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FINAL

Environmental Impact Statement

Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site

(Selected portions on K-65)

April 1986

U. S. Department of Energy
Washington, D.C. 20585

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U.S. Department of Energy
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COVER SHEET
FINAL ENVIRONMENTAL IMPACT STATEMENT
LONG-TERM MANAGEMENT OF EXISTING RADIOACTIVE
WASTES AND RESIDUES AT THE
NIAGARA FALLS STORAGE SITE

a) Lead Agency: U.S. Department of Energy (DOE)

b) Proposed Action: Long-term stabilization and control of existing radioactive wastes and residues at DOE's Niagara Falls Storage Site consistent with the guidance provided in the Environmental Protection Agency's regulations for uranium mill tailings (40 CFR 192).

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d) Designation: Final EIS (FEIS)

e) Abstract: The EIS assesses and compares several alternatives for long-term management and control of the existing radioactive wastes and residues at the Niagara Falls Storage Site (NFSS), Lewiston, New York. The alternatives include: (1) no action (continued interim storage at NFSS within a diked and capped containment area), (2) long-term management at NFSS (improved containment, with or without modified form of the residues), (3) long-term management at other DOE sites (Hanford, Washington, or Oak Ridge, Tennessee), and (4) offsite management of the residues at Hanford or Oak Ridge and either leaving the wastes at NFSS or removing them for disposal in the ocean. In addition to alternatives analyzed in depth, several options are also being considered, including: other modifications of residue form (vitrification and matrix isolation methods), modification of the basic conceptual designs, other containment design options, transportation routes, and transportation modes. Alternative 2 is DOE's preferred alternative.

The radiological health effects (primarily increased risk of cancer) associated with long-term management of the wastes and residues are expected to be much smaller than the nonradiological risks of occupational and transportation-related injuries and deaths. The increased risk of radiological health effects is estimated to range from 0.0013 to 0.24 for workers and from less than 0.0000005 to 0.30 for the general public as a result of actions that would be taken under the various alternatives. The greatest radiological risk for workers would occur if all the wastes and residues were removed to Hanford, whereas the greatest radiological risks for the general public would occur if the wastes were removed to the ocean and the residues were removed to Hanford. For the preferred alternative (long-term management at NFSS), the radiological risks for workers are estimated to range from 0.0051 to 0.10 and for the general public from less than 0.0000005 to 0.017--the higher risks being associated with treatment of the residues in Alternative 2a.

In comparison, the nonradiological risks are estimated to range from 0.0015 to 4 deaths and from 0.13 to 166 injuries. Both workers and the general public would incur these risks. The preferred alternative (long-term management at NFSS) is estimated to result in a risk of 0.12 deaths and 12 to 24 injuries.

For all alternatives, DOE would plan to take perpetual care of the waste containment areas and to restrict site access. If controls were partially lost (e.g., the containment area was not maintained), it is predicted that containment would still be effective for the design life (at least 200 years and, to the extent reasonably achievable, for 1000 years). Predicted time for erosion

of covers over the buried materials ranges from several hundred years to more than two million years, depending primarily on the use of the land surface. At all sites, releases of radioactive radon gas to the air through the earthen covers of the containment system are predicted to result in no significant adverse health effects. Also, at all sites, no offsite contamination of groundwater is predicted for the 1000-year design life. If all controls ceased, there would be risk of human intrusion into the contaminated materials. A 1-m (3-ft) layer of riprap (rock) in the earthen cover for preferred Alternative 2 is intended to discourage such intrusion. An additional intruder barrier over the more radioactive residues, such as a slab of reinforced concrete, is also being considered.

f) The Department has identified Alternative 2 (long-term management at NFSS) as the preferred alternative. Not less than 60 days after publication of the notice of availability of the Final EIS, a Record of Decision will be published in the Federal Register.

FOREWORD

This Final Environmental Impact Statement (Final EIS) is issued by the U.S. Department of Energy (DOE). It assesses the environmental impacts of various alternatives for the long-term management of existing radioactive wastes and residues stored at the Niagara Falls Storage Site (NFSS) near Lewiston, New York. These wastes and residues resulted from the processing of uranium ores. About 11,000 m^3 (15,000 yd^3) of residues and 180,000 m^3 (240,000 yd^3) of wastes are stored within a diked containment area at NFSS.

Although ongoing interim remedial actions involved improving the containment of the wastes and residues, DOE must decide how to manage these radioactive materials for the long term. Therefore, in accordance with the National Environmental Policy Act of 1969 (NEPA), as implemented by the regulations promulgated by the Council on Environmental Quality (CEQ) (40 CFR 1500-1508, November 1978) and DOE's implementing guidelines (45 FR 20694, March 28, 1980), DOE has prepared this Final EIS to provide environmental input to this decision. A Notice of Intent to prepare this FEIS was issued February 1, 1983, and a public scoping process was conducted. The Draft EIS was issued in August 1984. Public comment on the Draft EIS was received both in writing and at public meetings. After considering all comments, DOE is issuing this Final EIS. DOE will then issue a Record of Decision not less than 60 days following publication of the notice of availability of the Final EIS.

The format of this EIS follows the suggested format in the CEQ regulations. Section 1 documents the purpose and need for a decision. Section 2 summarizes and compares alternatives and predicted environmental impacts. Section 3 summarizes the affected environments at NFSS and alternative sites. Section 4 provides detailed information on analyses of the environmental consequences of the various alternatives. Section 5 presents the names and professional qualifications of the persons responsible for preparing the statement. More detailed information and analyses are provided in several appendices.

SUMMARY

The Niagara Falls Storage Site (NFSS) is located in the Town (Township) of Lewiston, Niagara County, New York, about 30 km (19 mi) north of Buffalo. The current site is part of a former Manhattan Engineer District (MED) site, which in turn was part of the former Lake Ontario Ordnance Works (LOOW). Beginning in 1944, the MED used the site for storage of radioactive residues that resulted from the processing of uranium ores during development of the atomic bomb. Additional residues were brought to the site for several years after World War II. The U.S. Department of Energy (DOE) is now responsible for the site.

Baseline conditions assumed for analysis of all alternatives for long-term management of the NFSS radioactive residues (from processing of uranium ores) and wastes (mostly contaminated soils) in this Final Environmental Impact Statement (Final EIS) are those conditions projected to exist upon completion of ongoing interim remedial actions in 1986*. At that time, all radioactive residues and wastes will be consolidated within a diked containment area in the southwest corner of NFSS. The diked area will contain about 11,000 m^3 (15,000 yd^3) of residues and 180,000 m^3 (240,000 yd^3) of wastes. The residues are located within a reinforced concrete structure at the bottom of the large pile of wastes. The residues account for less than 6% of the total volume of contaminated materials but almost 99% of the radioactivity. Most of the uranium was removed during processing of the ores; therefore, the radioactive contaminants in the residues and wastes are the naturally occuring decay products of uranium. The radioactivity will not diminish appreciably for thousands of years.

Although the interim remedial actions involve improving the containment of the wastes and residues and will result in reducing emissions of radioactive substances from the site and providing better control of the site, DOE must decide how to manage the radioactive wastes and residues for the long term. In addition to engineering, costs, and other considerations, environmental impacts will be factored into this decision. Therefore, in accordance with the National Environmental Policy Act (NEPA), DOE has prepared this Final EIS to assess and compare the potential environmental impacts of various alternatives for long-term management of the radioactive wastes and residues at NFSS.

DOE conducted a scoping process to determine the alternatives to be analyzed, the significant issues to be analyzed in depth, and the issues to be eliminated from further detailed study. Based on public and technical scoping input, the following alternatives were defined for analysis in this EIS:

Alternative 1: No Action--Alternative 1 would involve continued storage of all residues and wastes within the diked containment area in the southwest corner of NFSS. The containment area is surrounded by a dike and subsurface clay cutoff wall and is covered with a multilayered 1.4 m (4.5 ft) cap of clay and soil.* The entire NFSS site would remain under DOE ownership and control in perpetuity.

Alternative 2: Long-Term Management at NFSS in Perpetuity--DOE's Preferred Alternative

Alternative 2a: Long-Term Management at NFSS, Modified Containment--Under Alternative 2a, further actions would be taken to improve the long-term containment of the wastes and residues at NFSS. Such actions would include removal and temporary storage of the upper layers of the interim cap and construction of a long-term cap. The long-term cap would be 1.7-m (5.5-ft) thicker than the interim cap and would have extra clay and a layer of riprap (graded layers of gravel and rock). Only the containment area and a small buffer zone would be retained under DOE ownership and control in perpetuity.

Alternative 2b: Long-Term Management at NFSS, Modified Containment Plus Modified Form--Under Alternative 2b, in addition to the improved containment system described for Alternative 2a, the residues would be modified physically and chemically to reduce the rate of long-term migration of contaminated materials from NFSS. The residues would be removed from the containment area and processed to extract potentially valuable constituents (e.g., uranium, cobalt, nickel, molybdenum, and lead). Once processed, the vitrified (glass) residue slag and some precipitates would be reburied in the diked containment area, the processing facilities would be decontaminated and demolished, and the entire waste-containment area would be covered with the long-term cap. Only the containment area and a small buffer zone would be retained under DOE ownership and control in perpetuity.

*As of April 1986, the interim cap has been constructed over all of the containment area except the southern portion where the residues are located. In this EIS, the conceptual design for the interim cap included a 0.15-m (0.5-ft) sand layer between the clay and soil. A minor design modification eliminated this sand layer.

Alternative 3: Long-Term Management at Other Sites.

Alternative 3a: Long-Term Management at an Arid Site (Hanford)--Under Alternative 3a, both the residues and the wastes would be excavated from the containment area at NFSS and transported by truck to a radioactive waste-management site (218W5 Area) on the DOE Hanford Reservation near Richland, Washington. The residues would be packaged in large metal containers and transported on either flat-bed trailers or in shielded vans. The wastes are classified as nonradioactive under current transportation regulations and would be shipped in large dump trucks. About 16,000 truckloads would be needed to transport the wastes and residues over 4000 km (2500 mi) to Hanford. Following transport of the wastes and residues to the Hanford site, the excavated areas would be filled and regraded and NFSS would be released for other use. At Hanford, the contaminated materials would be buried in about 42 trenches in a manner similar to current practices for burial of other types of solid radioactive wastes at the Hanford Reservation. The residues and wastes would be covered with 3 m (10 ft) of local earthen materials, including a layer of riprap (with any necessary modifications to ensure compliance with 40 CFR 192). The wastes and residues would be controlled in perpetuity.

Alternative 3b: Long-Term Management at a Humid Site (Oak Ridge)--Under Alternative 3b, all the NFSS wastes and residues would be excavated and transported by truck to the Pine Ridge Knolls site on the DOE Oak Ridge Reservation near Oak Ridge, Tennessee. About 16,000 truckloads would be required, with a transportation distance of about 1200 km (750 mi). Following transport of the wastes and residues to the Oak Ridge site, the excavated areas at NFSS would be filled and regraded and NFSS would be released for other use. At Oak Ridge, the wastes and residues would be stabilized in several mounds. The mounds would be covered with a long-term cap similar to the cap at NFSS for Alternatives 2a and 2b. The wastes and residues would be controlled in perpetuity.

Alternative 4: Offsite Storage of Residues with Wastes at NFSS or Ocean Disposal

Alternative 4a: Storage of Residues at Hanford/Long-Term Management of Wastes at NFSS--Under Alternative 4a, the residues would be excavated, packaged, and transported to Hanford as in Alternative 3a. About 1,600 truckloads would be needed. The residue packages would be buried in 10 trenches at Hanford. The wastes would remain at NFSS and would be covered with a long-term cap identical to that described for Alternative 2a. The containment areas and small buffer zones at both NFSS and Hanford would be maintained and monitored in perpetuity.

Alternative 4b: Offsite Storage of Residues at Hanford/Ocean Disposal of Remaining Wastes--Under Alternative 4b, the residues would be excavated, packaged, and transported to Hanford as described for Alternative 4a. All remaining wastes would be excavated, transported in bulk in dump trucks to a dock in the New York/New Jersey harbor area, loaded onto barges, and transported to the 106-Mile Ocean Waste Disposal Site (Site 106) for dispersal. After removal of all wastes and residues from the site, NFSS would be released for other use. Only the residue containment area and a small buffer zone at Hanford would be maintained and monitored in perpetuity.

Alternative 4c: Offsite Storage of Residues at Oak Ridge/Long-Term Management of Waste at NFSS--Under Alternative 4c, the residues would be excavated, packaged, and transported to Oak Ridge as in Alternative 3b. About 1,600 truckloads would be needed. The residue packages would be stabilized in mounds and covered with a long-term cap similar to that described for Alternative 3b. The wastes would remain at NFSS and would be covered with a long-term cap identical to that described for Alternative 2a. The containment areas and small buffer zones at both NFSS and Oak Ridge would be maintained and monitored in perpetuity.

Alternative 4d: Offsite Storage of Residues at Oak Ridge/Ocean Disposal of Remaining Wastes--Alternative 4d is identical to Alternative 4c except that the NFSS wastes would be disposed in the ocean instead of remaining at NFSS. Ocean disposal would be the same as for Alternative 4b. After removal of all wastes and residues from the site, NFSS would be released for other use. Only the residue containment area and a small buffer zone at Oak Ridge would be maintained and monitored in perpetuity.

In addition to the alternatives analyzed in depth, several options are also considered, including options for (1) retrieval, packaging, and loading of contaminated materials, (2) modifications of the residue form (including various vitrification and matrix isolation methods), (3) modifications of the basic conceptual containment designs, (4) other containment design concepts, (5) transportation routes, and (6) transportation modes.

Implementation of any of the alternatives would permanently commit some land to use for radioactive waste management. Near-surface burial of the NFSS residues (and, in some alternatives, the wastes as well) would also unavoidably commit the federal government (or its successor) to perpetual care of the burial sites because the residues and wastes will remain hazardous for thousands of years. For alternatives 4a and 4c, two sites would be maintained and monitored in perpetuity.

Implementation of any of the action alternatives would expose workers to risk of injury and death associated with construction and earth-moving activities, ranging from an estimated risk of 12 injuries

and 0.0064 deaths in the case of Alternative 2a (modified containment at NFSS) to 100 injuries and 0.044 deaths for Alternative 3a (all wastes and residues at Hanford). Transport of the wastes and residues (Alternatives 3a, 3b, 4a, 4b, 4c, and 4d) would expose workers and the general public to injuries and deaths associated with transportation accidents, ranging from an estimated 2.5 injuries and 0.15 deaths for Alternative 4c (residues only to Oak Ridge) to 66 injuries and 3.9 deaths for Alternative 3a (all wastes and residues to Hanford).

The radiological health impacts (primarily increased risk of cancer) would be smaller than the risks of occupational and transportation-related injuries and deaths. During the action period, the risk is estimated to range from 0.0013 additional health effects for workers in Alternative 1 (site maintenance workers) to 0.24 additional health effects for workers in Alternative 3a (all wastes and residues moved to Hanford). For the general public, the risk is estimated to range from less than 0.0000005 additional health effects for Alternatives 1 and 2a to 0.30 additional health effects for Alternative 4b (residues to Hanford, wastes to ocean).

For Alternative 2 (preferred alternative), the release of radioactive radon gas through the thick earthen cover is estimated to be about the same as that which naturally escapes from the soils in the area because of the natural radioactivity in all soils. The maximum increased radiation dose to a nearby resident is estimated to be less than 0.001 mrem/yr. This compares with 2.0 mrem/yr that such a person would receive if he/she moved to Buffalo, New York, because of the increase in cosmic radiation at the higher altitude.

The long-term radiological risks to the general public are expected to be small. Even if site maintenance ceased in 200 years and there was very erosive use of the land, the number of additional adverse health effects at the year 1000 are estimated to range from less than 0.0000005/million persons/year for Alternatives 2a, 2b, 3b, 4c, and 4d (residues in the humid climate at NFSS or Oak Ridge) to 0.0061/million persons/year for Alternatives 4a and 4b (residues in the arid climate at Hanford). Long-term radiological risks to the general public are expected to be highest for Alternatives 3a, 4a and 4b, primarily because of the much higher releases of radon gas from the residues in the arid climate at Hanford.

For all alternatives, DOE would plan to take perpetual care of the waste containment areas and to restrict access to the site. Even if controls were partially lost (e.g., the containment area was not maintained), it is predicted that containment would still be effective for the design life (at least 200 years and, to the extent reasonably achievable, for 1000 years). Predicted time for erosion of the multilayered earthen covers ranges from several hundred years to more than 2 million years, depending on the use of the land surface. Given such uncertainties, there is no significant difference between alternatives with respect to erosion of the covers.

For all alternatives, no offsite contamination of groundwater is predicted for the 1000-year design life. DOE plans to implement a groundwater monitoring program in order to detect migration before contaminants reached the site boundary and to take any necessary corrective actions.

Dispersal of the slightly contaminated wastes in the ocean at Site 106 (Alternatives 4b and 4d) is not expected to result in any significant impacts on the ocean environment or to pose any significant radiological risk to humans. A potential institutional obstacle to implementation of Alternative 4b or 4d is the need to obtain an ocean dumping permit from the U.S. Environmental Protection Agency and the uncertainty as to how the wastes will be classified for ocean disposal purposes.

Implementation of any of the alternatives would require a commitment of money for long-term management of the NFSS residues, and, for some alternatives, the wastes as well. Estimated initial commitments for the action alternatives range from about $3.2-6.3 million for Alternative 2a (modified containment at NFSS) to about $130-260 million for Alternative 3a (move all wastes and residues to Hanford). Long-term commitments for perpetual care are estimated to range from $43,000/yr for Alternatives 4b and 4d (residues only at Hanford or Oak Ridge) to $130,000/yr for Alternatives 4a and 4c (in which two different sites must be managed).

