy urban and residential areas. These birds include the starling, mourning dove, crow, killdeer, robin, and a variety of swallows and sparrows. The raffinate pits also provide habitat suitable for waterfowl, and ducks and geese have been observed resting in the pits.

The proposed 0.6-ha (1.6-acre) support area at the quarry is located immediately west of the quarry. It consists primarily of slope forest similar to that found throughout the area and also within the boundaries of the quarry proper. Fauna in this area would be similar to that described for the quarry (see Section 2.3.1).

9.3.2 Aquatic

The principal aquatic habitats in the immediate vicinity of the proposed haul road near the quarry are the same as those described for the quarry area (see Section 2.3.2). Aquatic habitats in the vicinity of the chemical plant area include the raffinate pits, Schote Creek, Dardenne Creek, and numerous intermittent and perennial streams and drainages throughout the area. Additional aquatic habitat exists in the U.S. Army Reserve property and the Busch Wildlife Area; the latter contains more than 35 ponds and lakes ranging in size from approximately 0.4 ha (1 acre) to 74 ha (182 acres).

9.3.3 Threatened and Endangered Species and High-Quality Natural Communities

Federal- and state-listed species that might be affected by the proposed bulk waste action are discussed in Section 2.3.3. The only federally listed threatened or endangered species that occurs in the Weldon Spring area is the bald eagle. However, no critical habitat for this species exists at either the proposed TSA location or along the proposed haul road. The Cooper's hawk, a state-endangered species, and the sedge wren, a state watch-listed species, could potentially occur along portions of the proposed haul road.

9.4 AIR QUALITY

Climate and ambient air quality for the Weldon Spring area are discussed in Section 2.4; air quality near the proposed TSA location is discussed here. Selection of meteorological data representative of conditions at the TSA is discussed in Section 10.2.

Annual average radon concentrations at locations around the chemical plant area ranged from 0.3 to 0.6 pCi/L in 1986 and from 0.2 to 0.5 pCi/L in 1987. Annual average background concentrations of radon measured in the Busch Wildlife Area were 0.5 and 0.3 pCi/L in 1986 and 1987, respectively. The DOE maximum permissible concentration for the annual average above-background concentrations of radon-222 for uncontrolled areas is 3 pCi/L (see Appendix C).

During 1987, air particulate samples were collected at the proposed TSA location, at other locations in the chemical plant area, and at nearby off-site locations (DOE 1988a). Analysis of the samples indicated that the annual average alpha activity at each location is not statistically different (at the 95% confidence level) from the activity at a background station in the Busch Wildlife Area, which is less than 3×10^{-5} μCi/mL. Analyses for various radionuclides (uranium-238, uranium-235, uranium-234, thorium-232, thorium-230, thorium-228, radium-228, radium-226, and lead-210) indicated that the total activity at each sampling location (including the background station) was less than isotope-specific detection limits. All detection limits were well below the corresponding DCGs for each radionuclide (see Appendix C).

During 1987, gamma exposure rates were monitored at the perimeter of the chemical plant area (DOE 1988a). Annual average exposure rates at the perimeter fence, including background, ranged from 58 to 88 mR/yr. Average exposure rates within an 8-km (5-mi) radius of the chemical plant area ranged from 78 to 96 mR/yr in 1987, with an average of 85 mR/yr. The results indicate that gamma exposure rates at the fence line are at background levels.

9.5 LAND USE AND DEMOGRAPHY

Most of the area to the north of the chemical plant area is part of the Busch Wildlife Area and is undeveloped; its primary use is recreational. Francis Howell High School, which is used year-round, is approximately 1 km (0.6 mi) northeast of the chemical plant area; an estimated daily average of 2,300 persons occupied the campus during the 1988-1989 school year. A Missouri highway maintenance facility is situated between the high school and the chemical plant area. The U.S. Army Reserve and National Guard Training Area is located to the west of the chemical plant area. The Busch and Weldon Spring wildlife areas that surround the remainder of the chemical plant area receive an estimated 800,000 and 250,000 visitors each year, respectively (DeBruyckere 1989).

9.6 CULTURAL RESOURCES

The results of cultural resource surveys for the Weldon Spring area are discussed in Section 2.6. Archeological sites and historic structures that meet the criteria established for eligibility to the *National Register of Historic Places* would require mitigative action if subject to adverse effects as a result of the proposed action. In 1986, the SHPO determined that the Weldon Spring chemical plant area was not eligible for the *National Register* (Weichman 1986). Activities associated with the proposed action are currently being coordinated with the SHPO.

9.7 CONTAMINANT CHARACTERIZATION AT THE TSA

The soil at the location of the proposed TSA was characterized in 1988 to evaluate the possible presence of chemical and radioactive contaminants. Soil samples were collected from 20 boreholes at the proposed TSA location (MK-Ferguson Company and Jacobs Engineering Group 1990c). These samples were analyzed for nitroaromatic compounds, inorganic ions, metals, pesticides, PCBs, and semivolatile and volatile organic compounds. Samples were collected from areas suspected of being affected by past operations of the ordnance works and uranium-processing plant, as well as from unbiased locations. Contaminants identified in this study were nitroaromatic compounds, fluoride, nitrate, sulfate, metals, and uranium; no pesticides, PCBs, or semivolatile or volatile organic compounds were detected (MK-Ferguson Company and Jacobs Engineering Group 1990c). The volume of contaminated soil that would be removed during construction of the TSA is small and could be accommodated in the TSA, along with the quarry bulk wastes, without exceeding the design capacity for the facility.

Contamination with nitroaromatic compounds was identified at a location within the boundary of the proposed TSA that had previously been the site of the trinitrating house of TNT production line No. 4 of the ordnance works. The maximum soil concentrations of 2,4-DNT and 1,3,5-trinitrobenzene in this area were about 6 and 2 mg/kg, respectively. Contamination was detected 1.2 m (4 ft) below the surface, which corresponds to the amount of fill at this location. Fluoride contamination was also detected in the nitroaromatic-contaminated area of the proposed TSA. The fluoride concentration of about 110 mg/kg is almost eight times the upper background level* (MK-Ferguson Company 1989). The source of this contamination is unknown, although hydrofluoric acid was previously used at the uranium-processing plant.

Contamination of soils with nitrate and sulfate is fairly prevalent in the chemical plant area; various potential sources of this contamination are associated with past operations of the ordnance works and the uranium-processing plant. Some nitrate contamination is present at the location of the proposed TSA. The nitrate concentration measured at a depth of 2.4 to 4.6 m (8 to 15 ft) near Building 435 was 427 mg/kg, which is about four times the upper background level (MK-Ferguson Company 1989). The source of this contamination is unknown, although nitric acid was used during plant operations. Sulfate contamination is present at the location of the proposed TSA; the highest levels were probably caused by process wastewater released from the ordnance works. Sulfate concentrations at the location of the proposed TSA are as high as about 1,400 mg/kg, which is about 19 times the upper background level; the area with the greatest contamination appears to be limited in extent and is generally restricted to the upper 1.5 m (5 ft) of soil (MK-Ferguson Company 1989). Much lower levels of sulfate contamination are also present near Buildings 435 and 436 and probably resulted from ordnance works fill sources.

Isolated areas of metal contamination are present throughout the chemical plant area. Some of this contamination may have resulted from solubilization by acids that

*The upper background level is defined as the off-site mean concentration plus two standard deviations.

were used during both the ordnance works and uranium-processing operations. In areas within the location of the proposed TSA, concentrations of arsenic, barium, lead, and mercury were detected at two or more times upper background levels (MK-Ferguson Company 1989).

Low levels of uranium contamination are also present in soils at the proposed TSA location. This contamination is largely surficial, extending to a depth of about 0.45 m (1.5 ft), and most of the contamination probably resulted from the storage of contaminated equipment and debris during previous decontamination activities (MK-Ferguson Company and Jacobs Engineering Group 1990c). Contaminated soil in the top 15 cm (6 in.) that would be removed during construction of the TSA has an average uranium-238 concentration of about 45 pCi/g (MK-Ferguson Company and Jacobs Engineering Group 1990b).

The four buildings to be removed from the location of the TSA contain small volumes of radioactively and chemically contaminated materials. Two of the buildings were constructed with small amounts of asbestos-containing material; another building is used to store items containing asbestos. A small amount of PCB-contaminated material is present in one building, and light fixtures contaminated with PCBs are suspected in three buildings. These materials would be managed in a manner to control potential releases.

10 POTENTIAL ENVIRONMENTAL EFFECTS

Although removing the bulk wastes from the quarry is expected to provide environmental benefits, various activities associated with this action could potentially result in adverse environmental effects. These activities include construction and excavation at the quarry, construction of the haul road, hauling of materials from the quarry to the TSA, and construction and operation of the TSA. Potential environmental impacts on hydrology and water quality, air quality, ecology, land use and demography, and cultural resources are evaluated in Sections 10.1 through 10.5; potential health effects, including accidents, are evaluated in Chapter 11.

10.1 HYDROLOGY AND WATER QUALITY

10.1.1 Surface Water

Surface runoff would be affected by paving or altering surfaces during the action period. Surface modifications at the quarry support area, along the haul road, and at the TSA would tend to increase surface runoff. Surface runoff from the quarry itself would not be significantly affected because little runoff occurs to locations outside the quarry (see Section 2.2.1). Surface runoff controls would be implemented at the TSA to minimize the potential for any adverse effects. No significant effects on surface water hydrology are expected to result from the proposed action because (1) relatively small areas would be affected by surface alterations, (2) activities would be located outside the 100-year floodplain, and (3) the proposed action is temporary.

Construction activities at the quarry support area, at the TSA, and along the haul road could result in the release of sediment and subsequent transport to nearby surface waters. However, good management practices would be used during construction to minimize erosion — e.g., reseeding, covering surfaces with hay or mulch, and using revegetation mats in those areas with high water velocity. Also, the disturbances that could cause erosion would be temporary, and any impacts would be short term. Spill plans would be in place to address any spills of petroleum products or other chemicals during construction and operation activities.

Contaminants are not expected to reach surface waters as a consequence of transportation losses because the haul vehicles would be covered, tightly sealed, and leakproof. In addition, vehicles would be surveyed for contamination and washed before leaving the quarry or TSA. Also, the haul route would be surveyed routinely for radioactive contamination, and any contamination detected would be removed. The probability of a major accident involving a spill of contaminated materials outside the quarry or TSA is low. Such an accident would require the failure of the containment system on a haul vehicle or the overturning of a vehicle and the release of its load. In addition, loaded vehicles would use a dedicated haul road and travel at a maximum speed of about 32 km/h (20 mph), and a contingency plan would be in place for responding to spills. Even if State Route 94 were used for loaded vehicles, the probability of a serious accident is low (see Section 11.5).

Some contaminated materials could be released from the TSA, where it is expected that the bulk wastes would be stored for up to 10 years. However, control of both runon and runoff of water at the storage area would minimize any potential for contaminant migration to nearby surface waters. Surface waters in the vicinity of the quarry and the TSA would be monitored during the action period. If any contaminants were detected, appropriate action would be taken to control migration of contaminants and to mitigate potential adverse impacts. Therefore, no surface water contamination is expected to result from activities associated with the proposed action.

The water treatment plants at the quarry and the chemical plant area would discharge treated water to surface waters. A portion of the treated water would result from activities related to the bulk waste remedial action. Impacts related to discharges from the proposed quarry water treatment plant are discussed by MacDonell et al. (1989) and are expected to be minimal. Impacts related to discharges from the proposed water treatment plant at the chemical plant area will be discussed in the EE/CA for that facility.

10.1.2 Groundwater

Quarry Area. Removing the bulk wastes from the quarry would effectively remove a major source of groundwater contamination in the area. After eliminating this source, downstream contaminant concentrations would be expected to return to background levels. Complete removal of the bulk wastes is expected to take slightly more than 1 year to complete; the analyses in this document assume a period of 1.25 years (see Chapter 8). During that time, it is unlikely that contaminants would be introduced into the groundwater system as a result of waste disturbance because of (1) the hydrologic low that would be created at the quarry by pumping the pond and (2) the physical attributes of the flow system.

During removal of the ponded water, a pumping system would be used to create a cone of depression at the quarry (MacDonell et al. 1989). The hydrologic low created by this pumping would reverse the existing hydraulic gradient at the quarry, such that groundwater in the immediate vicinity would flow toward the quarry rather than away from it. Maintaining this pumping as planned during the bulk waste remedial action would help mitigate any contaminant releases to groundwater at the quarry. Even without a maintained cone of depression at the quarry, the effect of a perturbed source on solute concentrations near the western extremity of the St. Charles county well field is expected to be small, as discussed by Tomasko (1989).

During bulk waste excavation, the network of groundwater wells shown in Figure 8.4 would be monitored for contaminants. If any were detected, appropriate actions (e.g., use of capture wells) would be taken to mitigate potential adverse impacts.

Proposed Haul Road. Bulk wastes from the quarry would be transported to the TSA along a dedicated haul road. Because the trucks would be covered, tightly sealed, and leakproof and the exteriors would be surveyed before leaving the quarry, no contamination of the ground surface along the haul route is expected. If any contaminants did reach the ground, they could potentially be leached into the underlying soils by precipitation, such that they could ultimately reach the unconfined groundwater aquifer in the Burlington-Keokuk Limestone Formation. However, the probability of any significant groundwater contamination along the haul road is very small due to the following factors: (1) at worst, only small quantities of contaminated materials would be inadvertently deposited along the transportation route; (2) the haul road would be monitored routinely to identify any contamination and, if found, the contaminated areas would be remediated; (3) the duration of the cleanup activities would be short (slightly more than 1 year); (4) the hydraulic conductivity of some of the unconsolidated units above the Burlington-Keokuk Limestone Formation is low (the hydraulic conductivity of certain clays is approximately 1×10^{-8} m/s); and (5) the rate of solute sorption onto clays in the vadose zone is potentially high. Springs and other possible monitoring locations near the haul road would be identified for use in evaluating the spread of contamination in the event of a spill (see Section 9.2.2).

Proposed TSA. Bulk wastes removed from the quarry would be sorted according to physical characteristics and placed in temporary storage at the chemical plant area near the raffinate pits. Potential impacts on groundwater below the TSA are expected to be negligible because (1) the TSA would be situated 3 m (10 ft) above the historically high water-table elevation, (2) clay-rich units with low permeability and high sorptivity lie between the bottom of the proposed TSA and the water table, (3) the facility would have a properly designed and installed bottom liner and leachate collection system (see Section 8.4.1), and (4) runon and runoff controls would be installed and maintained. Perched groundwater occurs in an isolated area at the location proposed for the TSA (see Section 9.2.2) and could potentially be impacted by TSA activities. However, the consequences of contaminating an isolated, small saturated groundwater lens are expected to be minimal because the low permeability of unconsolidated deposits in that area would prevent rapid vertical or lateral migration. In addition, pumping could be employed to remove the zone of contaminated perched water before it would significantly affect the surrounding environment.

A groundwater monitoring network would be in place at the TSA to identify potential groundwater contamination in the vicinity (see Figure 8.9). If contaminants were detected, measures (e.g., capture wells) would be implemented to mitigate any adverse effects.

10.2 AIR QUALITY

Ambient air quality in areas accessible to the public is regulated by both federal and state standards. Missouri ambient air quality standards are identical to federal standards (see Appendix C). These standards address six pollutants: PM-10 (particles less than 10 μm in aerodynamic diameter), sulfur oxides, nitrogen dioxide, carbon monoxide, lead, and ozone. Because the bulk waste remedial action is mainly an excavation operation, the potentially most significant air quality impacts would result from fugitive dust sources that might affect PM-10 concentrations. The exhaust produced by excavation equipment is expected to be small, and nonparticulate pollutants are not expected to occur at significant levels. Potential health impacts from radioactive and chemical contaminants associated with airborne particulates are evaluated in Chapter 11.

To estimate potential air quality impacts associated with this action, 12 categories of fugitive dust sources were identified (at the quarry, along the proposed haul road, and at the TSA), and annual and 24-hour emissions were estimated for each of these sources. Details of this analysis are presented in Appendix B. Assumptions used to predict air quality impacts included a 40-hour work week, operation of 40 trucks per average day and 48 trucks per worst-case day, and a loaded truck weight of no more than 36 t (40 tons). The emissions generated by this action were assumed to be limited by specific techniques for fugitive dust control. The efficiencies of control strategies for fugitive dust sources considered for both the short-term and long-term analyses are also presented in Appendix B. The actual techniques used to control fugitive dust would be defined in subsequent detailed engineering studies; the techniques discussed in Appendix B are representative of those that might be used.

The selection of appropriate models for assessing air quality impacts from fugitive dust sources was based on EPA guidance (EPA 1987a). The most appropriate models meeting EPA criteria are the Industrial Source Complex, Long Term (ISCLT) model (Version 89319) for annual predictions and the Industrial Source Complex, Short Term (ISCST) model (Version 88348) for 24-hour predictions. The only limitation of these models for application to the bulk waste remedial action is the condition that the terrain be simple. For the populated area west of the quarry and for much of the area north and east of the TSA, the terrain can be classified as simple. Also, because the maximum impact of ground-level fugitive dust sources is relatively close to the sources, the focus is on the nearby terrain, which for the most part can also be classified as simple.

Air particulate concentrations at receptor locations were estimated separately for operations at the quarry, at the TSA, and along the haul road. The receptor locations considered in the analysis include local residences, Francis Howell High School, roads, trails, and DOE property lines. Separate estimates were made for these locations because meteorological conditions differ for the different operations and areas. Total PM-10 concentrations (both annual and short-term) due to all operations were obtained by adding the separate results.

Surface meteorological data were collected at the proposed TSA location in 1985 and are the most representative data available for assessing potential air quality impacts associated with activities both at the proposed TSA and along the proposed haul road; measurements taken during 1985 at a 10-m (30-ft) tower at the Labadie Power Plant were selected as most representative of wind fields at the quarry (Lazaro 1989). The Labadie tower is located in the Missouri River Valley, about 13 km (8 mi) southwest of the quarry. Fluctuations in horizontal wind directions were used to estimate stability classes, as discussed by Lazaro (1989). Mixing heights were estimated from upper-air meteorological measurements taken twice daily in 1985 at a station in Salem, Illinois, located about 112 km (70 mi) east of St. Louis. These data were used to interpolate expected hourly mixing heights for short-term modeling of potential air quality impacts. To support long-term modeling, the hourly values were further processed to compute average mixing heights for each stability category and wind speed class. Average ambient temperatures for each stability category were also computed from the surface station measurements for input into the long-term model.

The annual PM-10 standard is 50 $\mu g/m^3$, based on an averaging process that considers measured daily concentrations over 3 years or predicted daily concentrations for 1 year. The 24-hour standard for PM-10 is 150 $\mu g/m^3$, with not more than three expected exceedances permitted in any three consecutive years. To compare potential impacts with the PM-10 standard, the predicted concentration at a receptor location was added to a background value of 16 $\mu g/m^3$ for both the annual and 24-hour cases. This value represents an estimated PM-10 background concentration for the St. Louis area based on measurements taken during the regional air pollution study conducted in the 1970s (EPA 1980).

Figure 10.1 shows the estimated annual mean PM-10 concentrations surrounding both the quarry and the TSA (excluding the area near the western TSA fence line) that could result from the bulk waste remedial action. The highest annual arithmetic mean concentration for PM-10 shown in Figure 10.1 that is predicted to result from these operations is 41 $\mu g/m^3$, including background (all total concentrations include the background concentration of 16 $\mu g/m^3$). This concentration is predicted for a location on State Route 94 north of the nitroaromatic-contaminated area in the quarry. Major contributors to this estimate include 7.8 $\mu g/m^3$ from haul truck travel and bulldozer and grader activity in the quarry and 17.0 $\mu g/m^3$ from wind erosion. The highest annual mean concentration for PM-10 at the TSA is 23 $\mu g/m^3$. The estimated maximum PM-10 concentrations are below the annual air quality standard of 50 $\mu g/m^3$.

With the exception of concentrations near the TSA fence line, the highest 24-hour PM-10 concentration related to the bulk waste remedial action is estimated to be 102 $\mu g/m^3$ at a location on State Route 94 north of the quarry. The single major contributor to this estimate is bulldozer activity, which increases the concentration by 73 $\mu g/m^3$ above background. The estimated 24-hour maximum concentration is below the air quality standard of 150 $\mu g/m^3$. The highest 24-hour total PM-10 concentration for a day with wind erosion is estimated to be 116 $\mu g/m^3$. Contributions from wind erosion to the total PM-10 concentrations ranged from 84 to 95% for those five days in 1985 during which wind erosion probably occurred (1985 is the year for which meteorological data were available at both the quarry and the TSA/haul road locations). Based on the similarity of predicted total concentrations on days with and without wind erosion, it is expected that as impacts from wind erosion increase, impacts from most other sources decrease. This is probably due to the fact that the high wind speed generating wind erosion emissions also produces a large mass of air that dilutes the emissions, thereby lessening the impact of other potential sources of fugitive dust.

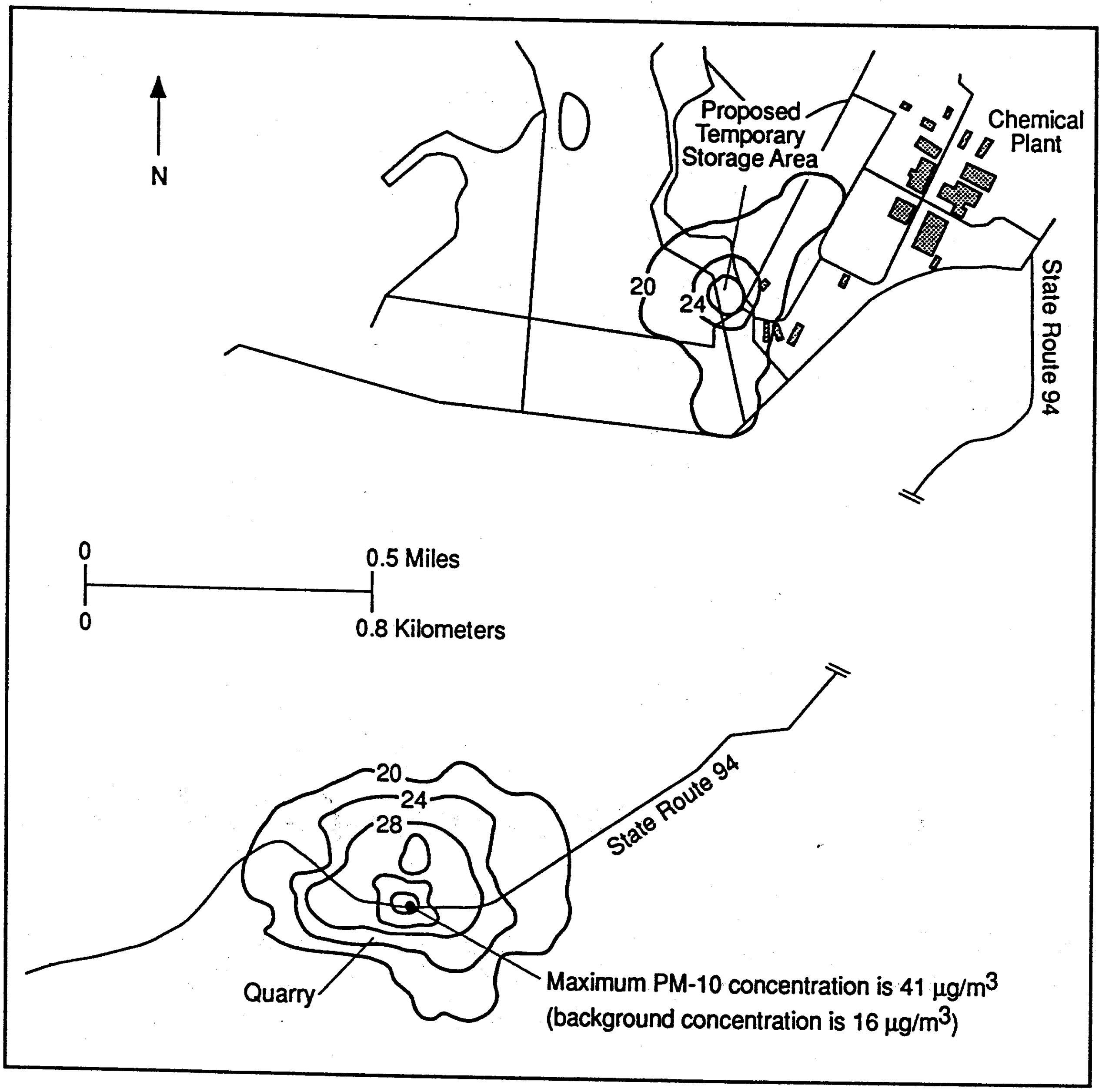

FIGURE 10.1 Estimated Total Annual Mean PM-10 Concentrations (μg/m^3) Resulting from the Bulk Waste Remedial Action (does not include estimates for the area near the western TSA fence line)

Concentrations of airborne particulates cannot be predicted accurately for receptors close to a source of fugitive dust. However, because the subarea for fine-grained, nitroaromatic-contaminated soils at the TSA could be close to the fence line (e.g., about 15 m [50 ft]), the 24-hour and annual total PM-10 concentrations at the fence line could be elevated. Concentrations above the 24-hour standard are predicted to occur at three receptor locations: the property fence line, 30 m (100 ft) west of the fence line, and approximately 100 m (300 ft) south of the contaminated-soils area. Maximum concentrations are estimated to be 388 μg/m^3 at the receptor west of the fence line and 213 $\mu g/m^3$ at the receptor south of the TSA. Conservative predictions identify a maximum 24-hour concentration at the fence line of 460 $\mu g/m^3$. The modeling analysis indicates that these concentrations would fall below the 24-hour and annual standards, including the concentration at the TSA fence line, if the nitroaromatic-contaminated soils were located about 50 m (150 ft) away from the fence line. The exact locations of the various materials at the TSA, shown conceptually in Figure 8.9, will be defined during the detailed engineering phase of this proposed action to ensure that concentrations would be below the PM-10 standards. Possible options include (1) moving the nitroaromatic-contaminated soils area farther from the property fence line, (2) moving the fence farther from the TSA (which would require permission from the Army), and (3) reorienting the TSA.

