US Army Corps of Engineers
Buffalo District

SITE CLOSEOUT REPORT
FOR THE
LINDE FUSRAP SITE

TONAWANDA, NEW YORK

AUTHORIZED PROJECT UNDER THE

FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM

(FUSRAP)

MARCH 2015

PREPARED BY:

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DECLARATION OF RESPONSE ACTION COMPLETION AND ISSUANCE OF THE SITE CLOSEOUT REPORT FOR THE LINDE FUSRAP SITE

The response actions at the Linde Formerly Utilized Sites Remedial Action Program (FUSRAP) Site in Tonawanda, New York, are complete in accordance with the records of decision (RODs) for the soils operable unit (OU) signed on March 3, 2000, Building 14 OU signed on April 10, 2003, and the groundwater OU signed on January 29, 2007, and in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). As a result of the remedial actions, no FUSRAP-eligible radioactive material addressed by the RODs remains on site above the cleanup requirements and no further action to address FUSRAP-eligible contamination will be required on site.

Steven J Roemhildt ______________________ 30 MAR 15 ______________

For Richard G. Kaiser
Brigadier General, US Army
Commanding

Date

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Attachments

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

ACM	asbestos-containing material
AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
Argonne	Argonne National Laboratory
AVG	average
β	beta
Bldg	building
BNI	Bechtel National Incorporated
BRA	baseline risk assessment
Cabrera	Cabrera Services, Incorporated
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm	centimeter(s)
cm^2	square centimeter(s)
COCs	constituents of concern
cpm	counts per minute
CSX	CSX Transportation, Incorporated
Ci	curies
DCGL	derived concentration guideline level
$DCGL_{emc}$	derived concentration guideline level - elevated measurement comparison
$DCGL_{ga}$	derived concentration guideline level – gross activity
DOE	United States Department of Energy
dpm	disintegrations per minute
DQOs	data quality objectives
EAs	excavation areas
EE/CA	Engineering Evaluation/Cost Analysis
EPA	United States Environmental Protection Agency
FBDU	Ford, Bacon & Davis Utah, Incorporated
FS	feasibility study
FSA	feasibility study addendum
FSS	final status survey
FSSP	final status survey plan
ft	foot (feet)
ft^2	square foot (feet)
FUSRAP	Formerly Utilized Sites Remedial Action Program
gal	gallon(s)
g/l	grams per liter
in	inch (inches)
ISOCS	*in situ* object counting system
IT	IT Corporation
IUC	International Uranium Corporation
JB	junction box
kg	kilogram(s)
km	kilometer(s)

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE (continued)

L	liter(s)
lb	pound(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MAX	maximum
MED	Manhattan Engineer District
mi	mile(s)
MIN	minimum
mrem	milliroentgen equivalent man
mrem/yr	milliroentgen equivalent man per year
MOU	memorandum of understanding
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission
NYCRR	New York Codes, Rules, and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOL	New York State Department of Labor
O&M	operations and maintenance
OU	operable unit
ORAU	Oak Ridge Associated Universities
ORNL	Oak Ridge National Laboratory
pCi/g	picocurie(s) per gram
PL	Public Law
Praxair	Praxair, Inc.
QA	quality assurance
QC	quality control
Ra-226	radium-226
Radian	Radian International, Incorporated
RAO	remedial action objective
RI	remedial investigation
ROD	record of decision
SB	subsurface soil
Shaw	Shaw Environmental, Incorporated
SOR	sum of ratios
SS	surface soil
SU	survey unit
TCLP	toxicity characteristic leaching procedure
TDP	technical data package
TEDE	total effective dose equivalent
Th-230	thorium-230
total U	total uranium
U-234	uranium-234

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE (continued)

U-235	uranium-235
U-238	uranium-238
µCi/mL	microcurie(s) per milliliter
UF_4	uranium tetrafluoride
UMTRCA	Uranium Mill Tailings Radiation Control Act
UO_2	uranium dioxide
U_3O_8	triuranium octoxide
µR/hr	microroentgens per hour
USACE	United States Army Corps of Engineers
UT	utility tunnel
UU/UE	unlimited use and unrestricted exposure
VOCs	volatile organic compounds
WCS	Waste Control Specialists, LLC
WL	working level
yd^3	cubic yard(s)

1.0 EXECUTIVE SUMMARY

1.1 SITE DESCRIPTION AND HISTORY

The Linde Site is located in the Town of Tonawanda, New York, which is just north of the City of Buffalo, New York. The approximately 55 hectare (135-acre) industrial site was previously owned by the Linde Air Products Division of Union Carbide and was used to process uranium ores under contract with the Manhattan Engineer District (MED) between 1942 and 1946. That activity resulted in residual radiological contamination (i.e. radium, uranium, and thorium) on portions of the Linde Site. The Linde Site was remediated under the Formerly Utilized Sites Remedial Action Program (FUSRAP) between 1996 and 2013. FUSRAP was initiated in 1974 to investigate, and if necessary, clean up or control sites throughout the United States contaminated as a result of MED or Atomic Energy Commission (AEC) activities conducted in support of the nation's early atomic energy and weapons program. Both the MED and the AEC were predecessors of the United States Department of Energy (DOE).

1.2 DOE ACTIVITIES

Between 1996 and 1997, the DOE conducted a non-time-critical removal action at the Linde Site, per an Approval Memorandum (DOE 1996b). The removal action included the demolition of Building 38 at the Linde Site, decontamination of Buildings 14 and 31, and complete excavation of contaminated soil next to Building 90 with off-site disposal. Approximately 4,636 metric tons (5,110 tons) [3,482 cubic meters (m^3) (4,554 cubic yards (yd^3))] of building rubble, contaminated soil, and soil-like material were shipped by rail to Energy Solutions' Clive, Utah disposal facility (formerly Envirocare of Utah).

1.3 USACE ACTIVITIES

Congress transferred administration and execution of FUSRAP cleanups from the DOE to the United States Army Corps of Engineers (USACE) in October 1997. Response actions conducted by USACE under FUSRAP were subject to, and conducted in accordance with, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (42 U.S.C 9601 et seq.), as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR Part 300).

Between 1998 and 1999, USACE conducted a non-time-critical removal action at the Linde Site, per an Action Memorandum (USACE 1998b). The removal action included the demolition of Building 30 at the Linde Site with off-site disposal. Approximately 1,964 metric tons (2,165 tons) [4,713 m^3 (6,165 yd^3)] and 1,164 metric tons (1,283 tons) [2,064 m^3 (2,700 yd^3)] of radiologically contaminated soil and debris were shipped by rail to Clean Harbors (formerly Safety-Kleen) in Buttonwillow, California and Energy Solutions' Clive, Utah disposal facility (formerly Envirocare of Utah), respectively.

In addition to the two non-time-critical removal actions, USACE conducted remedial actions for each of the three operable units (OUs) at the Linde Site: the Soils OU, Building 14 OU, and Groundwater OU.

USACE issued a Record of Decision (ROD) (USACE 2000b) for the Soils OU for the remediation of residual radioactive material in soil and on surfaces of buildings and infrastructure (with the exception of Building 14) with off-site disposal. Between 1999 and 2013, approximately 312,551 metric tons (344,529 tons) [131,706 m^3 (172,265 yd^3)] of radiologically contaminated soil and debris were shipped by rail to the International Uranium Corporation (IUC) in Blanding, Utah, Waste Control Specialists in Andrews, Texas, and US Ecology Idaho in Grand View, Idaho.

Between 2004 and 2005, USACE demolished Building 14 at the Linde Site, per the ROD for the Building 14 OU (USACE 2003a). Approximately 12,717 metric tons (14,018 tons) [10,858 m^3 (14,202 yd^3)] of radiologically contaminated soil and demolition debris were shipped by rail to Waste Control Specialists in Andrews, Texas, for disposal.

USACE issued a no action ROD for the groundwater OU (USACE 2006b) in January 2007 since naturally-occurring concentrations of constituents in groundwater underlying the Linde Site preclude its use without treatment, which would also remove any of the FUSRAP-eligible constituents that may be present in groundwater.

1.4 CURRENT STATUS

The privately-owned Linde FUSRAP Site is currently in the Site Closeout phase of the CERCLA process. This Site Closeout Report (SCOR) provides a consolidated record of all removal and remedial activities conducted at the Linde Site and documents compliance with all statutory requirements. The implemented remedies achieved the degree of cleanup and protection specified in the RODs (USACE 2000b, 2003a, and 2006b) for the Linde Site for all pathways of exposure. No further response is needed to protect human health and the environment from the FUSRAP-eligible constituents of concern (COCs). All ROD remedial action goals have been achieved, and all applicable or relevant and appropriate requirements (ARARs) have been met for the site. Since FUSRAP-eligible residual radiological concentrations remaining at the Linde Site allow for unlimited use and unrestricted exposure (UU/UE), no five-year reviews, land use controls, or operations and maintenance are required to maintain the protectiveness of the implemented remedies.

1.5 NEXT STEPS

The Linde Site will be officially transferred from USACE to the DOE Office of Legacy Management within two years from the signature date of this SCOR. Once transfer of the Linde Site from USACE is complete, the DOE will retain sole responsibility for its long-term stewardship, which is limited to records management for this site.

1.6 ADMINISTRATIVE RECORD FILE

The Administrative Record File for the Linde Site contains CERCLA-related documentation used in the decision-making process for the site. Reports and documents in the Administrative Record File may be viewed at the following locations:

USACE FUSRAP Public Information Center
1776 Niagara Street
Buffalo, NY 14207

Tonawanda Public Library
333 Main Street
Tonawanda, NY 14150

These Administrative Record File repositories will be retained by USACE until the Linde Site is officially transferred to DOE, after which the DOE will be responsible for records management for this site.

2.0 INTRODUCTION

The Linde Site, located at 175 East Park Drive (off of Sheridan Drive) in the Town of Tonawanda, Erie County, New York, has been remediated by USACE under FUSRAP.

Under FUSRAP, USACE is authorized to investigate, and if necessary, clean up or control sites throughout the United States contaminated as a result of Manhattan Engineer District (MED) or Atomic Energy Commission (AEC) activities conducted in support of the nation's early atomic energy and weapons program. In accordance with Section 611 of Public Law 106-60 (U.S. Congress 1999), response actions conducted by USACE under FUSRAP are subject to, and conducted in accordance with, CERCLA of 1980 (42 U.S.C 9601 et seq.), as amended, and the NCP (40 CFR Part 300)[1]. CERCLA and the NCP provide the following processes for characterizing the nature and extent of releases of hazardous substances, such as radionuclides, evaluating alternatives for remedial actions, proposing and considering state and public comments on a remedial action, and deciding upon and carrying out a remedial action.

CERCLA PROCESS FOLLOWED BY USACE FOR FUSRAP SITES

Potentially Eligible

DOE determines FUSRAP eligibility and refers an eligible site to USACE.

Congress can add a site to FUSRAP through the Energy and Water Development Appropriations Act.

↓

Pre-Designation Activities

- Preliminary Assessment
- Site Inspection
- Preliminary Legal Analysis of Government Responsibility

Preliminarily identify site hazards and evaluate the need for action under FUSRAP.

↓

Site Designation

Based upon results of the pre-designation activities, USACE may designate a site into FUSRAP for further investigation and potential remedial action.

↓

Remedial Investigation / Feasibility Study

- Nature and Extent of Contamination
- Baseline Risk Assessment
- Treatability Studies
- Development and Evaluation of Alternatives

Gather information sufficient to support an informed risk-management decision regarding whether an action is needed; and if so, which remedies appear to be the most appropriate for a site.

↓

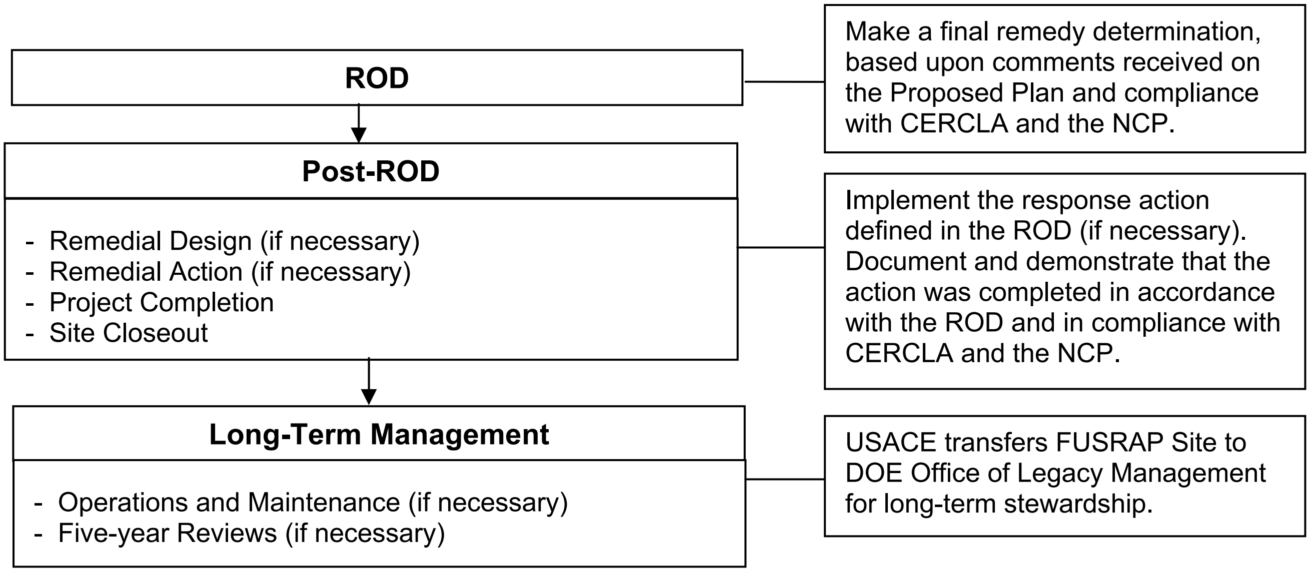
Proposed Plan

- Identification of Preferred Remedial Alternative
- Release for 30-day Public Comment Period

Identify the preferred alternative, based upon ranking alternatives against the nine criteria specified in the NCP, for public comment.