DOE plans to take perpetual care of the NFSS site. A 1-m (3-ft) thick layer of riprap (rock) in the earthen cover over the wastes under preferred Alternative 2 is intended to discourage human intrusion into the contaminated materials.

Alternative 2 is DOE's preferred alternative. Maintenance and monitoring of the NFSS interim storage system (Alternative 1) will continue until implementation of the long-term alternative. The long-term alternative selected for implementation will be identified in the Record of Decision. At the time of implementation, DOE will determine the final design features of the waste containment system and the residue form. At all times, DOE will continue to keep the public as well as federal, state, and local officials apprised of DOE plans, actions, and monitoring results.

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1. PURPOSE AND NEED FOR DECISION

1.1 INTRODUCTION AND BRIEF HISTORY

The Niagara Falls Storage Site (NFSS) is located in the Town (township) of Lewiston, Niagara County, New York, about 30 km (19 mi) north of Buffalo, New York (Figure 1.1). The current 77-ha (190-acre) site is part of a former 610-ha (1500-acre) Manhattan Engineer District (MED) site, which in turn was part of the former Lake Ontario Ordnance Works (LOOW). Beginning in 1944, the MED used the site for storage of radioactive residues that resulted from the processing of uranium ores (pitchblende) during development of the atomic bomb. Additional residues were brought to the site for several years after World War II.

Subsequent to MED, responsibility for the site has been transferred to the U.S. Atomic Energy Commission (AEC), the U.S. Energy Research and Development Administration (ERDA), and the U.S. Department of Energy (DOE). The site is currently administered by the Oak Ridge Operations Office of DOE and operated by Bechtel National, Inc. It is fenced and access is limited.

1.2 SUMMARY DESCRIPTION OF NFSS RESIDUES AND WASTES

The baseline for analysis of all alternatives for the long-term management of the NFSS residues and wastes in this Environmental Impact Statement (EIS) is assumed to be the condition of NFSS projected to exist upon completion in 1986 of the interim remedial actions that are currently under way.* At that time, all radioactively contaminated wastes (mostly soils) and residues (from processing of uranium ores) will be consolidated within a 3.4-ha (8.5-acre) diked containment area in the southwest corner of NFSS (Figure 1.2). This area will contain about 190,000 m^3 (250,000 yd^3) of contaminated materials. The area will be surrounded by a dike and subsurface clay cutoff wall. The cutoff is keyed into an existing layer of gray clay.** The containment area will have an earthen cover consisting of layers of clay (0.9 m [3 ft]) and soil (0.45 m [1.5 ft])--totaling 1.4 m (4.5 ft) (see Section 2.1 for conceptual design drawing).***

For purposes of analysis in this EIS, the NFSS contaminated materials are separated into two groups: (1) residues and (2) wastes (Table 1.1). The residues and wastes are described in detail in Section 3.1.7. The 11,000 m^3 (15,000 yd^3) of residues consist of the K-65, the combined L-30/F-32, and the L-50 residues--all of which will be stored in buildings within the diked area upon completion of interim remedial actions (Figure 1.2). The residues account for less than 6% of the total volume of contaminated materials stored at NFSS but almost 99% of the radium-226 inventory. The radium-226 concentrations in the residues range from 3,300 to 220,000 pCi/g and average 67,000 pCi/g. Radium-226 is a naturally occurring radionuclide that results from the decay of uranium-238. Soils in the Niagara Falls area naturally contain about 2 pCi/g of radium-226.

Until recently, these residues were owned by Afrimet-Indussa, Inc., an American firm incorporated in the state of New York and controlled by Union Miniere, a Belgian firm. During World War II, Afrimet supplied the federal government with uranium ore (pitchblende) from the Belgian Congo but retained ownership of the residues because of the radium and other, potentially recoverable, valuable elements that remained in the residues after the uranium was extracted.

Afrimet held a license from the state of New York for storage of the radioactive materials at NFSS and had a storage lease agreement with DOE. The lease agreement expired in June 1983. As a result of DOE negotiations with Afrimet, and in consideration of common defense and security arrangements between the United States and the government of Belgium, Afrimet and DOE signed an agreement

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*The impacts associated with the interim activities are not covered in this EIS on long-term management. The interim actions are addressed in separate documents (U.S. Dep. Energy 1982a, 1982b, 1983a, 1983b).

**The depth and thickness of the gray clay layer is variable, and it is not known if this layer is continous underneath the diked area.

***As of April 1986, the interim cap has been constructed over all of the containment area except the southern portion where the residues are located. In this EIS, the conceptual design for the interim cap included a 0.15-m (0.5-ft) sand layer between the clay and soil. A minor design modification eliminated this sand layer.

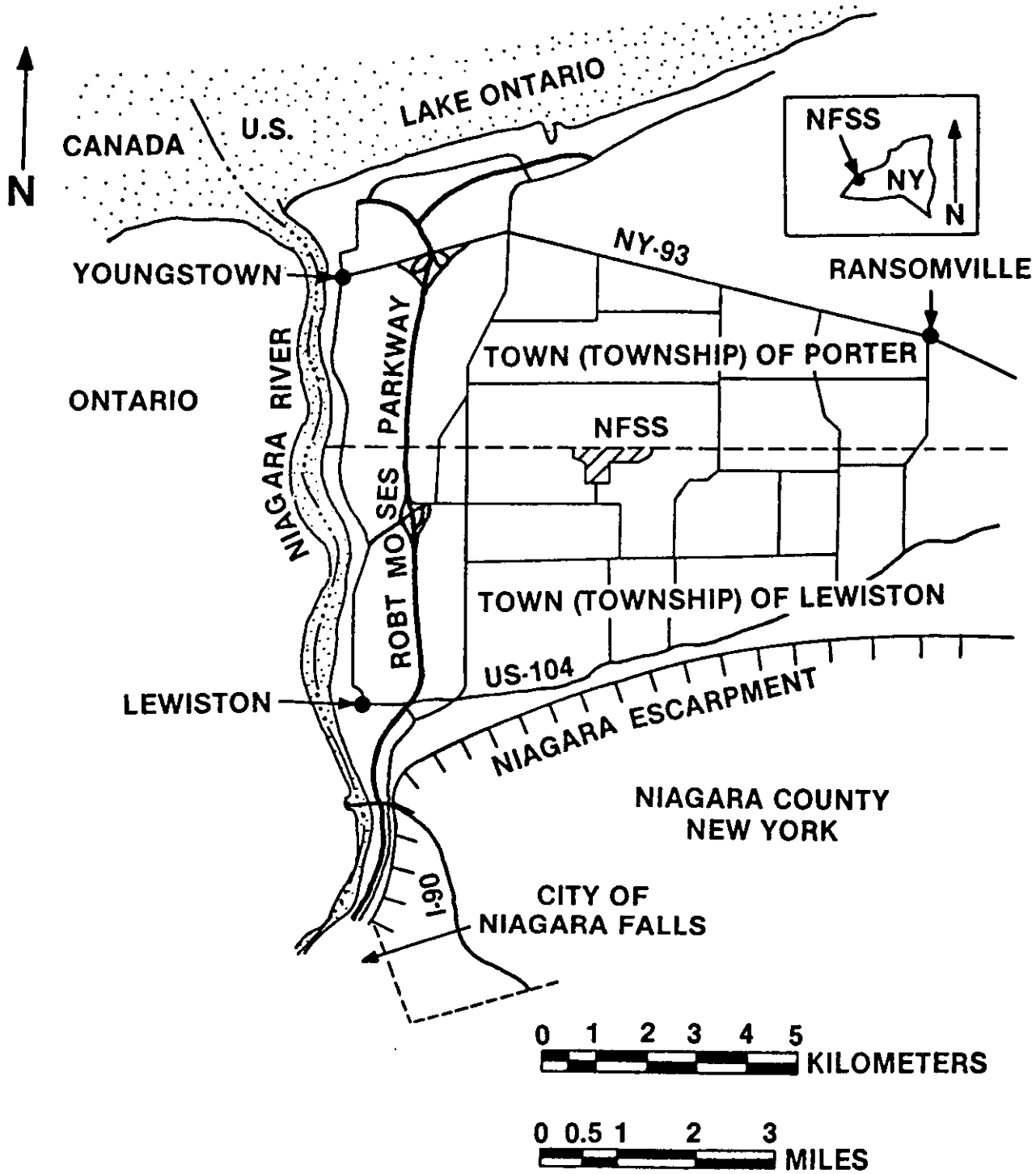

Figure 1.1. Niagara Falls Storage Site Location Map.

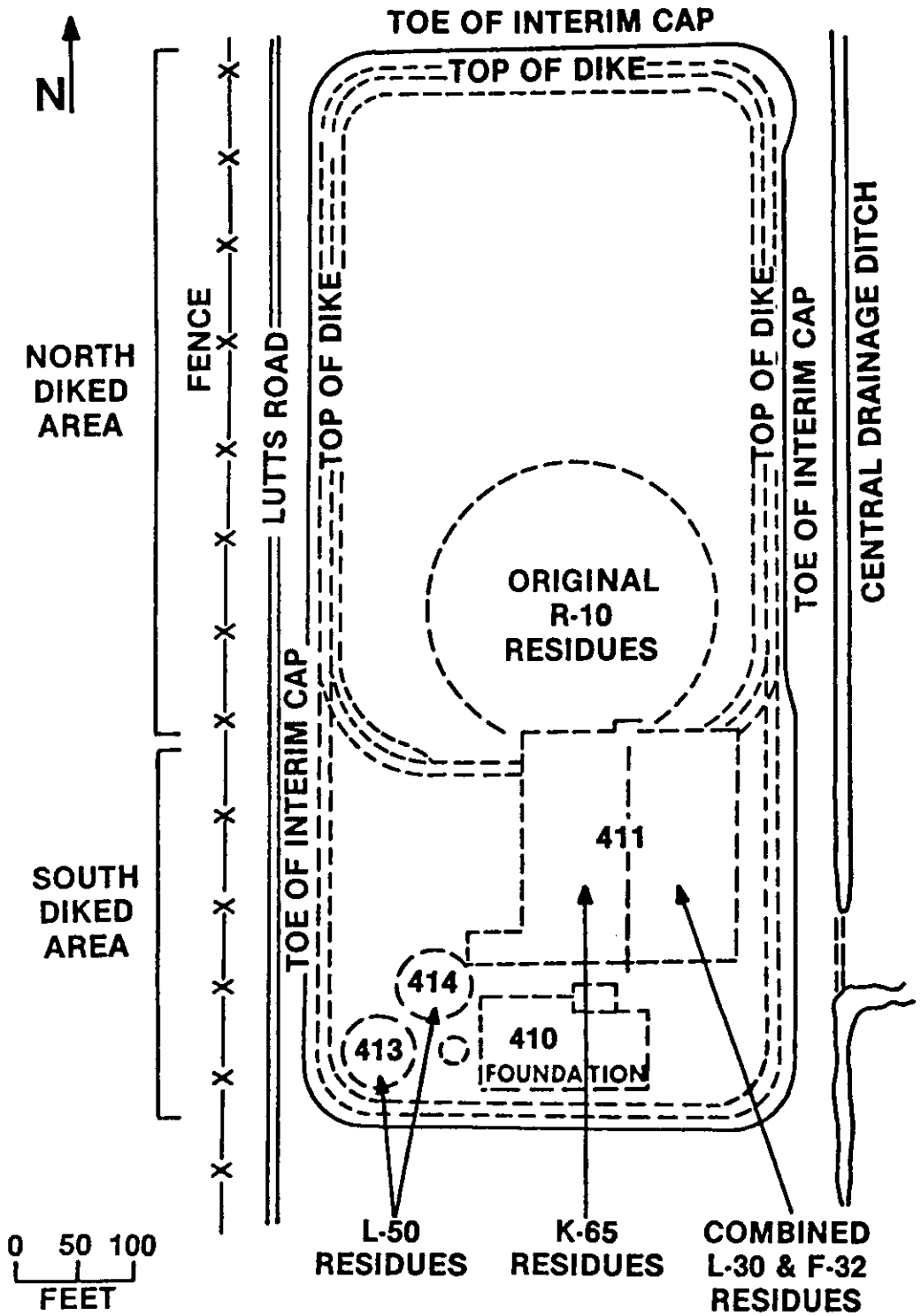

Figure 1.2. Plan View of the Waste-Containment Area in the Southwest Corner of NFSS Upon Completion of Interim Remedial Actions in 1986. Based on drawing provided by Bechtel National, Inc. Note: The exact placement of the K-65 and combined L-30/F-32 residues in Building 411 has been changed, but this has not changed the impacts predicted in this EIS.

Table 1.1. Radioactive Materials at NFSS†[1]

Description	Volume (m^3)†[2]	Average Radium-226 Concentration (pCi/g)†[3]	Radium-226 Inventory (Ci)
Residues†[4]	11,000	67,000	870
Wastes†[5]	180,000	36	7.8
Total	190,000	3,800	880

†[1] All values rounded to two significant figures. See Section 3.1.7 for details.

†[2] Estimated volumes. More precise estimates will be available after completion of interim remedial actions.

†[3] Dry weight concentrations.

†[4] Includes K-65, L-30/F-32, and L-50 residues. During the interim remedial actions, the volumes of residues were found to be less than the estimates used in the analyses in this EIS.

†[5] Includes all remaining contaminated materials, primarily slightly contaminated soils.

effective July 1, 1983, whereby Afrimet will pay DOE $8 million and DOE took title to the residues and released Afrimet from its obligations with respect to the residues (U.S. Dep. Energy 1983d).

The 180,000 m^3 (240,000 yd^3) of NFSS wastes consist primarily of slightly contaminated soils that have an average radium-226 concentration of 36 pCi/g. Detailed descriptions of the NFSS residues and wastes are given in Section 3.1.7.

1.3 DECISION TO BE MADE

Although the planned interim remedial actions involve placing the wastes and residues into a more secure condition and will result in markedly reduced emissions of radioactive substances from the site, DOE must decide how to manage the radioactive wastes and residues for the long term. In addition to engineering, cost, and other considerations, environmental impacts will be factored into this decision. Therefore, in accordance with the National Environmental Policy Act (NEPA), DOE prepared this EIS to assess and compare the potential environmental impacts of various alternatives for the long-term management of the radioactive wastes and residues at NFSS. The DOE decision-making process and supporting documents for NFSS are summarized in Figure 1.3.

1.4 EIS SCOPING

In accordance with regulations of the Council on Environmental Quality (CEQ) and DOE guidelines for implementing NEPA, the Department issued a Notice of Intent (NOI) to prepare this EIS (U.S. Dep. Energy 1983c) and conducted a scoping process to determine the alternatives to be analyzed in the EIS, the significant issues to be analyzed in depth, and the issues to be eliminated from further detailed study. Details of the scoping process are given in the Implementation Plan for this EIS (U.S. Dep. Energy 1984), and a summary is provided in Appendix G. Both technical and public scoping input were considered. Public input included presentations made at two public meetings held in Lewiston, New York, on February 17 and 19, 1983; presentations made at a public meeting held in Oak Ridge, Tennessee, on October 19, 1983; and letters received by DOE regarding the scope of the EIS. Technical scoping input was provided by Bechtel National, Inc., Argonne National Laboratory, DOE Operations Offices at Oak Ridge and Richland, DOE Headquarters, and state agencies (New York Departments of Environmental Conservation, Labor, and Health). The preliminary list of potential issues presented in the NOI was revised as a result of the scoping process. In particular, radiological contamination of the oceanic environment was added as a primary issue. Further discussion is given in Appendix G regarding the reasons for retaining or rejecting specific issues for detailed consideration in this EIS.

Based on the public and technical input, four basic alternatives were defined for analysis in this EIS:

1. No Action--Continue interim storage of all existing wastes and residues at NFSS in the diked and capped containment area in the southwest corner of NFSS.

	DOE ACTIVITIES	SUPPORT DOCUMENTS
INTERIM	INTERIM REMEDIAL ACTIONS (1982-1986)	Series of Action Description Memoranda and Memoranda to File Construction and Subcontract Documents (e.g., drawings, technical specifications, scope of work, engineering reports) Series of Monitoring Reports Site Characterization Reports
LONG-TERM MANAGEMENT	MAJOR ALTERNATIVES TO BE CONSIDERED IN DETAIL IN EIS (CONCEPTUAL DESIGNS)	Engineering Evaluation of Alternatives Scoping Comments (see Appendix G of Draft EIS) EIS Implementation Plan
	PREFERRED ALTERNATIVE(S)	Draft EIS Comments on Draft EIS (see Appendix K of Final EIS)
	MAJOR DECISION: WHICH BASIC ALTERNATIVE DOE PLANS TO IMPLEMENT AND WHAT BASIC MEASURES WILL BE TAKEN TO PRECLUDE, MITIGATE, AND/OR MONITOR POTENTIAL IMPACTS	Final EIS (including documents incorporated by reference) Interim Closure/Post-Closure Plan* Interim Containment Design Report* Environmental Monitoring Plan* Waste Containment Performance Monitoring System Report* Record of Decision (ROD)
	IMPLEMENTATION OF SELECTED LONG-TERM MANAGEMENT ALTERNATIVE	Detailed Plans for Selected Alternative (including engineering design, mitigative measures and monitoring plans, site configuration plans, etc.) Construction and Subcontract Documents RCRA/CERCLA Documents (as necessary) Other Reports (as necessary)
	IMPLEMENTATION OF PERPETUAL CARE	Monitoring Reports Corrective Action Plans, Engineering Evaluations, Environmental Assessments (as necessary)

*Will be finalized before ROD.