Fugitive dust and exhaust particulates from general traffic on State Route 94 are not directly included in the analysis. To justify this approach, a screening calculation was performed using the Gaussian equation for an infinite line source and the following reasonable, 24-hour average worst-case parameters: (1) 4 m/s mean wind speed, (2) D stability class, (3) ground-level source, and (4) 30-m downwind distance. The 24-hour reasonable worst-case concentration under these conditions is estimated to be about 8 $\mu g/m^3$. This concentration would not significantly impact receptors along Route 94 near the TSA because the highest 24-hour concentration from TSA sources is estimated to be about 30 $\mu g/m^3$ along the eastern fence line of the chemical plant area. At the quarry, the worst case would occur on Route 94 when the winds were predominantly from the south. At areas across Route 94 away from the quarry, the impact from the quarry would lessen and the impact from Route 94 traffic would increase. Although the inaccuracy of near-field predictions limits the value of formal predictive modeling in this case, a reduction in the quarry source impact is expected to more than offset an increase in the Route 94 impact.

Removing the bulk wastes from the quarry would eliminate the primary source of radon (other than background) in this area. Therefore, over the long term, radon levels at the quarry would be expected to approach background levels. Potential health effects associated with radon emissions as a result of the bulk waste remedial action are discussed in Chapter 11.

10.3 ECOLOGY

10.3.1 Terrestrial

Impacts to vegetation and wildlife resources would include (1) loss of habitat and a subsequent loss of carrying capacity for plant and wildlife populations, (2) loss of vegetation and loss or displacement of wildlife from the affected areas, and (3) disturbance of wildlife in nearby areas by noise, dust, and human activities.

Quarry Area. The clearing and grubbing of the quarry and adjacent support area would result in the loss of approximately 4.3 ha (10.6 acres) of primarily forest habitat.

All vegetation in the support area would be destroyed during preparation for bulk waste excavation, and all vegetation in the quarry would be destroyed prior to the actual removal of bulk wastes. In addition, wildlife from these areas would be lost or displaced.

The anticipated impacts to vegetation and wildlife resources would probably be greater at the quarry than at the proposed haul road or TSA locations, primarily because conditions at the quarry are more natural. However, the plant and wildlife species that would be disturbed at the quarry are not unique to that area and are widely distributed throughout the region. The vegetation that would be lost represents a very small portion of the vegetation resources present in the surrounding Weldon Spring Wildlife Area. Similarly, the affected areas represent a very small fraction of the total wildlife habitat that occurs in the area. Thus, the continued survival of local plant and wildlife populations would not be threatened by the bulk waste remedial action. Furthermore, the areas that would be disturbed have been affected by past human activities and contain no known critical wildlife habitats or any unique terrestrial communities.

Following completion of site preparation and construction activities, impacts to local wildlife would result primarily from disturbance by noise and human activities. These impacts are not expected to be significant and would be short-term, pending completion of remedial activities at the quarry area. Some impact could also result from fugitive dust emissions during construction and excavation activities. However, standard mitigative measures to reduce and control fugitive dust would be implemented to minimize potential adverse impacts during the action period (see Section 10.2).

Removing the bulk wastes would have a positive environmental impact to the extent that adverse effects on vegetation and wildlife resources may have occurred in the past due to their presence in the quarry and such effects could occur in the future if the wastes are not removed.

Proposed Haul Road. Approximately 5.3 ha (13.0 acres) of land would be disturbed by construction of the proposed haul road. However, impacts to local vegetation and wildlife resources resulting from the construction and subsequent use of this haul road would be minor. Construction along the railroad easement would disturb approximately 3.7 ha (9.1 acres) of land. During the original preparation of the railroad bed in the early 1940s, the slope and upland forest areas traversed by the easement were cleared and the terrain was significantly altered by cut and fill construction. Although some vegetation has reestablished since abandonment of this rail line, it consists primarily of scattered small shrubs and trees (breastheight typically less than 20 cm [8 in.] in diameter). Little wildlife habitat is present, and relatively few animals would be affected by the construction activities. In addition, the habitats that would be affected are not critical or heavily used by wildlife.

In contrast to the railroad easement, the area of the proposed haul road paralleling State Route 94 is relatively undisturbed, although this area is somewhat impacted by traffic along State Route 94. Construction of the haul road would disrupt approximately 1.5 ha (3.7 acres) of upland old-field habitat and result in the loss of all vegetation in the affected area. Overall, however, impacts to vegetation would be relatively minor; the species and habitats that would be affected are not unique or critical, and these species and habitats do exist at the adjacent Weldon Spring Wildlife Area. Similarly, some loss of habitat and displacement of mobile wildlife would occur. However, relatively few animals would be affected, and the amount of habitat lost relative to that present in the area would be very small. Thus, impacts to wildlife would be very minor, and survival of local wildlife populations would not be threatened by this action.

Some additional impacts to wildlife resulting from disturbance by noise and human activities (e.g., road kills due to truck traffic) could occur during transport of the bulk wastes from the quarry to the TSA. These impacts would be similar to those currently experienced by wildlife in areas adjacent to State Route 94, they are not anticipated to be significant, and they would cease following completion of bulk waste transport activities. Dust generated by the trucks hauling bulk wastes to the TSA from the quarry could also affect local vegetation and wildlife, but potential adverse impacts would be minimized by implementing appropriate mitigative measures.

Proposed TSA. Approximately 5.3 ha (13.0 acres) of grassland would be disturbed by construction of the TSA at the chemical plant area. Impacts to local biota from this construction would be very minor. Most of the area is actively mowed and represents only a small fraction of the grassland habitat present in the area. Little natural wildlife habitat exists at the proposed TSA location, and no habitats critical to, or highly used by, wildlife species would be affected. Similarly, operation of the TSA is not anticipated to affect local vegetation or wildlife. The bulk wastes would be stored in a manner that would minimize exposure of local biota, and impacts from fugitive dust or accidental spills or other contaminant releases would be minimized by implementing appropriate mitigative measures and contingency plans and procedures.

10.3.2 Aquatic

Quarry Area. Aquatic biota in the vicinity of the quarry could be adversely affected by activities associated with removal of the quarry bulk wastes. Potential impacts would result primarily from (1) increases in turbidity and sedimentation in local waterways from erosion and runoff and (2) increases in industrial pollutants associated with construction and operation equipment.

Clearing and grubbing, site preparation, construction, and other activities at the quarry and support area would result in extensive soil disturbance. If these activities accelerated erosion, turbidity and sedimentation could increase in Little Femme Osage Creek, Femme Osage Creek, Femme Osage Slough, and other waterways in the area and result in some degradation of aquatic habitats present in those drainages. Also, runoff from construction and support areas or from accidental spills (e.g., of motor oil, hydraulic fluid, or other petroleum products associated with construction machinery and support-area equipment) could contaminate Little Femme Osage Creek, Femme Osage Creek, and Femme Osage Slough.

The severity of impacts to aquatic habitats in the vicinity of the quarry would depend on a variety of factors — including the degree of runoff; the frequency, duration, and intensity of precipitation events; construction practices and procedures; and existing habitat quality at the quarry and support area. However, the impacts would be temporary and would cease following completion of remedial activities at the quarry. Potential adverse impacts resulting from the bulk waste remedial action at the quarry area would be minimized by implementing standard mitigative measures to control erosion and water quality impacts. Removal of the bulk wastes from the quarry would be expected to reduce any negative effects on aquatic biota in the vicinity of the quarry that might result from the presence of the wastes.

Proposed Haul Road. Construction of the haul road would disturb some soils, and erosion from the affected areas could cause minor degradation of some of the small, intermittent drainages in the vicinity. In particular, the relatively steep terrain along certain areas of the proposed haul road would be susceptible to accelerated erosion from surface runoff. However, impacts to local aquatic habitats from sediment loading would be minimal because habitats in these areas are limited to small, intermittent drainages. Potential impacts would be further minimized by implementing standard mitigative measures to reduce and control erosion during construction activities. No significant impacts to aquatic habitats in the area are anticipated during the transportation of bulk wastes from the quarry to the TSA. Potential impacts from accidental spills of construction materials (e.g., fuels and oils) or quarry wastes would be minimized by implementing appropriate operating procedures and contingency plans; an operational environmental, safety, and health plan is being prepared to develop procedures for responding to such spills.

Proposed TSA. No aquatic systems exist at the location of the proposed TSA. Construction of this facility would disrupt surface soils, some of which are radioactively and/or chemically contaminated (see Section 9.7). Subsequent erosion could result in the off-site transport of sediments to nearby surface waters. However, such erosion is expected to be minor because of the relatively flat terrain and would be further minimized by implementing standard mitigative measures to reduce soil erosion and potential water quality impacts during construction activities. Also, contaminated soil removed during construction of the TSA would be controlled to minimize any potential for dispersal. Sediment generated during construction would be contained, as would any leachate generated by the waste piles (see Section 8.4.1). No impacts to local aquatic ecosystems are anticipated to result from construction of the TSA, and any effects that would occur would be temporary, pending stabilization of the disturbed construction site. In addition, no impacts are anticipated to result from the activities associated with storing the bulk wastes at the TSA. The potential for accidental releases of contaminated materials would be minimized by use of engineering measures such as liners, covers, and runon and runoff controls. Contingency procedures would be in place to address any accidental releases that might occur (MK-Ferguson Company and Jacobs Engineering Group 1989a).

10.3.3 Threatened and Endangered Species and High-Quality Natural Communities

No impacts to any federal- or state-listed species are expected to result from the bulk waste remedial action. No critical habitat exists at any of the construction areas, and no listed species are known to occur or utilize habitats at these locations. In addition, no unique or high-quality natural communities exist at any of the construction areas. Thus, no impacts from construction, bulk waste removal and transport, or storage activities are anticipated to occur to high-quality communities that exist in the vicinity of the quarry, haul road, or TSA.

The ponded water in the quarry could provide habitat suitable for the wood frog, a species classified by the state as rare (see Section 2.3.3). The wood frog is primarily a terrestrial species as an adult but uses fishless, woodland ponds and pools for reproduction in the spring (i.e., generally between February and March). It is not known if the wood frog uses the quarry pond for breeding purposes. As currently planned, the ponded water will be removed and treated as a separate environmental response action at the quarry (see MacDonell et al. 1989). The Missouri Department of Conservation has stated that no survey for wood frog use of the quarry pond would be necessary prior to removal of the ponded water nor would any mitigative measures be required during water removal (Johnson 1990). This judgment was based on the presence of a large population of wood frogs and an abundance of suitable breeding habitat in St. Charles County and at the Weldon Spring Wildlife Area.

10.4 LAND USE AND DEMOGRAPHY

The impacts of remedial action at the quarry on local land use are expected to be relatively minor. Trucks carrying bulk wastes from the quarry to the TSA would cross State Route 94, which would require temporarily halting traffic on that road. Under the current plan, these trucks would make the return trip on Route 94, which would entail entering the traffic flow and making a left turn into the quarry area. The resulting delays to other travelers on Route 94 are expected to be short, although they might be frequent during the estimated 1.25-year action period.

In addition, some impacts on recreational use of the wildlife area between the quarry and the TSA might occur. For example, the noise, exhaust fumes, movement, and dust associated with excavation activities at the quarry and with trucks transporting the wastes could impact recreation in the immediate area. However, these negative consequences would be restricted to a relatively narrow corridor and would occur only during the action period. Removing vegetation from the quarry support area might detract from the aesthetic quality of this location. However, the vegetation in the surrounding wildlife area is relatively thick, so the openings would not be visible to recreational users for very great distances.

Limited effects are expected on local employment associated with constructing the haul road, TSA, and quarry support area and with carrying out cleanup activities. Fewer than 100 workers would be involved during the construction phase; fewer than 50 workers would be involved in the actual excavation and transport activities. For a metropolitan area the size of St. Louis, these numbers are not expected to pose any labor shortages or socioeconomic problems.

10.5 CULTURAL RESOURCES

The proposed action is not expected to adversely affect significant archeological sites or historic structures (i.e., sites or structures eligible for inclusion in the *National Register of Historic Places*). Although not surveyed, the bulk wastes in the quarry (which rest on bedrock) are unlikely to contain any archeological remains. Ground disturbance would occur at the location designated for the quarry support area (see Figure 8.1), but no archeological remains have been reported there (Walters 1988). The planned installation of a 10-cm (4-in.) pipe to connect the quarry with an existing county water main (for decontamination, fire-fighting capability, and other water requirements) could potentially impact archeological resources. This activity is being coordinated with the Missouri SHPO to ensure that significant archeological and cultural resources are not adversely affected. The preferred route for transport of the bulk wastes would traverse areas of prior disturbance, primarily the railroad easement (see Figure 8.7). Construction of a TSA at the chemical plant area could impact a few existing structures; however, the chemical plant area has been determined to be ineligible for inclusion in the *National Register* (Weichman 1988).

10.6 ADVERSE ENVIRONMENTAL EFFECTS THAT CANNOT BE AVOIDED IF THE PROPOSED ACTION IS CARRIED OUT

The quarry bulk waste remedial action would involve destroying about 4.3 ha (10.6 acres) of forest habitat from clearing and grubbing at the quarry and adjacent support area, about 5.3 ha (13.0 acres) of vegetation from constructing the haul road, and about 5.3 ha (13.0 acres) of grassland from constructing the TSA. Some small, fairly immobile wildlife would be lost; other wildlife could be lost or displaced; and wildlife would be disturbed due to construction and operations. The operation of trucks and other vehicles would temporarily increase noise levels and air pollutant emissions (engine exhaust). Daily traffic on State Route 94 would increase by about 2% if the highway were used for the return of empty vehicles. Workers would be exposed to the risk of injuries and death associated with the operation of excavation equipment, and workers and the general public would be exposed to the risk of injuries and death associated with transportation accidents (see Section 11.5). Implementing the bulk waste remedial action could expose workers and the general public to radioactive and chemical contaminants above levels typically received from background sources during the action period (see Chapter 11). These effects cannot be avoided during implementation of this action.

10.7 CUMULATIVE ENVIRONMENTAL EFFECTS

A water treatment plant is planned to be constructed at the quarry as part of a separate action prior to bulk waste removal. The plant would treat water removed from the quarry pond, and the treated water would be discharged to the Missouri River downstream from the county well field in compliance with a permit issued by the state of Missouri. The plant would continue to treat water from the quarry during bulk waste removal. Construction and operation of the water treatment plant is expected to cause only minor environmental impacts (MacDonell et al. 1989). Impacts associated with construction would be short term and would influence only the area immediately around the construction site. The environmental effects of the discharge, while longer term, are expected to be minimal because of the small volume of water discharged to the Missouri River and the extensive treatment of this water prior to its release.

Cumulative effects associated with the construction and operation of the quarry water treatment plant and the removal of the bulk wastes are expected to be negligible. Construction of the water treatment plant would be completed prior to the start of any activities related to bulk waste excavation. The total area disturbed by construction activities would increase because of waste removal, but other cumulative effects involving construction would not be significant because activities would occur at different times. Removal of the bulk wastes would not significantly affect the Missouri River, which would receive the treatment plant effluent; operation of the treatment plant would not significantly affect areas that might be influenced by activities related to bulk waste removal. Therefore, no significant cumulative effects are expected relative to the construction and operation of the water treatment plant at the quarry and the removal of the bulk wastes.

Storm-water runoff from the TSA, leachate from the wastes stored at the TSA, and wash water from vehicle decontamination at the TSA would be treated at a water treatment facility being planned for the chemical plant area. The primary purpose of the facility would be to treat water from the raffinate pits. Potential cumulative impacts associated with the construction and use of the TSA and the water treatment facility will be discussed in the EE/CA that is being prepared for this facility. Potential impacts associated with temporary storage of the bulk wastes at the TSA are presented in this FS; potential impacts of remediation of the chemical plant area will be discussed in the site RI/FS-EIS. Potential cumulative effects associated with storage of the bulk wastes at the TSA as part of the overall site remediation will also be addressed in the RI/FS-EIS.

11 POTENTIAL HEALTH EFFECTS

Potential health effects from the bulk waste remedial action were assessed by estimating the radiological and chemical doses and associated health risks to the general public and workers that could result from exposure to site releases. Such releases could occur during the remedial action period (i.e., while the wastes were being excavated, transported, and unloaded at the TSA) and during temporary storage of the wastes prior to their permanent disposal. For chemical contaminants, both carcinogenic and noncarcinogenic impacts were evaluated in this risk assessment. For radioactive contaminants, the potential impacts considered were induction of fatal cancers and serious genetic effects in the offspring of exposed individuals.

This health effects assessment was conducted according to guidance given in the *Superfund Public Health Evaluation Manual* (SPHEM) (EPA 1986) and the *Superfund Exposure Assessment Manual* (EPA 1988a). The scope of this assessment was limited to the time period for bulk waste removal and temporary storage at the TSA. Because bulk waste removal is an interim step in the overall remedial action planned for the quarry (see Section 1.1), this risk analysis does not include development of cleanup criteria. Furthermore, it does not provide a quantitative basis for evaluating the long-term effectiveness of the proposed remedial action alternatives with regard to protection of human health and the environment. The detailed characterization data required to make such an assessment can be obtained only after the bulk wastes have been removed from the quarry. The appropriate documentation for developing cleanup criteria and evaluating the effectiveness of the overall remedial action at the quarry will be prepared following removal of the bulk wastes (see Section 1.1).

The short-term impacts on human health and the environment that could result from exposure to contaminants released under current site conditions (i.e., prior to implementation of any remedial action) were assessed in the BRE for the Weldon Spring quarry; this evaluation was published as a separate report (Haroun et al. 1990) and is summarized in Chapter 3 of this document. The relationship between the health risk assessment presented in this chapter and that given in the BRE is discussed in Section 11.4; cumulative health impacts of currently planned actions for quarry remediation (i.e., bulk waste removal and construction and operation of a water treatment plant) are presented in Section 11.6.

Both radioactive and chemical contaminants are present in the quarry bulk wastes. The results of waste characterization studies are summarized in Sections 2.7 and 2.8; the contaminants detected in the bulk wastes are listed in Tables 2.5, 2.6, 2.7, and 2.8. Because of the large number of contaminants in the quarry, those presenting the greatest potential risk -- i.e., indicator contaminants -- were identified and analyzed in detail in the quarry BRE (see Section 3.1). The indicator chemicals for the BRE were selected according to SPHEM methodology (EPA 1986), which suggests that, where a large number of contaminants are present, the indicator chemicals should be selected on the basis of their (1) distribution and concentrations in environmental media, (2) toxicity, and (3) physical/chemical properties that affect their mobility and persistence in the environment. Additional factors considered in the selection of indicator radionuclides were the components of the relevant decay series and the half-lives of the radionuclides. Because the BRE focused on an evaluation of risks associated with current conditions at the quarry, this list of indicator contaminants was reviewed to determine if compounds should be added to or deleted from the list to reflect potentially different exposures associated with removal of the bulk wastes from the quarry. No changes were made to the list as a result of this review. The final list of indicator contaminants for the assessment of potential risks associated with the bulk waste remedial action is presented in Table 11.1. A general description of the toxicological effects associated with radiation exposure and short summaries of the major toxicological effects of these indicator chemicals are presented in the BRE (Haroun et al. 1990).

11.1 EXPOSURE ASSESSMENT

11.1.1 Exposure Pathways

A complete exposure pathway consists of four components: (1) a source and mechanism of contaminant release to the environment, (2) an environmental transport medium (e.g., air) for the released contaminants, (3) a point of human contact with the contaminated medium (referred to as the exposure point), and (4) a route of human exposure (e.g., inhalation) at the exposure point. If any one of these four components is missing, the pathway is incomplete and is not considered further in a risk assessment. The exposure pathways considered in the risk assessment for bulk waste removal were those complete pathways associated with implementing the remedial action, i.e., (1) excavating and loading the bulk wastes at the quarry, (2) transporting the wastes to the TSA, and (3) unloading and storing the wastes at the TSA.

The main source of contamination within the quarry is the bulk wastes. As identified in the BRE, the principal contaminant release mechanisms and transport media of potential concern for the bulk wastes are:

1. Emission of radon-220 and radon-222 from radium-contaminated materials to the atmosphere,

2. Emission of gamma radiation from contaminated materials to the atmosphere,

3. Emission of fugitive dusts from contaminated materials to the atmosphere,

4. Direct contact with contaminated materials, and

5. Leaching of contaminated surface and/or subsurface materials to groundwater.

TABLE 11.1 Final List of Indicator Radionuclides and Chemicals for the Quarry

Indicator Radionuclides[a]	Indicator Chemicals: Metals	Indicator Chemicals: Nitroaromatic Compounds	Indicator Chemicals: Other Organic Compounds
Uranium-238	Arsenic[b]	2,4-DNT and 2,6-DNT[b]	PAHs (carcinogens)[b,c]
Thorium-232	Lead[b]	2,4,6-TNT[b]	PAHs (total)[d]
Thorium-230	Nickel[b]	1,3,5-Trinitrobenzene	PCBs[b]
Radium-228	Selenium		
Radium-226	Uranium		
Radon-222			
Radon-220			

[a]Exposure to gamma radiation resulting from the presence of these radionuclides was also evaluated.

[b]Potential carcinogens.

[c]For this risk assessment, the following PAHs at the quarry are considered to be potential carcinogens: benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

[d]Includes both carcinogenic and noncarcinogenic PAHs.

The first three of these contaminant release pathways might be significant during the bulk waste remedial action. Elevated levels of radon gas and gamma radiation have been consistently measured at the quarry, as reported in the annual environmental monitoring reports. Because the bulk wastes constitute the source of these contaminants, the first two pathways could be important during bulk waste excavation, transport, and storage activities. Although present at the quarry, radon-220 and its short-lived decay products represent a much lower hazard than radon-222 and its short-lived decay products (see Haroun et al. 1990) and were therefore not considered further in this assessment. The manner in which the health risks associated with inhalation of radon-222 and its short-lived decay products were estimated is expected to account for the health risks associated with all forms of radon gas. The potential for generation of fugitive dusts at the quarry under current site conditions is minimal, but dust levels would be expected to increase during excavation, loading, and unloading of the bulk wastes. Thus, fugitive dust emissions were modeled (see Section 10.2 and Appendix B), and potential exposures to fugitive dusts were assessed for these activities. In addition, because dusts could deposit on the face and lips of a worker, potential exposure from incidental ingestion of contaminated dusts was assessed.

Two pathways -- direct contact with contaminated materials and exposure to contaminated groundwater -- were not assessed. Both the presence of workers at the quarry and the increased security during excavation of the bulk wastes would preclude entry into the quarry by a trespasser for any significant amount of time; hence, direct contact with contaminated soils is unlikely. Dermal contact by workers handling the bulk wastes would be prevented by protective clothing and other control measures. Although disturbance of the bulk wastes during excavation could increase contaminant migration to groundwater, several mitigative measures would be implemented to minimize potential impacts. These measures include (1) reversing the hydraulic gradient at the quarry to limit outflow by continuously pumping water from the quarry pond area, (2) selectively grouting the surfaces of exposed fractures in the quarry walls and floor as excavation work proceeds, and (3) implementing control technologies (e.g., capture wells) if the extensive monitoring well network currently in place indicates an increase in contaminant migration to groundwater. Wells at the St. Charles County well field located to the south of the quarry are routinely monitored to ensure the integrity of this potable water supply.

Based on the above considerations, the principal contaminants associated with the bulk waste remedial action and the potential routes of human exposure to these contaminants are:

- Inhalation of radon-222 and its short-lived decay products,

- Exposure to external gamma radiation,

- Inhalation of radioactively and chemically contaminated airborne dusts, and

- Incidental ingestion of radioactively and chemically contaminated dusts.

The receptors potentially exposed to these contaminants are identified in Section 11.1.2.

11.1.2 Exposed Populations and Exposure Scenarios

General Public. Inhalation would be the primary route for exposure of the general public to releases from the quarry and TSA. Based on estimated air concentrations of fugitive dusts resulting from the bulk waste remedial action (see Section 10.2 and Appendix B), areas have been identified around both the quarry and the chemical plant area that would be potentially impacted by site releases. Within these areas, the following scenarios -- i.e., receptors and exposure points -- were selected for the risk analysis:

- In the vicinity of the quarry
  - A passerby on State Route 94 and
  - The nearest resident, located west of the quarry on State Route 94.
- In the vicinity of the chemical plant
  - A student at Francis Howell High School and
  - An on-site worker (for analysis purposes, this worker is assumed to be located in the on-site project office building).

The location with the highest predicted off-site radon gas and airborne particulate concentrations is north of the quarry along State Route 94 (i.e., for the passerby); at the remaining three locations, an individual would be exposed to lower concentrations but for a longer duration. Although contaminant concentrations at the high school would be lower than those at the on-site office building, exposure to a receptor at this location was assessed because of the large number of students at the school and its proximity to the TSA. Other potential receptors were identified but not explicitly evaluated. These include individuals who frequently drive by the quarry on State Route 94, workers at facilities near the quarry or chemical plant area (e.g., the water treatment plant north of the quarry and the highway maintenance facility adjacent to the northeast boundary of the chemical plant area), additional on-site workers at the chemical plant area, and members of the general public visiting the surrounding wildlife areas (e.g., a hiker on Katy Trail). The exposures of these receptors would be similar to or less than the exposures estimated for the specific receptors considered in this analysis.

The passerby scenario addresses the potential exposure of a hypothetical individual who, during the remedial action period, is assumed to walk by the quarry along State Route 94 twice daily. The resident scenario addresses the potential exposure of an individual who is assumed to be present 100% of the time at the nearest residence, about 0.8 km (0.5 mi) west of the quarry. The office worker scenario addresses the potential exposure of an employee at the chemical plant area, who is assumed to be present in the on-site office building (approximately 0.7 km [0.4 mi] from the TSA) 8 hours per day, 5 days per week, for the 1.25 years required to implement the action. (For this assessment, the on-site office worker is considered to be a member of the general public, as distinguished from a remedial action worker involved in the actual handling of the bulk wastes.) Finally, the student scenario addresses exposure of a student at Francis Howell High School, who is assumed to be present at the school 8 hours per day, 180 days per year, over the 1.25-year action period. These four exposure scenarios are summarized in Table 11.2. Total exposures of the receptors identified in these scenarios were determined for (1) inhalation of radon-222 and its short-lived decay products and

TABLE 11.2 Exposure Scenario Descriptions and Intake Parameters

Exposure Scenario	Scenario Assumptions	Body Weight[a] (kg)	Inhalation Rate[b] (m^3/h)
Passerby	A hypothetical individual walks by the quarry twice per day, with an average occupancy time of 0.2 hours, 365 days per year, during the remedial action period of 1.25 years.	70	1.2
Resident	An individual is present in the residence closest to the quarry (about 0.8 km [0.5 mi] distant) 100% of the time during the remedial action period of 1.25 years.	70	0.83
Office worker	A worker occupies the Weldon Spring project office building 8 hours per day, 5 days per week, 50 weeks per year, during the remedial action period of 1.25 years.	70	1.2
Student	A student is present at Francis Howell High School 8 hours per day, 180 days per year, during the remedial action period of 1.25 years.	60	1.2
Maximally exposed worker	A worker occupies the quarry 8 hours per day, 5 days per week, 50 weeks per year, during the remedial action period of 1.25 years. This worker wears protective clothing but does not use respiratory protective equipment.	70	1.2
Other workers	Workers involved in bulk waste excavation and loading, transport, and unloading and storage activities work 8 hours per day, 5 days per week, 50 weeks per year, during the remedial action period of 1.25 years. These workers wear protective clothing and use respiratory protective equipment.	70	1.2

[a]Based on data from EPA (1989f).