↓

[1] For the Proposed Plan, CERCLA § 117(a)(2) requires that USACE provide a "reasonable opportunity for submission of written and oral comments and an opportunity for a public meeting at or near the facility." The NCP [40 CFR § 300.430(f)(3)(C)] specifies that USACE must "provide a reasonable opportunity, not less than 30 calendar days, for submission of written and oral comments" and that, "upon timely request, the lead agency will extend the public comment period by a minimum of 30 additional days…".



The Linde Site is currently in the Site Closeout phase of the CERCLA process. The site is comprised of three OUs; soils, Building 14, and groundwater. The remedy for each OU at the Linde Site is summarized below. In addition, two non-time-critical removal actions were conducted previously by the DOE.

USACE achieved the degree of cleanup and protection specified in the Records of Decision (RODs) for the Linde Site for all pathways of exposure. No long-term management (i.e. operations and maintenance, five-year reviews, etc.) is needed on the FUSRAP-designated Linde Site to protect human health and the environment from the FUSRAP-eligible COCs.

2.1 SOILS OU

The ROD for the soils OU was signed in March 2000, which authorized the remediation of residual radioactive material in soil and on surfaces of buildings and infrastructure (with the exception of Building 14). Remedial action and restoration were completed in May 2013. In accordance with the ROD for the soils OU, USACE safely removed and disposed of contaminated materials to permitted or licensed disposal facilities outside of New York State.

2.2 BUILDING 14 OU

The ROD for Building 14 was signed in April 2003, which authorized removal of Building 14 and contaminated material beneath the building. Remedial action was completed in May 2005. This action, conducted in accordance with the ROD for Building 14, resulted in material being shipped to permitted or licensed disposal facilities outside of New York State.

2.3 GROUNDWATER OU

USACE completed a feasibility study addendum (FSA) for site groundwater in October 2005, which concluded that there were no complete exposure pathways to groundwater; therefore, radiological constituents in the groundwater posed no current or future threat to human health or the environment, and further action under FUSRAP was not warranted. The ROD for the groundwater OU was signed in January 2007, and documents No Action as the selected alternative for groundwater at the Linde Site.

3.0 SITE LOCATION AND DESCRIPTION

The Linde Site is located at 175 East Park Drive (off Sheridan Drive) in the Town of Tonawanda, Erie County, New York, approximately 14 kilometers (km) [9 miles (mi)] north of downtown Buffalo and 3.4 km (1.5 mi) east of the Niagara River. The approximately 55 hectare (135-acre) industrial facility is owned by Praxair, Inc. (Praxair), as of the release date of this document. Figure 1 shows the location of the site.

The industrial-zoned site is bounded on the north and south by other industrial properties and small businesses, on the east by CSX Transportation Incorporated (CSX) [formerly Conrail Rail Corporation] railroad tracks and National Grid property and easements, and on the west by a park owned by Praxair that is open to the public. A residential area and Holmes Elementary School lie west of the park. The FUSRAP-designated Linde Site is illustrated in Figure 2 (circa 1995). The current, post-remedial action, configuration of the site is illustrated in Figure 3 (circa 2011).

This fenced property contains office buildings, fabrication facilities, warehouse storage areas, material lay down areas, and parking lots with access to the property controlled by Praxair. A series of utility tunnels underlies the site that interconnects some of the main buildings and by an extensive network of storm and sanitary sewers. Public water and sanitary sewer services are provided to the property. The cleanup criteria proposed by USACE was developed to provide for an acceptable level of protection in accordance with CERCLA and was based on a commercial/ industrial exposure scenario, which is the most likely future land use as discussed in Section 2.1.

Recreational uses near the property include Sheridan Park, owned by the Town of Tonawanda's Parks and Recreation Department, which is located a quarter mile to the northwest of the property. Two Mile Creek flows through this property. Sensitive uses within one mile of the Linde Site include five schools, two community buildings, and a senior citizens' center.

3.1 FUTURE LAND USE

USACE has determined that the reasonably anticipated future land use of the Linde Site will be for commercial/industrial purposes. However, no land use restrictions are required at the site since the implemented remedy resulted in FUSRAP-eligible residuals at levels that allow for UU/UE.

The Linde Site is currently an active industrial facility, owned by Praxair. The Linde Site has been an industrial site for more than 60 years, and is currently zoned as industrial. The site is bounded on the north and south by other industrial properties and small businesses, on the east by CSX railroad tracks and National Grid property and easements, and on the west by a park owned by Praxair that is open to the public.

Soils at the site are poorly suited for agricultural purposes, as native soils are high in clay content, and a layer of miscellaneous fill exists over much of the site along with various industrial support buildings underlain by a series of utility tunnels and extensive network of storm and sanitary sewers.

Groundwater at the Linde Site is not used as a drinking water source. The Niagara River is the water source for the Town of Tonawanda municipal water system and development of the deep groundwater at the Linde Site as a source of drinking water is precluded without costly treatment to remove naturally occurring high levels of total dissolved solids and other constituents. Development of the shallow groundwater at the Linde Site is precluded due to unsuitable subsurface conditions and the requirement for a permit required under Chapter 54 of the Town Code and Erie County Department of Health approval of any public water supply well.

4.0 SITE HISTORY

From 1942 to 1946, the Linde Air Products Division of Union Carbide at the Linde Ceramics Plant uranium refinery was contracted by MED to separate uranium from pitchblende uranium ore and domestic ore concentrates. These processing activities resulted in elevated levels of radionuclides in portions of the property and buildings.

Subsequent disposal and relocation of processing wastes from Linde resulted in elevated levels of radionuclides at three nearby properties in the Town of Tonawanda: the Ashland 1 property, the Seaway property, and the Ashland 2 property. These three properties, along with the Linde property, were referred by the DOE as the "Tonawanda Site."

4.1 SITE OWNERSHIP

Tax mapping records of the Town of Tonawanda indicate that portions of the land at the Linde Air Products Site were previously owned by the Town of Tonawanda, Excelsior Steel Ball Company, Metropolitan Commercial Corporation, and the Pullman Trolley Land Company, but the land was not used by any of these owners (Ford, Bacon & Davis Utah, Inc. (FBDU) 1981). Records indicate that commercial industrial processes were being conducted in 1936 by the Linde Air Products Division of Union Carbide at the site.

Under USACE's jurisdiction in the early 1940's, MED was established as the lead agency in the development of nuclear energy for defense-related projects. Due to the Company's experience in the ceramics business, which involved processing uranium to produce the salts used to color ceramic glazes, MED contracted with the Linde Air Products Corporation (now Praxair) to separate uranium from ore at its Tonawanda facilities. From 1942 to 1946[2], under the MED contract, four African pitchblende ores from the Belgian Congo and three domestic ore concentrates from the western United States (Colorado) were processed by the Linde Air Product Division. After the MED-related activities ceased, Union Carbide operations continued at the Linde Site and, in the 1990's, Praxair acquired the property and continues to perform commercial industrial processes while focusing primarily on research and development.

As described in the Remedial Investigation (RI) Report (DOE 1993a), five Linde buildings were involved in MED activities: Building 14 (built by Union Carbide in the mid-1930s) and Buildings 30, 31, 37, and 38 (built by MED on land owned by Union Carbide). Ownership of Buildings 30, 31, 37, and 38 was transferred to Linde when the MED contract was terminated (DOE 1993a). Currently, the Linde Site is owned by Praxair.

4.2 URANIUM PROCESSING AT LINDE

As discussed in the RI Report (DOE 1993a), under the MED contract, uranium ores from seven different sources were processed in Linde: four African ores (three low-grade pitchblendes and torbernite) and three domestic ore concentrates (carnotite from Colorado) (DOE 1993a).

[2] A radiological survey report prepared for the Linde Site by Oak Ridge National Laboratory (ORNL) in 1978 reports that the "site was used for the separation of uranium dioxide from uranium ores and for the conversion of uranium dioxide to uranium tetrafluoride during the period of 1940-1948" (ORNL 1978). The 1978 ORNL report also states that the Linde Air Products Division was under contract to MED to perform uranium separations from 1940 through approximately 1948 (ORNL 1978). Therefore, the actual end date of MED involvement at the Linde Center may be later than specified above.

The domestic ore concentrates sent to Linde resulted from commercial processing, conducted primarily in the western United States, to remove vanadium. The vanadium removal process resulted in disruption of the uranium decay chain and the removal of radium. For this reason, uranium supplied to Linde had low concentrations of radium compared with the natural uranium and thorium-230 (Th-230) concentrations.

The African ores, shipped to Linde as unprocessed mining ores, contained uranium in equilibrium with all of the daughter products in its decay chain (e.g., Th-230 and radium-226 [Ra-226]). The other constituents of the ores were similar to those of the domestic ores. Laboratory and pilot plant studies were conducted at Linde from 1942 to 1943 and uranium processing began at Linde in 1943 (DOE 1993a). From mid-1943 to mid-1946, a total of about 28,000 tons of ore was processed at Linde (Aerospace 1981).

There were three phases to the uranium processing conducted at Linde.

- Phase 1 – Uranium separation from ore (in Building 30)
  This phase consisted of separating triuranium octoxide (U_3O_8) from the feedstock materials by acid digestion, precipitation, and filtration. The filtrate (liquid remaining from the processing operations) from this phase was discarded as liquid waste into the injection wells, storm sewers, or sanitary sewers. The solid gelatinous filter cake from this phase was temporarily stored as solid waste at the Linde Site. The temporary waste pile was later combined with insoluble precipitates from the process and relocated to Ashland 1.

- Phase 2 – Conversion of U_3O_8 to uranium dioxide (UO_2) (in Building 30)
  - U_3O_8 from Phase 1 was processed into UO_2.

- Phase 3 – Conversion of UO_2 to uranium tetrafluoride (UF_4) (in Buildings 31 and 38)

The RI Report states that the COCs at the Linde Site were primarily associated with the waste streams and residues from the Phase 1 operation and that any residues from the Phase 2 and 3 operations were reprocessed. All phases of operation have been reported to have occurred during the 1943 to 1946 period. A review of historical and recent documents indicates that the operations may have extended to the year 1948, particularly the Phase 2 and 3 operations (DOE 1997). Regardless of the actual duration of operations, the primary activity over most, if not all, of the period during which MED-related activities occurred at the Linde Site was the separation of uranium from the ore; and the principal contaminants of concern were from the processing of wastes and residues from that operation since the residues from the other two phases were reported to have been recycled (Aerospace 1981).

4.3 MANAGEMENT OF THE SOLID WASTES FROM THE URANIUM PROCESSING AT LINDE

The principal solid waste resulting from the Phase 1 separation was a solid, gelatinous filter cake consisting of impurities remaining after filtration of the uranium carbonate solutions. Phase 1 also produced insoluble precipitates of the dissolved constituents. The precipitated species included large quantities of silicon dioxide, iron hydroxide, calcium hydroxide, calcium carbonate, aluminum hydroxide, lead sulfate, lead vanadate, barium sulfate, barium carbonate, magnesium hydroxide, magnesium carbonate, and iron complexes of vanadium and phosphorus (Aerospace 1981). All these wastes were eventually shipped off site for disposal depending on the ore's source of origin. The waste material that remained was consolidated into an uncovered waste pile west of Building 90 between 1979 & 1982 and was eventually covered with a Hypalon liner and clay cap in 1992 (DOE 1993a).

Between 1943 and 1946, approximately 7,300 metric tons (8,000 short tons (tons)) of filter cake from the Phase 1 processing of domestic ores were taken from the temporary waste pile at Linde and transported to the former Haist property, now known as Ashland 1. These residues contained approximately 0.54 percent uranium oxide [86,100 pounds (lb) of natural uranium], which corresponds to 26.5 curies (Ci) of natural uranium.

Because the residues from the African ore were relatively high in radium content compared to processed domestic ore residues, the African ore supplier required that the African ore residues be stored separately so that the radium could be extracted. Between 1943 and 1946, approximately 18,600 metric tons (20,500 tons) of residues were shipped to the former Lake Ontario Ordnance Works in Lewiston, New York, where they could be isolated and stored in a secure area (Aerospace 1981). The production progress reports also showed that approximately 140 metric tons (154 tons) of African ore residues were shipped to Middlesex, New Jersey (Aerospace 1981).

4.4 DISPOSAL OF LIQUID EFFLUENT FROM URANIUM PROCESSING IN GROUNDWATER AT THE LINDE SITE

Initially, the liquid effluent from the ore processing step was discharged to the sanitary sewer system[3]. By April 1944, approximately 100 million liters (L) (26.4 million gallons (gal)) had been discharged. Concentrations of UO_2 in the effluent averaged 0.15 grams per liter (g/L) in 1943 and 0.03 g/L during the first three months of 1944 (Aerospace 1981). Therefore, approximately 9,600 kg (21,000 lb) of UO_2 (i.e. 6.5 Ci of natural uranium) was released into the sanitary sewer system (Aerospace 1981).

Because process changes increased the pH of the effluent (less than 11.5), discharge to the sanitary sewer was halted in April 1944, and an on-site, deep-well injection of liquid effluent was implemented. Between June 1944 and July 1946, Linde disposed of liquid waste in seven wells (none of which remain on site): three wells east of Building 14 and four wells near Buildings 30 and 38, as shown in Figure 2. The disposal wells ranged from 28 to 46 meters (m) [90 to 150 feet (ft)] deep; some were drilled 9 to 12 m (30 to 40 ft) into bedrock (Aerospace 1981). The injection wells eventually became blocked and were subsequently backfilled with debris (DOE 1993a). When the injection wells became blocked and backed up, the effluent was discharged into a storm sewer conduit that emptied into Two Mile Creek. Approximately 208 million liters (55 million gal) of effluent were discharged into the seven disposal wells, and 212 million L (56 million gal) of effluent were discharged into Two Mile Creek between June 1944 and July 1946 (Aerospace 1981).

From April 1944 to July 1946, the average concentration of UO_2 in the liquid effluent was 0.026 g/L (Aerospace 1981). This concentration would imply that 5,600 kg (12,300 lb) of UO_2 (i.e., 3.8

[3] The Code of Federal Regulations, Title 10, Part 20 (NRC regulations at the time of the 1981 Aerospace report), states that the release of an effluent to a sewer is acceptable if the quantity, when diluted by the average daily quantity of sewage released to the sewer by the licensee, will result in an average concentration of less than 4×10^{-7} μCi (stated as 7×10^{-7} in the referenced 1981 Aerospace report) of soluble radium-226 per milliliter of solution and 9×10^{-4} μCi of insoluble radium-226 per milliliter of solution. It is further stated that the licensee shall not possess, use, or transfer licensed material so as to release to an unrestricted area radioactive material in concentrations that exceed 3×10^{-8} μCi of soluble radium-226 per milliliter of solution or 3×10^{-5} μCi of insoluble radium-226 per milliliter.