Figure 1.3. Niagara Falls Storage Site: DOE Decision-Making Process.

2. Long-Term Management at NFSS--Carry out further actions to improve the containment of the stored wastes and residues or, in addition to improved containment, to modify the form of the residues to reduce long-term migration of contaminated materials from NFSS.

3. Long-Term Management at Other Sites--Remove all wastes and residues from NFSS and transport them to another site for long-term management.

4. Offsite Storage of Residues--Remove the more radioactive residues to another site and either leave the wastes at NFSS or remove them for disposal in the ocean.

The first three alternatives were suggested in the NOI. Based on public and technical input to the scoping process, the fourth alternative was added. Although a preferred alternative was not identified in the Draft EIS, a preferred alternative (Alternative 2, Long-Term Management at NFSS) is identified in this Final EIS, as required by CEQ regulations.

The term "long-term management" is used in this EIS instead of the term "disposal" for those alternatives wherein the NFSS wastes and residues will remain on land. The term disposal has a connotation of permanent emplacement with no further management. Because the radionuclides in the NFSS wastes and residues have relatively long half-lives and the potential hazard will not diminish appreciably for thousands of years, there will be a continuing need for management of these materials. Thus, the term long-term management is used. The potential environmental impacts under conditions of continuing management (maintenance, monitoring, and corrective actions as necessary) and under conditions of loss of management are assessed in this EIS. The time periods for analysis and the assumptions about management controls for each time period are given in Section 4.

1.5 RELATED FEDERAL PROJECTS

The Department has recently prepared environmental impact statements for other programs and other sites under its Remedial Action Program, including:

U.S. Department of Energy. 1983. "Final Environmental Impact Statement, Remedial Actions at the Former Vitro Rare Metals Plant Site, Cannonsburg, Washington County, Pennsylvania." DOE/EIS-0096-F (2 volumes). July 1983.

U.S. Department of Energy. 1984. "Final Environmental Impact Statement, Remedial Actions at the Former Vitro Chemical Company Site, South Salt Lake, Salt Lake County, Utah." DOE/EIS-0099-D. July 1984.

U.S. Department of Energy. 1985. "Final Environmental Impact Statement. Remedial Actions at the Former Vanadium Corporation of America Uranium Mills Site, Durango, LaPlata County, Colorado." DOE/EIS-0111F. October 1985.

In addition, the U.S. Nuclear Regulatory Commission and the U.S. Environmental Protection Agency have prepared EISs on various related programs, proposed standards, and specific sites, including:

U.S. Nuclear Regulatory Commission. 1983. "Final Environmental Impact Statement Related to the Decommissioning of the Rare Earths Facility, West Chicago, Illinois." Docket No. 40-2061, Kerr-McGee Chemical Corporation. Office of Nuclear Material Safety and Safeguards. May 1983.

U.S. Environmental Protection Agency. 1982. "Final Environmental Impact Statement for Remedial Action Standards for Inactive Uranium Processing Sites (40 CFR 192)." Vols. 1 and 2; EPA 520/4/82-013-1, -2. Office of Radiation Programs. October 1982.

U.S. Environmental Protection Agency. 1980. "Final Environmental Impact Statement (EIS) for 106-Mile Ocean Waste Disposal Site Designation." Oil and Special Materials Control Division, Marine Protection Branch, Washington, DC. February 1980.

1.6 SUMMARY OF POTENTIALLY APPLICABLE LAWS AND REGULATIONS

Major laws and regulations that may be potentially applicable to the various alternatives are presented in Table 1.2. Detailed discussions of several major institutional issues associated with environmental regulation are given in Section 4.7 and Appendix D. Copies of DOE Orders are available for public inspection at the NFSS EIS public reference locations.

3. AFFECTED ENVIRONMENT

Following are descriptions of the affected environments at NFSS, the three alternative sites to which the NFSS wastes and residues could be taken (Hanford, Oak Ridge, or the ocean disposal site), and the transportation routes.

3.1 NIAGARA FALLS STORAGE SITE (NFSS)

3.1.1 Topography, Geology, Soils, Seismology, and Mineral Resources

The Niagara Falls Storage Site (NFSS) is located south of Lake Ontario on the Ontario Plain that begins at the base of the Niagara Escarpment (Figure 1.1) and slopes gently northwest towards Lake Ontario. The plain is relatively flat and featureless except for a few broad shallow valleys and the Niagara River Valley that lead to Lake Ontario. Elevations at NFSS are uniform, ranging between 96 and 105 m (315 and 344 ft) MSL; the lower elevations correspond to three man-made drainage ditches on the site and the higher elevations correspond to the top of the diked waste containment area in the southwest corner of the site. The natural site elevation is approximately 98 m (320 ft) MSL.

The bedrock of the region is composed of relatively undeformed, flat-lying sedimentary rocks over a basement of metamorphic rock. A 270-m (900-ft) sequence of shales and siltstones of the Queenston Formation lies at the base of the Niagara Escarpment and comprises the uppermost bedrock unit under NFSS. The Queenston Formation underlies NFSS at a depth of approximately 15 m (50 ft) (Acres American 1981). Unconsolidated glacial deposits overlie the Queenston Formation on the Ontario Plain. At NFSS, these deposits consist of five major stratigraphic units (Figure 3.1) (Acres American 1981; Wehran Eng. Corp. 1979).

The silty-loam soils within the vicinity of NFSS belong to the Rhinebeck-Ovid-Madalin association. These soils are nearly level to gently sloping, deep, and somewhat to very poorly drained. They have moderately fine to fine-textured subsoils and are of medium to low value for farming. Poor natural drainage is the major limitation to uses such as farming or urban development (Higgins et al. 1972). Soils within NFSS have been classified in the Niagara County, New York, Soil Survey as "made land" (Higgins et al. 1972). Made land consists of areas that have been filled with stone, brick, and other wastes and covered with a thin mantle of soil material. The properties of made land vary widely over the NFSS. Under the interim actions, much of the surface soil has either been removed in site cleanup operations or used as borrow material to place in the diked area.

The NFSS lies within the Central Stable Tectonic Region (Eardley 1962). Historically, earthquakes within this region have generally been of moderate seismic intensity (VI and VII or less on the Modified Mercalli scale). Near NFSS in western New York and adjoining Ontario, there is a small seismically active area (Hadley and Devine 1974) that is associated with an earthquake event that occurred near Attica, New York, 40 km (25 mi) southeast of NFSS (Fox 1970). The configuration of the seismic zone around Attica is not well defined, but earthquakes in the Attica seismic zone appear to govern the maximum historical intensity at NFSS.

No natural resources of importance are known to exist beneath the NFSS facility. Although clay of the region has been used historically in the manufacture of bricks, no manufacturing facilities currently exist near NFSS. Limestone, sand, and gravel are mined and natural gas fields have been identified in the region; however, none of these resources has been identified or mined in the NFSS area itself (Erie Niagara Co. Reg. Plan. Board 1978b).

3.1.2 Hydrology, Water Use, and Water Quality

3.1.2.1 Surface Water

The natural surface drainage patterns for the NFSS area are illustrated in Figure 3.2. Historically, only Fourmile, Sixmile, and Twelvemile creeks could have received runoff from NFSS. Streamflows for Fourmile, Sixmile, and Twelvemile creeks consist of natural surface runoff, agricultural drainage, and treated and institutional waste discharges (N.Y. State Dep. Environ. Conserv. 1975). The creeks are intermittent through much of their reaches, and they discharge into Lake Ontario.

In the 1940s, a system of ditches was constructed (as part of the Lake Ontario Ordnance Works) to drain surface waters to the central drainage ditch. Sixmile Creek, which originally flowed through the site, was diverted to the southwestern drainage ditch just outside the southwest corner of the site boundary, and surface waters from the southeast area that had flowed east into Twelvemile Creek

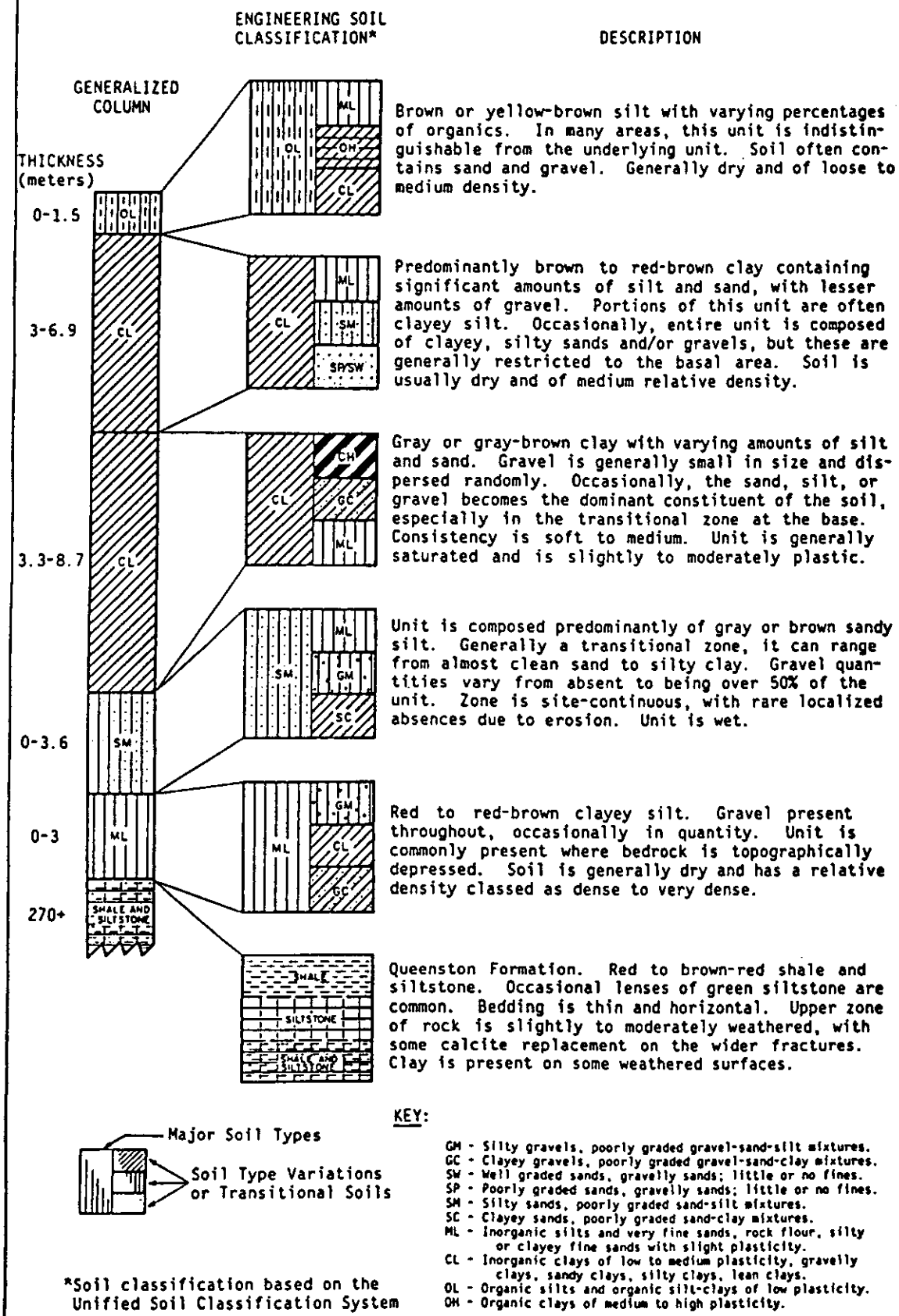

Figure 3.1. Generalized Geologic Column of Formations Under the Niagara Falls Storage Site. Source: Adapted from Acres American (1981).

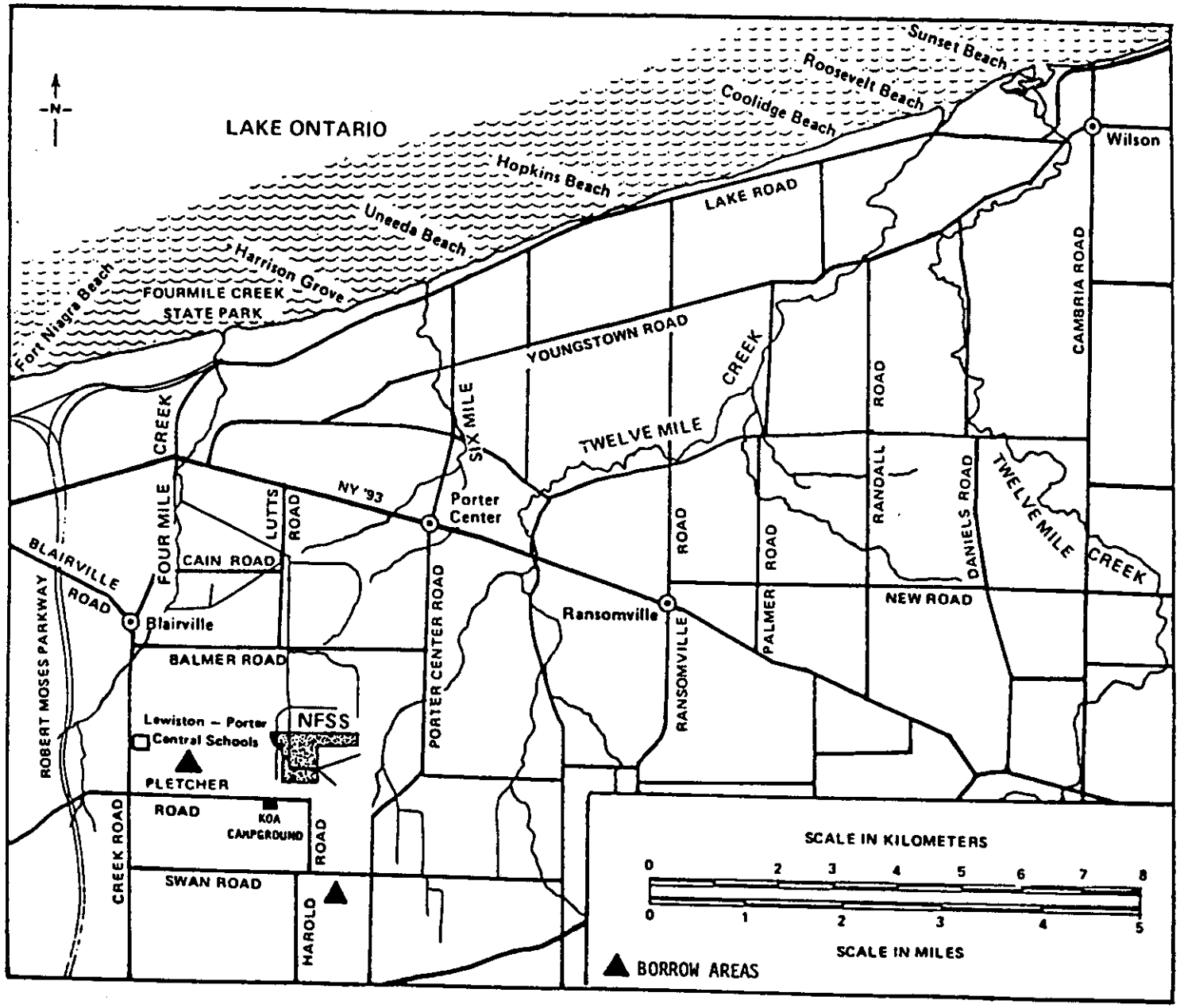

Figure 3.2. Natural Surface Drainage Patterns in the NFSS Area.
Adapted from Anderson et al. (1981--Figure 6.2).

were diverted to the South-31 ditch and then to the central ditch (Aerospace Corp. 1982). The existing man-made drainage system of the NFSS and surrounding area is illustrated in Figure 3.3. Site runoff via the central ditch discharges into Fourmile Creek.

The 100-year flood level within NFSS is estimated to be approximately 97 m (319 ft) MSL, and flooding is generally contained within the central drainage ditch (Acres American 1981; U.S. Dep. Housing Urban Dev. 1980). Major runoff occurs during the spring and, for most of the year, there is very little surface flow. Ponded water is common at NFSS during and following spring snowmelt.