[b]Inhalation rates are discussed in Section 11.2.

(2) inhalation of contaminated dusts. Exposure to direct external gamma radiation was also assessed for the passerby.

Although storage of the wastes prior to their permanent disposal is considered part of the bulk waste remedial action, the wastes would be covered to minimize gaseous and particulate releases so that exposures of the general public would be negligible. Thus, the risks to the general public associated with releases from the TSA during waste storage were not quantitatively assessed.

Contaminated materials could be released to the environment outside of the quarry or chemical plant area as a result of an accident during the excavation period (for example, a truck overturning along the haul road). Preventive measures and contingency plans would be in place to respond to accidents occurring at any time during the proposed action. Access controls would be implemented immediately to prevent the public from entering an area potentially impacted by releases resulting from an accident, and workers would be brought in to clean up any spills. Because the materials are primarily solids with low levels of contamination and the quantity transported in one load would be small, airborne releases as a result of an accident would be very small compared to the amount released during routine activities associated with the action. Hence, impacts to the general public from such releases were not explicitly analyzed in this risk assessment.

Workers. Workers could be exposed to contaminants from the quarry bulk wastes during the three major activities associated with the proposed action: (1) excavating and loading the bulk wastes at the quarry, (2) transporting the wastes to the TSA, and (3) unloading and storing the wastes at the TSA. These activities would be conducted in accordance with an operational environmental, safety, and health plan being developed for this action in order to minimize potential occupational exposures to contaminants. In addition, engineering controls would be employed to control dust and gaseous emissions. Workers at the quarry and TSA, either in contact with the bulk wastes or working in the vicinity of the wastes, would be supplied with protective clothing and equipment (such as respiratory protective equipment), as required. Potential exposures of workers associated with the activities were assessed assuming that these protective measures would be in place. In addition, exposures were assessed for a "maximally exposed worker" at the quarry not wearing respiratory protective equipment. This latter scenario evaluates the occupational hazards associated with the bulk wastes if protective measures fail, and it also represents the maximum exposure to a worker if it is determined that respiratory protection is not required in all areas of the quarry. The scenarios and potential exposures are described below.

Bulk waste excavation activities in the quarry would be performed using standard equipment with positive-pressure cabs into which forced air would be supplied through high-efficiency-particulate-air (HEPA) filters to remove airborne radioactively and chemically contaminated particulates. Other workers would use respiratory protective equipment, such as HEPA-filtered masks, while in the area to ensure that they did not incur significant chemical or internal radiation exposures. Although HEPA filters do not remove radon gas, they do remove the radioactive decay products (solids) that constitute the primary hazard associated with radon-222. Hence, exposure to external gamma radiation would be the only important route of occupational exposure during excavation activities.

The bulk wastes would be transported to the TSA in covered, tightly sealed, leakproof trucks. This would ensure minimal (essentially zero) releases of particulates during transport activities. The truck cabs would be maintained under positive pressure and would have HEPA-filtered air intakes, and workers involved with loading activities would wear respiratory protective equipment, as necessary. Hence, exposure to external gamma radiation would be the only significant route of occupational exposure during bulk waste transport.

Occupational exposures at the TSA could occur during (1) preparation of the area for construction of the TSA -- including the removal of four buildings, relocation of utilities, and excavation of low-level contaminated soils, (2) unloading and placement of the bulk wastes in the facility, and (3) maintenance of the TSA while the wastes were in temporary storage. The levels of hazardous contaminants in the area proposed for the TSA are low (see Section 9.7), and occupational exposures during preparation of this area for construction of the TSA would be much lower than those associated with unloading the bulk wastes at the TSA. Mitigative measures would be taken to minimize airborne releases, the air would be monitored, and appropriate worker protection measures would be implemented. Therefore, the occupational doses associated with these activities were not quantitatively estimated in this assessment.

The unloading and placement of wastes at the TSA would be carried out with standard equipment having positive-pressure cabs with HEPA filters. Workers not in cabs would use respiratory protective equipment, as necessary, while in the area. Hence, exposure to external gamma radiation would be the only significant route of occupational exposure during waste unloading and placement at the TSA, as well as during future maintenance activities.

These exposure scenarios assume that workers would be protected from all but gamma radiation by engineered controls and/or personal protective equipment. However, during bulk waste excavation at the quarry and unloading activities at the TSA, the air would be monitored for radon gas, particulates, and vapors. Because such monitoring might indicate that not all workers at the quarry or TSA would require respiratory protective equipment, the exposures of a worker wearing protective clothing but no respiratory protective equipment were assessed for a worker at the quarry. (Exposures at the TSA would be similar to but somewhat lower than those at the quarry because the TSA would be designed to allow for efficient handling of these wastes.) In addition to inhaling fugitive dusts, this worker could ingest contaminated dust deposited on the face and lips. Total exposures for a worker at the quarry were estimated for (1) inhalation of radon-222 and its short-lived decay products, (2) direct external gamma radiation, (3) inhalation of contaminated dusts, and (4) incidental ingestion of contaminated dusts.

Other workers at the chemical plant area not directly involved in waste-handling activities could be exposed to contaminant releases during unloading and storage activities at the TSA. The actual exposures of these workers would depend on their proximity to the TSA. However, the major exposure pathway would be the same, i.e., inhalation of airborne contaminants. Because air contaminant concentrations exterior to the office building were used to estimate exposures for the office worker (see Section 11.1.3), the exposures of these other on-site workers would be similar to that of the office worker described earlier in this section.

Accidents could occur during the proposed remedial action, resulting in short-term increases in worker exposures to contaminated materials. Preventive measures and contingency plans would be in place for responding to potential accidents. Workers would utilize protective clothing and respiratory protective equipment as necessary, and standard equipment and procedures would be used to clean up spills and conduct other activities required as a result of an accident. Hence, potential worker exposures to radioactive and chemical contaminants resulting from an accident would be similar to but much lower than exposures occurring during routine activities at the quarry and TSA. Exposures resulting from an accident were therefore not explicitly assessed in this analysis.

11.1.3 Exposure Point Concentrations

The concentrations of indicator chemicals and radionuclides at the exposure points for both the general public and worker scenarios were estimated based on (1) bulk waste characterization data presented in Sections 2.7 and 2.8, (2) environmental monitoring data, and (3) environmental transport modeling used to estimate airborne concentrations of particulates and radon gas for the bulk waste remedial action (see Section 10.2 and Appendix B).

Radon-222. The risk associated with radon-222 is due primarily to the inhalation of its short-lived decay products. Hence, the concentration of radon-222 alone is not a good measure of the hazard associated with this radionuclide. A more representative measure is an estimate of the potential alpha energy associated with its short-lived decay products; the working level is such a unit of measure. One working level (WL) corresponds to 100 pCi/L of radon-222 in equilibrium with its short-lived decay products.* The average value of radon-222 decay products measured in the quarry is 1.3×10^{-2} WL (MK-Ferguson Company and Jacobs Engineering Group 1990a). This value is expected to decrease somewhat during bulk waste excavation because the total amount of radon-222 released at the quarry is expected to decrease as the bulk wastes are removed (see MK-Ferguson and Jacobs Engineering Group 1990a). Hence, this average value was used as the exposure point concentration for the maximally exposed worker.

Concentrations of radon-222 at exposure points outside the quarry were calculated using the computer code MILDOS (Strenge and Bander 1981), which was modified to more accurately assess airborne concentrations resulting from releases from large areas (Yuan et al. 1989). The estimated quantity of radon-222 released during excavation of

*One working level is defined as any combination of short-lived radon decay products in one liter of air, without regard to degree of equilibrium, that will result in the ultimate emission of 1.3×10^{5} MeV of alpha energy.

the bulk wastes was used as input to this code. Radon-222 releases consist of two types: (1) those from undisturbed wastes (i.e., similar to those that are currently occurring at the quarry) and (2) those from the interstitial spaces exposed during excavation activities. Releases of the first type were estimated from the estimated radon-222 flux, exposed surface area, and length of time associated with excavation activities. Releases of the second type were estimated from the total radium-226 inventory in the bulk wastes (estimated to be 12.4 Ci) and the emanation coefficient (fractional amount of radon-222 gas that reaches the interstitial pore spaces). An emanation coefficient of 0.5 was used in these estimates (MK-Ferguson Company and Jacobs Engineering Group 1990a).

Two excavation scenarios were considered in the estimation of radon-222 releases. In the first scenario (referred to as Alternative I in the report of MK-Ferguson Company and Jacobs Engineering Group [1990a]), the wastes were assumed to be removed in one pass. The second excavation scenario (referred to as Alternative II) is similar to the first scenario except that excavation of the area with the greatest depth of wastes was assumed to occur in two lifts of approximately 6 m (20 ft) each. The estimated radon-222 releases from the undisturbed wastes are 40.3 Ci for Alternative I and 36.0 Ci for Alternative II (MK-Ferguson Company and Jacobs Engineering Group 1990a). These estimates were based on an assumed excavation time of 1 year, although the actual time might be shorter or longer depending upon the actual procedures used to excavate these wastes. A time period of 1.25 years was used to estimate radiation doses to workers and the general public in this risk assessment.

All of the radon-222 in the interstitial spaces of the bulk wastes was assumed to be released during excavation and loading onto transport vehicles. The total amount of radon-222 released from the interstitial spaces is estimated to be 8.8 Ci (MK-Ferguson Company and Jacobs Engineering Group 1990a). This release consists of two components: (1) radon-222 releases (6.2 Ci) associated with excavation; and (2) radon-222 releases (2.6 Ci) associated with loading onto transport vehicles after an assumed 3-day period in a sorting area. These releases were assumed to be the same for both excavation alternatives. Hence, the total radon-222 releases at the quarry are estimated to be 49.1 Ci for Alternative I and 44.8 Ci for Alternative II (MK-Ferguson Company and Jacobs Engineering Group 1990a). The larger value (i.e., 49.1 Ci) was used in this assessment. Most of the radon-222 emissions at the quarry are from the undisturbed wastes; releases associated with the actual excavation activities are estimated to account for only about 20% of the total.

These release rates do not assume the use of engineering controls to reduce radon-222 emissions during bulk waste excavation. Use of controls such as synthetic membrane liners as covers would reduce emissions from the undisturbed areas, which constitute the largest source of emissions. Radon controls could be difficult to maintain in the quarry due to the use of heavy earth-moving equipment and the limited area in which these activities would occur. The exact procedures for removing the wastes and controlling emissions will be finalized during detailed engineering. In this assessment, no credit is taken for engineering controls that would reduce radon-222 emissions from the quarry during bulk waste excavation, although some control is likely.

The bulk wastes would be transported to the TSA on a dedicated haul road. Most of the interstitial radon gas would be released as the wastes were excavated and loaded onto the transport vehicles. Because it takes several days for significant ingrowth of radon-222 to occur (radon-222 has a half-life of 3.8 days), radon-222 releases would not be significant during waste transport and placement in the TSA if these activities were performed expeditiously. However, after the wastes were placed in storage at the TSA, radon-222 ingrowth would occur. The TSA would be designed and operated to minimize radon gas and particulate releases; the open working faces would be kept as small as possible and would be covered at the end of each day during waste emplacement.

To minimize the release of radon-222 while the wastes were in storage, radium-contaminated soils would be covered with a flexible-membrane liner that would effectively attenuate radon gas releases. This cover would be installed progressively as such wastes were brought to the TSA for storage. The total amount of radon-222 released to the atmosphere prior to installation of the final cover and with no controls in place is estimated to be 44 Ci (MK-Ferguson Company and Jacobs Engineering Group 1990a). However, because this cover would be installed progressively as the wastes were brought to the TSA and other control measures would be instituted, the actual releases would be much lower. For this assessment, a release of 4.4 Ci from the TSA was assumed to occur during the action period, i.e., the releases were assumed to be reduced by a factor of 10 as a result of engineering controls. The actual reduction might be somewhat greater.

Use of flexible-membrane liners to control radon gas releases would result in the buildup of radon gas between the liner and the contaminated soil. The concentration of radon gas in the air space between the liner and the contaminated soil would not be greater than that in the interstitial air spaces in the soil. When the liner was removed, e.g., to place more wastes in the TSA, the radon gas that had built up would be released to the atmosphere. The small volume of radon released would rapidly mix with the ambient air and would be diluted to low levels. Hence, the dose to workers removing the liner is not expected to be significant given the low radon concentrations and the limited duration of exposure. This effect will, however, be considered in the selection of specific engineering controls for this action at the quarry and the TSA.

During the temporary storage period, releases of radon gas from the TSA would be very low because the cover would be routinely inspected and repaired as necessary. Field measurements have demonstrated that using flexible-membrane liners to cover soils contaminated with radium-226 decreases radon-222 emissions by a factor of about 80 (MK-Ferguson Company and Jacobs Engineering Group 1990a). Radon concentrations at off-site locations, e.g., at Francis Howell High School, are expected to be indistinguishable from background concentrations of radon gas in the Weldon Spring area.

Because the major hazard associated with radon-222 is its short-lived decay products, it is necessary to account for ingrowth of these decay products during transit to off-site exposure points. The degree of ingrowth is given by the working level ratio (WLR). The WLR is initially zero at the point of release and increases with time (and transit distance). The WLR has a value of one when the decay products have reached equilibrium with radon-222. The WLRs for the various exposure points outside the quarry were calculated using the computer code MILDOS. The WLRs and estimated exposure point concentrations of radon-222 (in pCi/L) and its short-lived decay products (in WL) associated with removal, transport, and placement of the bulk wastes into temporary storage at the TSA are given in Table 11.3.

External Gamma Radiation. Exposure to external gamma radiation is of concern only for a receptor in the immediate vicinity of the bulk wastes and was therefore not estimated for the resident, office worker, or student scenarios. The highest measured gamma exposure rate in the vicinity of the quarry was about 8 μR/h above background, as reported in the annual environmental monitoring reports for 1982 through 1987 (MK-Ferguson Company and Jacobs Engineering Group 1989a). It is estimated that the gamma exposure rates associated with bulk waste removal activities would be slightly higher along State Route 94 than at the quarry fence line under current site conditions. A value of 10 μR/h (above background) was used for the assessment to provide a conservative estimate of the actual hazard associated with external gamma radiation.

The dose rate from external gamma exposure within the quarry is estimated to be 0.5 mrem/h at 1 m above the wastes, using the average radionuclide concentrations given in Table 2.5 and the methodology and data provided in Gilbert et al. (1989). However, the gamma radiation levels would decrease with distance from the source (i.e., the bulk wastes), and most of the work would be performed using standard excavation equipment, which would shield the workers from gamma rays emanating from the bulk wastes. Hence, the workers would be exposed to a dose rate lower than 0.5 mrem/h. The dose rate is estimated to be reduced by about a factor of four as a result of shielding provided by excavation equipment. However, because some of the work would be performed manually, the average dose rate would be somewhat higher than the dose rate estimated for workers using excavation equipment. Therefore, in this assessment, the average dose rate to workers within the quarry was assumed to be 0.25 mrem/h during excavation activities. A dose rate of 0.5 mrem/h was assumed for the maximally exposed worker.

The average dose rate would be somewhat less to drivers transporting the wastes to the TSA than to workers excavating the wastes because the drivers would not perform any manual activities. Therefore, an average dose rate of 0.1 mrem/h was used for truck drivers in this assessment. The dose rate for workers at the TSA would be similar to (or less than) that for workers in the quarry during waste excavation because the activities are similar. Hence the same dose rate, i.e., 0.25 mrem/h, was used for workers at the TSA to assess potential impacts of waste placement and monitoring and maintenance activities during the temporary storage period.

Bulk Wastes. An extensive amount of data is available to estimate the concentrations of radioactive contaminants in the bulk wastes; the values used for this assessment are given in Table 2.5. In contrast, the data available to estimate concentrations of chemical contaminants in the bulk wastes are very limited. For this reason, and because the contamination in the quarry is highly variable, it was necessary to use different criteria to estimate representative concentrations of chemical contaminants

TABLE 11.3 Exposure Point Concentrations of Indicator Contaminants

Contaminant	Average Bulk Waste Concentration (pCi/g)	Estimated Air Concentration of Contaminants as Respirable Particulates[a] (pCi/m^3, except as noted)				
		Within Quarry	State Route 94	Nearby Residence	Office Building	High School
Radionuclides						
Uranium-238	200	2.0×10^{-1}	4.8×10^{-3}	1.6×10^{-5}	2.2×10^{-4}	1.7×10^{-5}
Thorium-232	26	2.6×10^{-2}	6.2×10^{-4}	2.0×10^{-6}	2.9×10^{-5}	2.2×10^{-6}
Thorium-230	330	3.3×10^{-1}	7.9×10^{-3}	2.6×10^{-5}	3.6×10^{-4}	2.8×10^{-5}
Radium-228	96	9.6×10^{-2}	2.3×10^{-3}	7.5×10^{-6}	1.1×10^{-4}	8.3×10^{-6}
Radium-226	110	1.1×10^{-1}	2.6×10^{-3}	8.6×10^{-6}	1.2×10^{-4}	9.5×10^{-6}
Radon-222 (pCi/L)	–[b]	–[c]	1.5	9.3×10^{-3}	6.0×10^{-4}	4.2×10^{-4}
Radon-222 (WLR)[d]	–[b]	–[c]	1.0×10^{-1}	3.0×10^{-1}	7.0×10^{-1}	8.0×10^{-1}
Radon-222 (WL)[d]	–[b]	1.3×10^{-2}	1.5×10^{-3}	2.8×10^{-5}	4.2×10^{-6}	3.4×10^{-6}

Contaminant	Average Bulk Waste Concentration[e] (mg/kg)	Estimated Air Concentration of Contaminants as Respirable Particulates[a] (mg/m^3)				
		Within Quarry	State Route 94	Nearby Residence	Office Building	High School
Nitroaromatic Compounds						
2,4,6-TNT	1,300	1.3×10^{-3}	3.1×10^{-5}	1.0×10^{-7}	1.4×10^{-6}	1.1×10^{-7}
2,4-DNT and 2,6-DNT	18	1.8×10^{-5}	4.3×10^{-7}	1.4×10^{-9}	2.0×10^{-8}	1.5×10^{-9}
1,3,5-Trinitrobenzene	14	1.4×10^{-5}	3.4×10^{-7}	1.1×10^{-9}	1.5×10^{-8}	1.2×10^{-9}
PAHs						
Carcinogens	60	6.0×10^{-5}	1.4×10^{-6}	4.7×10^{-9}	6.6×10^{-8}	5.2×10^{-9}
Total	140	1.4×10^{-4}	3.4×10^{-6}	1.1×10^{-8}	1.5×10^{-7}	1.2×10^{-8}

TABLE 11.3 (Cont'd)

Contaminant	Average Bulk Waste Concentration[e] (mg/kg)	Estimated Air Concentration of Contaminants as Respirable Particulates[a] (mg/m^3)				
		Within Quarry	State Route 94	Nearby Residence	Office Building	High School
PCBs	18	1.8×10^{-5}	4.3×10^{-7}	1.4×10^{-9}	2.0×10^{-8}	1.5×10^{-9}
Metals						
Arsenic	100	1.0×10^{-4}	2.4×10^{-6}	7.8×10^{-9}	1.1×10^{-7}	8.6×10^{-9}
Lead	380	3.8×10^{-4}	9.1×10^{-6}	3.0×10^{-8}	4.2×10^{-7}	3.3×10^{-8}
Nickel	80	8.0×10^{-5}	1.9×10^{-6}	6.2×10^{-9}	8.8×10^{-8}	6.9×10^{-9}
Selenium	23	2.3×10^{-5}	5.5×10^{-7}	1.8×10^{-9}	2.5×10^{-8}	2.0×10^{-9}
Uranium	600	6.0×10^{-4}	1.4×10^{-5}	4.7×10^{-8}	6.6×10^{-7}	5.2×10^{-8}

[a]Except for radon (a gas), calculated based on the annual average PM-10 concentrations originating from contaminated sources and the average contaminant concentrations in the bulk wastes. The PM-10 concentrations (above background) at each location are: within quarry, 1.0 mg/m^3 (assumed value, see text); State Route 94, 2.4×10^{-2} mg/m^3; nearby residence, 7.8×10^{-5} mg/m^3; office building, 1.1×10^{-3} mg/m^3; and Francis Howell High School, 8.6×10^{-5} mg/m^3. Radon concentrations calculated based on total estimated releases of radon gas (see text).

[b]Not applicable because radon-222 is a gas.

[c]Not applicable. Radon concentration, in WL units, obtained from measured values.

[d]WLR = working level ratio; WL = working level.

[e]For 2,4-DNT and 2,6-DNT, PAHs, PCBs, and metals, the average concentration is the arithmetic mean of the concentrations in surface and borehole samples above detection limits and does not include samples at or below detection limits. For 2,4,6-TNT and 1,3,5-trinitrobenzene, the average bulk waste concentration is assumed to be 10% of the concentrations of these compounds in surface soils in the northeastern corner of the quarry (see text).

for the bulk wastes. The "average" concentrations, as derived below, were used as the exposure point concentrations and to estimate airborne chemical contaminant concentrations.

For PAHs, PCBs, and metals (except uranium), the bulk waste concentration was taken to be the average of the surface and borehole samples. The concentration of uranium (in mg/kg) was determined from the activity concentration (in pCi/g) of uranium-238 given in Table 2.5. Although surface soils in the northeastern corner of the quarry are highly contaminated with nitroaromatic compounds, the concentration in this area is not considered to be representative of the entire bulk wastes because of the limited areal extent of this contamination. Therefore, for nitroaromatic compounds, the average bulk waste concentration was taken to be the higher of the following two values: (1) the average concentration in the borehole samples (from Table 2.7) and (2) 10% of the surface soil concentration. For all compounds, the calculated averages used as exposure point concentrations were the arithmetic means of the concentrations in samples above detection limits and did not include samples at or below detection limits. In addition, the studies from which the concentrations were derived tended to focus on the contaminated areas within the quarry (i.e., with biased sampling). Thus, within the limits of available data, these values are considered to be representative of the contaminated areas of the quarry, not of the entire quarry. This will tend to overestimate the exposure point concentrations because the average concentrations will be lower. The average bulk waste concentrations used in this assessment are given in Table 11.3.

Airborne Particulates. Estimated concentrations of chemically and radioactively contaminated airborne particulates at the exposure points were based on the average contaminant concentrations in the bulk wastes and the estimated air concentrations of contaminated fugitive dusts resulting from excavation, transport, and storage activities. The methodology used to estimate PM-10 particulate concentrations at exposure points outside the quarry is given in Section 10.2 and Appendix B. (The term PM-10 refers to the respirable fraction of particulates, i.e., particulates less than 10 μm aerodynamic diameter.) However, for the health effects analysis, only fugitive dusts originating from contaminated areas were inventoried for the PM-10 estimates (i.e., dusts generated from truck traffic on the haul road or from other uncontaminated sources were not included). For the on-site office worker, the exposure point concentrations were assumed to be the estimated air contaminant concentrations exterior to the office building; no credit was taken for attenuation of contaminant concentrations by the building or its ventilation system.

The models used to estimate airborne particulate concentrations cannot be applied to an area close to a source (e.g., within the quarry); hence, the average concentration of total airborne particulates to which an unprotected worker within the quarry (i.e., the maximally exposed worker) would be exposed is assumed to be 5.0 mg/m^3. This value is 33% of that allowed for worker exposure to nuisance airborne particulates without requiring respiratory protection (see Appendix C). Dust control measures would be implemented at the quarry to control air particulate concentrations to this level. The

PM-10 particulate concentration was assumed to be one-fifth of the total airborne particulate concentration, i.e., 1.0 mg/m^3.

Estimated air contaminant concentrations of the PM-10 fraction are presented in Table 11.3. The PM-10 concentrations were used to estimate the inhalation doses to potential receptors (see Section 11.2). Estimated concentrations of total particulates are presented in Table 11.4 for indicator radionuclides and in Table 11.5 for indicator chemicals. The total particulate contaminant concentrations are compared with potential ARARs in Tables 11.4 and 11.5 and are discussed in Section 11.1.4.

While the wastes are in temporary storage, those materials susceptible to windblown erosion would be covered. All covers would be routinely examined to ensure their integrity. Hence, airborne particulate emissions are expected to be minimal during the temporary storage period. The site perimeter would be monitored to ensure that airborne particulate emissions from the TSA were kept well below applicable limits. Therefore, potential exposures associated with this pathway were not quantitatively assessed.

11.1.4 Comparison with Standards and Criteria

Consistent with guidance provided in SPHEM (EPA 1986), the concentrations of contaminants at exposure points have been compared with ARARs. Because air and soil are the only environmental media of concern for the bulk waste remedial action (see Section 11.1.1), only ARARs that address contaminant concentrations in these media are presented.

Radioactive Contaminants. The DOE derived concentration guides (DCGs) for airborne radionuclides address protection of the general public from airborne radioactive contaminants. These DCGs are the concentrations that, under conditions of continuous inhalation exposure for 1 year, would result in either an effective dose equivalent of 100 mrem or a dose equivalent of 5 rem to any tissue, including skin and lens of the eye. These values are based on the inhalation of 8,400 m^3 of air per year. The DCGs for the major radionuclides, as listed in DOE Order 5400.xx, are presented in Table 11.4 and Appendix C. The estimated airborne concentrations at all exposure points outside the quarry are below the applicable DCGs, except for thorium-230 at State Route 94 (the estimated thorium-230 concentration at this location is 6.3×10^{-2} pCi/m^3 and the DCG is 4×10^{-2} pCi/m^3). However, the airborne radionuclide concentrations in Table 11.4 are given as total particulates, but the respirable amount for which the DCG is more directly applicable (i.e., the PM-10 concentration) is lower. The concentration of respirable particulates contaminated with thorium-230 at this location is estimated to be 7.9×10^{-3} pCi/m^3 (see Table 11.3); this concentration is considerably below the DCG. These results emphasize the need to control particulate emissions during excavation activities to ensure responsiveness to air quality limits because the concentrations of several radionuclides within the quarry exceed their respective DCGs.