Ci of natural uranium) were released to the storm sewer leading to Two Mile Creek, and 5,400 kg (11,900 lb) of UO_2 (i.e., 3.7 Ci of natural uranium) were injected into on-site wells.

The RI Report (DOE 1993a) indicated that precipitates formed in the bedrock formation where injection occurred and concluded that radioactive contamination probably occurs in the subsurface at Linde as minor percentages of uranyl sulfates and carbonates precipitated in the shale under the Linde Site. The subsequent feasibility study (FS) for the groundwater OU (USACE 2004) included a geochemical model of the underlying groundwater system, which verified that uranium in the Camillus Shale was immobile as observed in bedrock cores and monitoring wells installed near the injection wells.

4.5 DESIGNATION OF THE LINDE SITE UNDER FUSRAP

The AEC, predecessor of the DOE, initiated FUSRAP in 1974 to identify, investigate, and if necessary, clean up or control sites that were contaminated as a result of activities conducted in support of the Nation's early atomic energy and weapons program. These activities were performed by the MED (1942–1946) and/or under the AEC (1947–1975). Therefore, by law, only MED/AEC-related constituents, hereafter referred to as FUSRAP-eligible COCs, are authorized to be addressed under FUSRAP.

Due to the direct contractual evidence with MED, and a 1976 radiological survey conducted by Oak Ridge National Laboratory (ORNL 1978), the Linde Air Products facility (former uranium ore refinery) was designated for some form of remedial action under FUSRAP in February 1980. The designation was due to the fact that portions of the Linde Site were "contaminated with radioactive residue as a result of activities of the Manhattan Engineer District and Atomic Energy Commission" (DOE 1980). The Ashland 1 and Seaway properties were designated in June 1984, and the Ashland 2 property was designated in October 1984. Together, the Linde, Ashland 1, Ashland 2, and Seaway Industrial Park properties were referred to by the DOE as the "Tonawanda Site."

The DOE conducted environmental investigations and removal actions at the site as described in Section 4.1. In October 13, 1997, the Energy and Water Development Appropriations Act, Public Law (PL) 105-62, was signed into law, transferring the administration and execution of FUSRAP cleanups from the DOE to USACE. USACE continues to clean up sites that the DOE began and address sites added to FUSRAP by Congress, or referred to USACE by DOE's Office of Legacy Management under the USACE/DOE Memorandum of Understanding (MOU) (DOE and USACE 1999).

5.0 PREVIOUS INVESTIGATIONS

The Linde Site has undergone extensive investigations and studies relating to the occurrence of FUSRAP-eligible COCs. The following is a brief timeline of the key documents which are discussed in more detail in the following sections.

- 1976 Radiological Site Survey (ORNL)
- 1981 Radiological Site Survey (FBDU)
- 1981 Radiological Site Survey (Bechtel National Incorporated (BNI))
- 1993 Remedial Investigation Report (DOE)
- 1993 Baseline Risk Assessment (DOE)
- 1993 Feasibility Study Report (DOE)
- 1993 Proposed Plan for the Tonawanda Site (DOE)
- 1996 Engineering Evaluation/Cost Analysis (EE/CA) for Building 38 (DOE)
- 1996 Approval Memorandum for the Demolition of Building 38 (DOE)
- 1996 EE/CA for Building 30 (DOE)
- 1998 Action Memorandum for the Demolition of Building 30 (USACE)
- 1999 Radiological Site Assessment Technical Memorandum (USACE)
- 1999 Feasibility Study Addendum (USACE)
- 1999 Proposed Plan for the Linde Site (USACE)
- 2000 Record of Decision for the Linde Site (USACE)
- 2002 Proposed Plan for Building 14 (USACE)
- 2003 Record of Decision for Building 14 (USACE)
- 2004 Feasibility Study for Groundwater (USACE)
- 2005 FS Addendum for Groundwater (USACE)
- 2006 Proposed Plan for Groundwater (USACE)
- 2006 Record of Decision for Groundwater (USACE)
- 2010 Five-Year Review Report (USACE)

5.1 DOE INVESTIGATIONS AND ACTIONS

A three-phase remedial investigation of the Tonawanda Site, including Linde, was conducted by DOE from 1988 to 1992. The remedial investigation incorporated the findings of earlier site investigations including, but not limited to, a 1976 radiological survey of the site by ORNL (ORNL 1978), a 1981 survey of the site by FBDU (FBDU 1981), and a third survey also conducted in 1981 by BNI (BNI 1982). An evaluation of 1943 to 1946 liquid effluent discharge from the Linde plant (Aerospace 1981) was also used to complete the estimate of the extent of contamination at the site. The RI Report (DOE 1993a) lists these and other references relied upon by DOE in preparing the report. The RI Report describes the investigations conducted at the Linde Site and the findings of investigations and studies to characterize site conditions, determine the nature and extent of contamination, and characterize the fate and transport of contamination in site media.

Using the results of the investigations and studies reported in the RI report, DOE conducted a baseline risk assessment (BRA) and reported the findings in the BRA (DOE 1993b). The BRA described the potential risks to human health and the environment posed by the presence of FUSRAP-eligible contamination. No significant risks from chemical contamination were identified. The BRA found that radiological contamination could pose risks to human health if exposures to contamination in some Linde Site areas were not controlled or remediated.

Based on the findings of the RI report and BRA, DOE conducted a FS to identify and evaluate remedial alternatives for the Tonawanda Site properties, including Linde. Included was an alternative envisioning the excavation of FUSRAP-contaminated soil from the Linde Site, and the other three Tonawanda Sites (Ashland 1, Ashland 2 and Seaway) and containment of all the Tonawanda Site-contaminated soils in an engineered cell on Ashland 1, Ashland 2, or Seaway. Other alternatives included complete excavation with off-site disposal and partial excavation leaving inaccessible FUSRAP-contaminated soils in place. The details of the FS are available in the FS Report (DOE 1993c).

In November 1993, DOE issued its *Proposed Plan for the Tonawanda Site* (DOE 1993d). The remedial alternative recommended in the proposed plan was containment of all FUSRAP-contaminated soils from the Tonawanda Site at an engineered cell to be constructed at Ashland 1, Ashland 2, or Seaway. In 1994, due to public concern over this proposed on-site cell, DOE suspended further actions in order to re-evaluate remedial alternatives for the Tonawanda Sites, including Linde. While these evaluations were being undertaken and until a decision was made for remediation of the entire site, interim actions for portions of the site were evaluated.

In January 1996, DOE issued an EE/CA (DOE1996a) describing remedial alternatives for Building 38. Also included was the removal of contaminated soil and rubble (from the demolition of Building 37) stored adjacent to Building 90 that was found to be above the established soil cleanup guidelines for the site.

Two alternatives were considered in the EE/CA for the stored soil and rubble and for the demolition debris from Building 38. The first, no interim action, was required by CERCLA to establish a baseline for comparison. The second was decontamination and controlled dismantlement of Building 38, and the removal and shipping of the Building 38 rubble along with the stored soil and rubble pile to an off-site radioactive material disposal facility. Based on public comments and an evaluation of the alternatives as to the effectiveness of being protective to human health and the environment, the alternatives implementability and the alternatives cost, the selected alternative was to demolish Building 38 and transport it along with the contaminated soil and rubble stored adjacent to Building 90 to an off-site radioactive disposal facility. An Approval Memorandum for the demolition of Building 38 (DOE 1996b) was issued to formalize this decision and the work was accomplished over the spring and summer of 1996.

In November 1996, DOE issued a second EE/CA (DOE 1996c) describing the interim action alternatives for Building 30 at the Linde Site. Two alternatives were considered; no interim action and the controlled dismantlement of Building 30 and the shipping and disposal of the rubble at an off-site radioactive disposal facility. The preferred alternative was the latter of the two. Initially a third alternative (decontamination) was to be evaluated. However, this alternative was costly with a large amount of uncertainty. Since this building was constructed almost entirely of wood, decontamination could have compromised the structural integrity of the building.

5.2 USACE INVESTIGATIONS AND ACTIONS

On October 13, 1997, the Energy and Water Appropriations Act, PL105-62, was signed into law. This law transferred the administration and execution of FUSRAP cleanups from DOE to USACE. Since the Linde Site was designated for some form of remedial action under FUSRAP in February 1980, USACE continued cleanup activities at the Linde Site that DOE had begun.

USACE issued a revised EE/CA (USACE 1998a) for Building 30 to reflect the manner in which USACE implemented CERCLA requirements. USACE considered but rejected a third alternative of decontamination of Building 30. Once again the second alternative of controlled dismantlement of Building 30 with off-site disposal was chosen. Further, it was decided that although previous investigations revealed radionuclides in soil above the proposed contamination limits below the concrete floor slab of Building 30, this soil would not be removed under this action but would be addressed as part of the site-wide remedial plan for soils at the Linde Site.

An Action Memorandum for the demolition of Building 30 (USACE 1998b) was issued in February of 1998 formalizing the decision. The building dismantlement and rubble loading and shipping occurred during the summer and fall of 1998 under the direction of USACE.

In early 1999, USACE, having no specific ARAR-based standards that addressed residual concentrations of uranium in soils, prepared a document entitled Technical Memorandum: Linde Site Radiological Assessment, Rev.1. (USACE 2000a). This USACE assessment considered the radiological risk associated with the presence of uranium and other FUSRAP-eligible COCs in the Linde Site soils and also the risks associated with uranium due to its chemical toxicity. As described in this Technical Memorandum, a uranium cleanup level for the Linde Site soils based on limiting radiological risks was determined to be more restrictive than the cleanup level based on the chemical toxicity of uranium. USACE found that the total residual uranium concentration could range from approximately 7 to 740 picocuries per gram (pCi/g) for an intended future industrial land use, which would result in potential maximum radiological risks ranging from 10^{-6} to 10^{-4}, respectively.

Further, an evaluation of this radiological assessment report concluded that the risk associated with the residual radium and thorium concentrations remaining after remediation down to the recommended Title 40 Code of Federal Regulations Part 192 (40 CFR Part 192) standards at approximately 10^{-5} for the contaminated assessment areas. Therefore, USACE chose a conservative total uranium (total U) cleanup guideline of 600 pCi/g. This concentration was based on limiting potential radiological risks due to uranium in the Linde Site soils to less than 10^{-4}. USACE evaluated a cleanup guideline of 600 pCi/g for total U for the contaminated spots throughout the site to estimate what the residual uranium concentrations would be after removing the isolated spots exceeding this guideline. USACE found that the average residual uranium source term concentrations in the various assessment units site wide would be below 60 pCi/g (USACE 2000a).

Following that evaluation, new regulations amending 10 CFR 40, Appendix A, Criterion 6(6) were promulgated by the Nuclear Regulatory Commission (NRC) and became effective on June 11, 1999. These regulations were evaluated and determined to be relevant and appropriate for the Linde Site since they addressed residual uranium and other radionuclides present at uranium mill sites, similar to the Linde Site. USACE then used the information contained in this Technical Memorandum (USACE 2000a) to determine what the surface and subsurface cleanup benchmark doses would be for the average member of the critical group (commercial/industrial site worker scenario) and the associated concentration limits for each of the radionuclides to be used in computing the sum of the ratios (SOR). The results of the evaluation found that the surface and subsurface cleanup benchmark doses for a commercial/industrial worker scenario were 8.8 millirem per year (mrem/yr) and 4.1 mrem/yr, respectively. The various radionuclide concentration limits, above background, within a 100 square meter (m^2) [1,076 square foot (ft^2)] area for the surface cleanup benchmark dose were 554 pCi/g of total U, 5 pCi/g of Ra-226 and 14 pCi/g of Th-230. The various radionuclide concentration limits, above background, within a

100 m^2 (1,076 ft^2) area for the subsurface cleanup benchmark dose were 3,021 pCi/g of total U, 15 pCi/g of Ra-226 and 44 pCi/g of Th-230. These surface and subsurface soil concentrations, expressed as elevated measurement comparison derived concentration guideline levels or $DCGL_{emc}$. These ARAR-based limits ensure no small, discrete area of elevated activity will produce unacceptable doses and are considered protective of human health.

In early March 1999, USACE issued a feasibility study addendum for the Linde Site (USACE 1999a). The FSA focused solely on the Linde Site and summarized findings and assessments not available at the time the original FS Report for the Tonawanda Site (DOE 1993c) was prepared. Key findings of the 1993 DOE documents pertaining to the Linde Site, along with findings of the more recent USACE Linde documents were included. The status of building demolition and decontamination at Linde was updated, and updated information on radiological contamination was summarized. The alternatives considered for the Linde Site itself were described and evaluated, including risks and costs.

On March 26, 1999, USACE issued a proposed plan specifically for the Linde Site (USACE 1999b). The proposed plan revised the preferred alternative for the site remediation based on public comments and new findings during subsequent Linde Site investigations and studies conducted since the original proposed plan in 1993 (DOE 1993d). This proposed plan changed the critical group receptor from a resident farmer, as used in the EE/CAs, to an industrial site worker, which better represented the past and expected future site use. Further this proposed plan identified the cleanup criteria for Linde Site remediation, described the remedial action alternatives identified and evaluated by USACE, and proposed a plan for remediation. The preferred alternative, referred to as Alternative 4 in the proposed plan (USACE 1999b) involved excavation and off-site disposal of contaminated soils, decontamination of buildings, and the imposition of institutional controls in Building 14 of the Linde Site, where a minor amount of contamination would be left after remediation was completed. Building 57 would be demolished to reach the contaminated soil under that slab. Contaminated sediments in drain lines would be removed and the subsurface vault rumored to be located west of Building 73 would be investigated and removed if found to be contaminated. The adjacent National Grid and CSX properties, where radioactive contamination was already identified or may be identified as the remediation work was implemented, would be remediated, but would be limited to following releases that originated from the Linde Site resulting from MED-related operations.