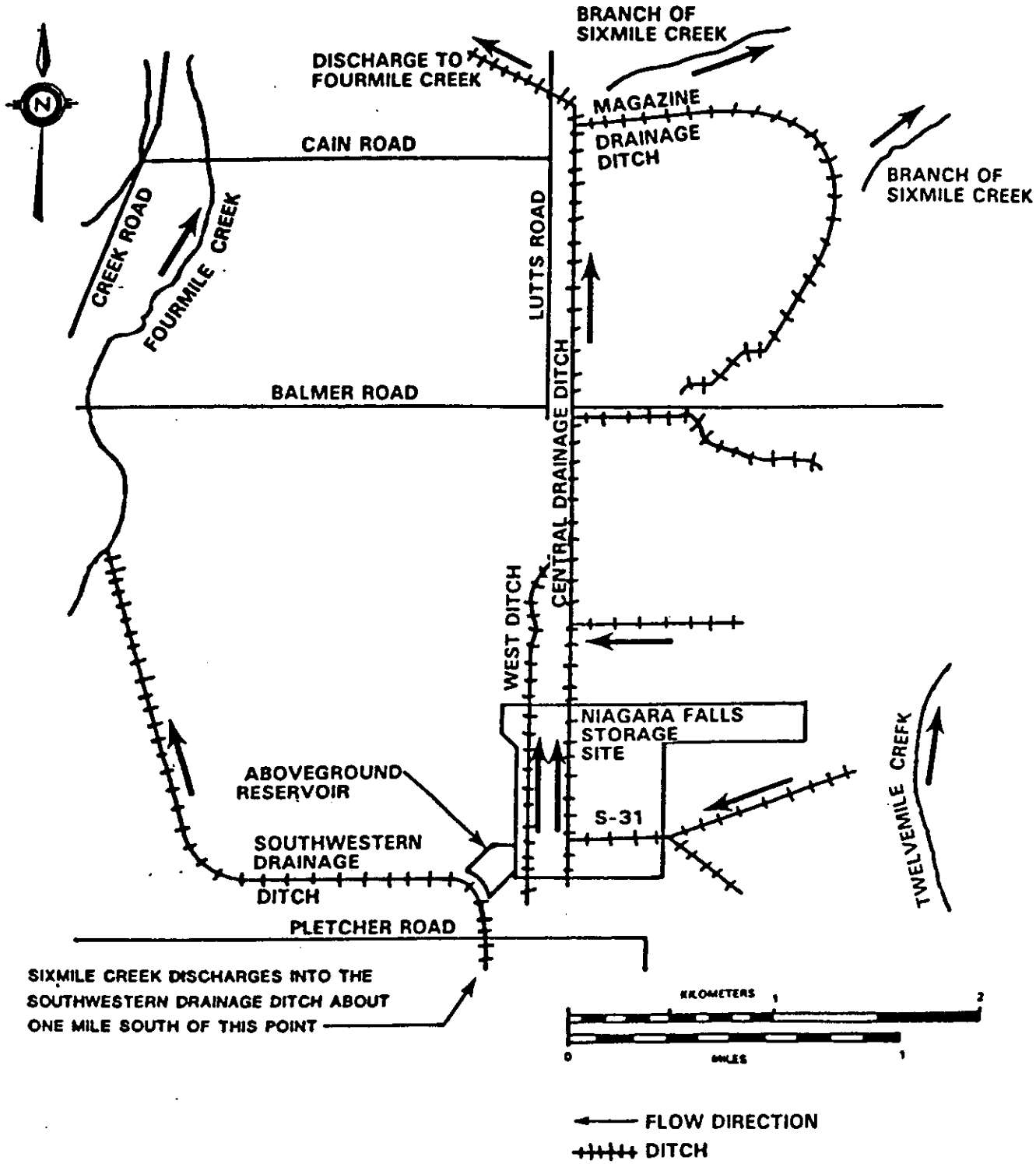

Figure 3.3. Surface Water Drainage at NFSS and in the Surrounding Areas. (Source: Bechtel National, Inc. (1984b) (originally modified from Acres American 1981).

In 1975, the entire length of Fourmile Creek was classified as "water quality limiting."* However, since that time, the Lewiston-Porter Central Schools have discontinued their discharge to the creek upon connection to the Town of Lewiston Sewage Treatment Plant; and the three remaining discharges (Bell Aerosystems, Whitnor Chemicals, and Fourmile Creek State Park) have upgraded their treatment to conform to New York State criteria governing intermittent streams (N.Y. State Dep. Environ. Conserv. 1975). DOE has a State Pollutant Discharge Elimination System (SPDES) permit (see Table 4.52) to discharge to the central drainage ditch, but upon completion of the interim remedial actions in 1985, no further discharges are anticipated. Currently, discharges from the SCA hazardous wastes landfill north of NFSS are piped to the Niagara River rather than the central ditch.

No nonradiological water quality information is available for the NFSS drainage ditches. Prior to the interim actions, central drainage ditch sediments had elevated concentrations of cobalt, nickel, copper, barium, lithium, fluorine, and cesium. West drainage ditch sediments had elevated concentrations of sodium, cobalt, and lithium (Anderson et al. 1981). Under the interim remedial actions, much of these contaminated sediments were removed from the ditches and placed within the diked containment area (Figure 1.2).

Approximately 90% of the population in Niagara and Erie counties is served by surface water supply systems. Surface water from Lake Erie serves 65% of the population and surface water from the upper Niagara River serves 25% of the population. Communities north of the Niagara Escarpment (and as far as 80 km [50 mi] from NFSS), including Lewiston and Porter townships, receive much of their water from Lake Erie and the Niagara River via the Niagara County Water District (Erie Niagara Co. Reg. Plan. Board 1978a).

Fourmile, Sixmile, and Twelvemile creeks are used primarily for boating and fishing (N.Y. State Dep. Environ. Conserv. 1975). At their confluence with Lake Ontario, both Fourmile and Twelvemile creeks are designated as recreational areas with public swimming sites (Erie Niagara Co. Reg. Plan. Board 1978a).

3.1.2.2 Groundwater

Within Niagara County, groundwater is present in both the surficial glacial deposits and the underlying bedrock. The three most significant water-bearing zones at NFSS are (1) the intermittent sand lenses found 3 to 6 m (10 to 12 ft) below ground surface (upper soil aquifer), (2) the brown gravelly sand-silt layer found 9 to 12 m (30 to 40 ft) below ground surface (lower soil aquifer), and (3) the weathered and fractured upper surface (about 3- to 4.5-m [9.9- to 15-ft] thick) of the Queenston Formation beginning about 15 m (50 ft) below ground surface (bedrock aquifer). None of these water-bearing zones are major aquifers.

Numerous extensive sand lenses or pockets were found during trench operations for construction of the dike and subsurface cutoff wall around the waste-containment area in the southwest corner of the site (Bechtel Natl. 1984a). Borings in the east dike area encountered 2-m (7-ft) thick lenses of sand, gravel, and cobbles. Isolated sand and gravel lenses 4.6-m (15-ft) thick were encountered in the north dike area. A sand and gravel deposit more than 7-m (20-ft) thick was encountered in the west dike area. These lenses are recharged by percolating water. No detailed information is available on the hydraulic conductivity or yield of these sand deposits. Depending on the surface moisture regime (rain, snowmelt, etc.), the moisture content of these sand lenses can vary from dry to saturated. Interconnection of the sand lenses has not been demonstrated.**

Shallow wells have been drilled to the surficial unconsolidated deposits near NFSS and, although water supplies are limited, the wells have yields sufficient for limited use (Johnston 1964). The zone that contains the sand lenses is referred to as the upper soil aquifer or upper aquifer. The average permeability of the brown sand aquifer (lower soil aquifer) is about 2×10^{-5} to 2×10^{-6} cm/s (Acres American 1981). The direction of groundwater flow in this aquifer is uncertain.

There is a network of underground pipes in the southern portion of the diked containment area. The location of known pipes is shown in Figure 3.4. During the interim remedial actions, these pipes were either removed or grouted to inhibit or prevent the potential migration of contaminated groundwater along these pipes.

The lower soil aquifer is generally continuous and confined*** by the less permeable overlying gray clay and underlying red till. This aquifer is recharged by leakage through the overlying

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*"Water Quality Limiting" is defined as waters that do not meet state stream standards and would not be expected to meet standards even after application of "best practical treatment" required by the 1972 Federal Water Pollution Control Act. The classification of Fourmile Creek has apparently not been revised since 1975.

**Bechtel National, Inc., is monitoring some of the sand lenses surrounding the containment area to determine whether or not the suspected disconnection of the sand lenses exists.

***This aquifer has a pizeometric surface that is above the surface elevation of the aquifer.

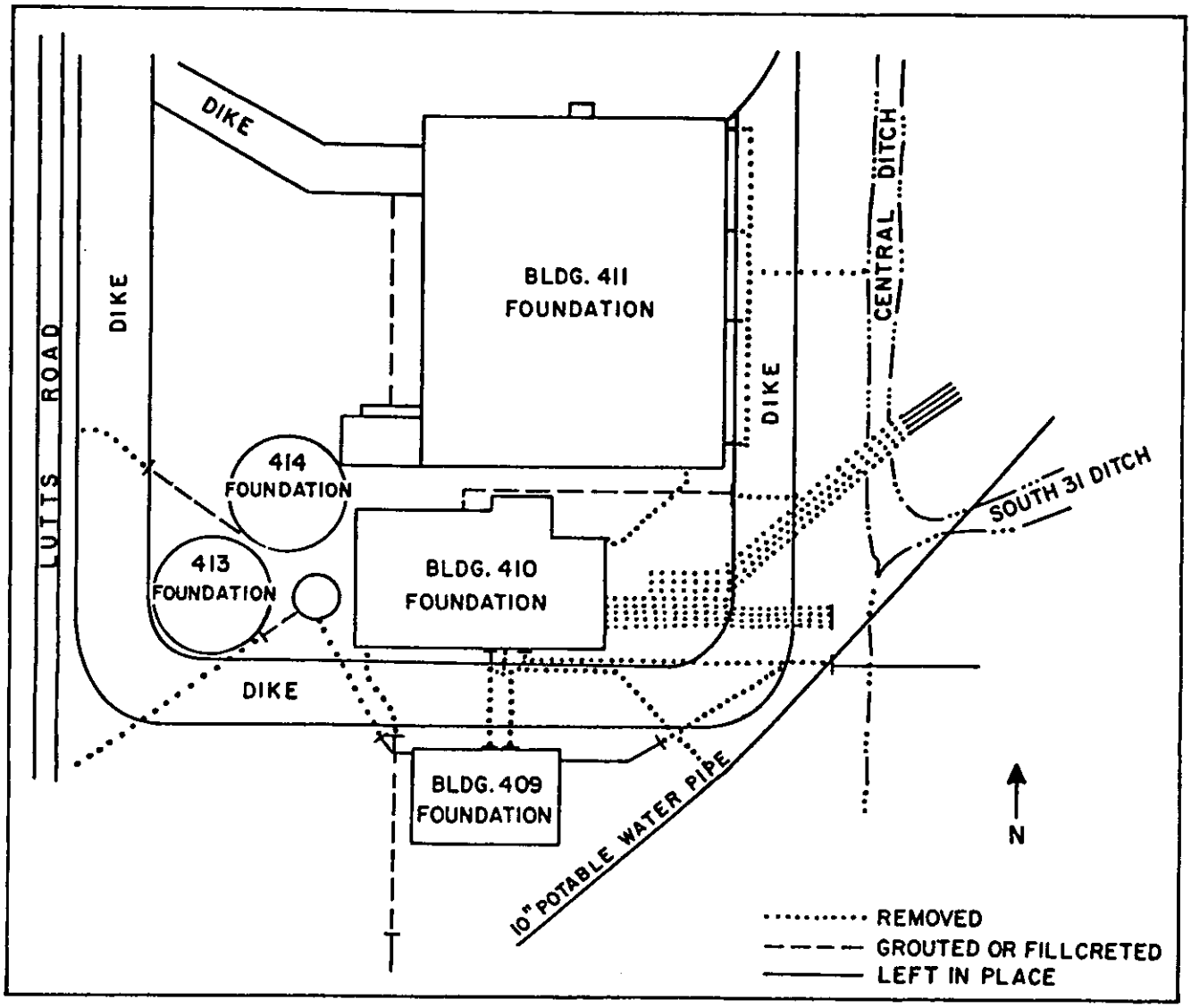

Figure 3.4. Location and Fate of Underground Pipes at NFSS. Adapted from drawing of Bechtel National, Inc. (Drawing No. 15-DD19-C-03).

unconsolidated deposits and by upward migration of water from the Queenston Formation. Water in this aquifer flows towards the northwest and discharges into Lake Ontario, the Niagara River, and local streams and drainage ditches. The average permeability in this aquifer is 1.3×10^{-3} cm/s (Wehran Eng. Corp. 1979), and the groundwater gradient across NFSS is 0.001 (Acres American 1981).

The major zone of groundwater movement is in the weathered and fractured zone (bedrock aquifer) in the upper portion of the Queenston Formation. Where the red till is absent, this aquifer is connected with the lower soil aquifer. At NFSS, the groundwater gradient of the bedrock aquifer is 0.001 (Acres American 1981). Well yields from this aquifer are typically less than 0.0004 m^3/s (7 gpm). Well yields of less than 0.00006 m^3/s (1 gpm) are estimated for the lower unweathered sections of the Queenston Formation (Johnston 1964).

The groundwater from all aquifers underlying NFSS is of low quality for drinking water (Acres American 1981). Groundwater from the Queenston aquifer is less alkaline than that from the upper aquifers. It is also more highly mineralized with higher concentrations of sulfate, chloride, calcium, sodium, iron, and magnesium (Johnston 1964). Trace concentrations of lead, barium, nickel, copper, chromium, cobalt, selenium, and zirconium have been detected in water samples collected by Battelle Columbus Laboratory from periphery wells on the west side of NFSS and from the waste containment area (Anderson et al. 1981). Details of water quality sampling performed in July 1981 can be found in a report by Acres American (1981). (Discussion of background groundwater quality relative to potential increases associated with burial of the NFSS wastes and residues is given in Section 4.4).

Groundwater is used to supply approximately 10% of the population of Niagara and Erie counties, primarily for small domestic and farm supplies in rural sections. Most of this water is obtained from the Lockport Dolomite aquifer, which is absent north of the Escarpment at NFSS. At NFSS, only very small supplies can be obtained from the Queenston shale (Johnston 1964; Erie Niagara Co. Reg. Plan. Board 1978b). Groundwater supplies at NFSS are generally of low yield and poor quality. Only the Middleport area (eastern Niagara County) is dependent on groundwater for municipal water (Erie Niagara Co. Reg. Plan. Board 1978b). The upper aquifers in the glacial deposits near NFSS are sometimes capable of supplying adequate groundwater for domestic uses, although these supplies may be depleted during dry seasons.

The results from monitoring several wells located around the containment area are presented in annual monitoring reports (U.S. Dep. Energy 1983c, 1983d, 1984).

3.1.3 Climate and Meteorology

Niagara County has a humid, continental climate that is moderated by Lakes Erie and Ontario. Average annual precipitation is 83 cm (33 in.), which is fairly evenly distributed throughout the year. Approximately 140 cm (56 in.) of snow falls, primarily between November and March (Acres American 1981). The wind is predominantly from the southwest.

3.1.4 Ecology

Western New York is considered to be within the distribution of the beech-maple forest association (VanKat 1979), but the nature of NFSS soils--i.e., deep, very poorly drained, and poorly aerated (Higgins et al. 1972)--suggests that, prior to agricultural development in the 1800s, the vegetation of the site was likely a red maple-white oak forest type adapted to these wet conditions (Braun 1972; Garrison et al. 1977). This is further supported by the predominance of maple, ash, and oak in the canopy of wooded areas of the site.

The native and agricultural ecosystems of NFSS were completely destroyed by U.S. Army construction activities during the early 1940s (Anderson et al. 1981). Since the mid-1940s, most of the site has been untended until recent interim remedial actions. As part of these cleanup activities, about two-thirds of the NFSS has now been cleared of vegetation. Prior to the interim remedial actions, two other terrestrial plant communities occurred at NFSS: a northern shrub community and a pasture-grass community (Anderson et al. 1981). It is likely that these communities were actually old-field communities in the later stages of old-field succession (Mellinger and McNaughton 1975).

The forest, shrub, and pasture grass communities provided habitat for a variety of wildlife. Although no quantitative wildlife surveys have been conducted on the site, mammals that have been observed on NFSS (Anderson et al. 1981) and that are common to Niagara County are typical of those encountered in forested and shrub-dominated areas. Surveys of bird populations on and in the vicinity of NFSS indicate that at least 60 species breed or are thought to breed in the area. No information concerning amphibians and reptiles of the NFSS is available, but it is expected that species characteristic of the forests and agricultural communities of the area (Shelford 1974) are present.

No species designated as threatened or endangered under state or federal law are known to occur in the immediate vicinity of NFSS. However, the site is located within the distribution of a number of species considered endangered under the federal Endangered Species Act (Pub. L. 93-205). Among these are the bald eagle, American peregrine falcon, and Indiana bat (U.S. Fish Wildl. Serv. 1980). The arctic falcon is thought to migrate through the state of New York but does not nest there. The local office of the U.S. Fish and Wildlife Service had no comments on the NFSS alternatives relative to endangered species (Hamilton 1983).

Aquatic biota are restricted to the drainageways that carry surface runoff from the site (Figure 3.3). The plant communities of the largest ditches (central ditch, west ditch, and South-31 ditch) were dominated by cattails and various marsh grasses (Anderson et al. 1981) prior to the excavation of radioactively contaminated sediments as part of interim remedial actions. Although the interim actions completely destroyed the cattail-marsh grass community, it is likely that this community will become reestablished in these drainageways within a few years.

Little is known of the biota of Fourmile Creek. It has been reported that the creek supports a limited spring migration for salmonids such as coho salmon and rainbow trout (Erie Niagara Co. Reg. Plan. Board 1978a). The creek also supports spawning populations of northern pike and a variety of panfish. Fourmile Creek is also regularly stocked with chinook salmon by the New York State Department of Environmental Conservation (1981).

3.1.5 Land Use

The NFSS is currently enclosed by a fence and is used only for storage of radioactive residues and wastes. Most of the site is zoned "I-2, Industrial, no houses permitted" with the exception of the northwest portion of the site which is zoned "I-1 Industrial, houses permitted".

Land uses immediately adjacent to the site are varied. A hazardous waste disposal facility operated by SCA Chemical Waste Services is located north and east of the site. A sanitary landfill operated by Modern Disposal, Inc., is adjacent to the east side of NFSS. South of the site is federal government property controlled by the General Services Administration, which is used for training construction equipment operators. There is also a sanitary landfill south of the site, which is owned by the town of Lewiston. West of the facility is a Niagara Mohawk Power Corporation transmission line corridor. Property west of the site is privately owned. All these properties are located on land that was once part of the original Manhattan Engineering District site (Figure 3.5).