The DOE derived air concentrations (DACs) for airborne radionuclides address protection of workers from airborne radioactive contaminants. The DACs are based on

TABLE 11.4 Comparison of Average Radionuclide Concentrations at Exposure Points with Selected Exposure Guidelines and Standards

Radionuclide	Estimated Air Concentration of Contaminants as Total Particulates[a] (pCi/m^3, except as noted)					Concentration Limits[b] (pCi/m^3)	
	Within Quarry	State Route 94	Nearby Residence	Office Building	High School	DAC	DCG
Uranium-238	1.0	3.8×10^{-2}	2.2×10^{-5}	4.0×10^{-4}	5.0×10^{-5}	2×10^{1}	1×10^{-1}
Thorium-232	1.3×10^{-1}	4.9×10^{-3}	2.9×10^{-6}	5.2×10^{-5}	6.5×10^{-6}	5×10^{-1}	7×10^{-3}
Thorium-230	1.7	6.3×10^{-2}	3.6×10^{-5}	6.6×10^{-4}	8.3×10^{-5}	3	4×10^{-2}
Radium-228	4.8×10^{-1}	1.8×10^{-2}	1.1×10^{-5}	1.9×10^{-4}	2.4×10^{-5}	5×10^{2}	3
Radium-226	5.5×10^{-1}	2.1×10^{-2}	1.2×10^{-5}	2.2×10^{-4}	2.8×10^{-5}	3×10^{2}	1
Radon-222[c]	–[d]	1.5×10^{3}	9.3	6.0×10^{-1}	4.2×10^{-1}	3×10^{4}	3×10^{3}
	(1.3×10^{-2})	(1.5×10^{-3})	(2.8×10^{-5})	(4.2×10^{-6})	(3.4×10^{-6})		

[a]Except for radon (a gas), calculated from the annual average total particulate concentrations originating from contaminated sources and the average contaminant concentrations in the bulk wastes (from Table 11.3). For exposure points outside the quarry, total particulate concentrations were estimated using methodology similar to that described in Section 10.2 and Appendix B for estimating the PM-10 concentrations. Total particulate concentrations (above background) at each location are: within quarry, 5.0 mg/m^3 (assumed value, see text); State Route 94, 1.9×10^{-1} mg/m^3; nearby residence, 1.1×10^{-4} mg/m^3; office building, 2.0×10^{-3} mg/m^3; and Francis Howell High School, 2.5×10^{-4} mg/m^3. Calculated radon concentrations are based on total estimated releases of radon gas.

[b]Limits for protection from airborne radioactive contaminants: DAC = derived air concentration (for protection of workers); DCG = derived concentration guide (for protection of the general public).

[c]The DAC can also be expressed as one-third working level (WL); because these concentrations may constitute the relevant measurement, the associated WL estimate is listed in parentheses beneath each radon-222 concentration entry.

[d]Not applicable. Radon concentration, in WL units, was used for the exposure estimate.

TABLE 11.5 Comparison of Average Air Contaminant Concentrations at Exposure Points with Selected Occupational Exposure Guidelines and Standards

	Estimated Air Concentration of Contaminants as Total Particulates[a] (mg/m^3)					Occupational Standard/Guideline (mg/m^3)	
Contaminant	Within Quarry	State Route 94	Nearby Residence	Office Building	High School	OSHA PEL[b]	NIOSH REL[c]
Nitroaromatic Compounds							
2,4,6-TNT	6.5×10^{-3}	2.5×10^{-4}	1.4×10^{-7}	2.6×10^{-6}	3.3×10^{-7}	0.5[d]	–[e]
2,4-DNT and 2,6-DNT	9.0×10^{-5}	3.4×10^{-6}	2.0×10^{-9}	3.6×10^{-8}	4.5×10^{-9}	1.5[d]	–[e,f]
1,3,5-Trinitrobenzene	7.0×10^{-5}	2.7×10^{-6}	1.5×10^{-9}	2.8×10^{-8}	3.5×10^{-9}	–[e]	–[e]
PAHs							
Carcinogens	3.0×10^{-4}	1.1×10^{-5}	6.6×10^{-9}	1.2×10^{-7}	1.5×10^{-8}	0.2[g]	0.1[f,h]
Total[i]	7.0×10^{-4}	2.7×10^{-5}	1.5×10^{-8}	2.8×10^{-7}	3.5×10^{-8}	0.2[g]	0.1[f,h]
PCBs	9.0×10^{-5}	3.4×10^{-6}	2.0×10^{-9}	3.6×10^{-8}	4.5×10^{-9}	0.5[d,j]	0.001[f]
Metals							
Arsenic	5.0×10^{-4}	1.9×10^{-5}	1.1×10^{-8}	2.0×10^{-7}	2.5×10^{-8}	0.01[k]	0.002[f,ℓ]
Lead	1.9×10^{-3}	7.2×10^{-5}	4.2×10^{-8}	7.6×10^{-7}	9.5×10^{-8}	0.05[m]	<0.1
Nickel	4.0×10^{-4}	1.5×10^{-5}	8.8×10^{-8}	1.6×10^{-7}	2.0×10^{-8}	0.1[n]	0.015[f]
Selenium	1.2×10^{-4}	4.4×10^{-6}	2.5×10^{-9}	4.6×10^{-8}	5.8×10^{-9}	0.2[o]	–[e]
Uranium	3.0×10^{-3}	1.1×10^{-4}	6.6×10^{-8}	1.2×10^{-6}	1.5×10^{-7}	0.05[p]	–[e]

[a]Calculated from the annual average total particulate concentrations originating from contaminated sources and the average contaminant concentrations in the bulk wastes (from Table 11.3). For exposure points outside the quarry, total particulate concentrations were estimated using methodology similar to that described in Section 10.2 and Appendix B for estimating PM-10 concentrations. Total particulate concentrations (above background) at each location are: within quarry, 5.0 mg/m^3 (assumed value, see text); State Route 94, 1.9×10^{-1} mg/m^3; nearby residence, 1.1×10^{-4} mg/m^3; office building, 2.0×10^{-3} mg/m^3; and Francis Howell High School, 2.5×10^{-4} mg/m^3.

TABLE 11.5 (Cont'd)

[b]Occupational Safety and Health Administration (1989) permissible exposure limit (PEL); PELs are 8-hour time-weighted average (TWA) concentrations.

[c]Recommended exposure limit (REL) of the National Institute for Occupational Safety and Health (1987). Unless otherwise noted, RELs are the 10-hour TWA concentrations.

[d]Skin designation. Refers to a potential contribution to the overall exposure by the cutaneous route, including mucous membranes and eyes -- either through airborne contact or, more particularly, through direct contact with the substance.

[e]Standard/guideline has not been established.

[f]Carcinogen; reduce exposure to lowest feasible level.

[g]PEL for coal tar pitch volatiles, measured as the benzene-soluble fraction of total particulate matter.

[h]REL (10-hour TWA) for coal tar pitch volatiles, measured as the cyclohexane-extractable fraction of total particulate matter.

[i]Includes concentrations of both carcinogenic and noncarcinogenic PAHs.

[j]PEL for chlorodiphenyl (PCB, 54% chlorine).

[k]Inorganic compounds, as arsenic.

[ℓ]15-minute ceiling.

[m]Metallic lead and inorganic compounds, as lead.

[n]Soluble compounds, as nickel; PEL for metallic nickel and insoluble compounds is 1 mg/m^3, as nickel.

[o]Selenium compounds, as selenium.

[p]Soluble compounds, as uranium; PEL for insoluble compounds is 0.2 mg/m^3, as uranium, with a short-term exposure limit (15-minute exposure period) of 0.6 mg/m^3.

limiting either the committed effective dose equivalent to 5 rem/yr or the dose equivalent to any organ to 50 rem/yr, whichever is more restrictive. These values are based on the inhalation of 2,400 m^3 of air per year (i.e., 1.2 m^3/h during a 2,000-hour work year). The DACs for the major radionuclides, obtained from DOE Order 5480.11, are presented in Table 11.4 and Appendix C. The estimated airborne concentrations at all exposure points are below the appropriate DACs.

Chemical Contaminants. The Clean Air Act establishes National Ambient Air Quality Standards (NAAQS) for certain pollutants, and these standards are potentially relevant and appropriate to airborne chemical contaminants at the quarry (see Appendix C). However, NAAQS are not available for contaminants present at the quarry other than particulate matter and lead. Standards for particulate matter are discussed in Section 10.2 and Appendix C of this document. The NAAQS requirement for lead and its compounds, measured as elemental lead, is 1.5 $\mu g/m^3$ (as the maximum arithmetic mean averaged over a calendar quarter). Estimated concentrations of lead within the quarry, 1.9 $\mu g/m^3$, exceed this level; however, the estimated lead concentrations at locations external to the quarry are considerably below this level (see Table 11.5).

Standards and guidelines that are available for occupational exposures to chemicals include permissible exposure limits (PELs) of the Occupational Safety and Health Administration (OSHA); recommended exposure limits (RELs) of the National Institute for Occupational Safety and Health (NIOSH), and threshold limit values (TLVs) of the American Conference of Governmental Industrial Hygienists (ACGIH). The PELs are promulgated standards and are applicable to worker exposures during implementation of the proposed action. Based on a final rule issued January 19, 1989, the PELs of OSHA (1989) are now generally the same as or lower than the TLVs of ACGIH (1987). Although not appropriate for assessing exposures of the general public, estimated exposure point concentrations may be compared to the PELs. The estimated exposure point concentrations, PELs, and RELs for airborne contaminants are presented in Table 11.5. All estimated air concentrations at the exposure points are considerably below the recommended occupational exposure limits. No occupational standards are available with respect to levels of chemicals or radionuclides in soils.

11.2 CONTAMINANT INTAKES

Exposure is expressed in terms of intake, which is the amount of contaminant taken into the body per unit body weight per unit time. Estimates of exposure are based on the concentrations of contaminants in the exposure medium (e.g., air) and intake factors appropriate to that medium (e.g., inhalation rates). The potential exposures (intakes) associated with the pathways considered in this assessment depend upon parameters specific to the scenarios. The assumptions used to estimate radiological and chemical exposures for the general public and worker scenarios are summarized in Table 11.2. Inhalation rates depend on the age and size of an individual and the level of activity during the exposure period. Inhalation rates for estimating exposures to members of the general public are based on data reported in Anderson et al. (1985), EPA

(1989f), Report No. 76 of the National Council on Radiation Protection and Measurements (NCRP 1984), and Publication 23 of the International Commission on Radiological Protection (ICRP 1975).

The EPA recommends using a value of 20 m^3/d (or 0.83 m^3/h averaged over 24 hours) for continuous exposure situations, e.g., for a resident (EPA 1989a). Data compiled by Anderson et al. (1985) and summarized in EPA (1989f) provide inhalation rates for specific levels of activities. For example, the reported rates in adult males are 0.7, 0.8, 2.5, and 4.8 m^3/h during resting, light, moderate, and heavy levels of activity, respectively. Except for the resident scenario, the level of activity for the scenarios considered in this risk assessment was assumed to be between light (e.g., similar to performing domestic work) and moderate (e.g., similar to performing heavy outdoor cleanup activities or climbing stairs). Therefore, a value of 1.2 m^3/h was used for estimating inhalation exposures. The EPA recommended value of 0.83 m^3/h was used for the resident scenario. Although the inhalation rate for the student is the same as that for adults and therefore may appear high because of the lower body weight of the student, data in Anderson et al. (1985) indicate that inhalation rates for adolescents are similar to or higher than those of adults at the same activity. With the exception of workers involved in monitoring and maintenance activities at the TSA during the temporary storage period, the exposure period was assumed to be 1.25 years (the estimated time for implementation of the action) for all scenarios. The only exposure pathway associated with the temporary storage period would be exposure to gamma radiation, which would be of concern only for receptors in the immediate vicinity of the TSA.

11.2.1 General Public

Exposures of the general public were estimated for four exposure scenarios: (1) an individual who routinely walks by the northern boundary of the quarry along State Route 94, (2) a resident living 0.8 km (0.5 mi) from the quarry, (3) an office worker at the Weldon Spring site office building, and (4) a student at Francis Howell High School. The exposure pathways applicable to these scenarios are (1) inhalation of radon-222 and its short-lived decay products and (2) inhalation of radioactively and chemically contaminated dusts. The passerby would also be exposed to external gamma radiation.

Inhalation of Radon-222 and Its Short-Lived Decay Products. The exposure from inhalation of radon-222 and its short-lived decay products was estimated by multiplying the radon-222 decay product concentrations (in WL) by the amount of air inhaled during the exposure period. The exposure is expressed in the working-level-month (WLM) unit (see Haroun et al. [1990] for an explanation of this concept). The estimated exposures to radon-222 and its decay products for the bulk waste remedial action are given in Table 11.6.

Exposure to External Gamma Radiation. The dose from external gamma radiation is calculated by multiplying the exposure duration by the gamma radiation field

TABLE 11.6 Estimated Radiological Exposures

Receptor	Radon-222 Decay Products (WLM)	External Gamma Exposure (mrem)	Inhalation of Contaminated Airborne Dusts (mrem)
Maximally exposed worker	1.9×10^{-1}	1.3×10^{3}	7.6×10^{2}
General public			
Passerby	1.6×10^{-3}	1.8	1.3
Resident	1.2×10^{-3}	NQ[a]	1.8×10^{-1}
Office worker	6.2×10^{-5}	NQ	8.4×10^{-1}
Student	3.6×10^{-5}	NQ	4.7×10^{-2}

[a]NQ = Not quantified.

strength. For the general public scenarios, this exposure pathway would be significant only for the passerby. The estimated external gamma exposure for this receptor is given in Table 11.6.

Inhalation of Contaminated Airborne Dusts. Intakes resulting from exposure to radioactively and chemically contaminated airborne dusts were estimated for all indicator contaminants for the general public scenarios. The exposures are obtained by multiplying the airborne concentrations of the various contaminants by the amount of air inhaled during the exposure period. The radiological doses are obtained by multiplying this result by a dose conversion factor, which is the dose (in mrem) for a unit intake of a radionuclide. These dose conversion factors are taken from Gilbert et al. (1989). The chemical doses (in mg/kg-d) are obtained by dividing the amount of inhaled contaminant by the assumed body weight of the individual and by the number of days over which exposure is averaged (i.e., the number of days in the exposure period for noncarcinogenic effects and the number of days in a lifetime for carcinogenic effects). The estimated exposures resulting from inhalation of airborne radioactive and chemical contaminants for the bulk waste remedial action are given in Tables 11.6 and 11.7, respectively.

11.2.2 Workers

Workers involved in excavation, transport, and unloading activities during the bulk waste remedial action are assumed to be wearing respiratory protective equipment and protective clothing or working in heavy earth-moving equipment having positive-pressure cabs with HEPA-filtered air intakes. This would protect the workers from

TABLE 11.7 Estimated Daily Intakes of Indicator Chemicals from Exposure to Fugitive Dusts

Contaminant	Estimated Daily Intake Averaged Over Exposure Period[a] (mg/kg-d)				
	Maximally Exposed Worker	General Public			
		Passerby	Resident	Office Worker	Student
Nitroaromatic Compounds					
2,4,6-TNT	1.2×10^{-4}	2.1×10^{-7}	2.8×10^{-8}	1.3×10^{-7}	8.7×10^{-9}
2,4-DNT and 2,6-DNT	1.7×10^{-6}	2.9×10^{-9}	4.0×10^{-10}	1.9×10^{-9}	1.2×10^{-10}
1,3,5-Trinitrobenzene	1.3×10^{-6}	2.3×10^{-9}	3.1×10^{-10}	1.4×10^{-9}	9.5×10^{-11}
PAHs (total)	1.3×10^{-5}	2.3×10^{-8}	3.1×10^{-9}	1.4×10^{-8}	9.5×10^{-10}
PCBs	1.7×10^{-6}	2.9×10^{-9}	4.0×10^{-10}	1.9×10^{-9}	1.2×10^{-10}
Metals					
Arsenic	9.4×10^{-6}	1.6×10^{-8}	2.2×10^{-9}	1.0×10^{-8}	6.8×10^{-10}
Lead	3.6×10^{-5}	6.2×10^{-8}	8.5×10^{-9}	3.9×10^{-8}	2.6×10^{-9}
Nickel	7.5×10^{-6}	1.3×10^{-8}	1.8×10^{-9}	8.3×10^{-9}	5.4×10^{-10}
Selenium	2.2×10^{-6}	3.8×10^{-9}	5.1×10^{-10}	2.3×10^{-9}	1.6×10^{-10}
Uranium	5.6×10^{-5}	9.6×10^{-8}	1.3×10^{-8}	6.2×10^{-8}	4.1×10^{-9}

TABLE 11.7 (Cont'd)

Contaminant	Estimated Daily Intake Averaged Over Lifetime[a,b] (mg/kg-d)				
		General Public			
	Maximally Exposed Worker	Passerby	Resident	Office Worker	Student
Nitroaromatic Compounds					
2,4,6-TNT	2.2×10^{-6}	3.8×10^{-9}	5.1×10^{-10}	2.3×10^{-9}	1.5×10^{-10}
2,4-DNT and 2,6-DNT	3.0×10^{-8}	5.3×10^{-11}	7.1×10^{-12}	3.4×10^{-11}	2.1×10^{-12}
PAHs (carcinogens)	1.0×10^{-7}	1.7×10^{-10}	2.4×10^{-11}	1.1×10^{-10}	7.3×10^{-12}
PCBs	3.0×10^{-8}	5.3×10^{-11}	7.1×10^{-12}	3.4×10^{-11}	2.1×10^{-12}
Metals					
Arsenic	1.7×10^{-7}	2.9×10^{-10}	4.0×10^{-11}	1.8×10^{-10}	1.2×10^{-11}
Lead	6.4×10^{-7}	1.1×10^{-9}	1.5×10^{-10}	7.0×10^{-10}	4.6×10^{-11}
Nickel	1.3×10^{-7}	2.3×10^{-10}	3.1×10^{-11}	1.5×10^{-10}	9.7×10^{-12}

[a]Calculated using exposure parameters from Table 11.2 and exposure point concentrations from Table 11.3.

[b]Estimated for carcinogenic indicator chemicals only.

potential exposures resulting from direct contact, inhalation, and ingestion. Thus, the only exposure pathway of concern for protected workers is external gamma radiation (see Section 11.1.2). The occupational doses to the protected workers involved in the proposed action are given in Table 11.8. These dose estimates are based on the assumptions and intake parameters given in Table 11.2 and the exposure point concentrations determined in Section 11.1.3. The dose to a protected worker from external gamma radiation, either in the quarry or at the TSA, is estimated to be 0.65 rem over the 1.25-year period, and the dose to a truck driver is estimated to be 0.13 rem. The cumulative occupational dose to all protected workers involved in the bulk waste remedial action is estimated to be 29 person-rem.

The maximally exposed worker would be exposed to radon-222 and its short-lived decay products, external gamma radiation, and contaminated airborne dusts. The doses to this hypothetical worker are estimated to be 0.19 WLM from inhalation of radon-222 and its short-lived decay products and 2.1 rem from external gamma exposure and inhalation of contaminated airborne dusts (see Table 11.6); these values are below the DOE occupational dose limits given in DOE Order 5480.11 (see Appendix C). The estimated exposure of this worker resulting from inhalation of chemical contaminants is given in Table 11.7.

Another potential route of exposure to an unprotected worker is incidental ingestion of contaminated dusts deposited on the face and lips and by transfer of soil on hands and fingers to food and/or cigarettes. Interim guidance from the EPA (Porter 1989) for soil ingestion rates is 100 mg/d for adults. Although the maximally exposed worker was assumed to wear protective clothing (including gloves) and would not smoke

TABLE 11.8 Estimated Occupational Doses Resulting from the Bulk Waste Remedial Action

Activity[a]	Dose Rate (mrem/h)	Duration (weeks)	Number of Workers	Exposure Time[b] (worker-hours)	Occupational Dose (person-rem)
Excavation	0.25	65	19	49,400	12
Transport	0.1	65	10	13,000[c]	1.3
Unloading	0.25	65	25	65,000	16
Total					29

[a]Exposures of the maximally exposed worker are given in Tables 11.6, 11.7, and 11.9. Exposures of workers involved in monitoring and maintenance activities at the TSA are discussed in the text.

[b]Assumes 8 hours of exposure per day.

[c]Assumes that drivers are exposed to wastes 4 hours per day.

or eat within a contaminated area, the soil ingestion rate of 100 mg/d was used to estimate potential exposure for this assessment. The intake (in mg/kg-d) is obtained by dividing the amount of contaminant ingested over the exposure period by the assumed body weight of the individual and by the number of days over which exposure is averaged (i.e., the number of days in the exposure period for noncarcinogenic effects and the number of days in a lifetime for carcinogenic effects). The estimated intakes of chemical contaminants for this route of exposure are given in Table 11.9. Because the estimated radiation doses and risks associated with incidental soil ingestion are small relative to the other pathways considered for the maximally exposed worker (i.e., less than 3% of the total radiation risk), the radiation doses and risks resulting from this pathway are not included in this risk assessment.

TABLE 11.9 Estimated Average Daily Intakes of Indicator Chemicals from Incidental Ingestion for the Maximally Exposed Worker

	Estimated Daily Intake[a] (mg/kg-d)	
Contaminant	Averaged over Exposure Period	Averaged over Lifetime
Nitroaromatic Compounds		
2,4,6-TNT	1.3×10^{-3}	2.3×10^{-5}
2,4-DNT and 2,6-DNT	1.8×10^{-5}	3.1×10^{-7}
1,3,5-Trinitrobenzene	1.4×10^{-5}	NQ[b]
PAHs		
Total	5.9×10^{-5}	NQ
Carcinogens	1.4×10^{-4}	1.0×10^{-6}
PCBs	1.8×10^{-5}	3.1×10^{-7}
Metals		
Arsenic	9.8×10^{-5}	1.7×10^{-6}
Lead	3.7×10^{-4}	6.6×10^{-6}
Nickel	7.8×10^{-5}	1.4×10^{-6}
Selenium	2.3×10^{-5}	NQ
Uranium	5.9×10^{-4}	NQ

[a]Calculated using exposure parameters from Table 11.2 and exposure point concentrations from Table 11.3.

[b]NQ = not quantified; estimated for carcinogenic indicator chemicals only.

The occupational doses associated with the temporary storage period are expected to be low. Erodible wastes would be covered to minimize gaseous and particulate releases. The dose to a worker from external gamma radiation would depend on the monitoring and maintenance schedule for the TSA during the storage period. The occupational dose commitment from gamma exposure is estimated to be 0.13 person-rem/yr, assuming a dose rate of 0.25 mrem/h and 500 person-hours/yr for this activity.

Expedited excavation of the quarry bulk wastes with temporary storage at the TSA would require that these wastes be removed from the TSA in the future for subsequent treatment and/or permanent disposal. Thus, a future occupational dose commitment would result from implementation of such action. This dose commitment would be less than that associated with the proposed action because the wastes would be stored in a manner to allow for easy retrieval. The incremental dose to the work force associated with retrieval of these wastes in the future is estimated to be about one-third of that for the proposed action, or about 10 person-rem.

11.3 HEALTH RISK EVALUATION

11.3.1 Radiological Risks

Radiological risks were estimated based on the radiation doses given in Tables 11.6 and 11.8 and appropriate risk estimators. The risks from inhalation of radioactive particulates and direct gamma exposure were estimated using the risk factor of 1.65×10^{-7}/mrem for the induction of fatal cancers and serious genetic effects in the first two generations (ICRP 1977). The risk of a fatal cancer from inhalation of radon-222 decay products was estimated using the risk factor of 3.5×10^{-4}/WLM recommended in the BEIR IV study (National Research Council 1988). The estimated radiological risks to potential receptors are given in Table 11.10.

The lifetime risk to the general public from radiation exposure as a result of this action would be very low, i.e., about equal to or less than 1×10^{-6} for all scenarios. For purposes of comparison, the dose from background radiation is about 300 mrem/yr (NCRP 1987), which corresponds to an annual risk of about 5×10^{-5}/yr for the induction of fatal cancers and serious genetic effects in future generations. The risks to workers are also expected to be low. The estimated risks are 1.1×10^{-4} for a protected worker in the quarry or at the TSA, 2.1×10^{-5} for a truck driver, and 4.1×10^{-4} for the maximally exposed worker. The cumulative risk to the entire work force for completing this action is estimated to be 4.8×10^{-3}. It is highly unlikely that the proposed action would result in adverse health effects to the work force from exposure to radioactive contaminants.

11.3.2 Chemical Risks

Carcinogenic Risks. The potential risk to an individual resulting from exposure to chemical carcinogens is expressed as the increased probability of a cancer occurring over the course of a lifetime. To calculate the excess cancer risk, the daily intake

TABLE 11.10 Estimated Radiological Risks to Potential Receptors from the Bulk Waste Remedial Action

Receptor	Radon-222 Decay Products[a]	External Gamma Exposure[b]	Inhalation of Contaminated Airborne Dusts[b]	Total Risk
Maximally exposed worker	6.7×10^{-5}	2.1×10^{-4}	1.3×10^{-4}	4.1×10^{-4}
General public				
Passerby	5.6×10^{-7}	3.0×10^{-7}	2.1×10^{-7}	1.1×10^{-6}
Resident	4.2×10^{-7}	NQ[c]	3.0×10^{-8}	4.5×10^{-7}
Office worker	2.2×10^{-8}	NQ	1.4×10^{-7}	1.6×10^{-7}
Student	1.3×10^{-8}	NQ	7.8×10^{-9}	2.1×10^{-8}

[a]Obtained using a risk factor of 3.5×10^{-4}/WLM.

[b]Obtained using a risk factor of 1.65×10^{-7}/mrem.

[c]NQ = not quantified.

averaged over a lifetime is multiplied by a chemical-specific carcinogenic potency factor (q_1*). The potency factors for a number of carcinogens have been derived by the EPA and represent the lifetime cancer risk per milligram of carcinogen per kilogram of body weight, assuming that the exposure occurs over a lifetime of 70 years.

A potency factor is specific to the chemical and the route of exposure (i.e., inhalation or ingestion; potency factors have not been derived for the dermal route). For some indicator carcinogens -- 2,4,6-TNT, 2,4-DNT and 2,6-DNT, PCBs, and arsenic -- potency factors are available only for the oral route of exposure. Therefore, in the absence of inhalation potency factors, oral potency factors were used in this assessment to estimate the risks associated with these compounds for the inhalation pathway. The justification for the extrapolation of potency factors from one route of exposure to another and the uncertainty this introduces into the estimated risks is discussed by Haroun et al. (1990). A potency factor was not available for lead.