On March 3, 2000, the *Record of Decision for the Linde Site* (USACE 2000b), hereafter referred to the ROD for the soils OU, was signed. The remedy selected for the Linde Site included the residual radioactive material removal and building slab removal actions of Alternative 2 as described in the proposed plan (USACE 1999b), but did not include Building 14 nor the soils beneath Building 14. An explanation of the significant differences between the proposed plan (USACE 1999b) and the ROD was provided in Section 11 of the ROD.

USACE determined that the cleanup standards found in 40 CFR Part 192, the standards for cleanup of the uranium mill sites designated under the Uranium Mill Tailings Radiation Control Act (UMTRCA), and the NRC standards for decommissioning of licensed uranium and thorium mills, found in 10 CFR Part 40, Appendix A, Criterion 6(6), were relevant and appropriate for cleanup of MED-related contamination at the Linde Site. The major elements of this remedy involved the excavation of soils with FUSRAP-eligible COCs (radium, thorium and uranium) above the soil cleanup levels and placement of clean material to meet the other criteria of 40 CFR 192, and cleanup of contaminated surfaces in buildings with FUSRAP-eligible COCs above the surface cleaning levels.

There were no FUSRAP-eligible chemical COCs identified for the Linde Site. All three FUSRAP-eligible COCs posed risks to human health above limits established in NCP under an industrial-use scenario, which had been identified as the reasonable future-use scenario for the Linde Site. Building 14 and groundwater were addressed under subsequent RODs.

The selected remedy involved the demolition of buildings necessary to remediate soils at the site. This included Buildings 57, 67, 73, 73B, 75 and 76 and also included the building slabs and foundations. The slabs that remained after the demolition of Buildings 30 and 38 and the tank saddles north of Building 30 were also removed. A wall in Building 31 was removed to access sub slab and sub-footing soils exceeding criteria. The selected remedy also included remediation of the adjacent National Grid and CSX properties, where radioactive contamination was already identified or may have been identified as the remediation work was implemented and would be limited to following releases that originated from the Linde Site resulting from MED-related operations. The plan also included the removal of contaminated sediments from drain lines and sumps, the removal of contaminated soil from a blast wall structure located east of Building 58, and remediation of a subsurface vault structure located just west of Building 73, if found.

On October 10, 2002, USACE issued the proposed plan (USACE 2002) for the Building 14 OU for public review and comment. Building 14 was one of five buildings used at the Linde Site for MED activities. Specifically Building 14 was used for laboratory and pilot plant studies to optimize the uranium separation process in the early part of MED operations. This proposed plan presented the remedial action objectives (RAOs) and cleanup standards for the project and examined five remedial alternatives. The proposed plan identified the preferred alternative as Alternative 5, removal and off-site disposal at an appropriately permitted or licensed waste facility.

On April 10, 2003, USACE issued the ROD for the Building 14 OU (USACE 2003a) that included a public comment responsiveness summary. The selected remedy described within the ROD was Alternative 5 from the proposed plan; removal and off-site disposal. Implementation of the selected remedy required the dismantlement of Building 14 and the removal of the building demolition debris from the site. The utility tunnel located beneath Building 14 was relocated to allow removal of contamination within and around the tunnel structure. The building structure surfaces and underlying soils were evaluated as part of the final status survey (FSS) to determine if residual concentrations of the contaminants of concern (radium, thorium, and uranium) were present above the cleanup criteria. All building materials and soils found to be above the cleanup criteria were remediated and disposed of at an appropriately permitted or licensed waste facility. As it was expected that no contaminants would remain above levels allowing unrestricted use, a five-year review was not required or planned for the Building 14 OU.

In October 2004, USACE issued a FS Report for the groundwater OU at the Linde Site (USACE 2004). The FS Report described earlier Linde Site groundwater investigations by the DOE and groundwater investigations conducted at the Linde Site by USACE in 2001 and 2002. ARARs for groundwater at the Linde Site were identified. The need for groundwater remediation at Linde was assessed and two alternatives for Linde Site groundwater were identified and evaluated in terms of CERCLA evaluation criteria; no action and a limited action alternative, where groundwater would be periodically monitored and land-use controls would be established.

A comparative evaluation of the alternatives for Linde Site groundwater was then presented in detail and the FS concluded that remediation was not required.

In September 2005, after USACE received a comment requesting that other non-drinkable uses of the Linde groundwater such as irrigation for gardening be evaluated, an addendum to the FS Report for the groundwater OU at the Linde Site (USACE 2005) was developed and issued. Based on the additional assessment, USACE concluded that no complete pathways for current or future exposure to MED/AEC-related constituents in Linde groundwater existed. Since the groundwater OU at the Linde Site posed no current or potential threat to human health or the environment, the consideration of ARARs or land-use controls was not required and no action was warranted. This addendum to the FS Report was prepared to document the findings of these additional assessments by USACE and amend the FS Report to delete references to ARARs and related FS narrative that developed and assessed alternatives for Linde groundwater.

On April 18, 2006, USACE issued the proposed plan for the groundwater OU at the Linde Site (USACE 2006a). This plan provided background information on the shallow and deep groundwater at the Linde Site in the area of the underground injection wells used during the MED/AEC era. It summarized the findings and conclusions of USACE groundwater investigations of 2001 and 2002 conducted to address the significance of FUSRAP-eligible constituents in Linde groundwater. Finally, it presented the rationale for the USACE recommendations for Linde groundwater. Given the extensive excavation and removal of soil from the site containing elevated levels of uranium and other radionuclides, potential sources for leaching of radionuclides to shallow groundwater were greatly reduced and any potential for impacts were not significant. In assessing whether CERCLA action was warranted for groundwater at Linde, USACE considered the two threshold criteria for remedy selection established in CERCLA Section 121, and described in the NCP at 40 CFR 300.430(f)(I)(i)(A), namely protection of human health and the environment and compliance with ARARs. USACE also addressed the requirement in NCP Section 300.430(e)(6) that the No Action alternative be considered in CERCLA decisions. Because there was no exposure pathway to a human or environmental receptor for any FUSRAP COC in the affected groundwater, the No Action alternative was protective. Therefore, there were no ARARs for the groundwater at this site because the water was not and would not become suitable for drinking. Therefore, the No Action alternative was appropriate, and the conclusion was that no CERCLA action was warranted for the groundwater OU at the Linde Site.

In December 2006, USACE issued the ROD for the groundwater OU at the Linde Site (USACE 2006b). It stated that, as described in the proposed plan (USACE 2006a), no action for Linde Site groundwater was warranted because there were no exposure pathways to human or environmental receptors for any FUSRAP-eligible constituents in the affected groundwater.

This conclusion was based on the USACE's determination that naturally occurring concentrations of constituents in groundwater at the Linde Site precluded its use without treatment, and the treatment to remove the naturally occurring constituents would also remove any of the FUSRAP-eligible constituents that may be present. Since no remedial actions were warranted, it was determined that there was no need for further reviews and monitoring at the site with respect to the groundwater OU.

In August 2010, USACE issued a Five-Year Review Report for the Linde FUSRAP Site (USACE 2010) for the Soil OU in accordance with the Comprehensive Five-Year Review Guidance (United States Environmental Protection Agency (EPA) 2001). The purpose of the CERCLA five-year review was to determine the effectiveness and protectiveness of the selected remedial actions as outlined within the ROD for the Linde Site (USACE 2000b) and report and evaluate the progress of any remediation currently taking place. The five-year review process found that the soils OU remedy, being implemented at the Linde Site, was expected to be protective of human health and the environment upon completion and, in the interim, exposure pathways that could result in unacceptable risk were being controlled.

This *Site Closeout Report for the Linde FUSRAP Site* was prepared in accordance with USACE Engineer Regulation 200-1-4 (USACE 2014), which defines the USACE's roles and responsibilities under FUSRAP.

6.0 SELECTED REMEDY

The Linde Site is comprised of three OUs:

- Soils and Structure Surfaces (except for Building 14),
- Building 14, and
- Groundwater.

The remedy for each OU, and two prior non-time-critical removal actions, is summarized below.

6.1 NON-TIME-CRITICAL REMOVAL ACTION (BUILDING 38)

The remedy selected for interim removal actions at the Linde Site was referred to as Alternative 2, demolition of Building 38 and shipment of building rubble and stored soil that exceed cleanup guidelines to a permitted or licensed disposal facility, in the EE/CA issued in January 1996 (DOE 1996a). Implementation of the selected remedy in accordance with the Approval Memorandum for Praxair Interim Actions (DOE 1996b) involved the demolition of Building 38 and excavation of stored soil, off-site transportation, and disposal at an appropriately permitted or licensed disposal facility.

In accordance with DOE guidelines (DOE 1990) and Regulatory Guide1.86 (AEC 1974) for commercial nuclear operations at that time, the allowable average, maximum, and removable radioactivity levels for uranium for unrestricted use of buildings and equipment was 5,000 disintegrations per minute per 100 square centimeters (dpm/100cm^2), 15,000 dpm/100cm^2, and 1,000 dpm/100 cm^2, respectively.

There were no specific guidelines at that time for allowable residual uranium in soil. General guidance from DOE guidelines (DOE 1990), that were in effect at that time, stated that the exposure of members of the public to radiation sources shall not cause an effective dose equivalent greater than100 mrem/yr. A highly conservative (i.e. resident farming) scenario model predicted that 150 pCi/g of residual uranium could be left in soil without exceeding a 100 mrem/yr dose. After applying an as low as reasonably achievable (ALARA) approach, DOE proposed a site-specific uranium guideline of 60 pCi/g total U and 28.4 pCi/g for U-238. For residual radium (Ra-226 and radium-228) and thorium (Th-230 and thorium-232) in soil, DOE Order 5400.5 (DOE 1990) specified an isotopic limit of 5 pCi/g averaged over the first 15 centimeters (cm) [6 inches (in)] below the surface and 15 pCi/g averaged over 15-cm (6-in) thick layers of soil more than 15 cm (6 in) below the surface.

Although no data was available to assess the concentration of residual radioactivity in the stored soil, a removal action was warranted due to the sources of the material and the likelihood that a portion exceeded the 60 pCi/g criterion for uranium and/or the 5 pCi/g criterion for radium and thorium. If the site use was altered, the stored soil could have potentially migrated and the risk to human health or the environment would have increased.

6.2 NON-TIME-CRITICAL REMOVAL ACTION (BUILDING 30)

The remedy selected for the non-time-critical removal action of Building 30 at the Linde Site was referred to as Alternative 2, demolition of the building and shipment of building rubble that exceeded cleanup guidelines to a licensed disposal facility, in the EE/CA issued in November 1996 (DOE 1996c). Implementation of the selected remedy involved the demolition of Building 30, off-site transportation, and disposal at an appropriately permitted or licensed disposal facility. The demolition of Building 30 was completed in accordance with the Action Memorandum (USACE 1998b) in September 1998.

In accordance with DOE guidelines (DOE 1990) and Regulatory Guide1.86 (AEC 1974) for commercial nuclear operations at that time, the allowable average, maximum, and removable radioactivity levels for uranium for unrestricted use of buildings and equipment was 5,000 dpm/100cm^2, 15,000 dpm/100cm^2, and 1,000 dpm/100 cm^2, respectively.

6.3 SOILS OU

The remedy selected for the soils OU at the Linde Site, was referred to in the proposed plan issued in March 1999 (USACE 1999b), as Alternative 2, complete excavation and decontamination with off-site disposal. Building 14, and the soils beneath it, were not included in the scope of the ROD for the soils OU. Implementation of the selected remedy involved excavation of soils containing FUSRAP-eligible COCs above guidelines and off-site disposal at an appropriately permitted or licensed disposal facility and decontamination of the surfaces of structures exceeding guidelines.

The USACE determined that the EPA's health and environmental protection standards for uranium and thorium mill tailings found in Title 40, Part 192, Subpart B of the Code of Federal Regulations (40 CFR 192) and the NRC standards for the domestic licensing of source material found in Title 10, Part 40, Appendix A, Criterion 6(6) of the Code of Federal Regulations (10 CFR 40) were relevant and appropriate for cleanup of FUSRAP-contamination in the soils OU at the Linde Site.

Subpart B of 40 CFR Part 192 sets standards for residual concentrations of Ra-226 in soil. It requires that radium concentrations shall not exceed background by more than 5 pCi/g in the top 15 cm (6 in) of soil or 15 pCi/g in any 15 cm (6 in) layer below the top layer, averaged over an area of 100 m^2 (1,076 ft^2).

Subpart B also provides standards for any occupied or habitable building associated with the soils beneath or surrounding the building, not the equipment or surfaces within the building. These standards require that the remedial action will:

- Achieve an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 working level (WL). In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL, and that
- The level of gamma radiation shall not exceed the background level by more than 20 microroentgens per hour (µR/hr).

10 CFR 40, Appendix A, Criterion 6(6) requires that residual radioactive materials remaining after remediation will not result in a total effective dose equivalent (TEDE), considering all radionuclides present (e.g., radium, thorium, and uranium) to the average member of the critical group exceeding a benchmark dose established based on cleanup to the radium standards of 5 pCi/g in the top 15 cm (6 in) and 15 pCi/g in subsequent 15 cm (6 in) layers below the top layer and must be ALARA. This benchmark dose is then used to establish allowable surface and subsurface soil concentration levels for the various radionuclides present other than radium.

Using the information contained in the radiological assessment (USACE 2000a), USACE computed the benchmark doses for the cleanup of surface and subsurface soil. The results of the evaluation found that the surface and subsurface cleanup benchmark doses for a commercial/industrial worker scenario were 8.8 mrem/yr and 4.1 mrem/yr, respectively. The various radionuclide concentration limits, above background, within a 100 m^2 (1,076 ft^2) area for the surface cleanup benchmark dose were 554 pCi/g of total U, 5 pCi/g of Ra-226 and 14 pCi/g of Th-230. The various radionuclide concentration limits, above background, within a 100 m^2 (1,076 ft^2) area for the subsurface cleanup benchmark dose were 3,021 pCi/g of total U, 15 pCi/g of Ra-226 and 44 pCi/g of Th-230. These criteria applied to the soils remediated at Linde. The surface criteria were developed for specific buildings or surfaces based on likely exposure scenarios and meeting the surface cleanup benchmark dose of 8.8 mrem/yr.