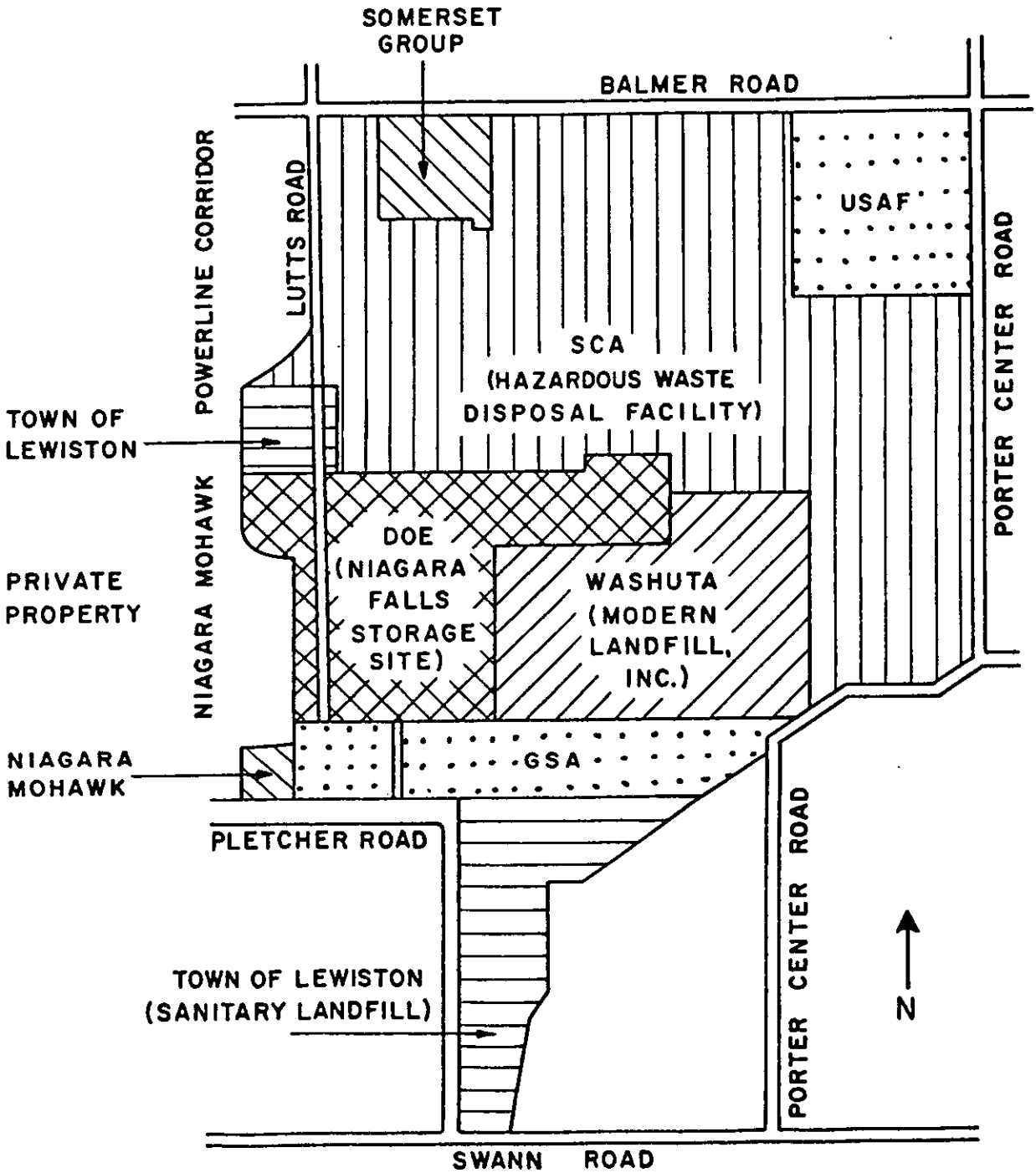

Figure 3.5. Current Ownership of the Original Manhattan Engineer District Site at the Lake Ontario Ordnance Works.

Relative to the waste containment area, the nearest permanent residence is 1.1 km (0.7 mi) southwest, there is a trailer park 2.6 km (1.6 mi) northwest on Balmer Road, the Lewiston-Porter Central Schools are located approximately 2.4 km (1.5 m) west on Blairville/Creek Road, and SCA Chemical Waste Services personnel work outdoors 1.2 km (0.7 mi) to the north. During the summer, there are campers at the KOA campground 0.7 km (0.4 mi) southwest on Pletcher Road. Hunters occasionally use the area west of the Niagara Mohawk corridor. There are several residences along Pletcher and Creek roads.

Land uses within the towns (townships) of Lewiston and Porter are predominantly rural and include row-crop agriculture, orchards, recreational areas, old abandoned fields, and second-growth forests. Limited population growth in the area is projected, and the area is expected to remain rural through the year 2000 (Table 3.1). A recreational area, Fourmile Creek State Park, is located at the confluence of Fourmile Creek and Lake Ontario, about 3 km (2 mi) downstream from the central drainage ditch (Figure 3.2).

Table 3.1. Existing (1975) and Projected (2000) Land Uses for the Towns (Townships) of Lewiston and Porter and for Niagara County†[1]

		Percent of Land Area						
Location	Status of Land Use	Residential	Commercial/ Public/ Semipublic	Industrial	Forest/Brush/ Outdoor Recreation/ Vacant	Agriculture	Water/ Wetland	Transportation
Town of Lewiston (10,000 ha)	Existing	7.7	6.2	1.0	32	44	7.7	1.4
	Projected	8.0	6.5	1.0	32	43	7.7	1.4
Town of Porter (8,500 ha)	Existing	4.1	4.6	1.5	26	62	0.3	1.6
	Projected	4.2	4.8	1.5	26	62	0.4	1.6
Niagara County (140,000 ha)	Existing	6.4	2.1	1.7	20	65	3.5	0.9
	Projected	6.6	2.2	1.8	20	65	3.6	0.9

†[1] All values rounded to two significant figures.

Data from Interstate Commerce Commission (1981).

3.1.6 Population and Socioeconomics

3.1.6.1 Population

The primary areas of population near NFSS are the towns of Lewiston, Porter, Niagara, and Niagara Falls City--all in Niagara County. From 1970 to 1980, there was a small percent decline in population in Niagara County and the town of Porter, a small percent increase in the town of Lewiston (Mathiason 1981), and somewhat larger population changes in the town of Niagara (+15%) and in Niagara Falls City (-17%) (see Table 3.2). From the available data, it appears that Niagara County and its bordering counties (Erie, Genesee, and Orleans) have been experiencing similar patterns of population change since 1960 (U.S. Bur. Census 1977).

Almost three-quarters of the population of Niagara County live in urban areas. Population density in Niagara County in 1980 was about 170 persons/km^2 (430 persons/mi^2) (U.S. Bur. Census 1982). The populations located within a 16-km (10-mi) and an 80-km (50-mi) radius of NFSS are estimated at 1,400,000 and 3,800,000, respectively, including populations of both the United States and Canada. The U.S. 1980 census data were supplied by Urban Decision Systems (1983). The Canadian population is based on population density data supplied by Statistics Canada Ottawa (1983).

3.1.6.2 Economy

The current economic situation in Niagara County and its municipalities is similar to that of nearby areas and the nation as a whole. Although the population of Niagara County declined 6.3% between 1959 and 1979, total employment declined only 0.9% over the same time period (Econ. Consult. Organ. 1982). This disparity reflects the national trend toward increased female labor force participation rates and a strengthening of the service and retail trades (N.Y. State Dep. Labor 1982).

Table 3.2. Population and Percent Population Change in Niagara County and Selected Municipalities, 1970-1980

Location	1970	1980	Percent Change
Niagara County	236,000	227,000	-4
Town of Lewiston	15,900	16,200	+2
Town of Porter	7,430	7,250	-2
Town of Niagara	8,370	9,650	+15
Niagara Falls City	85,600	71,400	-17

Source: Mathiason (1981).

Niagara County experienced a slightly higher rate of unemployment in 1981 (9.9%) in comparison to the United States as a whole (7.6%) because a disproportionate number of industries in local areas were particularly hard hit by the recession (N.Y. State Dep. Labor 1982--p. 11-24). Although few data are available to quantify Niagara County's dependence on the tourist industry, nearby Niagara Falls (12 km [7.5 mi]) is an international tourist attraction and there are many tourist-related businesses in the area.

3.1.6.3 Public Facilities

There are 16 police and 29 fire stations scattered throughout Niagara County, most of which are full-time protection units. Six major hospitals are located within 26 km (16 mi) of the site, the closest of which is 8 km (5 mi) away. Additionally, there are 11 schools within 2.4 to 11 km (1.5 to 7 mi) of NFSS, with a combined school enrollment in 1982 of about 22,000 students (Brado 1982). The Lewiston-Porter Central Schools are closest to NFSS (within 2.4 km) and have a combined enrollment of just over 3000 students.

There are several parks and recreational areas near the site. Of the 10 parks in the area, 6 are state-owned, 1 is owned by Niagara County, and 3 are municipal parks. Historic sites located near NFSS include the Frontier House (6.4 km SW), Lewiston Mound (6.4 km SW), Lewiston Portage Landing (7.2 km SW), and Old Fort Niagara (7.2 km NW) (Erie Niagara Co. Reg. Plan. Board 1978a). Two primary attractions, the Our Lady of Fatima Shrine and the Lutz Century Farm, are located within 3.2 km (2 mi) of the site. None of these sites is located along the roads that will be used to transport the NFSS wastes and residues to other sites.

Major highway transportation routes near the site are State Route 93 to the north, U.S. Route 104 to the south, and the Robert Moses Parkway and State Route 18 (Blairville/Creek Road) to the west (Figures 1.1 and 3.2). The region is served by Consolidated Rail and the Norfolk & Southern Railroad (see Appendix D).

The 1981 traffic count data on an hourly and yearly basis along key sections of the transportation routes that could be used to transport NFSS wastes to other sites are listed in Table 3.3. The local route to the interstate highway system (Section 3.5.1) is in a semirural area. Several private residences are located along the route.

3.1.7 Radiological Characterization of NFSS Residues and Wastes

The radiological baseline for analysis of all alternatives in this EIS is the condition of NFSS that is projected to exist upon completion of the scheduled interim remedial actions in 1985 (U.S. Dep. Energy 1982a, 1982b, 1983a, 1983b). For purposes of analysis in this EIS, the contaminated materials at NFSS have been divided into two groups: (1) residues (from processing of uranium ores) and (2) wastes (mostly soils). Upon completion of interim actions, all residues and wastes will be consolidated within a 3.4-ha (8.5-acre) diked area in the southwest corner of NFSS (Figure 1.2). This area will contain about 190,000 m^3 (250,000 yd^3) of contaminated materials (Table 3.4) having an average radium-226 concentration of 3,800 pCi/g (Table 3.5). The area will be surrounded by a dike and subsurface clay cutoff wall and will be capped with 0.9 m (3 ft) of clay, 0.15 m (0.5 ft) of sand, and 0.45 m (1.5 ft) of soil. (The depths of the various materials and cover layers are presented in Figure 4.3.)

3.1.7.1 Residues

For purposes of analysis in this EIS, the residues consist of the K-65 residues, the combined L-30 and F-32 residues, and the L-50 residues for a total of 11,000 m^3 (15,000 yd^3) (Table 3.4). The

Table 3.3. 1981 Traffic Count Data Along Sections of Potential Local Transportation Routes

Route No. or Name	Section Length (km)	Section Description		Count Year	Estimated for Count Year†[1]	
		From	To		AADT	DH
Balmer Road†[2]	6.1	1800 ft west of Dickersonville Road	Rt. 18	1982	530	
18†[3]	2.7	CR 86, Blairville Road	Pletcher Road	1981	3,400	210
18	1.2	Pletcher Road	CR 9, Swann Road	1978	3,300	200
18	2.8	CR 9, Swann Road	Rt. 104, Ridge Road	1981	3,550	260
104	1.1	Rt. 18	Acc. Rbt. Moses Pkwy, Rt. 18F	1979	4,800	310
104	0.5	Acc. Rbt. Moses Pkwy, Rt. 18F	Rt. 18	1979	9,700	710
104	1.2	Rt. 18	Rt. 265, Military Road	1979	14,200	1,040

†[1] AADT = Annual Average Daily Traffic; DH = Design Hourly Volume (30th highest hourly traffic volume in one direction).

†[2] Data from Wilson (1982).

†[3] These and all remaining data from New York State Department of Transportation (1982).

residues formerly belonged to Afrimet-Indussa, an American firm incorporated in the state of New York and controlled by Union Miniere, a Belgian firm. As a result of a recent international agreement (Section 1), the residues now belong to the U.S. government and are the responsibility of DOE. Upon completion of interim actions, most of the residues (K-65 and combined L-30/F-32) will be stored in Building 411 within the diked area (Figure 1.2). The L-50 residues are stored in Buildings 413 and 414. The residues account for less than 6% of the total volume of contaminated materials at NFSS but contain 871 Ci of radium-226, or almost 99% of the NFSS radium-226 inventory. The average radium-226 concentration of these residues is 67,000 pCi/g (Table 3.5).

K-65 Residues. The K-65 residues (stored in the bottom of Building 411 as of completion of interim remedial actions in 1985) resulted from the processing of high-grade African pitchblende ore containing 40-50% uranium oxide (Anderson et al. 1981). Most of the uranium was removed, and the radium was precipitated as radium sulfate in the residues. Several metal hydroxides (iron, aluminum, manganese) and other impurities such as precious metals (Anderson et al. 1981) were also precipitated. Some precious metals (e.g., gold, platinum, palladium, silver) were extracted from some shipments of the ore prior to processing for uranium.

The K-65 residues exist as a wet clay containing about 30% water. Two distinct types of materials are present within the residues: 73% is characterized as "slimes" (particle size <37 μm) containing recrystallized compounds including radium-contaminated barium sulfate (Table 3.6), and the remainder is sand (particle size >37 μm). Most of the radium (average radium-226 concentration of 220,000 pCi/g) is found in the "slimes" fraction. Based on a gamma-ray spectral analysis of the K-65 residues (Anderson et al. 1981), it appears that lead-214, bismuth-214, and lead-210 are in secular equilibrium (see Glossary) with the parent radionuclide, radium-226. No information is available regarding the thorium-230 (parent radionuclide of radium-226) content of the residues, and it is thus assumed that the radium-226 and thorium-230 were in secular equilibrium in the pitchblende ore and that only the uranium was removed during processing. Therefore, because of thorium-230 decay, the radium-226 concentrations will remain approximately the same throughout the 1000-year period during which impacts are analyzed in this EIS (Section 4). Anderson et al. (1981) estimated the uranium-238 concentrations in these residues to be between 470 to 650 pCi/g (140 to 1965 ppm). The residues contain small amounts of other radionuclides resulting from decay of the small amount of uranium-235 (Anderson et al. 1981).

L-30 Residues. The L-30 residues (stored in Building 411 as of completion of interim remedial actions in 1985) resulted from the extraction of uranium from low-grade pitchblende containing about 10% uranium oxide. Based on a gamma-ray spectral analysis of the L-30 residues, it appears that uranium-238 concentrations vary greatly, ranging from 280 to 1660 pCi/g (830 to 5000 ppm) (Anderson et al. 1981). The average radium-226 concentration is about 12,000 pCi/g (Table 3.5), and it appears that the daughters of radium-226 are in equilibrium with the parent radionuclide.

Table 3.4. Estimated Volumes of Contaminated Materials at NFSS as of Completion of Interim Remedial Actions in 1985

I. Residues			II. Wastes					
			A. Contaminated Soils, R-10 Residues, etc.			B. Contaminated Portions of Containment System		
	Volume†[1]			Volume†[1]			Volume†[1]	
Description	m^3	yd^3	Description	m^3	yd^3	Description	m^3	yd^3
K-65	3,000	4,000	R-10 area, 1972 cleanup above ground†[2]	11,500	15,000	413/414 covers (over L-50 residues)	750	1,000
L-30/F-32†[3]	6,500	8,500						
L-50	1,500	2,000	R-10 area, 1980, below ground†[4]	26,500	35,000	1/5 N dike†[6]	3,000	4,000
			N dike area, 1982 add'l†[5]	12,000	15,500	1/5 S dike†[6]	750	1,000
						S dike backfill†[8]	7,000	9,000
			N dike area, 1983-1985 add'l†[7]	30,500	40,000	1/5 interim cap over N + S diked areas†[10]	10,500	14,000
			Bldg. 411 cover†[7]	9,000	11,500			
			N + S dike area (remaining bottom)†[9]	10,000	13,000			
			S dike area buildings and rubble	9,000	11,500			
			S dike area, add'l from other vicinity properties†[8]	14,000	18,000			
Subtotal	11,000	14,500		122,500	159,500		22,000	29,000
20% Contingency	NA	NA		24,500	32,000		4,500	6,000
			Middlesex sands (residues)	Neglig.	Neglig.			
			R-10 residues	7,000	9,500			
TOTAL	11,000	14,500		154,000	201,000		26,500	35,000

GRAND TOTAL†[1] = 190,000 m^3 (250,000 yd^3)

†[1] Rounded to nearest 500 m^3 (500 yd^3); grand total rounded to two significant figures. During the interim remedial actions, the volumes of residues were found to be less than the estimates used in the analyses in this EIS.