The indicator carcinogens for which the carcinogenic risk could be estimated are 2,4,6-TNT, 2,4-DNT, 2,6-DNT, PAHs, PCBs, arsenic, and nickel. The estimated chemical risks to the maximally exposed worker and the general public from exposure to these compounds are given in Table 11.11. The total risks estimated for the four general public exposure scenarios range from 6.8×10^{-10} to 1.7×10^{-8}. Based on these very low risks, no adverse effects to the general public from exposures to releases of chemical carcinogens are expected to result from the bulk waste remedial action. The total chemical

TABLE 11.11 Estimated Chemical Carcinogenic Risks to Potential Receptors from the Bulk Waste Remedial Action[a]

Contaminant	Potency Factor[b] ($[mg/kg\text{-}d]^{-1}$)	Estimated Risk to Maximally Exposed Worker[c]	Estimated Risk to the General Public[d]			
			Passerby	Resident	Office Worker	Student
Nitroaromatic Compounds						
2,4,6-TNT	0.03	7.6×10^{-7}	1.1×10^{-10}	1.5×10^{-11}	6.9×10^{-11}	4.5×10^{-12}
2,4-DNT and 2,6-DNT	0.68	2.3×10^{-7}	3.6×10^{-11}	4.8×10^{-12}	2.3×10^{-11}	1.4×10^{-12}
PAHs (carcinogens)	6.1 (I) 11.5 (O)	1.3×10^{-5}	1.0×10^{-9}	1.5×10^{-10}	6.7×10^{-10}	4.5×10^{-11}
PCBs	7.7	2.6×10^{-6}	4.1×10^{-10}	5.5×10^{-11}	2.6×10^{-10}	1.6×10^{-11}
Metals						
Arsenic	50 (I) 1.75 (O)[e]	1.2×10^{-5}	1.5×10^{-8}	2.0×10^{-9}	9.0×10^{-9}	6.0×10^{-10}
Nickel	1.7	2.2×10^{-7}	3.9×10^{-10}	5.3×10^{-11}	2.6×10^{-10}	1.6×10^{-11}
Total risk		2.9×10^{-5}	1.7×10^{-8}	2.3×10^{-9}	1.0×10^{-8}	6.8×10^{-10}

[a]Calculated by multiplying the chemical-specific carcinogenic potency factor by the daily intake, averaged over a lifetime exposure period (from Tables 11.7 and 11.9).

[b]I = inhalation; O = oral. Sources: TNT, arsenic, nickel, and PCBs (EPA 1989a); DNT (EPA 1989c); and PAHs (EPA 1986).

[c]Risk from inhalation and oral exposures.

[d]Risk from inhalation exposure.

[e]Calculated from unit risk value of 5×10^{-5} μg/L.

carcinogenic risk to the maximally exposed worker is estimated to be 2.9×10^{-5}. This represents the risk to a worker who is assumed to be present in the quarry without respiratory protective equipment for 8 hours per day over the 1.25 years required to implement this action. The actual risk to a worker would be lower because workers at the quarry and the TSA would be protected by the use of engineering controls and/or respiratory protective equipment for most activities.

Noncarcinogenic Risks. Potential adverse health effects resulting from exposures to noncarcinogens are assessed by comparing exposure estimates (intakes) to EPA-established reference doses; a reference dose is the average daily dose that can be incurred without likely adverse health effects, assuming long-term exposure to a compound. A reference dose is specific to the chemical and the route of exposure. As in the case of carcinogenic potency factors, reference doses are not available for all compounds for the inhalation route of exposure; the oral reference dose was used in this assessment for those indicator contaminants for which an inhalation reference dose was not available. Potential risks from exposure to a compound are assessed by dividing the estimated intake by the reference dose to derive the "hazard index" for the compound. The individual hazard indexes are then summed to obtain an overall hazard index for an exposure scenario. If the hazard index for any individual compound or scenario is greater than one, adverse health effects could potentially occur.

Reference doses are available for all of the noncarcinogenic indicator chemicals at the quarry and for some of the carcinogenic indicator chemicals. (Chemical carcinogens induce other toxic -- i.e., noncarcinogenic -- effects, and reference doses based on these noncarcinogenic effects have been established for some carcinogens.) Thus, a hazard index was calculated for all compounds except 2,4-DNT, 2,6-DNT, PAHs, and PCBs. The hazard indexes for the general public scenarios and the maximally exposed worker are presented in Table 11.12. Because most of the available reference doses used to derive the hazard index were for the oral and not the inhalation route of exposure, the degree of uncertainty associated with the estimated hazard indexes is high. However, for the general public scenarios, the hazard indexes are less than 0.001, which is considerably below EPA's level of concern for noncarcinogenic effects (i.e., a hazard index of one). Although the lack of reference doses for 2,4-DNT, 2,6-DNT, PAHs, and PCBs results in underestimating the potential for adverse health effects based on the overall hazard index, the daily intakes of these compounds would result in very low doses and the potential for adverse health effects from exposure to these contaminants would also be low.

For the maximally exposed worker scenario, the total hazard index is 4.2, indicating some potential for adverse health effects to an unprotected worker. Approximately 90% of the hazard index is attributable to the soil ingestion pathway -- i.e., the pathway-specific hazard indexes were 3.8 and 0.38 for the ingestion and inhalation pathways, respectively. No information was located in the available literature to ascertain if the assumed soil ingestion value of 100 mg/d was overly conservative for this scenario. However, using an ingestion rate of 25 mg/d would still result in a hazard index of approximately 1.1. Workers would be provided with respiratory protective equipment (which would also prevent incidental ingestion of soils), such that no worker

TABLE 11.12 Hazard Indexes for Noncarcinogenic Chemicals[a]

Contaminant	Reference Dose[b] (mg/kg-d)	Hazard Index for Maximally Exposed Worker[c]	Hazard Index for the General Public[d]			
			Passerby	Resident	Office Worker	Student
Nitroaromatic Compounds						
2,4,6-TNT	5×10^{-4}	2.8	4.2×10^{-4}	5.6×10^{-5}	2.6×10^{-4}	1.7×10^{-5}
1,3,5-Trinitrobenzene	5×10^{-5}	3.1×10^{-1}	4.6×10^{-5}	6.2×10^{-6}	2.8×10^{-5}	1.9×10^{-6}
Metals						
Arsenic	1×10^{-3}	1.1×10^{-1}	1.6×10^{-5}	2.2×10^{-6}	1.0×10^{-5}	6.8×10^{-7}
Lead	4.3×10^{-4} (I) 6×10^{-4} (O)	7.0×10^{-1}	1.4×10^{-4}	2.0×10^{-5}	9.1×10^{-5}	6.0×10^{-6}
Nickel	2×10^{-2}	4.3×10^{-3}	6.5×10^{-7}	9.0×10^{-8}	4.2×10^{-7}	2.7×10^{-8}
Selenium	1×10^{-3} (I) 3×10^{-3} (O)	9.9×10^{-3}	3.8×10^{-6}	5.1×10^{-7}	2.3×10^{-6}	1.6×10^{-7}
Uranium	3×10^{-3}	2.2×10^{-1}	3.2×10^{-5}	4.3×10^{-6}	2.1×10^{-5}	1.4×10^{-6}
Total hazard index		4.2	6.6×10^{-4}	8.9×10^{-5}	4.1×10^{-4}	2.7×10^{-5}

[a] Calculated by dividing the average daily intake over the exposure period (from Tables 11.7 and 11.9) by the chemical-specific reference dose. A hazard index of less than one is considered to indicate a nonhazardous situation; a hazard index of greater than one is considered to indicate a potential for adverse health effects.

[b] I = inhalation; O = oral. Sources: 2,4,6-TNT, 1,3,5-trinitrobenzene, and uranium (EPA 1989a); arsenic, nickel, and selenium (EPA 1989c); lead, inhalation (EPA 1986); and lead, oral -- derived from previously recommended maximum contaminant level in water of 20 µg/L (EPA 1989a). Reference doses not available for DNT, PAHs, or PCBs.

[c] Hazard index from inhalation and oral exposures.

[d] Hazard index from inhalation exposure.

would actually be exposed to levels estimated for the maximally exposed worker. However, the results of this analysis indicate the need to monitor airborne particulates and use appropriate worker protective equipment during the proposed action.

11.3.3 Discussion

The estimation of health effects associated with radiation exposure was based on risk estimators provided in ICRP (1977) and the BEIR IV study (National Research Council 1988). Estimators from both sources are based on adult exposures. The internal radiation dose is greater for children than adults for the same intake of radioactive substances (see Cristy et al. [1986] for discussion of the relative dose conversion factors for ingestion and inhalation of certain alpha-emitting radionuclides). In addition, children are more susceptible to the effects of radiation than adults and, due to their age, children generally have a longer time in which to develop a cancer caused by radiation. Thus, children are at greater risk from radiation exposure than adults. The EPA estimates for age dependence of risk due to whole-body radiation are given in Table 11.13; this risk distribution was used in recent revisions to the National Emission Standards for Hazardous Air Pollutants under Section 112 of the Clean Air Act (EPA 1989d). Based on these EPA estimates, children are about three times more at risk from whole-body radiation than adults.

The age dependence of radiation risk is very relevant to this action because of the close proximity of Francis Howell High School to the TSA. Even if the radiation risk to a student shown in Table 11.10 were increased by a factor of 10 to account for the greater sensitivity of children to radiation exposure, this risk would be considerably below EPA's target level of 1×10^{-6}. Hence, it is a valid conclusion that the risk to the general public from radiation exposure is very low.

TABLE 11.13 Age Dependence of Risk Due to Whole-Body Radiation

Period of Exposure (age of individual)	Percent of Lifetime Risk[a]	Cumulative Percent of Lifetime Risk[a]
0-9	30	30
10-19	30	60
20-34	20	80
35-50	10	90
50+	10	100

[a]For exposure at a constant rate for a lifetime.

Source: Data from EPA (1989d).

The evaluation of risks to the general public and workers presented in this risk assessment was, by necessity, based on a number of assumptions. In addition, many uncertainties are inherent to the risk assessment process. The effect on risk estimates of uncertainties and of the assumptions required for estimating the risks associated with the bulk wastes are discussed in detail in the BRE (Haroun et al. 1990). Although some of the procedures used tend to underestimate risks, most of the assumptions built into this risk assessment result in overestimating the potential risks -- including the use of conservative estimates for exposure point concentrations and the use of conservative methods for estimating the reference doses and carcinogenic potency factors needed to calculate risks. These procedures should ensure that the estimates presented in this assessment are realistic, yet conservative, representations of the potential risks to the general public and workers resulting from the bulk waste remedial action.

11.4 RELATIONSHIP TO THE BASELINE RISK EVALUATION

The purpose of the BRE summarized in Chapter 3 was to evaluate potential risks to human health resulting from exposures that could occur in the short term under existing site conditions, whereas the risk assessment presented in Sections 11.1 through 11.3 assessed potential risks to the general public and workers resulting from exposure to releases during the bulk waste remedial action. It is therefore inappropriate to make direct comparisons between the risks reported in Section 3.3 and those reported in Section 11.3. The exposure scenarios addressed in these two analyses are premised on different underlying assumptions. For example, the risks reported in Section 3.3 are for a 10-year exposure period assuming current conditions at the quarry, whereas the risks reported in Section 11.3 are for the 1.25-year period during which the bulk wastes would be excavated and placed into temporary storage. The only significant exposure during the temporary storage period would be to workers monitoring the TSA and performing any required maintenance activities.

The methodology used in the two assessments was essentially the same, except for that used to assess airborne contaminant concentrations. Under current site conditions, the potential for generation of airborne particulates at the quarry is low. For this reason, a simple, but conservative, box model approach was used in the BRE to estimate airborne contaminant concentrations (excluding radon and associated decay products, for which actual measurements were available). This conservative approach was considered to be appropriate for the level of analysis required, particularly because the risks resulting from airborne particulates were estimated to be very low. In contrast, to assess potential impacts of the bulk waste remedial action, a more detailed level of analysis was required to estimate the airborne particulate concentrations from the various activities occurring during the actual excavation, transport, and storage of the bulk wastes. The ISCLT model was used to estimate airborne concentrations of particulates at points outside the quarry. The computer code MILDOS was used to estimate radon-222 concentrations outside the quarry. Because these (and other) models are not appropriate for estimating air concentrations at the quarry or at the TSA, the estimated concentrations at these locations were based on measurements and knowledge of the levels of emissions typically associated with the types of activities that would be performed at the quarry and the TSA and the control measures that would be implemented during the remedial action.

The estimated risks to the passerby and trespasser considered in the BRE (summarized in Chapter 3) were based on conservative assumptions, under which (1) the passerby would be exposed to the same airborne concentrations as an individual within the quarry and (2) while in the quarry, the trespasser would always be present in the most highly contaminated area. This was not a realistic approach to use for estimating worker exposures, for which more representative exposure concentrations over the period of the remedial action were developed. Thus, the estimated risks to the passerby and trespasser under current site conditions may appear to be disproportionately high relative to the risks estimated for the passerby and exposed worker scenarios during implementation of the remedial action because of the more conservative assumptions used in the BRE.

11.5 ACCIDENTS

Some potential exists for occupational accidents during construction and operation activities. The estimated numbers of occupational fatalities and injuries that could occur during the quarry bulk waste remedial action are summarized in Table 11.14. The estimated total number of occupational fatalities is 0.02, and the estimated total cases of occupational injury is 14.6, with 6.2 cases involving lost workdays. The fatality value is based on the industry-wide incidence rate for occupational fatalities; even if this assumption results in underestimating the rate for fatalities occurring during the bulk waste remedial action by as much as a factor of 2, the expected number of occupational fatalities would still be much less than 1. However, such an underestimate appears unlikely because occupational injury rates for heavy construction are about the same as the average for all construction (U.S. Department of Labor 1986, 1988); also, the average annual incidence rate for fatalities in mining — the industry sector with the highest rate — was 32.3 per 100,000 full-time workers for the period between 1983 and 1986 (U.S. Department of Labor 1986, 1988), which is much less than twice the average rate for construction (namely 24.9 per 100,000 full-time workers).

Some potential also exists for accidents and fatalities while transporting the bulk wastes that could involve both workers and the general public. The estimated 0.02 total occupational fatalities includes 0.003 fatalities associated with 13 person-years of effort to operate the trucks transporting the wastes from the quarry to the TSA. More specific estimates for vehicle accidents that include the potential for affecting the general public are provided in Table 11.15; these estimates are conservative because they are for two-way travel by trucks on State Route 94 between the quarry and the TSA, which is one of the alternatives to the preferred use of a dedicated haul road from the quarry to the TSA with return of empty trucks on Route 94.

Average daily traffic on State Route 94 near the quarry was 1,820 vehicles per day in 1987, based on traffic counts taken on Route 94 just east of Highway "DD" (Rankin 1989). Forty or 80 trips per day by trucks enroute between the quarry and the TSA would increase traffic by about 2 or 4%, assuming one-way or two-way use of the highway, respectively. Two-way use of State Route 94 during the action period would result in an estimated number of accidents ranging from about 0.03 to 0.35 (depending on the

TABLE 11.14 Estimated Numbers of Occupational Fatalities, Injuries, and Related Lost Workdays Associated with the Bulk Waste Remedial Action[a]

Category	Estimated Number
Total occupational fatalities	0.02[b]
Total cases of occupational injuries	14.6[c]
Total cases of nonfatal occupational injuries, without lost workdays	8.4[c]
Total cases of occupational injuries, with lost workdays	6.2[c,d]
Total lost workdays due to occupational injuries	127.0[c]

[a]All estimates are based on 97 person-years of effort and on average incidence rates for 1983-1986, calculated from annual estimates provided by the U.S. Department of Labor (1986, 1988). The latest year for which results are available is 1986. Averages are used to reduce year-to-year variation in incidence rates.

[b]Based on results for the construction industry. Because of the relatively small number of occupational fatalities that occur annually in each category of the construction industry, the incidence rate for fatalities is provided by the Department of Labor only for the construction industry as a whole and not for various categories. The average for the 1983-1986 period is 24.9 fatalities per 100,000 full-time workers.

[c]Based on results for heavy construction, except highways.

[d]Includes cases that involve days away from work, days of restricted activity, or both.

TABLE 11.15 Estimated Numbers of Transportation Accidents and Related Fatalities Associated with the Bulk Waste Remedial Action, Assuming Two-Way Use of State Route 94[a]

Basis for Estimate	Estimated Number of Accidents	Estimated Number of Fatalities
Missouri state-numbered routes	0.30[b]	–[c]
Missouri, all highways	–[d]	0.0021[e]
Heavy combination trucks on federal-aid secondary highways in Missouri	0.030[f]	0.0090[g]
State Route 94 between County Route "D" and Highway "DD"	0.35[h]	–[i]

[a]Total distance traveled by haul trucks would be about 150,000 km (94,000 mi).

[b]Based on 2.0 vehicle accidents per million vehicle-kilometers traveled; applies to all vehicles (Krull 1989). Based on 1987 data and a definition of an accident as an incident that includes any damage greater than $500 or an injury or death.

[c]The state of Missouri provides fatality rates only for all highways, not for state-numbered routes.

[d]Not estimated because other estimates provided are more relevant.

[e]Based on 1.4 fatalities per 100 million vehicle-kilometers traveled (Krull 1989); for 1987 data and all vehicle types.

[f]Based on 0.20 accidents of heavy combination trucks per million vehicle-kilometers traveled (Saricks 1989); applies only to heavy combination trucks. Data for 1986 obtained from U.S. Department of Transportation public-use files. An accident is defined to include incidents with damage greater than $4,200.

[g]Based on 6.0 fatalities per 100 million vehicle-kilometers traveled by heavy combination trucks in 1986 (Saricks 1989).

[h]Based on 2.3 accidents per million vehicle-kilometers traveled in 1987 and the definition of an accident, as given in footnote b (Krull 1989); applies to all vehicles.

[i]Inadequate data available to estimate.

definition of an accident) and an expected number of fatalities ranging from about 0.002 to 0.009. The preferred transportation alternative would use a dedicated haul road for loaded trucks, with empty return along Route 94. The accidents and fatalities expected for this operation would be considerably less than for two-way use of the highway. The dedicated haul road would have little traffic, trucks would travel at low speeds, and any accidents would probably involve only a single vehicle. Precautions would be taken where the trucks crossed Route 94. In summary, the number of fatalities and significant accidents associated with transporting the bulk wastes are expected to be negligible.

11.6 CUMULATIVE HEALTH EFFECTS

The cumulative effects to human health associated with actions currently planned for quarry remediation were assessed to ensure that the sum of the impacts associated with each individual action would not result in an unacceptably high overall threat to human health. The two major activities currently planned for the quarry are (1) removal of the bulk wastes (which is addressed in this document) and (2) construction and operation of a water treatment plant for the contaminated water in the quarry pond, which is part of a separate but related response action prior to bulk waste removal. Cumulative health effects associated with these two activities are presented in this section; cumulative environmental effects resulting from the activities are discussed in Section 10.7. An assessment of the potential health effects associated with future remedial action activities at the Weldon Spring site will be presented in future environmental compliance documents (i.e., the RI/FS-EIS for activities at the chemical plant area and additional documentation for follow-on activities at the quarry area).

An EE/CA report was prepared to evaluate removal action alternatives for managing the radioactively and chemically contaminated surface water currently in the quarry (MacDonell et al. 1989). Based on the analysis in that report, the selected alternative was construction and operation of a water treatment plant to treat water from the quarry pond, with discharge of the treated water into the Missouri River downstream of the county well field. The plant has been designed to accommodate continued water treatment at the quarry during the bulk waste remedial action.

Potential impacts to human health associated with the water treatment plant were assessed in the EE/CA report. The two primary pathways of potential radiation exposure of the general public are ingestion of drinking water and ingestion of fish from the Missouri River (the release point for the treated water). The estimated total incremental dose to an individual from exposure via these pathways is approximately 2.8×10^{-10} mrem/yr. The corresponding risk is about 4.6×10^{-11}/yr, and the incremental lifetime risk is about 4.6×10^{-10}, assuming 10 years of plant operation.

Risks associated with chemical contaminants in the effluent via the same exposure pathways were not quantified because their concentrations would be maintained at or below levels established in the permit issued by the state of Missouri for the effluent release. These levels were established based on health and environmental protection. The health effects to the public from pumping, treatment, and temporary storage activities associated with operation of the water treatment plant at the quarry would also be insignificant because the quarry is in an unpopulated area and all activities would be conducted in a manner that would minimize potential impacts.

Impacts to workers could occur during pumping, treatment, and storage activities. However, the plant itself would be located in an uncontaminated area, its operation would not involve direct contact with untreated water or treatment of contaminated solids, and all activities associated with the proposed action would be conducted in accordance with health and safety plans for the Weldon Spring site to ensure worker protection. Therefore, the potential for occupational exposure to contaminants by direct contact, ingestion, or inhalation is expected to be minimal.

Cumulative effects associated with the water treatment plant and the bulk waste remedial action were conservatively estimated by assuming that individuals potentially impacted by the bulk waste removal activities would also be impacted by the water treatment plant activities. In this case, the risks estimated for the two actions are additive. The estimated radiological risks associated with water treatment plant activities are much lower than those associated with the bulk waste remedial action for both the general public and worker scenarios (which range from 2.1×10^{-8} to 4.1×10^{-4} for the student and maximally exposed worker scenarios, respectively; see Section 11.3.1). The same conclusion is true for potential chemical risks. Therefore, the cumulative risks associated with implementation of these two actions are essentially the same as those estimated for the bulk waste remedial action. Hence, no significant cumulative health effects are expected to result from implementation of the water treatment plant removal action and the bulk waste remedial action.

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Weichman, M.S., 1988, letter from M.S. Weichman (Senior Archaeologist, Division of Parks, Recreation, and Historic Preservation, Missouri Department of Natural Resources, Jefferson City, Mo.) to K.D. Lee (Subcontractor Administrator, MK-Ferguson Company, Weldon Spring, Mo.), Nov. 28.

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13 AGENCIES CONTACTED

Missouri Department of Conservation, Jefferson City.

Missouri Department of Conservation, August A. Busch Memorial Wildlife Area, St. Charles County.

Missouri Department of Natural Resources, Division of Environmental Quality, Jefferson City.

Missouri Highway and Transportation Department, Jefferson City.

National Weather Service, St. Charles, Mo.

St. Charles County Planning and Zoning Commission, St. Charles, Mo.

U.S. Army Corps of Engineers, Kansas City District, Kansas City, Mo.

U.S. Department of the Interior, Fish and Wildlife Service, Columbia, Mo.

U.S. Department of Labor, Bureau of Labor Statistics, Office of Occupational Safety and Health Statistics, Washington, D.C.

U.S. Occupational Safety and Health Administration, Washington, D.C.

14 LIST OF CONTRIBUTORS

This feasibility study has been prepared by the U.S. Department of Energy (DOE) with contractual assistance from Argonne National Laboratory. Staff members of the DOE Oak Ridge Operations Office have provided guidance and direction for the analyses used in this report. The following individuals contributed to the preparation of this report.

Name	Education/Expertise	Contribution
Y.-S. Chang	Ph.D., Chemical Engineering 8 years experience in air quality research and assessment	Assessment of air quality impacts
T. Cuscino	M.S., P.E., Mechanical Engineering 14 years experience in assessing fugitive emissions	Assessment of air quality impacts; inventory of fugitive emissions
M.J. Davis	Ph.D., Electrical Engineering 13 years experience in environmental and technology assessment and regulatory analysis	Description of proposed action; assessment of surface water impacts; assessment of occupational and transportation risks
L.A. Haroun	M.P.H., Environmental Health Sciences 9 years experience in health effects assessment	Assessment of chemical risks
I. Hlohowskyj	Ph.D., Zoology 13 years experience in ecological research and environmental assessment	Assessment of ecological impacts
J.F. Hoffecker	Ph.D., Anthropology 15 years experience, including 6 years in environmental assessment	Assessment of cultural resource impacts
M.A. Lazaro	M.S., Environmental Science and Engineering 17 years experience in environmental science	Assessment of air quality impacts

Name	Education/Expertise	Contribution
M.M. MacDonell	Ph.D., Civil Engineering/ Environmental Health Engineering 8 years experience in environmental research and assessment	Development, evaluation, and comparison of alternatives; assessment of ARARs
J.M. Peterson	M.S., P.E., Nuclear Engineering 14 years experience in nuclear programs, including 11 years in environmental assessment	Assessment of radiological risks
D. Tomasko	Ph.D., Civil Engineering 15 years experience in nuclear programs and geohydrology	Assessment of groundwater impacts
D.R. Wernette	Ph.D., Sociology 16 years experience in socioeconomic impact analysis and public perception studies	Assessment of demographic and land use impacts
D.J. Wyman	M.S., Botany; M.A., Library Science 14 years experience in technical editing	Overall editorial responsibility

APPENDIX A:

LETTERS OF CONSULTATION

MISSOURI DEPARTMENT OF CONSERVATION

MAILING ADDRESS:
P.O. Box 180
Jefferson City, Missouri 65102-0180

STREET LOCATION:
2901 West Truman Boulevard
Jefferson City, Missouri

Telephone: 314/751-4115
JERRY J. PRESLEY, Director

August 24, 1988

Dr. Ihor Hlohowskyj
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

Dear Dr. Hlohowskyj:

In response to your recent request for species information in the Weldon Spring-St. Charles County area, I have provided copies of available data. The information is not in a format that allows us to provide separate lists for Weldon Spring Chemical Plant and Quarry Site, Weldon Spring Wildlife Area, Busch Wildlife Area, Howell Island Wildlife Area, St. Charles County and St. Louis County.

Hopefully, these lists will provide you with enough information to complete your environmental assessment.

Sincerely,

Dan F. Dickneite

DAN F. DICKNEITE
ENVIRONMENTAL ADMINISTRATOR

Enclosure

MISSOURI DEPARTMENT OF CONSERVATION

MAILING ADDRESS:
P.O. Box 180
Jefferson City, Missouri 65102-0180

STREET LOCATION:
2901 West Truman Boulevard
Jefferson City, Missouri

Telephone: 314/751-4115
JERRY J. PRESLEY, Director

September 8, 1988

Mr. Ihor Hlohowskyj
Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439

Dear Dr. Hlohowskyj:

Enclosed is a printout from our Heritage data base on rare and endangered plants and animals, and high quality natural communities. This listing includes plants, although I notice there aren't many plant records in St. Charles County.

The absence of occurrences of sensitive species and communities does not mean that they do not occur within the area, merely that no other information is stored in the Heritage database at this time.

The printout is self explanatory, with the following exceptions:

Precision:	S = location known exactly
	M = location precise to within 1.5 mi.
	G = location precise to within 5.0 mi.
Fed Status:	C2 = federal candidate for listing as a threatened or endangered species
	C3C = former federal candidate species
	LT = listed as a federally threatened species
	LE = listed as a federally endangered species
State Status:	WL = watchlisted
	SU = status undetermined
	R = rare
	E = endangered
	PE = possibly extirpated.