The RAOs for the Soils OU at the Linde Site were to:

- Remove soils exceeding the 40 CFR 192 standards for radium, which includes consideration of thorium, when averaged over 100 m^2 (1,076 ft^2);
- Remove soils with residual radionuclide concentrations within a 100 m^2 (1,076 ft^2) area that result in exceeding unity for the SOR of Ra-226, Th-230, and total U concentrations to the associated concentration limits, above background, as described in Table 1 for surface and subsurface soil cleanups;
- Remove residual radioactive materials from building and structure surfaces necessary to meet the benchmark dose for surfaces of 8.8 mrem/yr based on the specific location of the surfaces and exposure scenarios; and
- Remediate the Linde Site to ensure that no concentration of total U exceeding 600 pCi/g above background would remain in the site soils.

Table 1 –Derived Concentration Guideline Levels - Elevated Measurement Comparison ($DCGL_{emc}$) for the Soils Operable Unit at the Linde Site

COCs	Average Site Background Concentrations (pCi/g)[d]	$DCGL_{emc}$ for Commercial/Industrial Worker Protection (pCi/g)[a,b]	
		Surface: 8.8 mrem/yr	Subsurface: 4.1 mrem/yr
Ra-226	1.1	5	15
Th-230	1.4	14	44
total U [c]	6.1	554	3,021

[a] These cleanup goals represent COC concentrations above average site background averaged over a 100 m^2 (1,076 ft^2) area.

[b] If a mixture of radionuclides was present, then the SOR applied per the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). For example, using the residual concentration limits for soil, the following sum of ratios equation is obtained for surface soil (SS) and subsurface soil (SB):

$$SOR_{SS} = \frac{Ra\text{-}226}{5} + \frac{Th\text{-}230}{14} + \frac{total\ U}{554}$$

$$SOR_{SB} = \frac{Ra\text{-}226}{15} + \frac{Th\text{-}230}{44} + \frac{total\ U}{3,021}$$

where SOR = sum of ratios (SOR) result:
Ra-226 = net Ra-226 soil concentrations
Th-230 = net Th-230 soil concentrations
total U = net total U soil concentrations

Note: Net soil concentrations exclude average background.

[c] Total U is the sum of the isotopes (uranium-234 (U-234), uranium-235 (U-235), and U-238).
[d] Average site background concentrations (DOE 1993a and USACE 2000b)

The selected remedy addressed the principal threat from FUSRAP-eligible COCs at the site by removing radioactively contaminated soil from the site that may pose a future threat to the health of persons at the site. Implementation of this remedy was intended to meet the release criteria defined in the ARARs discussed above for a commercial/industrial worker. The selected remedy only addressed FUSRAP-eligible COCs, and did not address any other hazardous substances that may have been present at the site. The determination of the need for and performance of response actions related to other potential releases of hazardous substances at this site was not within the authority of USACE under FUSRAP.

6.4 BUILDING 14 OU

The remedy selected for the Building 14 OU at the Linde Site was referred to as Alternative 5, removal, in the proposed plan (USACE 2002) issued in August 2002. Implementation of the selected remedy involved demolishing Building 14 and removing the demolition debris from the Linde Site. The utility tunnel located beneath Building 14 was relocated to allow for removal of contamination within and around the tunnel structure. Building components and soils under the building were surveyed to determine the material and soils radioactively contaminated with COCs above the cleanup criteria. All contaminated materials and soils were disposed of at a permitted or licensed disposal facility.

The USACE determined that cleanup standards found in 40 CFR 192, the standards of cleanup of the uranium mill sites designated under the Uranium Mill Tailings Radiation Control Act, along with the NRC standards for decommissioning of licensed uranium and thorium mills found in 10 CFR 40, Appendix A, Criterion 6(6) were relevant and appropriate for cleanup of FUSRAP-eligible contamination in the Building 14 OU at the Linde Site.

USACE also determined that the New York State Department of Labor (NYSDOL) Regulations for Ionizing Radiation Protection, 12 New York Codes, Rules, and Regulations (NYCRR) Part 38 were relevant and appropriate to the cleanup of any building or structural surface if such building or structural surface were to remain in place after the building was removed. Compliance with these requirements required that such building or structural surface be remediated in accordance with Table 1 of 12 NYCRR Part 38 or removal of FUSRAP-eligible residual radioactive materials from such surfaces as would be necessary to meet the benchmark dose for surfaces of 8 mrem/yr in accordance with 10 CFR 40, Appendix A, Criterion 6(6), based on the specific location of the surfaces and exposure scenarios, whichever was more stringent.

The RAOs for the Building 14 OU at the Linde Site were to:

- Remove FUSRAP-eligible soil exceeding the 40 CFR 192 standards for radium (see Table 1), which includes consideration of thorium, when averaged over 100 m^2 (1,076 ft^2);
- Remove Building 14, so that no contaminated occupied or habitable building remains;
- Remove soils with residual radionuclide concentrations within a 100 m^2 (1,076 ft^2) area that result in exceeding unity for the SOR of Ra-226, Th-230, and total U concentrations to the associated concentration limits, above background, as described in Table 1 for surface and subsurface soil cleanups;
- Remove residual radioactive materials from surfaces necessary to meet the benchmark dose for surfaces of 8.8 mrem/yr based on the specific location of the surfaces and exposure scenarios; and
- Remediate the Linde Site to insure that no concentration of total U exceeding 600 pCi/g above background would remain in the site soils.

The selected remedy for the Building 14 OU addressed the principal threat from FUSRAP-eligible COCs at the site by eliminating radioactive contamination in soils and on building structures that may pose a future threat to the health of persons at the site. Because it was expected that this remedy would not result in FUSRAP-eligible hazardous substances, pollutants, or contaminants remaining at the Building 14 OU above levels that allow for UU/UE, a five-year review was not required for this remedial action.

6.5 GROUNDWATER OU

USACE issued a no action ROD (USACE 2006b) for the groundwater OU at the Linde Site on January 29, 2007. As described in the proposed plan (USACE 2006a), USACE concluded that no complete pathways to human or environmental receptors exist for current or future exposure to FUSRAP-eligible constituents in affected groundwater at Linde. This conclusion was based on USACE's determination that naturally-occurring concentrations of constituents in groundwater at the Linde Site preclude its use without treatment, and treatment to remove naturally-occurring constituents would also remove any of the FUSRAP-eligible constituents that may be present. Since no actions were warranted, there was no need for further CERCLA reviews and/or monitoring of the groundwater OU.

7.0 REMEDIAL ACTION SUMMARY

Two non-time-critical removal actions and three phases of remedial action were conducted at the Linde Site as follows:

- **Non-Time-Critical Removal Action (1996-1998)**
  - Demolition of Building 38
  - Excavation of Radioactively Contaminated Soil Stored Next To Building 90
  - Decontamination of Buildings 14, 30, and 31

- **Non-Time-Critical Removal Action (1998-1999)**
  - Demolition of Building 30

- **Remedial Action (1999-2010) of Soils OU**

- **Remedial Action (2004-2005) of Building 14 OU**

- **Remedial Action (2010-2013) of Soils OU**

7.1 NON-TIME-CRITICAL REMOVAL ACTION (1996-1998)

DOE issued an EE/CA (DOE 1996a) to support a non-time-critical removal action at the Linde Site. An *Approval Memorandum for Praxair Interim Actions* (DOE 1996b) documented the selected alternative for interim actions of:

- Demolition of Building 38, and
- Cleanup of radioactively contaminated soil stored next to Building 90.

7.1.1 Demolition of Building 38

A 1976 radiological survey by Oak Ridge National Laboratory (ORNL 1978) found above background levels of radioactivity in Building 38. A spot-check 1981 radiological survey by FBDU (FBDU 1981) confirmed the 1976 survey results. A subsequent radiological survey (DOE 1993a) found most surfaces in Building 38 had levels of fixed radioactivity exceeding guidelines, but no removable activity above guidelines was detected on floors or walls.

Results from radiological surveys conducted inside Building 38 indicated that the building contained sufficient residual radioactivity to require radiological controls. Although radioactivity in Building 38 was contained, a removal action was warranted to prevent further deterioration of the building that could have resulted in the migration of radioactivity from the building materials.

The removal action recommended in the EE/CA (DOE 1996a) and documented in the *Tonawanda Site – Approval Memorandum for Praxair Interim Actions* (DOE 1996b) was the demolition of Building 38 and the off-site disposal of contaminated debris. The EE/CA estimated that 412 m^3 (550 yd^3) of rubble would be radiologically impacted and required off-site transport to a permitted or licensed disposal facility.

The demolition of Building 38 was accomplished by BNI in August 1996 on behalf of the DOE as discussed in the *Close-out Packages for the Three Remedial Actions Conducted at the Linde Site during Calendar Years 1996, 1997* (BNI 1998). Approximately 208.14 metric tons (229.44 tons) [612 m^3 (800 yd^3)] of low-level radioactively contaminated debris was contained in 34 intermodals and shipped by rail to Energy Solutions' Clive, Utah, disposal facility (formerly Envirocare of Utah) in October 1996.

7.1.2 Excavation of Radioactively Contaminated Soil Stored Next to Building 90

In 1977, during preparation for construction of Building 90, soil containing residual radioactive material was removed from the construction site and placed in two elongated windrows along the northern and eastern fences on the property and in a temporary storage area on the northern portion of the property. Between 1979 and 1982, the windrows along the fence and temporary storage area were consolidated into one stored soil area west of Building 90.

The soil stored next to Building 90 was comprised of different sources of material (i.e. wastes from the process operations, radioactive soil from the Building 90 construction site and utilities construction, materials removed from Buildings 14 and 37 during decontamination activities, and debris from the demolition of Building 37).

The removal action recommended in the EE/CA (DOE 1996a) and documented in the *Tonawanda Site – Approval Memorandum for Praxair Interim Actions* (DOE 1996b) was the off-site disposal of the contaminated soil near Building 90.

The EE/CA estimated volume of material stored next to Building 90 was 9,000 m^3 (12,000 yd^3). The percentage of radiologically contaminated material from this waste stream requiring off-site transport to a permitted or licensed disposal facility was unknown.

The soil pile was originally stored next to Building 90. Later it was moved into Building 30 where radiological surveys and samples confirmed that approximately 2,294 m^3 (3,000 yd^3) of the 9,000 m^3 (12,000 yd^3) soil pile exceeded site radiological release criteria.

About 535 m^3 (700 yd^3) of radiologically contaminated soil and soil-like material was later added to the 2,294 m^3 (3,000 yd^3) soil pile. Approximately 41 m^3 (54 yd^3) of radiologically contaminated material was generated during decontamination activities discussed in Section 6.1.3. BNI shipped the resulting 4,428 metric tons (4,881 tons) [2,870 m^3 (3,754 yd^3)] soil pile by rail to Energy Solutions' Clive, Utah, disposal facility (formerly Envirocare of Utah) between October 6 and December 4, 1997.

7.1.3 Decontamination of Buildings 14, 30, and 31

Decontamination of Buildings 14, 30, and 31 was also planned during this phase of interim actions. The decontamination did not require an EE/CA since it was conducted inside buildings and there was no substantial threat of release to the environment. A categorical exclusion was prepared by DOE under the National Environmental Policy Act (NEPA) to address the decontamination of Buildings 14 and 31 (DOE 1996a). Although Building 30 was also included in the categorical exclusion, further analysis determined demolition would be more economical and feasible. Building 30 was a wood framed structure consisting of wood columns, trusses, stud walls, and roof framing. A majority of the wood members contained radioactive materials. An attempt to decontaminate the wooden structural members may have compromised the structural integrity of the building. Therefore, DOE prepared a subsequent EE/CA (DOE 1996c) to evaluate the demolition alternative for Building 30.

Decontamination work at Buildings 14 and 31 was completed by USACE in 1998. The decontamination criteria for the soils and surfaces used during this effort were established by DOE (DOE 1990). The decontamination efforts were completed by USACE as part of the transfer of FUSRAP from DOE to USACE and Congress' mandate for USACE to honor DOE's past commitments. During the decontamination effort, a few inaccessible areas were identified where removal to the criteria established by DOE was not possible.

The *Post Remedial Action Report for Building 14 at the Linde Site, Tonawanda, New York* (USACE 1999c) provided details of efforts initiated under DOE to decontaminate Building 14 interior surfaces and subsurface soils beneath slabs inside the building where MED-related activities occurred. The report (USACE 1999c) indicated that risks from residual materials remaining in currently inaccessible areas would be acceptable under current circumstances and building uses and controls.

The *FUSRAP Technical Memorandum: Delineation and Remedial Action Performed in Building 31* at the Praxair Site (BNI 1997) described the decontamination performed in Building 31. The decontamination work was performed by DOE using criteria established by DOE. An ORNL report, *Results of the Independent Radiological Verification Survey of Remediation at Building 31, Former Linde Uranium Refinery* (ORNL 1998), indicated the decontamination in accordance with DOE criteria was successful. The report noted that there was still radioactive contamination under part of the Building 31 slab. Removal of the Building 31 slab and the contamination beneath the slab was included in the remedy selected for implementation at the Linde Site.

Approximately 41 m^3 (54 yd^3) of radiologically contaminated material was generated during decontamination activities, which was consolidated with radioactively contaminated soil stored next to Building 90, discussed in Section 6.1.2, for disposal purposes.

7.2 NON-TIME-CRITICAL REMOVAL ACTION (1998-1999)

DOE issued an EE/CA (DOE 1996c) to support a non-time-critical removal action addressing the demolition of Building 30 at the Linde Site and off-site disposal. USACE issued a responsiveness summary (USACE 1998a) and Action Memorandum (USACE 1998b) selecting the preferred alternative as the appropriate course of action. The demolition of Building 30 was completed in accordance with the Action Memorandum (USACE 1998b) in September 1998.

7.2.1 Demolition of Building 30

A 1976 radiological survey by Oak Ridge National Laboratory (ORNL 1978) found radioactive material on the interior surface of Building 30. A spot-check 1981 radiological survey by FBDU (FBDU 1981) was conducted to confirm the 1976 survey results. The FBDU survey found that most of the floor area, rafters, walls, ceilings, and exhaust fans in Building 30 exceeded guidelines for fixed radioactivity. Transferrable radioactivity above criteria was found on the rafters. Borings through the floor revealed the soil beneath Building 30 contained radionuclides above guidelines. A subsequent radiological survey (DOE 1993a) confirmed most of the floor area with radioactivity exceeding DOE guidelines was in the southern third of the building, the building had both fixed and removable radioactivity above DOE guidelines, and radioactive soil was present beneath and around the building.