†[2] About 11,500 m^3 (15,000 yd^3) of contaminated soils were placed in the R-10 area during a 1972 remedial action. Analysis of the data for core samples taken in 1980 (Anderson et al. 1981) generally confirms this amount. Based on the Anderson data and an engineering drawing of the R-10 area prior to commencement of interim remedial actions in 1982, there were about 18,500 m^3 (24,000 yd^3) of contaminated soils and residues (with radium-226 concentrations greater than 15 pCi/g) above the original grade in the R-10 area (covering about 1.6 hectares or 4 acres). Subtracting the 7,000 m^3 (9,500 yd^3) of R-10 residues, there were about 11,000 m^3 (14,500 yd^3) of contaminated soils above ground.

†[3] The L-30 and F-32 residues have been combined during the interim remedial actions.

†[4] Based on the core samples taken in 1980 (Anderson et al. 1981) and the abovementioned drawing, there was an estimated 26,500 m^3 (35,000 yd^3) of contaminated soils (greater than 15 pCi/g radium-226) below the original grade. It was conservatively assumed that the 15 pCi/g contaminated contour approached the shape of an upside-down wedding cake. The greatest depth of contamination was 3.75 m (12.5 ft). For alternatives involving removal of NFSS wastes, it is also assumed that after excavation of these contaminated soils, the area would be backfilled with clean soil materials such that the top 15 cm (6 in.) would not exceed radium concentrations of 5.0 pCi/g.

†[5] It is assumed that the portion with radium-226 concentrations between 5 and 15 pCi/g could not be practicably separated from the portion with concentrations greater than 15 pCi/g.

†[6] It is assumed that it would be practicable to selectively remove about 0.6 m (2 ft) of clay material from the insides of the dikes as contaminated material for shipment offsite. It is also assumed that any decision to remove such materials would be within the next few years such that radionuclides from contaminated materials stored within the diked areas would not have had sufficient time to migrate through the clay dikes more than 0.6 m (2 ft).

†[7] Of the estimated 39,400 m^3 (51,500 yd^3) of contaminated materials to be cleaned up both onsite and offsite during the 1983-1985 interim remedial actions, about 30,600 m^3 (40,000 yd^3) would be placed in the north dike area and 8,800 m^3 (11,500 yd^3) would be placed over the dewatered residues in Bldg. 411.

†[8] There are several properties in the vicinity of NFSS that were recently surveyed to determine if contaminated materials occur in sufficient concentrations to necessitate removal of these materials and placement within the diked areas at NFSS. Such cleanup will be part of the ongoing interim remedial actions, the completion of which is assumed to be the base case under the no-action alternative for this EIS. In addition to the space occupied by the buildings, rubble, and residues within the south diked area, there is an additional volume of 20,600 m^3 (27,000 yd^3) that could be filled with any materials from these vicinity properties, supplemented with uncontaminated (clean) fill material, as necessary, to provide a base for the interim cap over the entire diked area. Estimates for respective amounts of contaminated and clean fill materials will not be available until radiological survey reports have been finalized, the need for interim remedial action established, and preliminary engineering studies made. For purposes of analysis in this EIS, it is therefore assumed that 13,800 m^3 (18,000 yd^3) will be slightly contaminated vicinity-property materials and 6,900 m^3 (9,000 yd^3) will be clean fill and that all of this material would have to be treated as contaminated for removal under the offsite alternatives.

†[9] 3.4 hectares minus 1.6 hectares (1980 R-10 pile area) minus 0.2 hectares (dikes) = 1.6 hectares. 1.6 hectares × 0.6-meter deep (assumed average depth of contamination) = 10,000 m^3 [8.5 acres minus 4 acres (1980 R-10 pile area) minus 0.5 acre (dikes) = 4 acres. 4 acres × 2-feet deep (assumed average depth of contamination) = 13,000 yd^3].

†[10] 3.4 hectares × 0.3 m (assume top 1.2 meters can be removed as uncontaminated materials = 10,500 m^3 [8.5 acres × 1 foot (assume top 4 feet can be removed as uncontaminated materials) = 14,000 yd^3].

Table 3.5. Estimated Radium-226 Inventory in Contaminated Materials at NFSS as of Completion of Interim Remedial Actions in 1985

Description	Volume†[1] (m^3)	Density Dry†[2] (kg/m^3)	Density Damp†[3] (kg/m^3)	Average Conc. (dry wt.)†[4] of Ra-226 (pCi/g)	Ra-226 Inventory (Ci)
Residues					
K-65 residues	3,000	1,150†[5]	1,800	220,000†[6]	775†[7]
L-30 residues†[8]	6,000	1,240†[5]	1,800	12,000†[6]	90†[7]
F-32 residues†[8]	500	1,180†[5]	1,800	300†[6]	0.1†[7]
L-50 residues	1,500	1,050†[5]	1,800	3,300†[6]	6†[7]
SUBTOTAL	11,000	--	--	67,000	871
Wastes†[9]					
R-10 area 1980, incl. R-10 residues	45,000	1,200†[10]	1,800	95†[6]	5.2†[11]
Remaining contaminated soils, etc.	83,500	1,200†[10]	1,800		
Contaminated portions of containment system	22,000	1,200†[10]	1,800	16†[12]	2.6†[12]
20% contingency on non-residue materials	29,000	1,200†[10]	1,800		
SUBTOTAL	179,000	--	--	36	7.8
GRAND TOTAL	190,000	--	--	3,800	879

	% of Total Volume	% of Total Ra-226 Inventory
K-65 residues	1.5	88
L-30/F-32 residues	3.4	10
L-50	0.8	0.7
TOTAL	5.8	99

†[1] Rounded to nearest 500 m^3. Grand totals rounded to two significant figures. During the interim remedial actions, the volumes of residues were found to be less than the estimates used in the analyses in this EIS.

†[2] Based on volumes and dry weights reported in Anderson et al. (1981). Approximately equal to density of dry clay as reported in Peele and Church (1941). The NFSS residues are expected to be similar to clays as they are composed primarily of particles smaller than 37 μm (Litz 1974).

†[3] Considering the particle-size distribution for the residues (Litz 1974) and the nature of the contaminated soils that comprise most of the wastes, it is expected that the damp residues and wastes will both have densities similar to wet clay (Peele and Church 1941) upon completion of interim remedial actions.

†[4] Damp weight concentrations (condition of residues and wastes as stored in the dikes area at NFSS upon completion of remedial actions) will be less. To obtain damp weight concentrations, multiply dry weight concentrations by a factor of 1.2 ÷ 1.8, or 0.67.

†[5] Densities based on weights and volumes as reported in Table 3-1 of Anderson et al. (1981). Assumed to be dry weights since the calculated densities roughtly correspond to the density of dry clay (1200 kg/m^3) as reported in Peele and Church (1941).

†[6] Geometric mean of data given in Anderson et al. (1981).

†[7] Estimated inventory based on dry weights times estimated average concentrations as reported in Anderson et al. (1981).

†[8] The L-30 and F-32 residues have been combined during the interim remedial actions.

†[9] Volumes of wastes taken from Table 3.4.

†[10] Assumed density of dry clays (Peele and Church 1941); about the same as dry densities of residues.

†[11] Estimated inventory based on average concentration (dry weight) × volume × dry density.

†[12] No data available. Because most of the soil materials cleaned up during the 1982-1985 remedial actions were contaminated as a result of erosion of the original R-10 residues, it is assumed that the total radium-226 inventory of these materials is no greater than half of the 1980 R-10 pile inventory, or about 2.6 Ci. The average concentration of the 134,500 m^3 is therefore 16 pCi/g.

Table 3.6. Physical Characteristics of NFSS Residues and Wastes

	Volume (m^3)	Percent of Particle Size (μm)†[1]						
		>840	840-240	240-150	150-74	74-44	44-37	<37
I. Residues								
K-65	3,000	4.1	9.5	1.8	5.2	4.0	2.3	73.1
L-30/F-32	6,500	17.1	7.0	1.9	5.4	3.8	5	59.7
L-50	1,500	17.1	7.0	1.9	5.4	3.8	5	59.7

	Volume (m^3)	Percent of Particle Size (μm)†[2]		
		>20 (sands)	20-2 (silts)	<2 (clays)
II. Wastes				
Primarily soils	180,000	37	26	37

†[1] Data from Litz (1974).

†[2] Assumed particle-size distribution based on characterization of NFSS contaminated wastes as primarily clayey soils.

F-32 Residues. The relatively small amount of F-32 residues (combined with the L-30 residues in Building 411 as part of the interim remedial actions) also resulted from the extraction of uranium from African pitchblende ore. Although no spectrographic analysis appears to have been carried out for these residues, inventory data suggest that the uranium-238 concentration is 1300-2200 pCi/g (4000-6500 ppm) and the radium-226 concentration is about 300 pCi/g (Anderson et al. 1981).

L-50 Residues. The L-50 residues (stored in Buildings 413 and 414) are the by-product of treatment of African pitchblende ores containing approximately 7% uranium oxide. Uranium-238 concentrations range from 330 to 700 pCi/g, and the radium-226 concentration is about 3300 pCi/g (Anderson et al. 1981).

3.1.7.2 Wastes

For purposes of analysis in this EIS, the "wastes" consist of all contaminated materials not defined as residues. The wastes total about 180,000 m^3 and have an average radium-226 concentration of 36 pCi/g (Table 3.5). The wastes consist of two groups of materials: (1) the R-10 pile in 1980 and (2) the remaining wastes and contaminated portions of the containment system.

R-10 Pile in 1980. In 1980, the R-10 pile consisted of one large continuous pile of contaminated soils and what had originally been the U.S. government-owned R-10 residues. The R-10 residues resulted from the processing of a pitchblende ore containing about 3.5% uranium oxide. In 1946, about 7,000 m^3 of these residues were placed on the ground north of Building 411. The wind and rain gradually eroded these residues into the ditches and other portions of the site. Radionuclides were also leached into the ground underneath the pile. In 1972, some of the nearby soils contaminated by wind and water erosion from the pile were cleaned up and placed on top of the pile. Based on reanalysis of survey data obtained by Anderson et al. (1981), the R-10 pile in 1980 (above and below ground) contained approximately 45,000 m^3 of contaminated materials having radium-226 concentrations greater than 15 pCi/g (11,500 m^3 from 1972 cleanup, 26,500 m^3 below ground, and 7,000 m^3 of the original residues). The average uranium-238 concentration in 1980 was 1.7 pCi/g and the average radium-226 concentration was 95 pCi/g (Table 3.5).

Remaining Wastes and Contaminated Portions of Containment System. Since 1980, contaminated soils and sediments have been added to the diked area around the R-10 pile. These wastes resulted from cleanup of onsite and offsite areas under the interim remedial actions. Portions of the containment system (dikes, cover, underlying soils) will be contaminated as a result of being in contact with the contaminated wastes (Tables 3.4 and 3.5). In addition, experience thus far during the interim remedial actions indicates that additional soils and cover materials (20% contingency) will probably have to be treated as contaminated under alternatives involving removal of the wastes to another location. The total amount of remaining wastes and contaminated portions of the containment system is therefore estimated to be 134,000 m^3.

Because most of the remaining wastes and contaminated portions of the containment system were contaminated as a result of erosion and leaching from the R-10 pile, it is assumed that the total

radium-226 inventory of these materials is no greater than half the inventory in the 1980 R-10 pile, or about 2.6 Ci. The average radium-226 concentration of these materials is therefore about 16 pCi/g (Table 3.5).

3.1.8 Nonradiological Characteristics of NFSS Residues and Wastes

3.1.8.1 Residues

Concentrations of nonradiological elements in the residues are given in Table 3.7. The K-65 residues have much less cobalt, nickel, and copper and more rare earths, palladium, molybdenum, and lead than do the other residues. The L-30 residues have more uranium. All the residues have a small amount of gold, platinum, and the other noble metals. It should be noted that broad ranges of concentrations have been reported for lead and uranium in the K-65 residues and for uranium, iron, copper, and nickel in the L-30 residues. These differences are thought to result from the heterogeneity of the residues rather than from uncertainties in experimental sampling techniques.

3.1.8.2 Wastes

The NFSS wastes are neutral to slightly basic. The elemental composition of portions of the 180,000 m^3 of wastes is given in Table 3.8. The range of concentrations represent samples from different locations. Weighted average concentrations for the entire 180,000 m^3 are also shown in Table 3.8. Because most of the wastes are contaminated native soils, the ranges of concentrations occurring in uncontaminated soils (worldwide) are also given for comparison.

In 1980, one or more locations in the R-10 pile had concentrations of cobalt, nickel, copper, lead, and uranium that appear to be in excess of naturally occurring concentrations. In the central ditch sediments, fluorine, cobalt, nickel, barium, and uranium appear to be in excess of natural concentrations (Table 3.8).

There are also organic chemicals in the NFSS wastes. During the interim remedial actions, the central ditch north of NFSS was excavated and radioactively contaminated sediments were placed in the diked containment area at NFSS. Some of the ditch sediments were contaminated with organic pesticides and other organic compounds (Haywood 1983; Urbanczyk 1983). Characterization of the organic contamination is limited because only nine samples were analyzed and, for some of the samples, the analyses were not sensitive (high upper limits were reported). For analysis in this EIS, it is assumed that these organically contaminated wastes comprise 2% of the total NFSS wastes.* Estimated concentrations of organic chemicals are presented in Table 3.9.

3.2 HANFORD

The Hanford Reservation** is a large, federally owned site of approximately 1500 km^2 (570 mi^2) operated by DOE. It has not been open to the general public since 1943. Except for a few hectares occupied by energy facilities, the Hanford Reservation has been designated as a National Environmental Research Park (U.S. Nucl. Reg. Comm. 1981) and is available for environmental research that is compatible with DOE activities at Hanford.

The Hanford Reservation is divided into five major subareas: (1) the 100 Area, which borders on the Columbia River in the northern section of the Reservation and is the area where plutonium production reactors were constructed, (2) the 200 Area, which is located in the central area of the Reservation and is the area where the nuclear fuel, waste processing, and waste storage facilities are located, (3) the 300 Area, which is located near the town of Richland and is the area where the research and development laboratories and the Fuel Fabrication Facility are located, (4) the 400 Area, which is located north of the 300 area and is the site of the Fast Flux Test Reactor, and (5) other areas that are not designated under the 100, 200, 300, or 400 areas and are considered to be part of the 600 area (U.S. Energy Res. Dev. Admin. 1975). The northwest corner of the 200-West area (designated as the 218W5 area) is the alternative site used for purposes of analysis in this EIS.*** A map of

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*This amounts to 3600 m^3, which is a conservatively high estimate based on the amount of material excavated from the ditches.

**The name of the "Hanford Reservation" has recently been changed to the "Hanford Site." However, the older, more familiar name is used throughout this EIS to distinguish the large Reservation from the small specific site within the Reservation that is assumed for disposal of the NFSS wastes and residues.

***Analysis of alternative sites within the DOE Hanford Reservation is beyond the scope of this EIS (Appendix G). The DOE Richland Operations Office has identified the 218W5 area as being a site that is reasonable to assume for purposes of analysis and comparison of alternatives in this EIS. It is an extension of a large area that is being used for disposal of wastes generated on the Hanford Reservation, and it is potentially available for management of the NFSS wastes and residues. Site-specific information is available for this site.

Table 3.7. Concentrations of Nonradiological Elements in the NFSS Residues†[1],†[2]

	Concentration (ppm)						
	K-65		L-30†[3]		L-50		Weighted
Element	Average	Range	Average	Range	Average	Range	Average†[4]
Arsenic	5	--	27	15-50	31	20-50	2
Barium	30,000	--	6,100	1,900-20,000	20,000	--	15,000
Boron	300	--	140	100-200	100	--	172
Cadmium	<5	--	<1	--	<1	--	2.1
Cerium	2,000	--	1,200	1,000-1,500	240	200-300	1,200
Cesium	1	--	1.4	1-2	0.71	0.5-1	1.2
Chromium	100	--	244	200-300	140	100-200	180
Cobalt	2,000	--	5,100	2,600-10,000	7,700	5,900-10,000	4,700
Copper	500	--	2,300	1,100-5,000	2,400	2,000-3,000	1,800
Fluorine	30	--	39	30-50	50	--	37
Gold	0.2	--	0.37	<0.2-0.7	<0.2	--	0.28
Iodine	1	--	0.35	0.3-1	0.55	0.3-1	0.68
Iron	5,000	--	26,000	10,000-66,000	20,000	--	19,000
Lanthanum	2,000	--	1,000	--	220	100-500	1,100
Lead	56,000	33,000-95,000	13,000	7,500-23,500	4,900	3,200-7,600	23,000
Lithium	100	--	200	--	200	--	170
Manganese	100	--	31,000	20,000-50,000	71,000	50,000-100,000	30,000
Molybdenum	10,000	--	860	500-1,500	300	--	3,300
Mercury	0.5	--	0.3	--	0.5	--	0.5
Neodymium	1,000	--	160	50-500	100	--	390
Nickel	3,000	--	17,000	6,200-50,000	24,000	20,000-30,000	14,000
Niobium	50	--	24	20-30	14	10-20	30
Palladium	20	--	3.5	2-6.2	2.4	2-3	8
Platinum	<0.5	--	0.32	0.2-<0.5	<0.5	--	0.41
Praesodymium	2,000	--	55	20-150	24	20-30	590
Selenium	100	--	50	--	39	30-50	62
Silver	<3	--	1	<0.5-<2	<0.5	--	1.4
Strontium	500	--	240	200-300	240	200-300	310
Tellurium	20	--	24	20-30	39	30-50	26
Thorium	5	--	2.4	2-3	1.4	1-2	4.8
Uranium	3,800	500-30,000	5,000	830-30,000	790	300-2,100	3,900
Vanadium	2,000	--	2,400	2,000-3,000	2,400	2,000-3,000	1,500
Yttrium	30	--	39	30-50	30	--	35
Zinc	100	--	77	30-200	200	--	100
Zirconium	300	--	100	--	71	50-100	140

†[1] Adapted from Anderson et al. (1981--Appendix F and Tables 3-2, 3-3, and 3-4) and Litz (1974).