I am also enclosing a copy of our rare and endangered species checklist and Rare and Endangered Species of Missouri. If you need any further information, please to not hesitate to contact Mike Sweet or me.

Sincerely,

Eleanor P. Gaines

Eleanor P. Gaines
Data Manager

United States Department of the Interior

FISH AND WILDLIFE SERVICE
COLUMBIA FIELD OFFICE (ES)
P.O. Box 1506
Columbia, Missouri 65205

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:

December 22, 1988

Ihor Hlohowskyi, Ph.D.
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

Dear Dr. Hlohowskyi:

This is in reference to your letter and attached map of December 6, 1988 requesting Threatened and Endangered Species information for Federally listed species.

Endangered Species Comments

Under Section 7(c) of the Endangered Species Act, Federal agencies are required to obtain from the Fish and Wildlife Service information concerning any species, listed or proposed to be listed, which may be present in the area of a proposed action. Therefore, we are providing you with the following list of species which may be present in the concerned area:

Endangered

Bald eagle (*Haliaeetus leucocephalus*)

Under 7(c) of the Endangered Species Act of 1973, as amended, the Federal agency responsible for actions authorized, funded, or carried out in the furtherance of a construction project that significantly affects the quality of the human environment, is required to conduct a biological assessment. The purpose of the assessment is to identify listed or proposed species likely to be adversely affected by their action and to assist the Federal agency in making a decision as to whether they should initiate consultation.

If you have any questions regarding this response or if we can be of any further assistance, please contact Mr. Tom Nash, Columbia Field Office, P. O. Box 1506, Columbia, Missouri 65205, (314)875-5374 or (FTS)276-5374.

Sincerely yours,

Joe Tieger

Joe Tieger
Field Supervisor

TJN:mb:1124STWELDOB

APPENDIX B:

ANALYSIS OF POTENTIAL AIR QUALITY IMPACTS

APPENDIX B:

ANALYSIS OF POTENTIAL AIR QUALITY IMPACTS

The approach used to predict air quality impacts of the bulk waste remedial action is presented in this appendix. Section B.1 describes the methodology used to prepare both the long-term (annual) and short-term (daily) uncontrolled PM-10 particulate emission inventories and to convert the results into appropriate input for the predictive air quality models. Section B.1.1 identifies fugitive dust sources. Sections B.1.2 and B.1.3 address the annual uncontrolled inventory and the worst-case daily uncontrolled inventory of PM-10 emissions, respectively. Section B.2 identifies representative strategies for fugitive dust control assumed in the analysis, and Section B.3 summarizes both the uncontrolled and controlled PM-10 emission inventories. For simplicity of presentation, most units in this appendix are given in English units only; conversion factors are provided in Appendix D. Those data originally measured in metric units (i.e., meteorological data) are expressed in metric units.

The air quality analysis was based on the following specific assumptions concerning how the bulk waste remedial action would be conducted:

1. The daily number of haul trips averaged over all workdays during the project would be 40 (Ferguson 1989).

2. The daily maximum number of haul trucks would be 48 (Ferguson 1989; MK-Ferguson Company and Jacobs Engineering Group 1990).

3. The number of hours of heavy equipment use would be limited to 8 hours per day and 5 days per week, i.e., no overtime would be employed.

4. A loaded truck would weigh no more than 40 tons; the maximum bulk waste load would be about 21 tons based on manufacturer ratios of capacity to tare weight.

5. Assuming an average bulk waste density of 2 tons per banked cubic yard (bcy) and a potential 124,000 bcy of material to be moved (MK-Ferguson Company and Jacobs Engineering Group 1990), 248,000 tons of materials would be moved in about 11,800 trips.

6. The average volume of materials hauled from the quarry would be 10.5 bcy or 11.9 loose cubic yards (lcy), assuming a 21-ton capacity truck, an average density of 2 tons/bcy, and an estimated 1.13 lcy/bcy (MK-Ferguson Company and Jacobs Engineering Group 1990).

7. The number of workdays needed to move the bulk wastes would be 294, i.e., about 15 months, allowing for downtime due to weather, holidays, and equipment failures. Work would not begin during fall or winter and therefore all downtime due to weather is assumed to be during the first year of operation.

8. Haul trucks would travel to the temporary storage area (TSA) on an unpaved road and would return to the quarry on State Route 94.

9. The haul road through the quarry support area from State Route 94 to the mouth of the quarry would be paved over a 700-ft length.

10. Two bulldozers would operate at the TSA at 50% capacity on an average day and at 60% capacity on a worst-case day; one bulldozer would operate at the quarry at 30% capacity on an average day and at 36% capacity on a worst-case day.

11. A 4-lcy front-end loader would travel between the sort pad and the piles within the TSA; the loader would weigh 18 tons empty and carry a rated safe load of 6 tons.

12. A road grader would be active 100% of the time, with 75% of the activity at the quarry and 25% on the haul road to the TSA. The 75/25% split is based on expected better road conditions on the haul road and a higher level of traffic at the quarry.

B.1 METHODOLOGY FOR ESTIMATING PM-10 EMISSIONS

The methodology used to develop inventories of PM-10 emissions for estimating annual and reasonable worst-case daily emissions is presented in Sections B.1.1 through B.1.3. The PM-10 emissions address particles less than 10 μm in aerodynamic diameter and serve as input for comparison with both annual and daily National Ambient Air Quality Standards (NAAQS) (see Appendix C), as well as input for determination of potential radiological and chemical health effects.

B.1.1 Fugitive Dust Sources

Fugitive dust could be generated by a variety of sources during removal of the bulk wastes from the quarry. Fugitive dust is defined as particulates emitted to the atmosphere in any manner other than through a duct, stack, or flue. Potential sources of fugitive dust resulting from the bulk waste remedial action are:

- Bulldozer activity in the quarry,
- Front-end loader activity at the quarry,

- Truck transport of bulk wastes within the quarry,
- Worker and visitor transport at the quarry,
- Supply truck transport at the quarry,
- Wind erosion of exposed areas at the quarry,
- Wind erosion of exposed areas at the quarry support area,
- Truck transport of bulk wastes from the quarry to the TSA on an unpaved road,
- Wind erosion of the bulk waste piles at the TSA,
- Worker and visitor transport at the TSA,
- Supply truck transport at the TSA,
- Front-end loader/bulldozer operations at the TSA, and
- Grader operations on quarry roads and the haul road to the TSA.

Certain of these sources were determined to have such a small impact that they were not addressed further. For example, the loading of haul trucks at the quarry with a front-end loader would probably increase particulate concentrations by less than 1 $\mu g/m^3$ on an annual basis. Similarly, emissions from truck and front-end loader activity at the TSA would be small, as would emissions from the travel of haul trucks back to the quarry on State Route 94. Emissions from haul truck travel on Route 94 are estimated to be only 0.1% of those for travel on the unpaved road to the TSA.

B.1.2 Annual Inventory of Uncontrolled PM-10 Emissions

The primary references used in this analysis were as follows: for emission factors, EPA guidance (EPA 1988), hereafter referred to as AP-42; and for source activity, Hlavacek (1988) and MK-Ferguson Company and Jacobs Engineering Group (1990). Wind erosion emission factors were taken from EPA guidance (EPA 1985). The emission factors in AP-42 are in the form of predictive equations; hence this discussion will deal with the values selected for appropriate independent variables.

Bulldozer Activity at the Quarry. Bulk waste excavation at the quarry would include the use of a bulldozer to feed materials to a backhoe or dragline, which in turn would place the materials in a pile accessible to front-end loaders and trucks. The predictive equation for the bulldozer emission factor is taken from Section 8.24 of AP-42 and is dependent on the silt and moisture content of the material being handled. The average values for overburden silt and moisture content given in Section 8.24 of AP-42 are 6.9% and 7.9%, respectively. However, for exposed topsoil, the average values for silt and moisture content are given as 15% and 3.4%, respectively, in Section 11.2.3 of AP-42. Because the action would include both topsoil and subsurface material, overall averages of 11% and 5.7% for silt and moisture contents were used. Assuming a 30% operation time (Hlavacek 1988), the bulldozer would be active 2.9 hours of each work day. Based on this input, the uncontrolled PM-10 emissions are estimated to be 1,430 lb during the first 12-month operating period and about 30% of that during the remaining three months. (The average monthly emissions would be higher during the last three months than during the first 12 months, because all downtime is assumed to occur during the first year.)

Haul Truck Activity at the Quarry. The emissions from vehicular transport on unpaved quarry roads would depend on the physical characteristics of the road aggregate, vehicle characteristics, and number of dry days per year. Because the quarry support area and the more permanent of the unpaved roadways in the quarry would probably be covered with crushed limestone, an average silt content of 9.6% for this material was assumed (AP-42, Section 11.2.1). An empty truck weight of 21 tons and a loaded weight of 40 tons were assumed for 40 daily truck trips in this analysis. The trucks were assumed to be standard 10-wheel vehicles operating at a loaded speed of 10 mph and an empty speed of 20 mph. From AP-42 (Section 11.2.1), the normal number of dry days in the Weldon Spring area is estimated to be 255 per year.

The emissions from haul truck transport on the 700 ft of paved road in the quarry support area would depend on the silt loading of the surface dust on the two-lane road. The average dust loading for industrial roads in iron and steel plants -- the industry with the most complete data base -- is estimated to be 1,750 lb/mi, 12.5% of which is silt. Based on this input, the uncontrolled PM-10 emissions from truck hauling within the quarry on unpaved and paved roads combined are estimated to be 17,100 lb in the first year and about 30% of that amount in the second year.

Worker and Visitor Transport at the Quarry. The emissions from worker and visitor transport would be affected by the same variables as those for haul truck transport. Such transport would occur mainly in the quarry support area on the paved access road and the crushed stone parking lot and occasionally in the quarry. A silt content of 9.6% was assumed for the crushed stone parking lot. An average of 39 people were projected to enter the quarry daily (Hlavacek 1988). Vehicle speeds were estimated at 15 mph, and the average vehicular weight and the number of wheels were estimated at 3 tons and 4 wheels, respectively. The average travel distance was estimated to be 100 ft on asphalt and 100 ft in the parking lot. Based on these data and on the unpaved and paved road emission factor equations in AP-42 (Sections 11.2.1 and 11.2.5), the uncontrolled PM-10 emissions from unpaved and paved surfaces combined are estimated to be 250 lb in the first year and 30% of that amount during the second year.

Supply Truck Traffic at the Quarry. The input variables for the predictive emission factor equation for supply trucks traveling on the paved road in the quarry support area have the same values as those for worker and visitor transport except that the empty and loaded weights were estimated to be 15 tons and 25 tons, respectively. An average of two supply trucks per day were assumed to enter the support area and travel 350 ft one way, i.e., half the length of the paved road in this area. Based on these assumptions, the uncontrolled PM-10 emissions are estimated to be 35 lb in the first year and about 30% of that amount during the second year.

Wind Erosion at the Quarry. Potential wind erosion emissions from the quarry, excluding the support area, were based on a long-term limited erosion equation (Cowherd et al. 1985). The emission rate is dependent on the degree of vegetation, the annual average monthly frequency of disturbance, the fastest mile of wind expected, and the wind speed needed to generate a threshold friction velocity at the surface of 90 cm/s, assuming a roughness height of 0.3 cm. Emissions were estimated for eight individual areas within the quarry, and the average annual monthly frequency of disturbance was calculated for each area by dividing the number of workdays spent in that area by 12. In other words, each workday would generate a disturbance of the surface that would result in an erodible mass. The fastest recorded mile in the St. Louis area, which is not to be confused with the peak wind speed, is 21.2 m/s (Cowherd et al. 1985). The wind speed at 7 m that would generate enough surface shear stress to cause the dust to become airborne was calculated as 17.1 m/s. A Thornthwaite precipitation-evaporation (PE) index value of 84 was used in this analysis. No vegetation was assumed to exist in the quarry because land clearing would be one of the first tasks carried out. (However, the exposed surface area might be reduced because portions of the surface might be covered to reduce radon emissions.) The predictive emission rate equation is designed to spread the emissions equally over every second of the year even though they actually occur in bursts. In the predictive air quality model for annual emissions -- Industrial Source Complex, Long Term (ISCLT) -- emissions are assumed to occur only when wind speed exceeds the threshold; therefore an adjustment was made to the steady-state average emission rate by dividing by the fraction of time wind erosion occurred. Based on this input, the uncontrolled PM-10 emissions for the first year of operation are estimated to be 11,800 lb and about 30% of that amount during the second year.

Wind Erosion at the Support Area. The effects of wind erosion at the support area would be different from those in the quarry because the eroding surface would be crushed stone rather than soil. The PE index and the fastest mile for the support area would be the same as for the quarry. The frequency of disturbance was assumed to be 19 times monthly; the wind speed at 7 m necessary to produce a friction velocity of 90 cm/s, assuming a roughness height of 0.2 cm, is 18.7 m/s. Only 70% of the support area was estimated to erode because temporary buildings would be expected to cover the remainder of that area. Based on this input, the uncontrolled PM-10 emissions are estimated to total 8,100 lb in the first year and about 30% of that amount during the second year.

Haul Truck Traffic on the Haul Road. The most significant source of PM-10 emissions on an uncontrolled basis would be the hauling of bulk wastes from the quarry to the TSA on a 5.4-km (3.4-mi) unpaved road. Input data to the predictive emission factor equation for this source are the same as those discussed for hauling on quarry roads except that the loaded speed was estimated to be 20 mph and an average of 40 one-way trips per day was assumed (Ferguson 1989). Based on these data, the uncontrolled PM-10 emissions are estimated to total 319,000 lb during the first year and about 30% of that amount during the second year.

Wind Erosion at the TSA. Wind erosion at the TSA would depend on the same variables as those for the quarry and support areas. Because the available meteorological data that are most representative of the TSA (Lazaro 1989) did not identify wind speeds high enough to generate wind erosion in 1985 -- the only year in which meteorological data specific to the TSA location were available -- this value was assumed to be zero.

Worker and Visitor Transport at the TSA. Worker and visitor transport at the TSA would occur over both paved and unpaved roads. For the paved road portion, the silt content was estimated to be 12.5% and the road dust loading was estimated to be 1,750 lb/mi (based on data from iron and steel plants). The two-lane road is wide enough that light-duty vehicles passing in opposite directions are not expected to be forced onto the unpaved berms of the road. For the unpaved road portion, the silt content was estimated at 9.6%, as for crushed stone at the quarry; and the vehicle weight, number of wheels, and speed were estimated at 3 tons, 4 wheels, and 25 mph, respectively. An estimated 28 people were projected to travel on the road daily (Hlavacek 1988). An estimated 0.25 mi of the road is paved and 0.4 mi is unpaved (Myers 1988). Based on this input, the uncontrolled PM-10 emissions from this source are estimated to be 5,880 lb during the first year and about 30% of that amount during the second year.

Supply Truck Traffic at the TSA. Supply trucks would travel to the TSA over the same roads as workers and visitors. For both the paved and unpaved road equations, all the input data are the same as those listed for worker and visitor transport, with the following exceptions: (1) the loaded and empty truck weights were estimated to be 25 tons and 15 tons, respectively, and (2) the 10-wheel supply trucks were expected to move at 25 mph whether loaded or not. Two trips per day were estimated to occur over the 3400-ft length of road. Based on these data, the uncontrolled PM-10 emissions are estimated to be 2,300 lb during the first year and about 30% of that amount in the second year.

Bulldozer Activity at the TSA. Bulldozer activity would be required to build and maintain the TSA. The only available predictive emission factor for bulldozer operations is contained in AP-42 (Section 8.24). Work on overburden piles was estimated to be similar to work on the TSA piles. Values for silt and moisture content were assumed to be 11% and 5.7%, respectively, as identified for bulldozer activity at the quarry. Two bulldozers were assumed to operate at the TSA 50% of the time (Hlavacek 1988). Based on this input, the uncontrolled PM-10 emissions are estimated to be 4,800 lb for the first year and about 30% of that amount during the second year.

Front-end Loader Activity at the TSA. Front-end loader activities at the TSA would include moving the waste materials (including fine-grained soil and other soil contaminated with nitroaromatics) from the sort pad to the appropriate pile; the majority of uncontrolled emissions from this activity would be generated by travel over unpaved surfaces. A silt content of 11% and a vehicular speed of 5 mph were assumed. The empty weight of the 4-wheel loader was estimated to be about 18 tons, with a safe load of about 6 tons. An average haul distance of 310 ft was assumed, with some trips to the fine-grained soils area being less than that and trips to the nitroaromatics area being greater (see Figure 8.9 of this report for layout of the TSA). Based on these assumptions, the uncontrolled PM-10 emissions are estimated to total 3,300 lb in the first year and about 30% of that amount during the second year.

Grading on Quarry Roads and the Haul Road. Road grading would be necessary to maintain both the unpaved roads at the quarry and the haul road to the TSA. The predictive emission factor for grading is contained in AP-42 (Section 8.24). The only variable in the equation is grader speed, which was estimated to average 5 mph. The activity level was estimated at 8 hours per day, with 6 hours spent in the quarry and 2 hours on the haul road. Based on this input, the uncontrolled PM-10 emissions are estimated to total 9,500 lb in the first year and about 30% of that amount during the second year.

B.1.3 Inventory of Worst-Case Daily Emissions

The PM-10 standard is the only air quality regulation applicable to the bulk waste remedial action that requires a worst-case daily concentration determination. The standard requires that the daily concentration on any given day not exceed 150 $\mu g/m^3$ more than three times in 3 years. The approach used in this analysis to predict compliance status was to determine the worst-case situation that has a reasonable probability of occurring and perform a refined modeling analysis to determine how the results compare with the standard. This discussion presents only the worst-case assumptions related to the daily emission inventory.

The reasonable worst-case day was developed by identifying the longest haul distance within the quarry that was also close to locations with the greatest likelihood of public exposure. The selected scenario was the hauling of bulk wastes from the northeast portion of the quarry near State Route 94 -- including the area just inside the upper gate, the sloped area going down to the quarry floor, and the area at the base of the slope. The analysis was structured to allow this worst-case day to occur every day of the year because it cannot be known exactly when this day might fall during an actual calendar year. This approach permits the identification of any combination of reasonable worst-case daily emissions and daily meteorology that could produce an exceedance of the standard.

The above scenario represents the worst case not only at the quarry but also at the TSA. The fine-grained soil contaminated with nitroaromatics from the northeastern corner of the quarry would be deposited only 50 ft from the western boundary of the TSA and the site, thus placing considerable activity near the boundary on the worst-case day.

Bulldozer Activity at the Quarry. Input variables necessary to estimate the impact of bulldozer activity in the quarry on the worst-case day are the same as those for the annual case except that the operating time was increased to 36% (from 30% for the annual case) to account for the increased activity assumed on this day. Based on this input, the uncontrolled PM-10 emission rate on the worst-case day is estimated to be 7.6 lb per day.

Haul Truck Traffic at the Quarry. Emissions from haul truck traffic on unpaved and paved roads at the quarry were determined using the same input values as for the annual case except that the worst-case day was assumed to be a dry day, with no mitigation of emissions from ongoing or recent rainfall, and 48 truck trips were assumed rather than the average of 40 used for the annual emissions estimate. Based on this input, the uncontrolled PM-10 emission rates on the worst-case day are estimated to be 151 lb per day on unpaved roads and 9.8 lb per day on paved roads.

Worker and Visitor Transport at the Quarry. The peak emission scenario for emissions from worker and visitor transport at the quarry was obtained by doubling the average number of visitors assumed for the annual case. A total of 44 workers and visitors were assumed to visit the quarry on the worst-case day, with an occupancy of one person per vehicle. All other variables are the same as in the annual emission inventory. Based on this input, the combined uncontrolled PM-10 emission rate for unpaved and paved surfaces on the worst-case day is estimated to be 2.7 lb per day.

Supply Truck Traffic at the Quarry. The maximum daily emissions for supply truck deliveries to the quarry was calculated by assuming five trucks daily instead of the two assumed for the annual inventory. It was also assumed that all deliveries would be made to the southernmost edge of the support area on the worst-case day, constituting a one-way trip distance of 700 ft on the paved road. All other variables are the same as in the annual inventory. Based on these data, the uncontrolled PM-10 emission rate on the worst-case day is estimated to be 0.2 lb per day.

Wind Erosion of the Quarry. On a worst-case day, a frequency of disturbance of once per calendar day (i.e., about 30 times per month) can be assumed (Cowherd 1985). This disturbance factor was applied only to the area along the northern edge of the quarry because the southern areas are not expected to be disturbed during the worst-case day. With all other variables being the same as in the annual inventory, an uncontrolled PM-10 emission rate of 13 lb per day is estimated for wind erosion on the worst-case day. In fact, wind erosion could only have occurred on 5 days at the quarry in 1985 (which is the year of meteorological data being used in this analysis), and there is a limited probability that a high wind-speed day would also occur on the same day that the excavation activity is increased. Nevertheless, these 5 days have been conservatively modeled to consider such a possibility.

Wind Erosion at the Staging Area. Using a maximum frequency of disturbance of 30 times per month and the same values for other variables as used in the annual emission inventory, the uncontrolled PM-10 emission rate for wind erosion in the quarry support area on the worst-case day is estimated to be 35 lb per day. Although the simultaneous occurrence of high wind speed and increased excavation activity is unlikely, this scenario was conservatively assumed in the analysis.

Haul Truck Traffic on the Haul Road. Maximum emissions from haul truck transport between the quarry and the TSA were estimated by assuming that 48 trips (instead of 40) occur on the worst-case day. The worst-case day was also assumed to be a dry day with no mitigation of emissions from ongoing or recent rainfall. All other variables are the same as those used for the annual inventory. Based on this input, the uncontrolled PM-10 emission rate on the worst-case day is estimated to be 2,400 lb per day, assuming travel to the TSA on an unpaved road.

Wind Erosion at the TSA. Wind erosion emissions from the TSA pile on the worst-case day were assumed to be zero because the meteorological data measured for this area in 1985 indicate that wind speeds never reached a level high enough to generate wind erosion.

Worker and Visitor Transport at the TSA. Estimated maximum emissions from worker and visitor transport at the TSA were based on the assumption that twice the average number of visitors would be present in that area as were estimated for the annual emission-rate calculation, with one person per vehicle. It was also assumed that dry-day conditions exist. Based on this input, the uncontrolled PM-10 emission rates on the worst-case day are estimated to be 13.5 lb per day from the paved portion of the road and 39.8 lb per day from the unpaved portion.

Supply Truck Traffic at the TSA. Worst-case emissions from supply truck deliveries to the TSA were estimated by assuming five deliveries on the worst-case day (compared to two on the average day) and by assuming that dry-day conditions would exist. The uncontrolled PM-10 emission rates on the worst-case day are estimated to be 1.9 lb per day from the paved portion of the road and 33.6 lb per day from the unpaved portion.

Front-end Loader and Bulldozer Activities at the TSA. Front-end loader and bulldozer activities at the TSA were predicted to increase on a worst-case day for which 48 truckloads of waste would be processed instead of the average of 40. The two bulldozers were each assumed to be working 60% of the time on this worst-case day (instead of 50% for the annual case). The longest possible haul distance of 650 ft (i.e., the distance from the sort pad to the nitroaromatic-contaminated pile, Area D) was assumed for the front-end loaders for all trips. Based on this input, the uncontrolled PM-10 emission rates on the worst-case day are estimated to be 25.2 lb per day from the bulldozers and 52.6 lb per day from the front-end loaders.

Grader Activity at the Quarry and the Haul Road. Grader activity was assumed to remain the same on a worst-case day as on an average day. Hence, the PM-10 emission rate is estimated to be 42.4 lb per day, with a 75/25% split between the quarry and the haul road, respectively.

B.2 CONTROL TECHNIQUES FOR PARTICULATE EMISSIONS

When assessing air quality impacts, various fugitive dust control strategies, as summarized in Table B.1, are assumed to be in place during the bulk waste remedial action. The values shown in Table B.1 have been used in the short-term analysis of air quality impacts. The results of the long-term analysis were below the air quality standard under much less stringent control strategies.

The bulldozer activity at the quarry would be a significant source of dust, in part because the emissions would emanate from a relatively small area in which the bulldozer was operating and therefore would be concentrated. The control strategy for these emissions assumed that a water truck would be operating with both a water canon and a rear spray bar located on the bench above the bulldozer, with the primary task of spraying water on the bulk material when it became dry. If the material was sufficiently wet or if the bulldozer was temporarily idle, no watering would be required. At these times, the water truck would be free to flush the paved access road leading into the quarry.

Haul truck travel in the quarry, especially along the northern portion of the quarry parallel with State Route 94, would require substantial mitigation. Actual field testing of emulsified petroleum resins has demonstrated that these dust suppressants are very effective in reducing road dust (EPA 1984; Cuscino 1984). These petroleum resins have several advantages over lignin sulfonates and salts, including reduced solubility in water after curing. Also, the best available field-test data are for petroleum resins. The control effectiveness of petroleum resins depends on the application intensity (the amount applied per unit surface area) and the dilution ratio (the volume of chemical per volume of water). As might be expected, the efficiency decays with time as a function

TABLE B.1 PM-10 Control Strategies Assumed in the Short-Term Air Quality Analysis

Source	Description of Control	Estimated Control Efficiency (%)
Bulldozer in quarry	Watering with dedicated truck	65.0
Haul trucks traveling on quarry unpaved roads	Petroleum-resin chemical dust suppressant applied at 1.0 gal/yd^2 and 12% dilution every 400 vehicle passes	98.3
Vehicles traveling on paved quarry roads	Pressurized water flushing at 0.5 gal/yd^2 every 160 vehicle passes	50.0
Vehicles traveling on unpaved parking lot in support area	Petroleum-resin chemical dust suppressant applied at 1.0 gal/yd^2 and 12% dilution every 1,100 vehicle passes	95.3
Haul trucks traveling on unpaved haul road	Petroleum-resin chemical dust suppressant applied at 1.0 gal/yd^2 and 12% dilution every 1,100 vehicle passes	95.3
Front-end loaders and other vehicles traveling on TSA unpaved access road and on roadways between the piles	Petroleum-resin chemical dust suppressant applied at 1.0 gal/yd^2 and 12% dilution every 1,100 vehicle passes	95.3
Bulldozer activity at the TSA	Watering with dedicated truck	60.0
Grader activity on unpaved quarry roads	Residual effects of petroleum-resin chemical dust suppressant	85.0
Grader activity on unpaved haul road	Residual effects of petroleum-resin chemical dust suppressant	50.0

of the weight of the vehicles, the strength of the road, and the number of vehicle passes. The empirical equation used to develop this control strategy is

$$CE = 100 - 0.0043 \times V$$

where

CE = the instantaneous PM-10 control efficiency (%) and

V = the number of vehicle passes over the road.