In accordance with DOE guidelines (DOE 1990) and Regulatory Guide1.86 (AEC 1974) for commercial nuclear operations at that time, the allowable average, maximum, and removable radioactivity levels for uranium for unrestricted use of buildings and equipment was 5,000 dpm/100cm^2, 15,000 dpm/100cm^2, and 1,000 dpm/100 cm^2, respectively.

Results from radiological surveys conducted inside Building 30 indicated that the building contained sufficient residual radioactivity to require radiological controls. Radioactivity in Building 30 was contained and the building was no longer used, so no current human radiation exposure associated with this material was happening. However, a removal action was warranted since, if the site use was altered, increased exposure to humans could potentially occur and the risk to human health or the environment would increase.

The removal action recommended in the EE/CA (DOE 1996c) and *EE/CA and Responsiveness Summary for Building 30 at Praxair* (USACE 1998a), and documented in the Action Memorandum (USACE 1998b), was the demolition of Building 30 and the off-site disposal of contaminated debris. The EE/CA estimated that 3,736 m^3 [4,486 yd^3] of rubble would be radiologically impacted and required off-site transport to a permitted or licensed disposal facility. Radioactive soil beneath Building 30 was not addressed as part of this removal action.

Between June 1998 and May 1999, Radian International, Incorporated (Radian) conducted fieldwork for the demolition and off-site debris removal associated with Building 30 (Radian 1999), in accordance with the Action Memorandum (USACE 1998b). Demolition activities were conducted in September of 1998.

A total of 1,964.27 metric tons (2,165.24 tons) of radioactively contaminated debris was shipped by rail then trucked to the Clean Harbors' (formerly Safety-Kleen) landfill in Buttonwillow, California, for disposal. The majority of this material was wood (90% wood and 10% masonry). In addition, 1,163.60 metric tons (1,282.65 tons) of radioactively contaminated soil and debris were shipped by rail to Energy Solutions' Clive, Utah, disposal facility (formerly Envirocare of Utah), for a total of 3,127.87 metric tons (3,447.89 tons) of radioactive waste shipped off site.

7.3 REMEDIAL ACTION (1999-2010) OF SOILS OU

USACE issued a ROD (USACE 2000b) for the soils OU for the remediation of residual radioactive material in soil and on surfaces of buildings and infrastructure with off-site disposal, as described below. Building 14 and its sub slab soils and site groundwater were excluded from the scope of the ROD (USACE 2000b).

The selected remedy for the soils OU included:

- Demolition of buildings (i.e. Buildings 57, 67, 73, 73B, 75, and 76 including slabs and foundations) necessary to remediate soil at the site;
- Removal of slabs from former Buildings 30 and 38, along with tank saddles north of former Building 30;
- Removal of a wall in Building 31 to access sub slab and sub-footing soils exceeding ROD criteria (The entirety of Building 31 was removed during remedial action to access impacted soils beneath);
- Remediation of radiologically contaminated soils above ROD criteria on adjacent National Grid and CSX properties, which may have been released from the Linde Site;
- Removal of contaminated sediments from drain lines and sumps;
- Removal of contaminated soil from a blast wall structure located east of Building 58; and
- Remediation of a subsurface vault structure located west of Building 73.

The FS Addendum (USACE 1999a) estimated that 13,762 in situ m^3 (18,000 in situ yd^3), or 17,164 ex situ m^3 (22,450 ex situ yd^3), of soil was radiologically impacted and required off-site transport to a permitted or licensed disposal facility.

Between July 1999 and March 2010, IT Corporation (IT) and its successor, Shaw Environmental, Incorporated (Shaw) conducted remedial activities at the Linde Site in accordance with the ROD (USACE 2000b) for the soils OU that was signed on March 3, 2000. The demolition of Buildings 8 East Annex, 8A, 31, 58, 73A, and 90 were not included in the ROD, but deemed necessary during remediation activities to access contaminated soils underneath the buildings.

Excavation areas (EAs) were developed as a means to identify the location and boundaries of areas requiring soil remediation to meet cleanup goals. EAs were identified with letters or building designations with boundaries established in consideration of the expected limits of contamination, physical site features, and the operational approach for safe and effective soils excavation.

IT and its successor, Shaw, completed remedial activities in 19 EAs across the Linde Site, as shown in Figure 4. The following presents a general description of the nineteen EAs remediated by IT/Shaw. Excavation Area P was reserved for a potential utility-related excavation that was not performed during this remedial action effort.

Excavation Area A (EA-A) was the area of the former Building 67, Building 38 pad, and Building 39 pad. The original cover in this area was primarily gravel and concrete slabs.

Excavation Area B (EA-B) was the area located north and west of the former Building 90. The area was primarily covered with grass. A portion of Parking Lot 3 to the south of the excavation and a road west of the excavation was included in this EA.

Excavation Area C (EA-C) was around and included the perimeter foundation of the former Building 31, the concrete floor slab (after demolition), and the soil material beneath the footprint of the building.

Excavation Area D (EA-D) included the former Building 30 pad and extended:

- East to the road between the former Building 30 pad and the former Building 31;
- West to the east face of Building 70;
- North along the east face of the former Building 90 to the north limit covering approximately 2/3 of the former Building 90 concrete pavement and on the south side of Building 70 west to Building 2B; and the
- South limit extended part way down the road east of Building 2C and west of Building 50.

Excavation Area E (EA-E) was the area of the former Buildings 57, 58, 73, 73A, and 73B. The area included a road, gravel, and grassy areas and concrete pads where the buildings were located.

Excavation Area F (EA-F) was located east of Building 8 along the west side of the east property boundary. This area was the location of the large spoils piles, which required relocation prior to classifying and excavating the area. These piles consisted of concrete construction debris, asphalt, steel and concrete pipes and soil-like material. This area also was where the original city-supplied high pressure natural gas service and fiber optic lines entered the site. These utilities required relocation prior to excavation. There was also a small area on the northwest corner of Building 8 known as F-West, which included a portion of the utility tunnel from Building 14. Each of these separate excavations consisted primarily of stone and soil.

Excavation Area G (EA-G), which included EA-G1 and EA-G2, was located within the site boundary and outside the northeastern property line. This area included properties owned by National Grid, CSX, Mil-Sher Complex, Carrier property occupied by Old Dominion Trucking Co., and a small portion of the R.P. Adams property. The area consisted primarily of grassy cover with stone/slag and cinders near the CSX right-of-way and an assortment of dumped debris material in the Mil-Sher property including wood piles, trees and stumps, old empty fuel oil tanks, cinder blocks, tires and various mechanical equipment.

Excavation Area H (EA-H) encompassed the Praxair gate located between former Building 90 and Building 70 and a portion of Parking Lot 4. The area was primarily asphalt and concrete with contaminated fill used as bedding for storm and sanitary sewer lines, and thus required utility bypass work prior to excavation activities.

Excavation Area I (EA-I) was located in the western portion of the site from the entrance gate through a portion of Parking Lot 1, north of Building 101 along the entrance road east to Parking Lot 4. The area consisted of asphalt, steel canopy covered sidewalks, steel pavilion structures, and grassy areas with trees and sprinkler systems. This area also contained contaminated fill used as bedding for storm and sanitary sewer lines, and thus required utility bypass prior to excavation.

Excavation Area J (EA-J) was located in the southern part of the site, north of Building 43. This area consisted of two separate asphalt areas located at the edge of former Building 14. It also included a reinforced concrete utility chase, which was poured concrete with steel plate covers that housed specialty gas lines.

Excavation Area K (EA-K) was located east of former Building 14 and west of the Building 8. The EA was an asphalt road.

Excavation Area L (EA-L) was northeast of the main site electrical substation providing electrical service to the facility. It was also between two railroad spurs on the site and was primarily a stone and grass area.

Excavation Area M (EA-M) was located north and west of the former Building 31 between EA-A and EA-E heading south along the west side of the former Building 31 adjacent to EA-D to the south limit at the east/west tunnel between junction box (JB) 7 to JB 9. This area also had the north/south tunnel between JB 6 to JB 7 remain in place and was excavated on both sides.

Excavation Area N (EA-N) was the slot excavated north of former Building 14 and south of Building 2A and the old Nomex area. This slot was excavated to provide a cleared unit to install the new utility tunnel to reroute the site utilities around former Building 14, which underwent demolition. The sidewalls for this area were two long rows of sheet piles driven deep into the ground, in order to withstand lateral pressure loading from former Building 14 and Building 2A foundations.

Excavation Area O (EA-O) was a very small excavation area on the south side of the site along the south property boundary fence line. This EA was in the grass area between the parking lot and the south fence.

Excavation Area P (EA-P) was reserved for a potential utility-related excavation that was not needed.

Excavation Area Q (EA-Q) was located in the northwest portion of the site, north of and including a portion of Parking Lot 3, east of the Sheridan Drive entrance to the site and south of the north property boundary line fence. This area consisted of the northern entrance roadway asphalt, concrete sidewalk, concrete pavers, and grassy areas with trees.

Excavation Area R (EA-R) was in the old Nomex area east of Building 2A and consisted of four separate excavations, which were primarily in a stone and soil area. The northern-most excavation was in the asphalt paved road leading to an overhead door into Building 2A.

Excavation Area S (EA-S) was a relatively small area located at the north side of the eastern portion of the site adjacent to EA-A and bordering the west edge of EA-M. This area was stone and soil material with some concrete.

Excavation Area T (EA-T) was located in the grass courtyard area west of Building 34 and east of Building 100 South. This was also a small area that required excavating between live fiber optic lines, water main lines and around storm and sanitary manholes.

Table 2 summarizes the buildings and utility tunnels (UTs) demolished during the 1999-2010 remedial action.

Table 2 – Demolition Summary (1999-2010 Remedial Action)

Description	Structure	Demolition Date(s)
Bldg 8 East Annex	Building	04/21/09-04/27/09
Building 8A	Building	01/12/09
Building 31	Building	02/02/09-02/26/09
Building 57	Building	06/02/00-07/20/00
Building 58 and adjacent Blast Wall	Building	10/02/00-11/11/00
Building 67	Building	12/07/00-12/08/00
Building 73	Building	07/25/00-07/28/00
Building 73A	Building	07/21/00
Building 73B	Building	07/13/09-07/14/09
Building 90	Building	05/06/09-05/27/09
UT junction box (JB)1 to JB6	Utility Tunnel	05/08/03
UT JB1 to JB5	Utility Tunnel	09/08/03

As described in the *Project Construction Report, Linde FUSRAP Site* (Shaw 2010), soil excavation activities were conducted between September 2000 and December 2009.

Table 3 summarizes the excavation areas, dates of excavation, and *in situ* excavation volumes from the 1999-2010 remedial action. These volumes exclude material used for backfill and material from building debris. Figure 4 illustrates the aerial extent of remedial actions, including EAs associated with the 1999-2010 and 2010-2013 remedial actions of the Soils OU.

Table 3 – Soil Excavation Summary (1999-2010 Remedial Action)

Excavation Area (EA)	Excavation Dates	Soil Volume Excavated (*in situ* yd^3)
A	03/01-08/01	5,616
B	12/00-11/01	14,740
C	05/01-08/01, 07/02-08/02, 03/09-07/09	3,994
D	03/01-04/02, 07/02-09/02, 03/03-09/04, 07/05-12/05, 05/06-08/06, 02/07-03/07, 01/08-02/08, 06/09-09/09	40,247
E	04/02-05/02, 07/02-11/02, 03/03-03/04, 10/08-11/08	30,137
F	11/05-02/06, 11/07-02/09	9,605
G1	05/02-07/02, 12/02-02/03, 11/07-12/07, 03/08, 05/08	1,966
G2	06/04-06/05, 11/05-05/07, 02/08	17,524
H	07/07-11/07, 07/08-11/08, 08/09-09/09	5,687
I	01/03-07/03, 06/07-10/07, 03/08, 06/08-07/08	13,924
J	10/07-12/07	877
K	11/08-02/09	551
L	09/02-12/02	298
M	10/02-07/03, 09/05-06/06	16,587
N	12/03-03/04	3,044
O	02/05	4
P	Not Excavated	-
Q	04/04-06/05, 08/05-11/05, 03/06-06/06, 03/08-05/08	15,991
R	10/08-02/09	819
S	03/08-06/08	1,085
T	11/08	100
Bldg 70	NA	438
	Total	183,233

Radiologically contaminated soils were detected during the RI (DOE 1993a) at depths 0 to 1.2 m (0 to 4 ft) above the native clay overburden except near some of the former injection wells where contamination was observed to approximately 1.8 m (6 ft) below ground surface. This was explained as overflow of effluent during injection operations discussed in Section 3.4. Additionally, the RI Report (DOE 1993a) indicated that precipitates formed in the bedrock formation where injection occurred. Therefore, radioactive contamination likely remains in the subsurface at Linde as minor percentages of uranyl sulfates and carbonates precipitated in the shale under the Linde Site. However, these radioactive residuals in subsurface bedrock pose no current or future threat to any receptor (including a resident). There are no complete exposure pathways to the radioactive precipitates from the injection wells due to their depth (minimum of 28 m (90 ft)), inaccessibility (backfilled with debris), and USACE's determination that naturally-occurring concentrations of constituents in groundwater at the Linde Site preclude its use without treatment, which would also remove any of the FUSRAP-eligible constituents that may be present (USACE 2006b).

During remedial action, impacted soils were present at varying depths, ranging from approximately 0.9 to 5.5 m (3 to 18 ft) below ground surface (USACE 2010). A total of 312,551 metric tons (344,529 tons) [approximately 131,710 m^3 (172,265 yd^3)] of radiologically contaminated soil and debris were handled by IT/Shaw and transported via rail to permitted or licensed facilities outside of New York State as shown in Table 6.

Remedial activities at the Linde Site, conducted by IT and its successor Shaw, conducted in accordance with the ROD (USACE 2000b) for the soils OU, were continued by Cabrera Services, Incorporated (Cabrera) as discussed in Section 6.5.