†[2] For many elements, two or more analyses were performed. The lack of range for an entry indicates agreement among the analyses or that only one analysis was completed. Averages are geometric means of the high and low values in the range or are the single number reported.

†[3] The small amount of F-32 residues have been combined with the L-30 residues during the ongoing interim remedial actions, but the resulting concentrations of elements in the combined residues will be almost the same as in the L-30 residues.

†[4] Weighted averages based on: K-65, 28%; L-30, 55%; L-50, 18%.

Table 3.8. Concentrations of Nonradiological Elements in the NFSS Wastes

Element	Concentration (ppm)							
	R-10 Pile in 1980†[1]		New Naval Waste Area†[1]		Onsite Central Ditch Sediments†[1]		Weighted Average†[2]	Natural Soil†[3] (Worldwide)
	Average	Range	Average	Range	Average	Range		
Arsenic	1.6	0.5-5	1.2	0.5-3	1.2	0.5-3	1.4	0.1-40
Barium	230	100-500	100	20-500	500	50-5000	280	100-3000
Cadmium	0.3	--	0.2	--	0.2	--	0.26	--
Cerium	22	5-100	5.5	1-30	14.1	2-100	17.7	3-170
Chromium	24	20-30	16	5-50	45	10-200	28	5-1500
Cobalt	100	5-2000	7.7	2-30	55	10-300	75	0.05-65
Copper	141	20-1000	24	3-200	45	10-200	99	2-250
Fluorine	17	3-100	20	10-50	141	10-2000	48	20-700
Iron	14,000	10,000-20,000	31,000	10,000-100,000	22,000	10,000-50,000	19,000	2000-550,000
Lanthanum	14	2-100	4.5	1-20	7.1	1-50	11	2-180
Lead	51	4-650	17	<0.4-740	4.5	<0.4-51	34	2-300
Lithium	244	200-300	63	20-200	95	30-300	180	3-350
Manganese	450	200-1000	450	200-1000	450	100-2000	450	20-10,000
Mercury	0.3	--	0.4	--	0.3	--	0.3	0.1-40
Nickel	240	20-3000	16	5-50	100	10-1000	170	2-750
Selenium	0.77	<0.3-<2	0.55	<0.3-<1	0.55	<0.3-<1	0.68	--
Silver	0.23	--	0.14	--	0.14	--	0.19	--
Strontium	100	50-200	77	30-200	122	30-500	100	4-2000
Uranium	14	1-200	5.5	0.1-300	14	1-200	13	0.7-9
Vanadium	95	30-300	22	10-50	141	30-100	96	3-500
Zinc	4.4	2-10	10	1-100	4.4	1-20	5.2	1-900
Zirconium	100	10-1000	17	3-100	12	5-30	66	60-2000

†[1] Adapted from Anderson et al. (1981--Section 6, Appendix A, and Appendix I). Ranges as reported in Anderson et al. (1981). Averages are geometric means of the high and low values in the range or are the single number reported.

†[2] Because these are the only wastes for which comparable elemental data are available, a weighted average for the total 180,000 m^3 of wastes was obtained by weighting the concentrations as follows: R-10 Pile, 60%; New Naval Waste Area, 15%; and Onsite Ditch Sediments, 25%.

†[3] Adapted from Bowen (1979). Data from heavily polluted soils, soils near ore bodies, and serpentine soils have been excluded.

Table 3.9. Concentrations of Various Organic Chemicals in the NFSS Wastes

Chemical	Estimated Average Concentration in NFSS Wastes†[1],†[2] (ppb)
PCBs	<26
Lindane, etc.†[3]	<10
Toxaphene	<13
Heptachlor	<10
Chlordane	<10
Dieldrin	<10
Phenol	<10
Benzo(a)pyrene	<10

†[1] Values given are the larger of 2% of the average concentrations for the nine samples reported in Haywood (1983) and Urbanczyk (1983)--assuming organically contaminated wastes comprise 2% of the total NFSS wastes--or 10 ppb (which was the detection limit in the cited studies).

†[2] The symbol < indicates that some of the sample concentrations were reported as upper limits.

†[3] Includes several isomers of benzene hexachloride.

the Hanford Reservation showing the location of the various areas, including the potential NFSS waste management area, is shown in Figure 3.6.

3.2.1 Topography, Geology, Soils, Seismology, and Mineral Resources

The Hanford Reservation is located on the Columbia River alluvial plain within the central part of the Pasco Basin in the Columbia Basin geologic province. The Reservation is bounded to the west and north by large ridges (Saddle Mountain and Rattlesnake Hills); to the east by the Columbia River; and to the southeast by the confluence of the Yakima and Columbia rivers (U.S. Energy Res. Dev. Admin. 1975; Brown and Isaacson 1977). The 200-West Area is located near the west central portion of the Reservation on an ancestral Columbia River bar. Elevations in this area range from 200 to 220 m (650 to 715 ft) above mean sea level.

Most of the Reservation is underlain by coarse-grained sediments deposited by several glacial floods. Because of the continuously semiarid climate in this region for nearly 12,000 years, these surficial sediments have been only slightly weathered. Sediments at or near the ground surface range from coarse boulder and cobble gravel in the extreme northern section of the Reservation to coarse sand in the southern section. As a result of the semiarid to arid environment, the entire Reservation has been blanketed by as much as 15 m (50 ft) of windblown deposits ranging from very fine sands and silts to coarse sands.* Numerous live dunes and relict dune features also exist within the Reservation. On the west side of the 200-West Area, adjacent to the Yakima and Rattlesnake hills, the sediments grade into silts and fine sands (U.S. Energy Res. Dev. Admin. 1975).

The Columbia River Plateau Physiographic Province was formed by a 3,700-m (12,000-ft) thick sequence of basaltic lava flows. Deformation of the accumulated lava created the Pasco Basin (U.S. Energy Res. Dev. Admin. 1975; Brown and Isaacson 1977). The major stratigraphic units underlying the Hanford Reservation in order of decreasing depth are (Figure 3.7): (1) the Columbia River Basalts, which exist to depths of greater than 3200 m (10,400 ft), (2) the Ringold Formation, consisting of semiconsolidated sediments that were transported and deposited by the ancestral Columbia River and accumulated to depths of 400 m (1300 ft), (3) unconsolidated sands, silts, and gravels, and buried former river channels of the Hanford Formation that were carried into the area by glacial floodwaters, and (4) windblown silt (loess), in part weathered to clay, and fine sand that overlie part of the eroded surface of the Ringold Formation (U.S. Energy Res. Dev. Admin. 1975; Brown and Issacson 1977). The major stratigraphic units in the unsaturated zone (above the water table) underlying the 200-West Area are (1) windblown silt, (2) the Hanford Formation, and (3) the upper portion of the Ringold Formation (Figure 3.8). The thickness of the unsaturated sediments ranges from 55 to 81 m (180 to 265 ft) beneath the 200-West Area.

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APPENDIX D. TRANSPORTATION OF NFSS WASTES AND RESIDUES

D.1 INTRODUCTION

All, or portions of, the NFSS contaminated materials will be shipped to other sites if Alternative 3a, 3b, 4a, 4b, 4c, or 4d is implemented (Table D.1). In Alternative 3, all 190,000 m^3 of the residues and wastes will be moved to either Hanford, Washington, (3a) or Oak Ridge, Tennessee (3b). In Alternative 4, the 11,000 m^3 of residues will be moved to either Hanford (4a, 4b) or Oak Ridge (4c, 4d), whereas the 180,000 m^3 of wastes will either remain at NFSS (4a, 4c) or be transported to the New York/New Jersey harbor area for ocean disposal (4b, 4d).

Detailed descriptions of the NFSS residues and wastes are given in Section 3.1.7 of this report. The residues have a much higher concentration of radium-226 than do the wastes (Table D.1). For transportation purposes, the NFSS residues will be classified as low-specific-activity (LSA) radioactive wastes. The NFSS wastes, on the other hand, are only slightly contaminated and do not need to be classified as radioactive for transportation purposes. (Details on transportation regulations and waste classification are provided in Section D.2.)

Table D.1. Summary of Alternatives Involving Transport of NFSS Residues and Wastes to Other Sites†[1]

Destination	Distance (km)	Alternative	NFSS Material to be Transported	Volume of Material (m^3)
Hanford	4100	3a, 4a, 4b	Residues	11,000
		3a	Wastes	180,000
Oak Ridge	1300	3b, 4c, 4d	Residues	11,000
		3b	Wastes	180,000
NY/NJ harbor area†[2]	770-1000	4b, 4d	Wastes	180,000

Contaminated Material	Volume (m^3)	Average Radium-226 Concentration†[3] (pCi/g)	Packaging	Type of Transport Vehicle
K-65 residues	3,000	220,000	Bins	Shielded vans
L-30/F-32 residues	6,500	12,000	Bins	Shielded vans
L-50 residues	1,500	3,300	Bins	Low-boy, semi-trailer, flat-bed trucks
Subtotal	11,000			
Wastes	180,000	36	None	Dump trucks
Total	190,000			

†[1] All values rounded to two significant figures.

†[2] From the barge dock in the New York/New Jersey harbor area, the wastes will be transported on barges to the ocean dump site. See Section 2.7 and Appendix E.

†[3] From Table 3.5.

There are three potential modes of transport for the NFSS residues and wastes: truck, rail, and barge. Barge transport has been shown to be unreasonable (Bechtel Natl. 1984), primarily because of the much greater distances involved and because of the need for truck transport at both ends, thus necessitating two additional transfers. Rail transport may be feasible (see Section D.5), but transport of bulk radioactive materials similar to the NFSS residues and wastes is currently accomplished primarily by truck. There may be some advantages in shipping the large volume of NFSS wastes and residues by rail rather than truck (e.g., fewer number of shipments) but there are also disadvantages (see Section D.5). For purposes of defining the major alternatives in this EIS, truck transport is assumed for all NFSS wastes and residues. If DOE decides to implement one of the transportation alternatives, the relative merits and costs of rail versus truck transport will be given more detailed consideration.

There are several alternative truck routes to the three sites. The preferred routes are described in Section 3.5; the criteria for choosing routes and descriptions of alternative routes are given in Section D.4. To the extent possible, all NFSS residues and wastes will be shipped on interstate highways.

A detailed discussion of truck transportation--including the bases for determining numbers of shipments, duration of shipments, and other parameters needed for the environmental impact analysis in this EIS--is provided in Section D.3. Barge transportation for the ocean disposal alternatives is described in Appendix E.

D.2 TRANSPORTATION REGULATIONS

D.2.1 Federal

The transportation of radioactive materials is subject to the regulations and jurisdiction of many federal, state, and local authorities. Four federal agencies have jurisdiction over shipments of radioactive materials:

- The Department of Transportation (DOT) has primary responsibility for issuing regulations for the safe transportation of all hazardous materials, including radioactive materials. The DOT regulations apply to all shippers and carriers of radioactive materials except for shipments made on federal government vehicles.
- The Nuclear Regulatory Commission (NRC) issues additional regulations for certain highly radioactive materials such as spent nuclear fuel and high-level wastes. Those regulations apply to all NRC licensees.* The NRC regulations also apply in certain cases to commercial carriers.
- The Interstate Commerce Commission (ICC) regulates rates, charges, and conditions of truck and rail services operating in interstate commerce. The role of th ICC in interstate commerce is diminishing as a result of gradual deregulation of the transportation industry.
- The Department of Energy (DOE) exerts operational control of the shipment activities of its "government-owned" contractors. Except for shipments made on government-owned vehicles, all DOE shipments are subject to DOT regulations. By the DOE's own internal directives, the additional safety standards imposed by NRC also apply to DOE shipments, although the administrative requirements of NRC do not apply.

Providing for adequate control of radiation is a requirement that must be met when transporting the NFSS residues. Radiation control limits are met by providing the necessary shielding to reduce external radiation levels to within allowable limits. Because the NFSS residues will probably be shipped in vehicles consigned for exclusive use, the following dose limits specified in 49 CFR Part 173.441 apply**:

- 1000 mrem/h at any point on the accessible external surface of a package (closed transport vehicle).
- 200 mrem/h at any point on the accessible external surface of a package (open transport vehicle).

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*The Afrimet residues were formerly owned by Afrimet-Indussa and were under a state of New York license (New York is an NRC agreement state). As a result of recently concluded negotiations with Afrimet-Indussa, DOE assumed ownership of the residues and, thus, they are no longer subject to a New York license.

**These regulations apply only to shipments of residues. The NFSS wastes are not considered to be radioactive for transportation purposes. See later discussion.

- 200 mrem/h at any point on the external surface of the vehicle.
- 10 mrem/h at 2 m (6.6 ft) from the sides of the vehicle.
- 2 mrem/h in any normally occupied position in the vehicle.

Recently revised regulations were issued by the Department of Transportation on March 10, 1983 (U.S. Dep. Transp. 1983a); these regulations went into effect on July 1, 1983. In Section 173.403 (y) of revised 49 CFR Part 173, radioactive material, for transportation purposes, is defined to be any material that has a specific activity greater than 0.002 μCi/g (2000 pCi/g).

The NFSS residues contain between 3,300 and 220,000 pCi/g of radium-226 (dry weight basis) as well as small amounts of uranium and other radionuclides. Assuming secular equilibrium between the radium-226 and its decay products, and noting that the residues will be shipped damp, the total specific activity of the residues, as transported, will range from 22,000 to 1,500,000 pCi/g.* All the residues will be classified as low-specific-activity (LSA) materials because they are physical and chemical concentrates of uranium ores (49 CFR 173.403 (n)); the residues will therefore be shipped as radioactive materials.

The NFSS wastes have an average radium-226 concentration of about 36 pCi/g and, using the same assumptions as for the residues, the estimated total specific activity of the wastes is about 240 pCi/g. Thus, these wastes could be transported as nonradioactive materials. However, due to heterogeneities in the wastes, some mixing of the wastes may be necessary to ensure that the individual shipments do not exceed a total specific activity of 2000 pCi/g.

Another major federal regulation concerning transport of the NFSS wastes and residues is the gross vehicle weight limit of 36,000 kg (80,000 lb) (Pub. L. 97-424, Highway Improvement Act of 1982), which applies to all states.

D.2.2 State and Local

Several state and local governments have issued regulations and passed statutes that impose restrictions on shipments of radioactive materials. The U.S. Congress has, by statute, given DOT preemptive regulatory authority over state and local jurisdictions in the matter of transportation of radioactive materials. The U.S. Supreme Court has recently upheld this preemptive authority in a case where the city of New York filed suit against DOT, challenging DOT's regulatory authority (U.S. Supreme Court 1984).

Although state or local regulations regarding the transport of radioactive materials are preempted by federal law (Federal Materials Transportation Act, Section 12, Title I, of Public Law 93-633), a state or local municipality has the option of filing with the Department of Transportation for a nonpreemption determination (i.e., a waiver of preemption). A state or local requirement influencing the transport of radioactive materials will cease to be preempted by federal law if, upon application for the nonpreemption determination, the Secretary of the Department of Transportation finds that the state or local ruling (1) provides an equal or greater level of public safety than the Hazardous Materials Transportation Act or regulations issued thereunder, and (2) does not burden commerce. Preemption determination, therefore, does offer the state or local area with a recourse in the case of disputes over federal preemption.

The NFSS residues will be classified as radioactive, but the NFSS wastes will be classified as nonradioactive materials under existing federal regulations. Although DOE shipments of NFSS wastes will also not be legally subject to state and local regulations, as a matter of comity (courtesy), DOE attempts to comply with state and local general transportation regulations.

D.3 PACKAGING AND VEHICULAR REQUIREMENTS FOR NFSS RESIDUES AND WASTES

D.3.1 General

It is assumed that the NFSS residues will be packaged prior to transportation to ensure compliance with regulations for transporting radioactive materials. There are a variety of packages that could be used to transport the NFSS residues, including 55-gallon drums and various-sized boxes. For

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*Assuming secular equilibrium between the radium-226 and its decay products, the total specific activity is approximately 10 times the radium-226 activity. Taking into account the increased weight of damp residues, another multiplier of 0.67 is applied (see Table 3.5). Loss of radon-222 gas and contributions from other radioactive elements such as uranium-238, -234, and -235 are not expected to significantly affect the estimated total specific activity.

purposes of analysis in this EIS, it is assumed that large steel boxes will be used, specifically the Mark-III bins that are used for transport and disposal of low-level radioactive wastes at Argonne National Laboratory. These bins are sturdy (made of 12-gauge welded steel), watertight (gasketed), certified for transport of LSA materials (meet DOT requirements of "strong and tight" packaging), of suitable size (1.2 m × 1.5 m × 1.8 m [4 ft × 5 ft × 6 ft]), could be filled with the NFSS residues using conventional construction equipment,* and could be easily loaded and unloaded from transport vehicles using cranes. Use of these containers also offers the advantage of enabling retrieval of the residues within a few (10 to 20) years should this be desired.