Testing to verify this equation was conducted with vehicles weighing an average of 43 tons on a road of moderate strength. The road was initially treated with 0.83 gal/yd^2 of 20% solution; after being used by vehicles, it was retreated with 1 gal/yd^2 of 12% solution.

Using the empirical equation, reapplication at 400 and 1,100 vehicle passes was calculated to achieve the desired efficiencies of 98.3% and 95.3% control, respectively (see Table B.1). One method of ensuring that reapplication would occur at the proper intervals would be to place an automatic traffic counter on the roadway into the quarry.

The paved road through the quarry support area would require flushing with a pressure spray truck every 160 vehicle passes to achieve 50% control (Cuscino 1984). This could be performed with the same truck assigned to the bulldozer because bulldozer activity is expected to occur less than 3 hours during each workday.

Bulldozers would operate on specific piles within the TSA, e.g., on the fine-grained soil pile and on the nitroaromatic-contaminated soil pile. The bulldozers' function would be to push materials up onto the top of the pile and then level out the top. The bulldozers would essentially build the piles higher than the front-end loaders could reach. This activity is expected to generate dust and could require intensive watering of the pile. Thus, the continuous presence of a water truck with a spray canon might be required at the TSA because the two bulldozers would each be active 50% of the time on the average day and 60% of the time on the worst-case day.

The unpaved roads at the quarry and the 5.4-km (3.4-mi) haul road to the TSA would be graded. After several applications of the petroleum-resin solution, the roadbed would probably be quite cohesive to a significant depth. Thus, grader activity is not expected to generate much surficial dust because of interparticle adhesion. A control efficiency of 85% is anticipated on the quarry roads because they would be treated most frequently; 50% control is considered easily achievable on the other roads.

B.3 SUMMARY OF EMISSION INVENTORIES

The long-term and short-term PM-10 emission inventories are summarized in Tables B.2 and B.3, respectively. The uncontrolled emission rate, control efficiency, and resultant controlled emission rate for each source category are presented.

TABLE B.2 Summary of the Long-Term PM-10 Emission Inventory

Source	Uncontrolled Emission Rate (lb/peak year)	Control Efficiency[a] (%)	Controlled Emission Rate (lb/peak year)
Quarry			
Bulldozer activity	1,430	0	1,430
Haul truck activity			
- Paved roads	1,100[b]	50.0	550
- Unpaved roads	16,000[b]	95.3	750
Worker and visitor activity			
- Paved roads	50	50.0	25
- Unpaved parking lot	200	95.3	9.4
Supply truck activity	35	50.0	17.5
Wind erosion, quarry area	11,800[c]	0	11,800
Wind erosion, support area	8,100[d]	0	8,100
Grading	7,140	50.0	3,570
Haul Road			
Haul truck activity	319,000	95.3	15,000
Grading	2,360	50	1,180
TSA			
Wind erosion, bulk waste piles	0	0	0
Worker and visitor activity			
- Paved roads	620	0	620
- Unpaved roads	5,260	95.3	247
Supply truck activity			
- Paved roads	170	0	170
- Unpaved roads	2,130	95.3	100
Bulldozer activity	4,800	0	4,800
Front-end loader activity	3,300	0	3,300

[a]Some of these control efficiencies are less stringent than those used in the short-term analysis. The short-term control strategies are those that would be employed in the field.

[b]Model was run with an additional 30% emissions that should have been allocated to the second year. Because the prediction was below the standard, no rerun was necessary.

[c]Model was run using 19,800 lb/peak year based on a very restrictive assumption of 75 cm/s threshold velocity. Because the prediction was below the standard, no rerun was necessary.

[d]Model was run using 18,100 lb/peak year based on a very restrictive assumption of 75 cm/s threshold velocity. Because the prediction was below the standard, no rerun was necessary. A 30% reduction in erodible area due to surface shielding by temporary buildings was incorporated in the uncontrolled emission rate calculation.

TABLE B.3 Summary of the Short-Term PM-10 Emission Inventory

Source	Uncontrolled Emission Rate (lb/day)	Control Efficiency (%)	Controlled Emission Rate (lb/day)
Quarry			
Bulldozer activity	7.6	65.0	2.7
Haul truck activity			
- Paved roads	9.8	50.0	4.9
- Unpaved roads	151	98.3	2.6
Worker and visitor activity			
- Paved roads	1.3	50.0	0.65
- Unpaved parking lot	1.4	95.3	0.066
Supply truck activity	0.2	50.0	0.1
Wind erosion, quarry area	13[a]	0	13
Wind erosion, support area	35[b]	0	35
Grading	31.8	85.0	4.8
Haul Road			
Haul truck activity	2,400	95.3	113
Grading	10.6	50.0	5.3
TSA			
Wind erosion, bulk waste piles	0	0	0
Worker and visitor activity			
- Paved roads	13.5	0	13.5
- Unpaved roads	39.8	95.3	1.9
Supply truck activity			
- Paved roads	1.9	0	1.9
- Unpaved roads	33.6	95.3	1.6
Bulldozer activity	25.2	60.0	10.1
Front-end loader activity	52.6	95.3	2.5

[a]Assumed that only the northeastern corner of the quarry has disturbed surfaces susceptible to wind erosion on the worst-case day.

[b]A 30% reduction in erodible area due to surface shielding by temporary buildings was incorporated in the uncontrolled emission rate calculation.

Due to the order in which the modeling was performed (i.e., long-term modeling first), some of the control strategies were more restrictive for the short-term modeling effort. Because the long-term predictions were less than the standard, it was not necessary to rerun the predictive long-term model with the more conservative (restrictive) controls used in the short-term model. Also, certain restrictive emission inventory assumptions mentioned in the footnotes of Table B.2 were not altered because they would only reduce the predicted impact even further.

A linear relationship seldom exists between emission rate and concentration impact in a multisource predictive effort. This is due to the effects of many other variables -- such as extent and configuration of the sources, relative source-receptor distances, and wind speed associated with certain sources (e.g., wind erosion). As an example of the impact of source configuration, the haul road to the TSA would generate most of the PM-10 emissions, but these emissions would be distributed over a 5.4-km (3.4-mi) length of road, which substantially lessens the impact. Consequently, the magnitude of the controlled emission rates given in Tables B.2 and B.3 should not be used to identify the sources producing the most significant impacts.

B.4 REFERENCES (Appendix B)

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APPENDIX C:

POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS TO THE PROPOSED BULK WASTE REMEDIAL ACTION

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POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS TO THE PROPOSED BULK WASTE REMEDIAL ACTION

Potential requirements for a proposed action can be grouped into two general categories: (1) applicable or relevant and appropriate requirements (ARARs) and (2) "to-be-considered" (TBC) requirements. The first category consists of promulgated standards (e.g., public laws codified at the state or federal level) that may be applicable or relevant and appropriate to all or part of the proposed action. The second category consists of standards or guidelines that have been published but not promulgated and that may have specific bearing on all or part of the action, e.g., U.S. Department of Energy (DOE) Orders.

Any regulation, standard, requirement, criterion, or limitation under any federal or state environmental law may be either *applicable* or *relevant and appropriate* to a remedial action, but not both. Consistent with guidance from the U.S. Environmental Protection Agency (EPA) on ARARs, only applicable requirements are evaluated for off-site actions, whereas both applicable and relevant and appropriate requirements are evaluated for on-site actions. On-site actions must comply with a requirement that is determined to be relevant and appropriate to the same extent as one that is determined to be applicable. However, a determination of relevance and appropriateness may be applied to only portions of a requirement, whereas a determination of applicability is applied to the requirement as a whole. On-site actions must comply with substantive requirements of ARARs but not related administrative and procedural requirements. For example, remedial actions conducted on-site would not require a permit but would be conducted in a manner consistent with the permitted conditions. Only those state laws may become ARARs that are (1) promulgated, such that they are legally enforceable and generally applicable (i.e., consistently applied) and (2) more stringent than federal laws.

In addressing a requirement that may affect the proposed action, a determination is made regarding its relationship to (1) the location of the action, (2) the contaminants involved, and (3) the specific components of the action. A potential ARAR is applicable if its prerequisites or regulated conditions are specifically met by the conditions of the proposed action (e.g., location in a floodplain); if the conditions of a requirement are not specifically applicable, then a determination must be made as to whether they are sufficiently similar to be considered both relevant *and* appropriate (e.g., in terms of contaminant similarities and the nature and setting of the proposed action).

Potential TBC requirements are typically considered only if no promulgated requirements exist that are either applicable or relevant and appropriate. Thus, TBC requirements may be considered secondary to ARARs; in fact, they are often based on promulgated standards and can necessitate the same degree of compliance as ARARs (e.g., DOE Orders). Potential location-specific, contaminant-specific, and action-specific ARARs and TBC requirements for the proposed bulk waste remedial action are identified and evaluated in Tables C.1, C.2, and C.3, respectively.

The preliminary ARAR and TBC determinations for these requirements are also indicated on the tables. Because this appendix presents a comprehensive list of requirements with considerable overlap of regulated conditions, all determinations have been identified as "potentially" applicable, relevant and appropriate, or to be considered. These determinations will be finalized in consultation with the state of Missouri and EPA Region VII prior to implementation of the proposed action. During finalization, the requirements identified as potentially applicable will be reviewed to confirm direct applicability; only one requirement will be finalized from among those that regulate the same conditions. For those identified as potentially relevant and appropriate and TBC requirements, the specific portion(s) of the requirements that have bearing on the proposed action, and the manner in which compliance would be achieved, will be finalized. After the finalization process, certain of the requirements will remain potentially an ARAR or a TBC requirement as the action proceeds, pending identification of the existence of their prerequisites or regulated conditions (e.g., the presence of cultural resources or threatened or endangered species in the affected area).

TABLE C.1 Potential Location-Specific Requirements

Potential ARAR	Location	Requirement	Preliminary Determination	Remarks
Antiquity Act; Historic Sites Act (16 USC 431-433; 16 USC 461-467; 40 CFR 6.301(a))	Land	Cultural resources, such as historic buildings and sites and natural landmarks, must be preserved on federal land to avoid adverse impacts.	Potentially applicable	No adverse impacts to such resources are expected to result from the proposed action; however, if these resources were affected, the requirement would be applicable.
National Historic Preservation Act, as amended (16 USC 470 et seq.; 40 CFR 6.301(b); 36 CFR 800)	Land	The effect of any federally assisted undertaking must be taken into account for any district, site, building, structure, or object included in or eligible for the *National Register of Historic Places*.	Potentially applicable	No adverse impacts to such properties are expected to result from the proposed action; however, if these resources were affected, the requirement would be applicable.
Archeological and Historic Preservation Act (16 USC 469; 40 CFR 6.301(c); PL 93-291; 88 Stat. 174)	Land	Prehistorical, historical, and archeological data that might be destroyed as a result of a federal, federally assisted, or federally licensed activity or program must be preserved.	Potentially applicable	No destruction of such data is expected to result from the proposed action. The quarry was excavated for limestone and now contains only fill and waste material; the temporary storage area (TSA) would be in an area that has been considerably disturbed by past human activities; the haul road connecting the quarry and the TSA would follow an existing railroad easement and would parallel a state highway, both of which have been considerably disturbed by construction and use activities. Therefore, these areas are not expected to contain any such data; however, if these data were affected, the requirement would be applicable.
Archeological Resources Protection Act (16 USC 470(a))	Land	A permit must be obtained if an action on public or Indian lands could impact archeological resources.	Potentially applicable	No impacts to archeological resources are expected to result from the proposed action. The quarry was excavated for limestone and now contains only fill and waste material; the TSA would be in an area that has been considerably disturbed by past human activities; the haul road would follow an existing railroad easement and would parallel a state highway, both of which have been considerably disturbed by construction and use activities. Therefore, these areas are not expected to contain any such resources; however, if these resources were affected, the requirement would be applicable.
Protection and Enhancement of the Cultural Environment (Executive Order 11593; 40 CFR 6.301)	Land	Historic, architectural, archeological, and cultural resources must be preserved, restored, and maintained, and must be evaluated for inclusion in the *National Register*.	Potentially applicable	No impacts to such resources are expected to result from the proposed action. The quarry was excavated for limestone and now contains only fill and waste material; the TSA would be in an area that has been considerably disturbed by past human activities; the haul road would follow an existing railroad easement and would parallel a state highway, both of which have been considerably disturbed by construction and use activities. Therefore, these areas are not expected to contain any such resources; however, if these resources were affected, the requirement would be applicable.

TABLE C.1 (Cont'd)

Potential ARAR	Location	Requirement	Preliminary Determination	Remarks
Endangered Species Act, as amended (16 USC 1531-1543; 50 CFR 17.402; 40 CFR 6.302(h))	Any	Federal agencies must ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify any critical habitat.	Potentially applicable	No critical habitat exists in the affected area, and no adverse impacts to threatened or endangered species are expected to result from the proposed action; however, if such species were affected, the requirement would be applicable.
Missouri Wildlife Code (1989) (RSMo. 252.240; 3 CSR 10-4.111), Endangered Species	Any	Endangered species, i.e., those designated by the Missouri Department of Conservation and the U.S. Department of the Interior as threatened or endangered (see 1978 Code, RSMo. 252.240) may not be pursued, taken, possessed, or killed.	Potentially applicable	No critical habitat exists in the affected area, and no adverse impacts to threatened or endangered species are expected to result from the proposed action. However, if such species were affected, the requirement would be applicable.
Missouri Wildlife Code (1989) (RSMo. 252.240; 3 CSR 10-4.110), General Prohibition; Applications	Any	Wildlife, including their homes and eggs, may not be taken or molested.	Potentially relevant and appropriate	No wildlife would be actively taken or molested as part of the proposed action. However, wildlife are likely to be disturbed during implementation. Mitigative measures would be taken to minimize potential adverse impacts.
Missouri Wildlife Code (1989) (RSMo. 252.240; 3 CSR 10-4.115), Special Management Areas	Any	Wildlife may not be taken, pursued, or molested on any state or federal wildlife refuge or any wildlife management area, except under permitted conditions.	Potentially relevant and appropriate	No wildlife would be actively taken, pursued, or molested in any wildlife areas as part of the proposed action. However, wildlife are likely to be disturbed during implementation. Mitigative measures would be taken to minimize potential adverse impacts.
Missouri Wildlife Code (1978) (RSMo. 252.040), Taking of Wildlife -- Rules and Regulations	Any	Wildlife may not be taken or pursued, except under permitted conditions.	Potentially relevant and appropriate	No wildlife would be actively taken or pursued as part of the proposed action. However, wildlife are likely to be disturbed during implementation. Mitigative measures would be taken to minimize potential adverse impacts.
Missouri Wildlife Code (1978) (RSMo. 252.240), Endangered species importation, transportation or sale, when prohibited -- how designated -- penalty	Any	The Missouri Department of Conservation must file with the state a list of animal species designated as endangered (for subsequent consideration of related requirements).	Potentially applicable	No critical habitat exists in the affected area, and no adverse impacts to threatened or endangered species are expected to result from the proposed action. However, if such species were affected, the requirement would be applicable.
Floodplain Management (Executive Order 11988; 40 CFR 6.302(b))	Flood-plain	Federal agencies must avoid, to the maximum extent possible, any adverse impacts associated with direct and indirect development of a floodplain.	Not an ARAR	No floodplain exists in the affected area.
Governor's Executive Order 82-19	Flood-plain	Potential effects of actions taken in a floodplain must be evaluated to avoid adverse impacts.	Not an ARAR	No floodplain exists in the affected area.
Protection of Wetlands (Executive Order 11990; 40 CFR 6.302(a))	Wetland	Federal agencies must avoid, to the extent possible, any adverse impacts associated with the destruction or loss of wetlands and the support of new construction in wetlands if a practicable alternative exists.	Not an ARAR	No wetland exists in the affected area.

TABLE C.2 Potential Contaminant-Specific Requirements

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040), Maximum Permissible Exposure Limits	Radiation	Air	For persons outside a controlled area, the maximum permissible whole-body dose due to sources in or migrating from the controlled area is limited to 2 mrem in any 1 hour, 0.1 rem in any 7 consecutive days, and 0.5 rem in any year. (Note: a controlled area is an area that requires control of access, occupancy, and working conditions for radiation protection purposes; 0.5 rem = 500 mrem.)	Potentially applicable	These requirements may be applicable to protection of the public during implementation of the proposed action.
Radiation Protection of the Public and the Environment (DOE Order 5400.xx)	Radiation	Air	The basic dose limit for nonoccupationally exposed individuals is 100 mrem/yr above background, committed effective dose equivalent. Further, all radiation exposures must be reduced to levels as low as is reasonably achievable.	To be considered	Although not promulgated standards, these requirements are derived from such standards and they constitute requirements for protection of the public with which the proposed action will comply.
National Emission Standards for Hazardous Air Pollutants (40 CFR 61), Subpart H, National Emission Standard for Radionuclide Emissions from Department of Energy (DOE) Facilities	Radionuclides other than radon-220 and radon-222 and their decay products	Air	The annual dose equivalent to any member of the public must not exceed 25 mrem to the whole body or 75 mrem to any critical organ from exposure to air emissions of radionuclides other than radon-220, radon-222, and their decay products. As an alternative emission standard, no member of the public being exposed to emissions from the facility is to receive a continuous exposure >100 mrem/yr effective dose equivalent or a noncontinuous exposure >500 mrem/yr effective dose equivalent from all sources excluding natural background and medical procedures.	Potentially applicable	These requirements may be applicable to protection of the public during implementation of the proposed action because the Weldon Spring site is a DOE facility. The EPA has recently issued revisions to its rules for control of radionuclide emissions from DOE facilities (EPA 1989); these revisions will be considered in planning the proposed action.
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192)	Radon	Air	Releases of radon from tailings disposal piles must not exceed an average rate of 20 pCi/m^2-s or increase the annual average concentration in air outside the disposal site by more than 0.5 pCi/L.	Not an ARAR	The Weldon Spring site is not a mill tailings site, so these requirements are not applicable; neither are they relevant and appropriate because disposal is beyond the scope of the proposed action. However, these requirements will be addressed as part of the follow-on remedial actions planned for the site.
	Radon decay products	Air	The annual average (or equivalent) radon decay product concentration, including background, in any habitable building must not exceed 0.02 working level (WL) or a maximum of 0.03 WL -- where a WL is any combination of short-lived radon decay products in 1 liter of air, without regard to the degree of equilibrium, that will result in the emission of 1.3×10^5 MeV of alpha energy. (For radon-222 in equilibrium with its decay products, 1 WL = 100 pCi/L.)	Not an ARAR	The Weldon Spring site is not a mill tailings site, so these requirements are not applicable; neither are they relevant and appropriate because no habitable buildings are involved in the proposed action.
	External gamma radiation	Air	The level of external gamma radiation in any occupied or habitable building must not exceed the background level by more than 20 μR/h.	Not an ARAR	The Weldon Spring site is not a mill tailings site, so these requirements are not applicable; neither are they relevant and appropriate because no habitable buildings are involved in the proposed action.

TABLE C.2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192) (Continued)	Radium and thorium	Soil	Average concentrations of residual radioactive material in soil over an area of 100 m^2 may not exceed background by more than 5 pCi/g in the top 15 cm of soil or 15 pCi/g in each 15-cm layer below the top layer.	Not an ARAR	The Weldon Spring site is not a mill tailings site, so these requirements are not applicable; neither are they relevant and appropriate because the identification and management of residual materials in the quarry is beyond the scope of the proposed action. However, these requirements will be addressed as part of the follow-on remedial actions planned for the quarry.
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040), Maximum Permissible Exposure Limits	Uranium, thorium, radium, and radon	Air	The concentrations of radionuclides in air outside a controlled area (above natural background), averaged over any calendar quarter, should not exceed the following limits:	Potentially applicable	These requirements may be applicable to protection of the public during implementation of the proposed action.

Isotope	Solubility Class	Concentration (µCi/mL)
$U_{natural}$	Soluble	3×10^{-12}
	Insoluble	2×10^{-12}
Uranium-238	Soluble	3×10^{-12}
	Insoluble	5×10^{-12}
Uranium-235	Soluble	2×10^{-11}
	Insoluble	4×10^{-12}
Uranium-234	Soluble	2×10^{-11}
	Insoluble	4×10^{-12}
Thorium-232	Soluble	7×10^{-14}
	Insoluble	4×10^{-13}
Thorium-230	Soluble	8×10^{-14}
	Insoluble	3×10^{-13}
Radium-228	Soluble	2×10^{-12}
	Insoluble	1×10^{-12}
Radium-226	Soluble	1×10^{-12}
	Insoluble	6×10^{-9}
Radon-222		1×10^{-9}
Radon-220		1×10^{-8}

TABLE C.2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Radiation Protection of the Public and the Environment (DOE Order 5400.xx)	Uranium, thorium, and radium	Air	Residual concentrations of radionuclides in air in uncontrolled areas are limited to the following. (For known mixtures of radionuclides, the sum of the ratios of the observed concentration of each radionuclide to its corresponding limit must not exceed 1.0.)	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the proposed action will comply.

Isotope	Derived Concentration Guide[a] (μCi/mL) D	W	Y
Uranium-238	5×10^{-12}	2×10^{-12}	1×10^{-13}
Uranium-235	5×10^{-12}	2×10^{-12}	1×10^{-13}
Uranium-234	4×10^{-12}	2×10^{-12}	9×10^{-14}
Thorium-232	-[b]	7×10^{-15}	1×10^{-14}
Thorium-230	-	4×10^{-14}	5×10^{-14}
Radium-228	-	3×10^{-12}	-
Radium-226	-	1×10^{-12}	-

[a] D, W, and Y represent lung retention classes; removal half-times assigned to the compounds with classes D, W, and Y are 0.5, 50, and 500 days, respectively. Exposure conditions assume an inhalation rate of 8,400 m^3 air per year (based on an exposure over 24 hours per day, 365 days per year).

[b] A hyphen means no limit has been established.

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
	Radon-222	Air	The above-background concentration of radon-222 in air above an interim storage facility must not exceed 100 pCi/L at any point, an annual average of 30 pCi/L over the facility, or an annual average of 3 pCi/L at or above any location outside the site. (See also the discussion for DOE Order 5820.2A in Table C.3.)	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the proposed action will comply.
	Radon-220 and radon-222	Air	The immersion derived concentration guide for both radon-220 and radon-222 in air in an uncontrolled area is 3 pCi/L.	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the proposed action will comply.

TABLE C.2 (Cont'd)

<table>
<tr><th>Potential ARAR</th><th>Contaminant</th><th>Medium</th><th>Requirement</th><th>Determination</th><th>Remarks</th></tr>
<tr><td>Occupational Safety and Health Administration Standards; Occupational Health and Environmental Control (29 CFR 1910; 1910.96), Subpart G, Ionizing Radiation</td><td>Radiation</td><td>Any</td><td>The dose per calendar quarter resulting from exposure to radiation in a restricted area from sources in that area is limited to the following:
<table>
<tr><th>Part of Body</th><th>Dose (rem)</th></tr>
<tr><td>Whole body: head and trunk, active blood-forming organs, lens of eye, and gonads</td><td>1 1/4</td></tr>
<tr><td>Hands and forearms, feet and ankles</td><td>18 3/4</td></tr>
<tr><td>Skin (of whole body)</td><td>7 1/2</td></tr>
</table>
The occupational exposure of an individual younger than 18 is restricted to 10% of these limits; the whole-body dose to a worker may not exceed 3 rem in a calendar quarter, and when added to the cumulative occupational dose may not exceed 5(N-18) rem, where N is the age of the exposed individual.</td><td>Potentially applicable</td><td>These requirements may be applicable to worker protection during implementation of the proposed action.</td></tr>
<tr><td>Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040), Maximum Permissible Exposure Limits</td><td>Radiation</td><td>Any</td><td>Limits for occupational doses from ionizing radiation in a controlled area are as follows:
<table>
<tr><th>Part of Body</th><th>Maximum Dose in Any Calendar Year (rem)</th><th>Maximum Dose in Any Calendar Quarter (rem)</th></tr>
<tr><td>Whole body, head and trunk, major portion of the bone marrow, gonads or lens of eye</td><td>5</td><td>3</td></tr>
<tr><td>Skin of large body area</td><td>30</td><td>10</td></tr>
<tr><td>Hands and forearms, feet and ankles</td><td>75</td><td>25</td></tr>
</table>
In addition, the whole-body dose added to the cumulative occupational dose must not exceed 5(N-18) rem, where N is the age of the exposed individual.</td><td>Potentially applicable</td><td>These requirements may be applicable to worker protection during implementation of the proposed action.</td></tr>
</table>

TABLE C.2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.050), Personnel Monitoring and Radiation Surveys	Radiation	Any	Personnel monitoring and radiation surveys are required for each worker for whom there is any reasonable possibility of receiving a weekly dose from all radiation exceeding 50 mrem, taking into consideration the use of protective gloves and radiation-limiting devices. An exemption from routine monitoring may be granted under certain conditions.	Potentially applicable	These requirements may be applicable to worker protection during implementation of the proposed action.
Radiation Protection for Occupational Workers (DOE Order 5480.11)	Radiation	Any	The effective dose equivalent received by any member of the public entering a controlled area is limited to 100 mrem/yr. Limiting values for the assessed dose from exposure of workers to radiation are as follows. (These values represent maximum limits; it is DOE policy to maintain radiation exposures as far below these limits as is reasonably achievable.)	To be considered	Although not promulgated standards, these constitute requirements for protection from radionuclide emissions in a controlled area with which the proposed action will comply.

Radiation Effect	Annual Dose Equivalent (rem)
Stochastic effects	5[a]
Nonstochastic effects	
Lens of eye	15
Organ, extremity, or tissue including skin of whole body	50
Unborn child Entire gestation period	0.5

[a]Annual effective dose equivalent.

TABLE C.2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Occupational Safety and Health Administration Standards; Occupational Health and Environmental Control (29 CFR 1910; 1910.96), Subpart G, Ionizing Radiation	Uranium, thorium, radium, and radon	Air	Within a restricted area, airborne radioactive material (averaged over a 40-hour work week of seven consecutive days) should not exceed the following limits. (For hours of exposure less than or greater than 40, the limits are proportionately increased or decreased, respectively.)	Potentially applicable	These requirements may be applicable to worker protection during implementation of the proposed action.