7.4 REMEDIAL ACTION (2004-2005) OF BUILDING 14 OU

USACE issued a ROD (USACE 2003a) for the Building 14 OU in April 2003. The selected remedy described in the ROD was Alternative 5, Removal, as identified in the proposed plan (USACE 2002). This alternative included the demolition of Building 14 and removal of building demolition debris from the Linde Site. The utility tunnel located beneath Building 14 would be relocated to allow for removal of contamination within and around the tunnel structure. Building components and an estimated 8.4 m^3 (11 yd^3) of soils under Building 14 that exceeded ROD criteria[4] were disposed of at an off-site permitted or licensed disposal facility.

Between February 2004 and May 2005, Shaw conducted remedial activities at the Linde Site in accordance with the ROD (USACE 2003a) for the Building 14 OU. As described in the *Project Closure Report, Linde Building 14 Operable Unit* (Shaw 2005a) demolition activities were conducted between May 2004 and August 2004. Excavation operations were initiated in August 2004 and completed in February 2005. A total of 4,735 metric tons (5,220 tons) of demolition debris and 7,981 metric tons (8,798 tons) of soil were shipped by rail to Waste Control Specialists in Andrews, Texas, for disposal.

7.5 REMEDIAL ACTION (2010-2013) OF SOILS OU

Cabrera continued remedial activities (i.e. structure demolitions, soil excavations, transportation and disposal, final status surveys, post-excavation topographic surveys, and site restorations) at the Linde Site between July 2010 and May 2013 in accordance with the ROD (USACE 2000b) for the soils OU.

Cabrera completed remedial activities in eight EAs across the Linde Site, as shown in Figure 4. The following presents a general description of the eight EAs addressed by Cabrera.

Excavation Area Building (Bldg) 8 (EA Bldg 8) included the perimeter foundation of the former Building 8 Annex, the concrete slab (after demolition), the soil material beneath the footprint of the building annex, and the soil material immediately north and south of the annex.

[4] Decontamination of Building 14 was completed in 1998, including removal of radioactively contaminated soils from beneath floor slabs. However, a small, inaccessible volume of radioactively contaminated soils was left under the structure support members, which were addressed under this ROD.

Excavation Area Building 90 (EA Bldg 90) included excavation activities mostly located outside the former Building 90 concrete slab along the south and southeast foundation walls. A small portion of the excavation in the southeast corner occurred within Building 90 subsoils which were part of a previously released Class II FSS unit. No excavation activities occurred within other areas of the released Class II FSS unit. The remainder of the Building 90 slab was crushed and used as place-back material in this area as part of restoration activities.

Excavation Area D (EA D) was located south of Building 70 and 70A and Buildings 75 and 76, north of Building 2A and abandoned Building 50, and extended west to the northeast corner of Building 2B and east to the existing EA M Boundary. This EA consisted of two separate excavations. The first excavation was primarily through areas of previously released Class I FSS units containing mostly stone and soil to support relocation of active utilities from the utility tunnel. Following successful relocation of the utilities, a second excavation was performed to remove impacted utility tunnels and subsurface soils. Excavation activities in this area were in close proximity to an active Praxair operations building which required additional coordination with Praxair representatives to prevent disruption to Praxair operations.

Excavation Area F (EA F) was located east of EA Bldg 8, east of Building 104, and northwest and southwest of the Main Site Electrical Substation. This area consisted of five separate excavations to remove abandoned utility tunnels and junction boxes, an abandoned sanitary sewer, and relocate utilities. Utility tunnels and junction boxes were removed east and northeast of Building 8, east of Building 104, and northwest of the Electrical Substation. The removed sanitary sewer was located southeast of Building 8. Various utilities were relocated northeast, east, and southeast of Building 104 and northwest and southwest of the Electrical Substation. An active water line feeding Praxair boilers could not be removed from service and was adequately supported during removal of the sanitary sewer. Each of these separate excavations was primarily stone and soil.

Excavation Area G1 (EA G1) was located within the site boundary and outside the northeastern property line. This area included properties owned by National Grid and CSX. The National Grid and CSX right-of-ways consisted partly of vegetation and stone. Prior to remedial activities, special consideration was given to active infrastructure and utilities traversing this area, including a railroad spur, power lines, and fiber optic cable. The rail spur leading to the Praxair property was properly locked out and disconnected by CSX prior to initiating excavation activities.

Excavation Area G2 (EA G2) was located outside the northeastern property line of the site across the CSX right-of-way. This area included property known as the Mil-Sher complex. The property owner had an assortment of non-FUSRAP related debris dumped across the property including cinder blocks, stone/soil piles, garbage, and vegetation. The debris was not disposed of, but relocated as needed to facilitate remediation.

Excavation Area M (EA M) was located north of the Main Site Electrical Substation and a Class 2 area, west of EA L and a Class II area, east of EA D and south of EA F and EA M areas remediated by the previous contractor. Sheet piling was installed prior to removal of tunnel sections to protect a nearby active electrical duct bank from undermining. The area was primarily stone and soil and included relocation of utilities and removal of abandoned utility tunnels, a junction box, and an electrical duct bank.

Excavation Area T (EA T) was located in the courtyard west of Building 34 and east of Building 100 South. This was a small area consisting of soil and concrete sidewalk slabs beneath an overhead walkway. Active utilities, including fiber optic cables, water lines, and storm and sanitary sewers were protected and maintained during excavation.

The selected remedy required demolition of structures, including the Building 8 Annex slab and foundation, the Building 90 slab and foundation, the Salt Barn slab, junction boxes 6, 7, and 8, and utility tunnel networks between JB 6 and 7, JB 7 and 8, and JB 7 and 9.

Table 4 summarizes the building slabs and foundations, and utility tunnels (UTs) demolished during the 2010-2013 remedial action.

Table 4 – Demolition Summary (2010-2013 Remedial Action)

Excavation Area	Excavation Description	Structure	Demolition Date(s)
Bldg 8	Bldg 8 Annex	Slab	07/02/10-07/06/10
		Foundation	07/20/10, 07/27/10-08/02/10
Bldg 90	Bldg 90	Slab	11/30/10-12/17/10, 05/25/11-07/12/11, 11/16/11-12/19/11, 05/14/12-07/11/12
		Foundation	12/01/10-12/17/10, 05/25/11-06/09/11, 03/01/12-06/06/12
		Loading Dock	03/02/12, 03/12/12-03/13/12
F	Coal Bin	Foundation	03/21/12-03/22/12
Bldg 90	Miscellaneous	Slab	10/30/12-11/15-12
F	Salt Barn	Slab	07/12/11-07/27/11
F	UT Bldg 8 to Bldg 104	Utility Tunnel	08/20/10-11/10/10
F	JB 8	Utility Tunnel	10/05/10-10/07/10
F	UT JB6 to JB7	Utility Tunnel	05/31/11-06/16/11
F	JB 6	Utility Tunnel	03/28/11-03/30/11
D	UT JB7 to JB9	Utility Tunnel	07/11/12-10/01/12
F	JB7 and abandoned duct bank	Utility Tunnel	10/25/12-11/08/12
F	UT JB7 to Bldg 104	Utility Tunnel	10/11/12-11/21/12

After building slabs were demolished, foundation and soil remediation was conducted to an excavation depth of approximately one foot below the slab, and in some cases one foot below the foundation (e.g., continuous footings, piers, or column footings). Slab concrete was either shipped for disposal, recycled or crushed and used as place-back material.

After the tunnels were free of asbestos-containing material (ACM) and the utilities disconnected, individual tunnel sections were demolished using two separate processes. Some tunnel sections were demolished as part of the remedial soil excavation around them. An excavator equipped with a hydraulic ram was used to break up the concrete and an excavator equipped with a hydraulic shear was used to cut and size-reduce rebar, pipes, conduits, and other debris. Tunnel sections demolished following this procedure were excavated and transported to the on-site railcar loading facility.

Tunnel sections also were recovered whole. Whole tunnel sections not meeting the requirements for local disposal or recycling were transported to the railcar loading pad and processed for load out using an excavator with a hydraulic shear. Whole tunnel sections approved for local disposal or recycling were demolished using an excavator with a hydraulic processor.

Table 5 summarizes the excavation areas, dates of excavation, and *in situ* excavation volumes from the 2010-2013 remedial action. These volumes exclude structural material from demolition activities.

Table 5 – Soil Excavation Summary (2010-2013 Remedial Action)

Excavation Area	Excavation Description	Excavation Dates	Soil Volume Excavated (*in situ* yd^3)
Bldg 8	Bldg 8 Annex Soils	07/10-08/10	70
	North and South Soils	-	1,300
Bldg 90	East and South Soils	12/10-03/11	3,170
D	Utility Tunnel	06/12-08/12	7,020
F	Sewer Line	07/11	1,830
	Utility Tunnel	08/10-04/11	12,480
G1	Rail Spur	08/11	1,060
G2	Mil-Sher Complex	04/11	150
M	Utility Tunnel	12/10-08/12	2,190
T	Bldg 100 South	04/11	30
		Total	29,300

Between July 20, 2010 and April 10, 2013, Cabrera shipped a total of 23,079 metric tons (25,440 tons) of contaminated soil and debris that did not meet free release criteria to US Ecology Idaho's Grand View facility for disposal.

7.6 WASTE DISPOSAL SUMMARY (1996-2013)

Table 6 summarizes the off-site permitted or licensed facilities that received contaminated soil and/or debris from the Linde Site associated with removal/remedial actions discussed in Sections 6.1 through 6.5.

Table 6 - Waste Disposal Summary (1996-2013)

Linde Removal/ Remedial Actions	Permitted/Licensed Facility	Tons Shipped	Cubic Yards Shipped
Non-Time-Critical Removal Action (1996) -Demolition of Building 38 (BNI)	Energy Solutions (Clive, Utah)	229	800
Non-Time-Critical Removal Action (1996-1997) -Excavation of Contaminated Soil Next to Building 90 (BNI) -Decontamination of Bldgs 14 and 31 (BNI)	Energy Solutions (Clive, Utah)	4,881	3,754
Non-Time-Critical Removal Action (1998-1999) -Demolition of Building 30 (Radian)	Clean Harbors (Buttonwillow, California)	2,165	6,165
	Energy Solutions (Clive, Utah)	1,283	2,700
Remedial Action (1999-2010)[a] -Soils OU (IT/Shaw)	International Uranium Corporation (IUC) (Blanding, Utah)	118,687	172,265
	Waste Control Specialists, LLC (WCS) (Andrews, Texas)	138,360	
	US Ecology Idaho, Inc. (Grand View, Idaho)	87,482	
Remedial Action (2004-2005) -Building 14 OU (Shaw)	Waste Control Specialists, LLC (Andrews, Texas)	14,018	14,202
Remedial Action (2010-2013) -Soils OU (Cabrera)	US Ecology Idaho, Inc. (Grand View, Idaho)	25,440	19,569[b]
	Total	**392,545**	**219,455**

[a] IUC and WCS were used simultaneously as disposal facilities because IUC could only accept a percentage of the total shipments as debris mixed with radiologically contaminated soils. WCS would allow all debris or debris mixed with a lower radioactive content. US Ecology was used exclusively later in the project due to their waste acceptance criteria, which accepted both radiologically contaminated soils and debris.

[b] Cubic yards shipped estimate assumes 1.3 tons per cubic yard.

7.7 COMMUNITY INVOLVEMENT

As required by CERCLA and the NCP, public comment was solicited to ensure that the remedies selected for the Linde Site met the needs of the local community in addition to being an effective solution. The administrative record file, which contains all of the documentation used to support the selected remedies, is available at the following locations. The verbiage below summarizes the community activities performed by USACE for the Linde Site.

USACE FUSRAP Public Information Center
1776 Niagara Street
Buffalo, NY 14207

Tonawanda Public Library
333 Main Street
Tonawanda, NY 14150

On March 26, 1999, USACE sent 858 individuals on the site mailing list, including elected officials, a letter announcing the release of the proposed plan (USACE 1999b) for the remediation of the Linde Site. The proposed plan was made available on the USACE website for the Linde Site and legal advertisements were placed in the *Buffalo News* (March 28, 1999), *Tonawanda News* (March 31, 1999), *Ken-Ton Bee* (March 31, 1999), *Kenmore Record Advertiser* (March 31, 1999), and the *Niagara Gazette* (March 28, 1999).

Invitations encouraging public attendance and comments were sent on April 8, 1999, to parties on the site mailing list for the first public meeting scheduled for April 22, 1999. A news release was faxed to the local newspapers on April 8, 1999. Legal ads were placed in *The Buffalo News* (April 18, 1999), the *Tonawanda News* (April 12, 1999), the *Ken-Ton Bee* (April 14, 1999), the *Kenmore Record-Advertiser* (April 14, 1999), and the *Niagara Gazette* (April 18, 1999). Copies of the news release, letters of invitation, ads, and the proposed plan were placed in the Administrative Record File for the Linde Site.

The public meeting for the proposed plan was held on April 22, 1999, from 7 to 9 p.m. in the auditorium of the Holmes Elementary School (365 Dupont Ave, Tonawanda, NY 14150), which was located adjacent to the Linde Site. Forty-four members of the public signed in. A court reporter was available at the meeting to record comments. During the meeting, USACE explained the history of the site, studies and investigations completed, areas of contamination, CERCLA evaluation criteria, the remedial action alternatives, and the schedule. Twelve formal comments were made at the meeting. Copies of the transcript were placed in the Administrative Record File and made available on the USACE website for the Linde Site.

A comment period extension to May 27, 1999, was announced at the public meeting. Postcards announcing the comment period extension were sent to the mailing list and ads were placed in *The Buffalo News* (May 2, 1999), the *Tonawanda News* (May 3, 1999), the *Ken-Ton Bee* (May 5, 1999), the *Kenmore-Record-Advertiser* (May 5, 1999), and the *Niagara Gazette* (May 2, 1999).

On May 21, 1999, a news release announcing the June 3, 1999, public meeting and a further extension of the public comment period through June 11, 1999, was issued to the local newspaper media and placed on the Buffalo District website. Letters of invitation for the June 3rd public meeting were sent to the site mailing list. Legal display advertisements were placed in *The Buffalo News* (May 23, 1999), the *Tonawanda News* (May 24, 1999), the *Ken-Ton Bee*

(May 26, 1999), the *Kenmore Record-Advertiser* (May 26, 1999), and the *Niagara Gazette* (May 30, 1999).