Three types of vehicles are assumed to be used to transport the NFSS residues and wastes (Table D.2): shielded vans, flat-bed semitrailer trucks, and dump trucks. The shielded vans (for transport of the K-65 and L-30/F-32 residue packages) are standard vans that can be modified to allow the bins to be easily loaded and unloaded and to allow for varying amounts of shielding to reduce the radiation levels outside of the van. The most stringent radiation limit of 10 mrem/h at 2 m (6.6 ft) from the side of the vehicle can be met by using vans equipped with lead shielding (Bechtel Natl. 1984). These vans will have canvas tops for ease of loading and unloading using cranes. The 200 mrem/h limit for the top of the van will be met by adding an extra 2 cm (0.75 in.) of steel shielding on top of the bins containing the K-65 residues (Table D.2). No special shielding is required for the L-50 residues, so they will be transported in the bins on flat-bed, semitrailer trucks.

Table D.2. Shipping Status of NFSS Wastes†[1]

Material Transported	Density (kg/m^3)	Average Concentration (dry wt.) of Ra-226 (pCi/g)	Average Ra-226 Inventory per Shipment (Ci)	Shielding Top	Shielding Side	Number of Bins	Number of Truck Trips
Residues:							
K-65	1,800	220,000	1.6	Yes	Yes	2,000	500†[2]
L-30 and F-32	1,800	12,000	0.10	No	Yes	3,900	960†[2]
L-50	1,800	3,300	0.043	No	No	850	140†[3]
Subtotal							1,600
Wastes:	1,800	36	0.00052	No	No	NA	15,000†[4]
TOTAL							16,000

†[1] All values rounded to two significant figures.

†[2] Assumes use of shielded vans with payload (reduced by shielding) of about 14,000 kg (30,000 lb) (Chem-Nuclear Systems 1983), or 4 bins per van.

†[3] Assumes use of low-boy, semitrailer, flat-bed truck weighing 14,500 kg (32,000 lb) when empty and able to carry 6 bins per trip.

†[4] Assumes use of dump trucks covered with canvas and having a gasketed seal for the rear end. Each vehicle has an empty weight of 15,000 kg (32,000 lb) and can carry a payload of 22,000 kg (48,000 lb) of NFSS wastes.

The NFSS wastes will not be classified as radioactive materials for transportation purposes and therefore will be transported in the most expeditious manner. It is assumed that these wastes will be transported in 15-m^3 (20-yd^3) dump trucks having gasketed seals on the rear end and canvas covers on top to minimize potential loss of the contaminated soils during transport. Gasketed trucks are assumed in order to avoid having to use and dispose of plastic liners.

It is assumed that all vehicles will be obtained from commercial operators and dedicated to NFSS operations (i.e., exclusive use for transporting these materials, returning empty to NFSS for another load). When necessary, extra shielding will be added to protect the driver. All vehicles will be decontaminated if necessary, according to the limits specified in 49 CFR Part 173.443 (U.S. Dep. Transp. 1983a), primarily by washing with water.

*Shielding on the equipment would be provided, as needed, to protect equipment operators.

D.3.2 Residue Packaging and Transportation

The lead-shielded vans for residue transport are assumed to weigh approximately 23,000 kg (50,000 lb). Because the interstate vehicle weight limit is 36,000 kg (80,000 lb) (Pub. L. 97-424), each van can carry about 14,000 kg (30,000 lb) of NFSS payload per trip. Each Mark-III bin has a volume capacity of 3.4 m^3 (4.4 yd^3), a container weight of 340 kg (750 lb), and a maximum weight capacity of 3600 kg (8000 lb) (including container weight). Additional steel shielding for the top of a bin containing K-65 wastes weighs 280 kg (630 lb). Assuming a residue density of 1800 kg/m^3 (3000 lb/yd^3), each bin could therefore carry a maximum of 3000 kg (6000 lb) or 1.7 m^3 (2.2 yd^3)* of K-65 residues. To meet the payload restrictions for the van (14,000 kg or 30,000 lb), however, each van will carry a maximum of 4 bins loaded with 2800 kg (6100 lb) or 1.5 m^3 (2.0 yd^3) per bin. Therefore, approximately 500 truck trips will be required to transport the 3000 m^3 (4000 yd^3) or 2000 bins of K-65 residues from NFSS.

No additional steel shielding on top of the bins will be required for the L-30/F-32 residues, so each van can carry a maximum of 4 bins loaded with 3000 kg (6100 lb) or 1.7 m^3 (2.2 yd^3) of L-30/F-32 residues and meet payload limitations. Approximately 960 truck trips will be required to remove the 6500 m^3 (8500 yd^3) or 3900 bins of L-30/F-32 residues.

Because of their lower specific activity, the L-50 residues will not require lead shielding during transport and will be transported on flat-bed, semitrailer trucks. Assuming an empty flat-bed, semitrailer truck weighs 15,000 kg (32,000 lb) and has a payload of 22,000 kg (48,000 lb), 6 Mark-III bins filled to their design weight limit can be loaded on each truck. Thus, each bin will contain 1.8 m^3 (2.4 yd^3) and each shipment will contain approximately 11 m^3. Assuming a total L-50 volume of 1,500 m^3 (2,000 yd^3), 140 truck trips will therefore be required to remove the 850 bins of L-50 residues from NFSS for a combined total of 1600 truck trips for all residues.

D.3.3 Waste Transportation

The NFSS wastes will be transported in 15-m^3 (20-yd^3) dump trucks. Assuming the empty weight of the truck is 15,000 kg (32,000 lb) with a payload of 22,000 kg (48,000 lb), and assuming a waste density of 1,800 kg/m^3 (3,000 lb/yd^3), one truck can carry at maximum weight 12 m^3 (16 yd^3) of waste per trip (allowing for an average 15% increase in volume with handling). Approximately 15,000 truck trips will therefore be required to remove the wastes from NFSS (Table D.2).

During implementation of any of the action alternatives, an additional small amount of radioactive waste will be produced (e.g., contaminated clothing, filters, gloves). These wastes will be treated to minimize their volume and will be disposed with the NFSS residues. These additional wastes are not covered explicitly in this EIS because their volume will be very small relative to the residues and wastes.

D.3.4 Time and Equipment Needs

About 16,000 truck trips will be required to transport all wastes and residues from NFSS. The equipment and time required to transport the contaminated materials from NFSS to Hanford or Oak Ridge under Alternatives 3a and 3b are listed in Table D.3. Assumptions made in performing the calculations of the values in Table D.3 include: a weather-restricted work period of 6 months each year consisting of 120 working days; a daily transport distance of 730 km (450 mi); and round-trip travel times (including loading/unloading) of 12 days to Hanford, Washington, and 5 days to Oak Ridge, Tennessee. A contingency of enough trucks to cover one additional working day has been included in the totals to serve as replacements for vehicles out-of-service or requiring maintenance. It is assumed that it will take 2 years to ship the residues to either Hanford or Oak Ridge. It is also assumed that it will take 5 years to complete transport of the wastes in Alternative 3a (shipping to Hanford) and 2 years in Alternative 3b (shipping to Oak Ridge), limited primarily because of the number of dedicated trucks required. Thus, implementation of Alternative 3a is limited by the 5 years needed to transport the wastes. The requirements associated with completing this activity in different time periods are also shown in Table D.3.

The vehicle and time requirements to implement Alternatives 4a, 4b, 4c, and 4d are listed in Table D.4. For this analysis, it is assumed that it will take 2 years to implement Alternative 4a, 4b, 4c, or 4d. The requirements associated with completing this activity in different time periods are also shown in Table D.4.

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*Volumes quoted represent preexcavation volumes. With excavation and handling of residue materials, volumes may be expected to increase by as much as 30% (Peele and Church 1941).

Table D.4. Truck Requirements for Shipment of NFSS Residues to Hanford or Oak Ridge and the Wastes to the New York/New Jersey Harbor Area in Alternatives 4a, 4b, 4c, and 4d†[1],†[3]

	Destination													
	Hanford, WA					Oak Ridge, TN					New York/New Jersey Harbor Area†[3]			
	1 yr	2 yr	3 yr	4 yr	5 yr	1 yr	2 yr	3 yr	4yr	5yr	2 yr	3 yr	4 yr	5 yr
Round trips	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	15,000	15,000	15,000	15,000
Rate:														
Departing NFSS														
trucks/day	13	6.7	4.4	3.3	2.7	1.3	6.7	4.4	3.3	2.7	61	41	31	25
trucks/hour	1.6	0.8	0.6	0.4	0.3	1.7	0.8	0.6	0.4	0.3	7.7	5.1	3.8	3.1
Departing and arriving at NFSS														
trucks/day	26	13	8.8	6.6	5.4	2.6	13	8.8	6.6	5.4	120	82	62	50
trucks/hour	3.2	1.6	1.2	0.8	0.6	3.4	1.6	1.2	0.8	0.6	15	10	7.6	6.2
Dedicated trucks required†[2]	180	87	57	43	35	70	36	24	18	15	170	110	84	68
Material transported:														
m^3/yr	11,000	5,500	3,700	2,800	2,200	11,000	5,500	3,700	2,800	2,200	90,000	60,000	45,000	36,000
m^3/mo	1,800	920	610	460	370	1,800	920	660	460	370	15,000	10,000	7,500	6,000
m^3/wk	640	320	210	160	130	640	310	210	160	130	3,500	2,300	1,700	1,400
Total distance travelled (km)	13,000,000					4,200,000					30,000,000			

†[1] Assumes (1) 11,000 m^3 of residues and 180,000 m^3 of remaining residues, soils, and rubble transported (see Table D.1); (2) 6-month (120-day) transport season; (3) 8-hour working day; (4) round-trip travel time of 12 days to Hanford; 5 days to Oak Ridge; and 2.5 days to the Harbor.

†[2] Includes 1-day excess of trucks to cover losses due to repair and maintenance.

†[3] All values rounded to two significant figures.

Table D.3. Truck Requirements for Shipment of NFSS Residues and Wastes in Alternatives 3a and 3b†[1],†[3]

	Destination							
	Hanford, WA				Oak Ridge, TN			
	2 yr	3 yr	4 yr	5 yr	2 yr	3 yr	4 yr	5 yr
Round trips	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000
Rate:								
Departing NFSS								
trucks/day	68	45	34	27	68	45	34	27
trucks/hour	8.5	5.7	4.3	3.4	8.5	5.7	4.3	3.4
Departing and arriving at NFSS								
trucks/day	140	90	68	54	140	90	68	54
trucks/hour	17	11	8.6	6.8	17	11	8.6	6.8
Dedicated trucks required†[2]	880	580	440	350	370	240	180	150
Material transported:								
m^3/yr	96,000	64,000	48,000	38,000	96,000	64,000	48,000	38,000
m^3/mo	16,000	11,000	8,000	6,400	16,000	11,000	8,000	6,400
m^3/wk	3,700	2,500	1,800	1,500	3,700	2,500	1,800	1,500
Total distance travelled (km)	130,000,000				42,000,000			

†[1] Assumes (1) 190,000 m^3 of total contaminated material transported (see Table D.1); (2) 6-month (120-day) transport season; (3) 8-hour working day; (4) round-trip travel time of 12 days to Hanford, and 5 days Oak Ridge.

†[2] Includes a 1-day excess contingency of trucks to cover repairs and maintenance.

†[3] All values rounded to two significant figures.

D.4 ALTERNATIVE TRUCK ROUTES

D.4.1 Route Selection Criteria

Guidelines listed in regulations on the routing of radioactive materials indicate that transportation of the NFSS residues will be restricted to certain routes to minimize the radiation risk to the general public (U.S. Dep. Transp. 1981). The routes selected for the various transportation alternatives in this EIS are based on the more restrictive transportation routing guidelines applicable for "route-controlled quantities" of radioactive materials, even though it may not be necessary to meet these restrictive guidelines (U.S. Dep. Transp. 1983a, 1983b). These more stringent requirements require transporters of radioactive materials to be confined to the interstate highway system, unless otherwise specified by the states. Interstate beltways or state-designated bypass routes are to be used around large metropolitan areas where possible. The restriction to interstate highways results from national average highway accident data being lower for interstates than on any other class of roadway; analyses also indicate that the radiological risk to the public from transporting radioactive materials on interstates is lower than that on other highways (U.S. Dep. Transp. 1981). Vehicles transporting radioactive materials can deviate from the interstate system for emergencies, for obtaining fuel and repairs, and for travel to and from off-interstate pick-up and delivery sites.

Three alternative routes to each destination (Hanford, Oak Ridge, Harbor) are identified. Because only county-level population data are readily available, the average population density for each route is determined by calculating the means of the mean population density for each county through which the route passes. The preferred route is the one that has the fewest people living near it. Preferred routes are described in Section 3.5.

D.4.2 Alternative Routes to Arid Site (Hanford)

Alternative Route 1 to Hanford (Figure D.1) consists of taking I-94 west from Wisconsin rather than I-90. The route then traverses central Minnesota, North Dakota, and Montana and merges with the

Table D.7. Comparison of Rail and Truck Transportation Options for NFSS K-65 and L-30/F-32 Residues

Option†[1]	Advantages	Disadvantages
Rail--Onsite loading and unloading	• Minimum handling • Minimum shielding (railcar only)	• Requires rail spur construction
Rail--Truck to offsite loading	• No rail spur construction	• Both truck trailers and railcars require shielding • Radiation protection required at offsite transfer facility
TOFC--Truck to nearest TOFC ramp	• Minimum handling • Minimum shielding (trailer only) • No rail spur construction	• Higher equipment requirements
Truck	• Minimum handling • Minimum shielding (trailer only) • No rail spur construction	• Highest equipment requirements • Highest labor requirements

†[1]TOFC = trailer-on-flatcar.

Table D.8. Comparison of Rail and Truck Transportation Options for NFSS L-50 Residues

Option†[1]	Advantages	Disadvantages
Rail--Onsite loading and unloading	• Minimal loading onsite	• Requires rail spur construction
Rail--Truck to offsite loading	• No rail spur construction	• Minimal loading offsite
TOFC--Truck to nearest TOFC ramp	• No rail spur construction	• Higher equipment requirements
Truck	• No rail spur construction	• Highest equipment requirements • Highest labor requirements

†[1]TOFC = trailer-on-flatcar.

Table D.9. Offsite Transportation Equipment Requirements for Rail Options for Alternatives 3a and 3b

	Trips Required per Destination							
	Hanford				Oak Ridge			
Option	2 yr	3 yr	4 yr	5 yr	2 yr	3 yr	4 yr	5 yr
Direct Rail								
Railcars†[1]	150	100	75	60	105	70	53	42
Semitrailers†[2]	-	-	-	-	-	-	-	-
Tractors†[2]	-	-	-	-	-	-	-	-
Truck/Rail:								
Railcars†[1]	150	100	75	60	105	70	53	42
Semitrailers†[3]	17	11	9	7	17	11	9	7
Tractors†[3]	17	11	9	7	17	11	9	7
TOFC:								
Railcars†[4]	272	180	136	108	170	90	68	54
Semitrailers†[4],†[5]	601	398	301	239	386	210	160	126
Tractors†[5]	57	38	29	23	46	30	24	18

†[1] Assumes dedicated unit train travel times with round trip of 10 days for Hanford (6 travel, 4 loading and unloading) and 7 days for Oak Ridge (3 travel, 4 loading and unloading).

†[2] Onsite equipment to move from containment area to rail spur or from rail spur to disposal location is not included.

†[3] Assumes 4 round trips per day between NFSS and loading location. No onsite equipment is included to move from rail spur to disposal locations.

†[4] Assumes dedicated unit train travel times with round trip of 8 days (6 travel, 2 loading and unloading) to Pasco, Washington, and 5 days (3 travel, 2 loading and unloading) to Knoxville, Tennessee.

†[5] Assumes 3 round trips per day between NFSS and the Buffalo TOFC ramp, 2 round trips per day between Hanford and the Pasco TOFC ramp and 3 round trips per day between Oak Ridge and the Knoxville TOFC ramp.

D.5.4 Routings for Rail and Trailer-on-Flatcar

D.5.4.1 Direct Rail Routings

Niagara Falls is served by Conrail, and both the Norfolk Southern (NS) and CSX systems have trackage rights between Niagara Falls and Buffalo, New York. All three of these railroads have trackage rights on lines on the north side of Lake Erie through Canada to Detroit, Michigan. In some cases, this route is part of the most direct route, but it was eliminated from consideration because of the sensitive nature of the material being transported.

The Oak Ridge disposal site is served by a rail spur connected to the Louisville and Nashville (L&N) line about 2 km (1.2 mi) south of Dossett, Tennessee. The L&N is part of the CSX system so it is reasonable for shipments from NFSS to Oak Ridge to be made entirely on the CSX system. A likely routing on the CSX system from Niagara Falls to Oak Ridge (1365 km [852 mi]) is shown in Figure D.5.* The Hanford site is served by a Burlington Northern (BN) rail line out of Richland Junction. Because the BN cannot originate shipments out of Niagara Falls, an interline is necessary with another originating carrier. Figure D.6 shows a likely route for shipments originated by Conrail with an interline with the BN at Gary, Indiana (4322 km [2698 mi]); Figure D.7 shows a likely route for shipments originated by the NS system with an interline in Peoria, Illinois (4308 km [2689 mi]); and Figure D.8 shows a route originating on the CSX system with an interline at Chicago (4619 km [2883 mi]). The Port of New York area is served by Conrail; Figure D.9 shows a Conrail route from Niagara Falls to Perth Amboy, New Jersey (658 km [411 mi]).

*The Oak Ridge Reservation is also served by a rail spur connected to the Norfolk Southern Railroad line west of Dossett. Shipments, therefore, could be made from Niagara Falls on the Norfolk Southern.