Isotope	Solubility Class	Concentration (μCi/mL)
$U_{natural}$	Soluble	5×10^{-12}
	Insoluble	5×10^{-12}
Uranium-238	Soluble	3×10^{-12}
	Insoluble	5×10^{-12}
Uranium-235	Soluble	2×10^{-11}
	Insoluble	4×10^{-12}
Uranium-234	Soluble	2×10^{-11}
	Insoluble	4×10^{-12}
Thorium-232	Soluble	1×10^{-12}
	Insoluble	1×10^{-12}
Thorium-230	Soluble	8×10^{-14}
	Insoluble	3×10^{-13}
Radium-228	Soluble	2×10^{-12}
	Insoluble	1×10^{-12}
Radium-226	Soluble	3×10^{-12}
	Insoluble	2×10^{-12}
Radon-222[a]		3×10^{-9}
Radon-220		1×10^{-8}

[a]Limit is appropriate for radon-222 combined with its short-lived decay products and may be replaced by 1/30 WL; the limit in restricted areas may be based on an annual average.

For mixtures of radionuclides, the sum of the ratios of the quantity present to the specific limit must not exceed 1. For uranium, chemical toxicity may be the limiting factor for soluble mixtures of uranium-238, uranium-235, and uranium-234 in air; if the percent by weight of uranium-235 is less than 5, the concentration limit for uranium is 0.007 mg/m^3 inhaled air.

TABLE C.2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040), Maximum Permissible Exposure Limits	Uranium, thorium, radium, and radon	Air	Concentrations of radionuclides in air, averaged over any calendar quarter, should not exceed the following limits. (Limits apply to exposure in a controlled area and are based on a work week of 40 hours; for longer work weeks, the values must be adjusted downward.)	Potentially applicable	These requirements may be applicable to worker protection during implementation of the proposed action.

Isotope	Solubility Class	Concentration (μCi/mL)
$U_{natural}$	Soluble	7×10^{-11}
	Insoluble	6×10^{-11}
Uranium-238	Soluble	7×10^{-11}
	Insoluble	1×10^{-10}
Uranium-235	Soluble	5×10^{-10}
	Insoluble	1×10^{-10}
Uranium-234	Soluble	6×10^{-10}
	Insoluble	1×10^{-10}
Thorium-232	Soluble	2×10^{-12}
	Insoluble	1×10^{-11}
Thorium-230	Soluble	2×10^{-12}
	Insoluble	1×10^{-11}
Radium-228	Soluble	7×10^{-11}
	Insoluble	4×10^{-11}
Radium-226	Soluble	3×10^{-11}
	Insoluble	2×10^{-7}
Radon-222		3×10^{-8}
Radon-220		3×10^{-7}

TABLE C.2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Radiation Protection for Occupational Workers (DOE Order 5480.11)	Uranium, thorium, radium, and radon	Air	Occupational exposure limits for specific radionuclides in air are as follows. (Values for radon isotopes assume 100% equilibrium with the short-lived decay products; these values may be replaced by 1 WL for radon-220 and 1/3 WL for radon-222.)	To be considered	Although not promulgated standards, these constitute requirements for worker protection with which the proposed action will comply.

	Derived Air Concentrations[a] (µCi/mL)		
Isotope	D	W	Y
Uranium-238	6×10^{-10}	3×10^{-10}	2×10^{-11}
Uranium-235	6×10^{-10}	3×10^{-10}	2×10^{-11}
Uranium-234	5×10^{-10}	3×10^{-10}	2×10^{-11}
Thorium-232	-[b]	5×10^{-13}	1×10^{-12}
Thorium-230	-	3×10^{-12}	7×10^{-12}
Radium-228	-	5×10^{-10}	-
Radium-226	-	3×10^{-10}	-
Radon-222	3×10^{-8}	-	-
Radon-220	8×10^{-9}	-	-

[a] D, W, and Y represent lung retention classes; removal half-times assigned to the compounds with classes D, W, and Y are 0.5, 50, and 500 days, respectively. Exposure conditions assume an inhalation rate of 2,400 m^3 air per year (based on an exposure over 40 hours per week, 50 weeks per year).

[b] A hyphen means no limit has been established.

TABLE C.2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Occupational Safety and Health Administration Standards (29 CFR 1910; 1910.1000), Subpart Z, Toxic and Hazardous Substances	Specific organic and inorganic substances	Air	Permissible occupational exposure limits for various airborne substances have recently been revised to the following final rule limits; they may be achieved by any reasonable combination of engineering controls, work practices, and personal protective equipment.	Potentially applicable	These requirements may be applicable to worker protection during implementation of the proposed action.

Substance	Limit[a] (mg/m^3)	Condition
2,4,6-TNT	0.5	Skin notation for potential contribution to overall exposure by cutaneous route (airborne or direct contact).
2,4-DNT and 2,6-DNT	1.5	As for 2,4,6-TNT.
Polynuclear aromatic hydrocarbons	0.2	Limit applies to the benzene-soluble fraction of volatiles from coal tar pitch.
Aroclor 1254 (PCB)	0.5	As for 2,4,6-TNT.
Arsenic	0.01	For inorganic compounds, as arsenic.
Lead	0.05	For metallic lead and inorganic compounds, as lead.
Nickel	0.1	For soluble compounds, as nickel; limit for metallic nickel and insoluble compounds, as nickel, is 1 mg/m^3.
Selenium	0.2	As selenium.
Uranium	0.05	For soluble compounds, as uranium; limit for insoluble compounds, as uranium, is 0.2 mg/m^3 with a short-term (15-minute) exposure limit of 0.6 mg/m^3.
Particulates:		
Total dust	15	For particulates not otherwise regulated (i.e., nuisance dust).
Respirable fraction	5	

[a]Permissible exposure limit expressed as the 8-hour time-weighted average.

TABLE C.2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Clean Air Act, as amended (42 USC 7401-7642); National Primary and Secondary Ambient Air Quality Standards (40 CFR 50)	Particulate matter	Air	For a major stationary source (see 40 CFR 52.2(b)(1)(i)(a)) that emits >250 tons/year of any regulated pollutant or >100 tons/year of a regulated pollutant for which the area is designated as non-attainment, particulate matter less than 10 μm in diameter (PM-10) should not exceed a 24-hour average concentration of 150 $\mu g/m^3$ or an annual arithmetic mean of 50 $\mu g/m^3$.	Potentially relevant and appropriate	Although not directly applicable, these requirements may be relevant and appropriate to the control of particulate emissions that could result from implementation of the proposed action.
	Lead	Air	As for the above conditions, the standard for lead and its compounds, as elemental lead, is 1.5 $\mu g/m^3$ maximum arithmetic mean averaged over one calendar quarter.	Potentially relevant and appropriate	Although not directly applicable, these requirements may be relevant and appropriate to the control of lead emissions that could result from implementation of the proposed action.
Missouri Air Conservation Law; Public Health and Welfare (RSMo. Title 12, 203.055), Commission may adopt rules for compliance with federal law -- suspension, reinstatement	Any regulated under federal Clean Air Act	Air	Standards and guidelines promulgated to ensure that Missouri is in compliance with the Clean Air Act are not to be any stricter than those required under that act (see related discussion of 40 CFR 50).	Potentially relevant and appropriate	Although not directly applicable, these requirements may be relevant and appropriate to the control of emissions that could result from implementation of the proposed action.
Missouri Air Quality Standards; Air Quality Standards, Definitions, Sampling and Reference Methods, and Air Pollution Control Regulations for the State of Missouri (10 CSR 10-6.010), Ambient Air Quality	Particulate matter (PM-10)	Air	Concentrations of PM-10 are limited to an annual arithmetic mean of 50 $\mu g/m^3$ and a 24-hour average of 150 $\mu g/m^3$. (These Missouri regulations cover the St. Louis metropolitan area, which includes the geographic areas of St. Charles County.)	Potentially relevant and appropriate	Although not directly applicable, these requirements may be relevant and appropriate to the control of particulate emissions that could result from implementation of the proposed action.
	Lead	Air	The standard for lead is 1.5 $\mu g/m^3$ as an arithmetic mean averaged over one calendar quarter.	Potentially relevant and appropriate	Although not directly applicable, these requirements may be relevant and appropriate to the control of lead emissions that could result from implementation of the proposed action.
Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.050), Restriction of Emission of Particulate Matter from Industrial Processes	Particulate matter	Air	Particulate matter from any industrial source may not exceed a concentration of 0.30 grain/ft^3 of exhaust gas; certain activities are exempted (e.g., grinding, crushing, and classifying operations at a rock quarry).	Potentially relevant and appropriate	Although not applicable because no industrial processes are involved in the proposed action, these requirements may be considered relevant and appropriate as they relate to the control of particulate emissions that could be generated during implementation.

TABLE C.2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.090), Restriction of Emission of Visible Air Contaminants	Particulate matter	Air	Emissions of particulate matter (<25 lb/h) from any single source, not including uncombined water, may not be darker than the shade or density designated as No. 2 on the Ringelmann Chart, or 40% opacity.	Potentially relevant and appropriate	Although not directly applicable, these requirements may be relevant and appropriate to the control of particulate emissions that could result from implementation of the proposed action.
Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.100), Preventing Particulate Matter from Becoming Airborne	Particulate matter	Air	No person may permit the handling, transport, or storage of any material in a way that allows unnecessary amounts of fugitive particulate matter to become airborne and that results in at least one complaint being filed. To prevent particulate matter from becoming airborne during construction, use, repair, or demolition of a road, driveway, or open area, the following measures may be required: paving or frequent cleaning of roads, applying dust-free surfaces or water, and planting and maintaining a vegetative ground cover. (Unpaved public roads in unincorporated areas that are in compliance with particulate matter standards are excluded.)	Potentially relevant and appropriate	Although not directly applicable, these requirements may be relevant and appropriate to the control of particulate emissions that could result from implementation of the proposed action (e.g., during haul road construction and use).
Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.180), Emission of Visible Air Contaminants from Internal Combustion Engines	Particulate matter	Air	Visible air contaminants (other than uncombined water) may not be released from an internal combustion engine for more than 10 seconds at any one time.	Potentially applicable	These requirements may be applicable to particulates released from any internal combustion engines used during the proposed action.
National Emission Standards for Hazardous Air Pollutants (40 CFR 61), Subpart M, National Emission Standard for Asbestos	Asbestos	Air	Warning signs must be posted, and discharge of visible emissions must not occur during the collection, processing, packaging, transporting, or deposition of any asbestos-containing material.	Potentially applicable	If the proposed action results in asbestos emissions (which might occur due to the presence of demolition debris at the TSA and in the quarry), this requirement may be applicable to protection of the public during implementation.
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-469 et seq.); Asbestos (40 CFR 763), Subpart G, Asbestos Abatement Projects	Asbestos	Air	Programs for worker training and protection (via clothing and equipment) must be implemented, and the permissible exposure limit for asbestos is 0.2 fiber/cm^3 of air as an 8-hour time-weighted average.	Potentially applicable	If the proposed action results in asbestos emissions (which might occur due to the presence of demolition debris at the TSA and in the quarry), this requirement may be applicable to worker protection during implementation.

TABLE C.2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Occupational Safety and Health Administration Standards; Occupational Health and Environmental Control (29 CFR 1910; 1910.1001), Subpart G, Asbestos, Tremolite, Anthophyllite, and Actinolite	Asbestos	Air	Various asbestos-management activities are required for worker protection, including monitoring, timely response to releases, and the use of high-efficiency-particulate-air (HEPA)-filtered equipment for vacuuming. The permissible occupational exposure limit for asbestos as an 8-hour time-weighted average is 0.2 fiber/cm^3 of air.	Potentially applicable	If the proposed action results in asbestos emissions (which might occur due to the presence of demolition debris at the TSA and in the quarry), this requirement may be applicable to worker protection during implementation.
Occupational Safety and Health Administration Construction Industry Standards (29 CFR 1926)	Asbestos	Air	Worker health and safety standards include a limit for occupational exposure to asbestos of 0.2 fiber/cm^3 of air as an 8-hour time-weighted average, with an action level of 0.1 fiber/cm^3 and a short-term (30-minute) limit of 1 fiber/cm^3 of air (fibers >5 μm).	Potentially applicable	If the proposed action results in asbestos emissions (which might occur due to the presence of demolition debris at the TSA and in the quarry), this requirement may be applicable to worker protection during implementation.
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-469 et seq.); Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761), Subpart A, General	PCBs	Air	The release of inadvertently generated PCBs at the vent point for emissions must be <10 ppm.	Potentially relevant and appropriate	This requirement is not applicable because no PCBs would be generated and vented from manufacturing/processing activities as part of the proposed action; however, portions of this requirement may be relevant and appropriate because PCB emissions could occur during implementation.
	PCBs	Waste	Inspection and testing are required for materials contaminated with PCBs.	Potentially applicable	This requirement may be applicable to characterization of the bulk wastes for PCBs, which would be conducted following removal of the wastes from the quarry.
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-469 et seq.); Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761), Subpart G, PCB Spill Cleanup Policy	PCBs	Soil	For spills of materials contaminated with >50 ppm PCBs, soil within the spill area must be excavated and backfilled with soil containing <1 ppm PCBs. Contaminated soil may be decontaminated to 10 ppm by weight by excavating a minimum of 10 inches and backfilling with soil containing <1 ppm PCBs.	Potentially applicable	No PCB spills of this concentration are expected to occur; however, if any such spills did occur (e.g., during transport), this requirement would be applicable. The identification and management of residual materials in the quarry is beyond the scope of the proposed action; however, these requirements will be addressed as part of the follow-on remedial actions planned for the quarry.
Occupational Safety and Health Administration Standards; Occupational Health and Environmental Control (29 CFR 1910; 1910.95), Subpart G, Occupational Noise Exposure	Noise	Air	The permissible occupational exposure level for noise is 90 dBA (slow response) for an 8-hour day; with decreasing times of exposure, the levels increase to 115 dBA per 1/4-hour day.	Potentially applicable	These requirements may be applicable to worker protection during implementation of the proposed action.

TABLE C.3 Potential Action-Specific Requirements

Potential ARAR	Action	Requirement	Preliminary Determination	Remarks
Hazardous Materials Transportation Act, as amended (49 USC 1801-1812); Solid Wastes (40 CFR 263), Standards Applicable to Transporters of Hazardous Waste	Transportation	Generic requirements are established for minimizing the environmental impacts of spills or releases of hazardous materials, as are procedures for transporting hazardous wastes; on-site activities are exempt from transportation requirements.	Not an ARAR	These requirements are neither applicable nor relevant and appropriate to the proposed action because the action does not involve transporting hazardous wastes along public roads. The haul road connecting the quarry and the TSA would be constructed along an easement; the highway separating the two areas of the Weldon Spring site would be crossed rather than used as the transportation route; and transport of the bulk wastes from the quarry to the TSA would essentially constitute an on-site action. However, certain substantive components, e.g., spill response requirements, would be addressed during implementation.
Hazardous Materials Regulations; Shippers -- General Requirements for Shipments and Packagings (49 CFR 173), Subpart I, Radioactive Materials	Transportation	Low-specific-activity radioactive materials must be packaged in strong, tight containers so that there will be no leakage of radioactivity under conditions normally incident to transportation, and the vehicles must be placarded. In exclusive-use vehicles, external radiation levels on packages must be <200 mrem/h, or <1,000 mrem/h if secured in a closed transport vehicle with no intermediate loading or unloading; external radiation levels on the outer surface of the vehicle are limited to <200 mrem/h at any point and <10 mrem/h at 2 m from the surface of the vehicle; and levels in any normally occupied space are limited to <2 mrem/h.	Potentially applicable	These requirements may be applicable to the transportation of bulk wastes from the quarry to the TSA because the average concentration of radionuclides in the bulk wastes is expected to meet the criteria for classification as low-specific-activity material.
Missouri Rules Applicable to Transporters of Hazardous Waste (10 CSR 25-6.263), Standards for Transporters of Hazardous Waste	Transportation	Equipment used to transport hazardous waste must meet state and federal standards and must be compatible with the waste and adequate to protect human health and prevent environmental damage. Motor vehicle operators must be licensed by the Department of Natural Resources.	Not an ARAR	These requirements are neither applicable nor relevant and appropriate to the proposed action because the action does not involve transporting hazardous wastes along public roads. The haul road connecting the quarry and the TSA would be constructed along an easement; the highway separating the two areas of the Weldon Spring site would be crossed rather than used as the transportation route; and transport of the bulk wastes from the quarry to the TSA would essentially constitute an on-site action. However, the substantive requirements for equipment and licensing would be addressed during implementation.
Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.310), Liquefied Cutback Asphalt Restricted	Roadway construction	The use of liquefied cutback asphalt (asphalt cement that is liquefied by blending with petroleum solvents as diluents) on roadways, driveways, or parking lots is not permitted during the months of May through September; this restriction applies to the asphalt used as a plant mix or road mix and does not apply to its use as pothole filler, for emergency repair, or as a primer coat or seal coat on absorbent surfaces.	Potentially applicable	These requirements may be applicable to construction of the haul road and other surfaces (e.g., parking lots) that would be paved as part of the proposed action.

TABLE C.3 (Cont'd)

Potential ARAR	Action	Requirement	Preliminary Determination	Remarks
Occupational Safety and Health Administration Standards for Hazardous Waste Operations and Emergency Response (29 CFR 1910)	Waste management	General worker protection requirements are established, as are requirements for worker training and the development of an emergency response plan and a safety and health program for employees. In addition, procedures are established for hazardous waste operations -- including decontamination and drum/container handling (e.g., for radioactive waste, asbestos, and PCBs).	Potentially applicable	Certain substantive components of these requirements may be applicable to worker protection during implementation of the proposed action. Emergency response plans and safety and health plans have been developed for the proposed action.
Radioactive Waste Management (DOE Order 5820.2A)	Waste management	External exposure to radioactive waste (including releases) should not result in an effective dose equivalent of >25 mrem/yr to any member of the public; releases to the atmosphere are to meet the requirements of 40 CFR 61 (see related discussion in Table C.2); and an environmental monitoring program must be implemented to address compliance with performance standards.	To be considered	Although not promulgated standards, these constitute requirements with which the proposed action will comply. An environmental monitoring program has been developed for implementation.
Radiation Protection of the Public and the Environment (DOE Order 5400.xx)	Interim waste storage and management	The control and stabilization features of a storage facility should be designed to ensure an effective life of 50 years, with a minimum life of at least 25 years, to the extent reasonably achievable; site access controls should be designed to ensure an effective life of at least 25 years, to the extent reasonable; and periodic monitoring, shielding, access restrictions, and safety measures must be implemented to control the migration of radioactive material, as appropriate.	To be considered	Although not promulgated standards, these constitute requirements with which the proposed action will comply.
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.080), Control of Radioactive Contamination	Waste management	All work must be carried out under conditions that minimize the potential spread of radioactive material that could result in the exposure of any person above any limit specified in 19 CSR 20-10.040 (see related discussion in Table C.2). Clothing and other personal contamination should be monitored and removed according to procedures established by a qualified expert; any material contaminated to the degree that a person could be exposed to radiation above any limit specified in 19 CSR 20-10.040 should be retained on-site until it can be decontaminated or disposed of according to procedures established by a qualified expert.	Potentially applicable	These requirements may be applicable to the management of radioactive wastes for the proposed action.
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-499, et seq.); Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761), Subpart D, Storage and Disposal	PCB storage	PCB articles or containers with PCB concentrations >50 ppm must be stored for disposal in a facility that meets the requirements of 40 CFR 761.65.	Potentially applicable	Articles or containers with PCB concentrations in excess of 50 ppm are not expected to be present in the bulk wastes, based on the disposal history and characterization results; however, if such substances were present, the requirement would be applicable.

TABLE C.3 (Cont'd)

Potential ARAR	Action	Requirement	Preliminary Determination	Remarks
Missouri Hazardous Substance Rules (10 CSR 24); Missouri Solid Waste Management Law (RSMo. 260.200 to 260.245) and Regulations (10 CSR 80); Missouri Hazardous Waste Management Law (RSMo. 260.350 to 260.552) and Regulations (10 CSR 25)	Waste treatment, storage, and disposal	Various requirements are identified for waste treatment, storage, and disposal facilities.	Not an ARAR	The requirements for treatment and disposal facilities are neither applicable nor relevant and appropriate because treatment and disposal are beyond the scope of the proposed action. However, these requirements will be addressed as part of the follow-on remedial actions planned for the site. The substantive storage requirements are being addressed for the TSA.
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.090), Disposal of Radioactive Wastes	Disposal	Various requirements are identified for radioactive waste disposal.	Not an ARAR	These requirements are neither applicable nor relevant and appropriate because disposal is beyond the scope of the proposed action. However, these requirements will be addressed as part of the follow-on remedial actions planned for the site.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264), Subpart B, General Facility Standards	Waste treatment, storage, or disposal	General requirements are established for facility location and inspection, waste compatibility determination, and worker training. Location requirements include (1) facilities must not be located within 61 m (200 ft) of a fault in which displacement has occurred in Holocene time (i.e., since the end of the Pleistocene) and (2) facilities located in a 100-year floodplain must be constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood.	Not an ARAR	The requirements for treatment and disposal facilities are neither applicable nor relevant and appropriate because treatment and disposal are beyond the scope of the proposed action. However, these requirements will be addressed as part of the follow-on remedial actions planned for the site. The storage facility for the proposed action would not be located in a 100-year floodplain, so these requirements are neither applicable nor relevant and appropriate. The substantive storage requirements are being addressed for the TSA.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264), Subpart C, Preparedness and Prevention; Subpart D, Contingency Plan and Emergency Procedures	Waste treatment, storage, or disposal	Facilities must be designed, constructed, maintained, and operated to minimize the possibility of a fire, explosion, or any unplanned sudden or nonsudden release of hazardous waste (or constituents) to air, water, or surface water that could threaten human health or the environment. A contingency plan must be in place and emergency procedures must be implemented to minimize releases of hazardous wastes from a facility.	Not an ARAR	The requirements for treatment and disposal facilities are neither applicable nor relevant and appropriate because treatment and disposal are beyond the scope of the proposed action. However, these requirements will be addressed as part of the follow-on remedial actions planned for the site. The substantive requirements for a contingency plan and emergency procedures and for storage are being addressed for the TSA.

TABLE C.3 (Cont'd)

Potential ARAR	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264), Subpart E, Manifest System, Recordkeeping, and Reporting; Subpart F, Releases from Solid Waste Management Units; Subpart G, Closure and Post-Closure; Subpart H, Financial Requirements; Subpart M, Land Treatment; Subpart N, Landfills; Subpart O, Incinerators; Subpart P, Thermal Treatment; Subpart X, Miscellaneous Units	Waste treatment, storage, or disposal	Various requirements (e.g., for facility design, operation, and closure, as appropriate) are established for treatment, storage, and disposal of hazardous wastes.	Not an ARAR	The requirements for treatment and disposal facilities are neither applicable nor relevant and appropriate because treatment and disposal are beyond the scope of the proposed action. However, these requirements will be addressed as part of the follow-on remedial actions planned for the site. The substantive storage requirements are being addressed for the TSA.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264), Subpart I, Use and Management of Containers; Subpart J, Tank Systems	Waste storage and treatment in containers and tanks	Containers and tank systems used to store or treat hazardous waste must be closed and in good condition and must have sufficient strength, secondary containment, overfill prevention, and corrosion protection.	Not an ARAR	These requirements are neither applicable nor relevant and appropriate because the proposed action does not involve the storage or treatment of hazardous waste in containers or tank systems.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264), Subpart K, Surface Impoundments; Subpart L, Waste Piles	Waste treatment, storage, or disposal	A surface impoundment or a pile for hazardous wastes must have a liner and leachate collection and removal system (or engineered alternatives), as well as runon and runoff control systems, and must be managed to control wind dispersal, as appropriate.	Not an ARAR	The requirements for treatment and disposal facilities are neither applicable nor relevant and appropriate because treatment and disposal are beyond the scope of the proposed action. However, these requirements will be addressed as part of the follow-on remedial actions planned for the site. The substantive requirements for surface impoundments and waste piles are being addressed for the TSA.
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.070), Storage of Radioactive Materials	Waste storage	Radioactive materials must be stored in a manner that will not result in the exposure of any person, during routine access to a controlled area, in excess of the limits identified in 19 CSR 20-10.040 (see related discussion in Table C.2); a facility used to store materials that may emit radioactive gases or airborne particulate matter must be vented to ensure that the concentration of such substances in the air does not constitute a radiation hazard; and provisions must be made to minimize the hazard to emergency workers in the event of a fire, or potential earthquake, flood, or windstorm.	Potentially applicable	These requirements may be applicable to the construction and operation of the TSA.

REFERENCE (APPENDIX C)

U.S. Environmental Protection Agency, 1989, *National Emission Standards for Hazardous Air Pollutants; Radionuclides: Final Rule and Notice of Reconsideration (40 CFR Part 61)*, Federal Register, 54(240):51654-51715, Dec. 15.

APPENDIX D

ENGLISH/METRIC - METRIC/ENGLISH EQUIVALENTS

TABLE D.1 English/Metric Equivalents

Multiply	By	To obtain
acres	0.4047	hectares (ha)
cubic feet (ft^3)	0.02832	cubic meters (m^3)
cubic yards (yd^3)	0.7646	cubic meters (m^3)
degrees Fahrenheit (°F) - 32	0.5555	degrees Celsius (°C)
feet (ft)	0.3048	meters (m)
gallons (gal)	3.785	liters (L)
gallons (gal)	0.003785	cubic meters (m^3)
inches (in.)	2.540	centimeters (cm)
miles (mi)	1.609	kilometers (km)
pounds (lb)	0.4536	kilograms (kg)
square feet (ft^2)	0.09290	square meters (m^2)
square yards (yd^2)	0.8361	square meters (m^2)
square miles (mi^2)	2.590	square kilometers (km^2)
tons, short (tons)	907.2	kilograms (kg)
tons, short (tons)	0.90718	tons, metric (t)

TABLE D.2 Metric/English Equivalents

Multiply	By	To obtain
centimeters (cm)	0.3937	inches (in.)
cubic meters (m^3)	35.31	cubic feet (ft^3)
cubic meters (m^3)	1.308	cubic yards (yd^3)
cubic meters (m^3)	264.2	gallons (gal)
degrees Celsius (°C) + 17.78	1.8	degrees Fahrenheit (°F)
hectares (ha)	2.471	acres
kilograms (kg)	2.205	pounds (lb)
kilograms (kg)	0.001102	tons, short (t)
kilometers (km)	0.6214	miles (mi)
liters (L)	0.2642	gallons (gal)
meters (m)	3.281	feet (ft)
square kilometers (km^2)	0.3861	square miles (mi^2)
square meters (m^2)	10.76	square feet (ft^2)
square meters (m^2)	1.196	square yards (yd^2)
tons, metric (t)	1.1023	tons, short (tons)