Forty-three members of the public signed in at the June 3, 1999, public meeting. A court reporter was available at the meeting to record comments. During the meeting USACE explained the history of the site, the remedial action alternatives, the cleanup criteria, the post-remedial modeling results, the quality assurance process and the schedule. Thirteen formal comments were made at the meeting. The transcript was placed in the Administrative Record File and on the USACE website for the Linde Site.

Comments that were received regarding the proposed plan were addressed in a responsiveness summary that was released in conjunction with the ROD (USACE 2000b). A news release was issued announcing the ROD for the Soil OU of the Linde Site on May 17, 2000. Legal advertisements were also placed in the local newspapers. The ROD and the news release were made available in the Administrative Record File and on the USACE website for the Linde Site. Copies of the legal advertisements were also placed in the Administrative Record File. Presentations were made to the employees of Praxair, before the initiation of remediation. A meeting was also held with members of the administrative staff of the Holmes Elementary School, which neighbored the site.

Postcards were sent to individuals on the site mailing list on September 11, 2002, informing them of the pending release of the proposed plan for the Building 14 OU (USACE 2002). Individuals wishing to receive a letter announcing the release of the proposed plan were instructed to return the postcards. On October 18, 2002, a letter announcing the release of the proposed plan for Building 14 OU on the Linde Site was sent to 22 individuals including elected officials and agency representatives. Approximately 100 postcards were returned and letters were sent to those individuals. Legal advertisements announcing the November 19, 2002, public meeting were placed in *The Buffalo News* (October 27, 2002), the *Ken-Ton Bee* (October 23, 2002), and the *Tonawanda News* (October 22, 2002). A correction to the legal advertisements was placed in these newspapers and this correction appeared on November 3, 2002, November 13, 2002, and November 3, 2002, respectively.

The public meeting was conducted on November 19, 2002, from 7 p.m. to 9 p.m. in the Holmes Elementary School Auditorium. Eleven members of the public indicated that they wanted to speak at the meeting. A court reporter was available at the meeting to record comments. During the meeting USACE explained the history of the site and Building 14, studies and investigations completed, areas of contamination, CERCLA evaluation criteria, the remedial action alternatives, the preferred alternative, and the schedule. The public was invited to submit comments at the public meeting and written comments were accepted through November 29, 2002.

Comments that were received regarding the PP for the Building 14 OU (USACE 2002) were addressed in a responsiveness summary that was released in conjunction with the ROD (USACE 2003a). A news release was issued announcing the ROD for the Linde Site Building 14 OU on April 25, 2003. Legal advertisements were also placed in the local newspapers. The ROD and the news release were made available in the Administrative Record File and on the USACE website for the Linde Site. Copies of the legal advertisements were also placed in the Administrative Record File. Presentations were made to the employees of Praxair, before the initiation of remediation. A meeting was also held with members of the administrative staff of the Holmes Elementary School, which neighbored the site.

On May 4, 2006, the Buffalo District issued a proposed plan for the groundwater OU at the Linde Site (USACE 2006a). On May 4, 2006, a letter announcing the release of the proposed plan was sent to the site mailing list, which included over 300 individuals including elected officials, and a news release was distributed to the local media. Legal advertisements announcing the June 13, 2006, public meeting were placed in *The Buffalo News*, the *Niagara Gazette*, and the *Tonawanda News* (May 14, 2006), the *Ken-Ton-Bee* (May 17, 2006), and the *Riverside Review* and the *Metro Community News* (June 4, 2006).

A public meeting was conducted on June 13, 2006, from 7 p.m. to 9 p.m. in the Holmes Elementary School Auditorium, during which the USACE explained the history of the Linde Site and the groundwater OU, studies and investigations completed, areas of contamination, the reasons no action was recommended for the groundwater OU, and the schedule. A court reporter was available at the meeting to record comments. Six members of the public indicated that they wanted to speak at the meeting. Written comments were accepted through early July 2006. Responses to comments received on the proposed plan were included with the ROD for the groundwater OU (USACE 2006b), which was released on March 11, 2007.

In December 2009, a newsletter announcing the commencement of a five-year review of the remediation of radiologically contaminated soils at the Linde Site was sent to the site mailing list and a news release was distributed to the local media. Community notifications were placed in the *Buffalo News (December 13, 2009)*, the *Tonawanda News* (December 13, 2009), and the *Ken-Ton-Bee* (December 16, 2009).

In August 2010, USACE issued the *Five-Year Review Report for the Linde FUSRAP Site* (USACE 2010). Newsletters summarizing the results of the five-year review and announcing the report's availability on the Buffalo District website were mailed to 543 community members on the Linde Site mailing list on September 30, 2010. Newspaper advertisements were placed in the Buffalo News and the Tonawanda News (October 3, 2010). A public notice was also placed in the Ken-Ton Bee (October 6, 2010).

7.8 PERIMETER AIR MONITORING

USACE performed perimeter air monitoring during all building demolition and excavation and soil handling activities conducted at the Linde Site. Air monitoring results were compared to limits established in 10 CFR 20. Specifically, these limits are presented in Column 1, *Air Effluent Concentrations* in microcuries per milliliter (µCi/mL), of Table 2 in Appendix B of 10 CFR 20 and are applicable to the assessment and control of dose to the general public. The regulatory air effluent release limits of 9E-13, 2E-14, and 6E-14 µCi/ml are equivalent to the Ra-226, Th-230, and U-238 concentrations, respectively, which, if inhaled or ingested continuously over the course of a year, would produce a TEDE of 50 mrem. Based upon the USACE perimeter monitoring data, no member of the public received a radiation exposure above regulatory limits.

7.9 RESIDUAL DOSE ASSESSMENT SUMMARY

A third-party post-remediation radiological dose assessment was conducted by Argonne National Laboratory (Argonne) using residual concentrations of FUSRAP-eligible COCs (i.e. Ra-226, Th-230, and total U) in soil to determine the potential radiation dose to the critical group (i.e. a commercial/industrial worker) at the Linde Site.

The USACE identified 40 CFR 192 and 10 CFR 40, Appendix A, Criterion 6(6) in the ROD (USACE 2000b) as ARARs for the soils OU at the Linde Site. In compliance with these standards, the Linde Site would be protective of the commercial/industrial worker if residual radionuclide concentrations, above background and within a 100 m^2 (1,076 ft^2) area, did not exceed unity for the SOR of Ra-226, Th-230, and total U concentrations (using the surface and subsurface soil cleanup criteria in Table 1).

Input parameters and detailed evaluations performed to verify compliance with the ARARs are in Attachment B of this report. The drinking and irrigation water pathways were not incorporated into this dose assessment since water was assumed to be obtained from the nearby Niagara River. Additionally, the naturally occurring levels of salts in the groundwater preclude its use without treatment (USACE 2006b).

The gross site-wide average residual Ra-226, Th-230, and total U concentrations in soil at the Linde Site were all below average background concentrations (as shown in Table 7 and discussed further in Attachment B). Since residual FUSRAP-eligible COCs in soil do not contribute to radiological dose, over naturally-occurring background radiation, the third-party post-remediation radiological dose assessment conservatively used gross residual concentrations (i.e. included contribution from background) to demonstrate compliance with the ROD (USACE 2000b).

Table 7 - Residual Soil Concentrations and Resultant Dose

Linde FUSRAP Site	Soil Concentrations (pCi/g)			Annual Residual Dose to Commercial/Industrial Worker (mrem)[b,c]
	Ra-226	Th-230	Total U [a]	
Site-Wide Average <u>Gross</u> Residual Soil Concentrations	**0.97**	**1.31**	**3.00**	**2.02**
Average Site Background Concentrations[d]	**1.1**	**1.4**	**6.1**	**-**

[a] Total U is the sum of the uranium isotopes (i.e. U-234, U-235, and U-238).
[b]The resultant dose <u>includes</u> background.
[c] The resultant dose, including background, to a construction worker was 0.50 mrem/yr.
[d] Average site background concentrations (DOE 1993a).

The residual dose to a commercial/industrial worker, including contribution from background, did not exceed the surface or subsurface benchmark dose of 8.8 mrem/yr and 4.1 mrem/yr, respectively, as specified in the ROD (USACE 2000b).

Additionally, since residual Ra-226, Th-230, and total U in soil at the Linde Site are indistinguishable from background (i.e. naturally-occurring, non-impacted) radionuclide concentrations, residual soil concentrations not only met, but exceeded RAOs and cleanup standards for the project. In other words, due to precise excavation and rigorous scanning methods, no FUSRAP-eligible hazardous substances, pollutants, or contaminants remain at the Linde Site that would preclude UU/UE. Therefore, the Linde Site is deemed protective for unrestricted use and no five-year reviews are required.

7.0 MONITORING RESULTS

The final status survey (FSS) is a process designed to determine whether concentrations of residual radioactivity comply with the cleanup criteria as defined in the ROD (USACE 2000b). The FSS process for the post-remediation radiological dose assessment of residual radioactivity at the Linde Site was conducted in accordance with MARSSIM guidance (EPA 2000), originally published in December of 1997 and approved by federal agencies, and the data quality objectives (DQOs) process (EPA 2006).

MARSSIM identified three classifications of areas, according to contamination potential:

- Class 1 areas were areas that had, prior to remediation, a potential for radioactive contamination or known contamination in excess of the derived concentration guideline level (DCGL) or building and structure surfaces that exceeded the derived surface contamination guideline values. Class 1 soil areas are ≤ 2,000 m^2. Class 1 building and structure areas were selected according to areas that had similar building materials, according to proximity (e.g., same location or room), and limited to ≤ 100 m^2 (1,076 ft^2).
- Class 2 areas were areas that have not been remediated, that had a potential for radioactive contamination or known contamination, but were not expected to exceed the DCGL or the derived building and structure surface contamination release limits. Class 2 soil areas were ≤ 10,000 m^2. Class 2 building and structure areas were selected according to areas that had similar building materials, according to proximity (e.g., same location or room), and areas limited to between 100 m^2 (1,076 ft^2) and 1,000 m^2 (10,764 ft^2).
- Class 3 areas were areas that were not expected to contain residual radioactivity, or were expected to contain levels of residual radioactivity at a small fraction of the DCGL. For soils, Class 3 areas were unlimited in size. There are no Class 3 building and structure survey units at the Linde Site.

USACE implemented FSS field and data collection activities in accordance with the final status survey plans (Shaw 2005b, Cabrera 2010, and Shaw 2003) during the years 1999-2010 and 2010-2013 for the soils OU and 2004-2005 for the Building 14 OU under independent contracts. Implementation of the FSS process included execution of some, or all, of the following activities for each FSS Unit within the Linde Site:

- DQOs were established to determine the number and locations of measurement and sample points required to demonstrate compliance with ROD criteria.
- Areas of the site were classified as Class 1, Class 2, or Class 3 FSS units as shown in Table 8.
- Gamma walkover scans were performed over 100 percent of accessible soil surfaces within Class 1 and 2 survey units and biased gamma walkover scans over Class 3 soil surfaces to measure surface gamma radiation, with results plotted against geographic locations.
- Quality assurance (QA) checks of the gamma walkover scans were conducted by both USACE and the New York State Department of Environmental Conservation (NYSDEC).
- Systematic (and some biased) surface and subsurface soil samples were collected from within individual survey units in accordance with the USACE-approved final status survey plans (FSSPs).
- Samples were analyzed at an off-site USACE-approved laboratory.
- Split samples were collected for USACE QA analysis.
- Laboratory data was validated.
- Technical data packages (TDPs), prepared for each FSS Unit, documented the review of the FSS data to ensure that each unit met the ROD cleanup criteria (i.e. DCGLs).

- TDPs were written, submitted to, and approved by USACE.
- Oversight and random checks were conducted by the NYSDEC, including biased samples and splits.

FSS data were collected by both IT (and its successor Shaw) and Cabrera using the methodologies for soil and buildings and structure surfaces listed below. Table 8 provides a summary of the survey unit number, MARSSIM classification, the contractor(s) responsible for collecting the FSS data, and the contractor that completed the TDP.

<u>FSS Evaluation of Soils</u>
Soils in excess of site criteria were initially excavated based on the data derived from the RI and/or indicated by gamma walkover surveys. As soils were removed, the newly exposed section of the excavation was scanned by a radiological control technician. The gamma exposure rate threshold was based on correlating a net counts per minute (cpm) on a sodium iodide crystal detector compared with concentrations (pCi/g) of residual radioactivity that were present at or near the surface of the excavation. This correlation factor was theoretically derived and established at 18,000 cpm, providing a 95% confidence level for detecting potential ROD exceedences. Off-site sample data was used to confirm the correlation and to confirm that the ROD criteria were satisfied within Class 1 units.

A one-minute gamma count was taken at the surface of the Class 1 FSS excavation and Class 2 and Class 3 FSS units prior to sample collection. Samples were obtained in accordance with USACE approved sampling plans utilizing an auger or trowel and material was homogenized using the quartering technique with a stainless-steel spoon and disposable aluminum sample tray. Surface soil samples were collected from 0 to 15 cm (0 to 6 in) below grade with subsurface samples being considered any 15 cm (0 to 6 in) vertical sample beneath the surface interval. An aliquot of the homogenized sample materials was containerized for analysis.

To address the unconventional locations of contamination encountered at the site, a triangular master sampling grid was established across the property as specified by Section 4.8.5 of MARSSIM. Each equilateral triangle had side lengths of 10.75 m (35.27 feet). The grid overlaid each unit depicting FSS sample locations and provided an investigation sample density of 1 sample per $100m^2$ (1,076 ft^2) average across the site. Samples from Class 2 and Class 3 FSS units were collected using direct push technology from surface grade down to the clay layer underlying the site.

Each direct push soil core was scanned in 10 cm (4 in) intervals using the custom built TSA Model TCS-405 core scanner and interval measurements were electronically logged. Logged gamma measurements were compared against an established threshold value of 6,000 net cpm. Anomaly-biased samples were collected if the threshold value was exceeded or if additional investigation was warranted. For Class 2 FSS purposes a composite sample was collected from cores at random master grid locations at least 1 sample per 500 m^2 (5,382 ft^2) area.

The Class 1 FSS samples and Class 2 and 3 composite samples were compared against ROD requirements for soils. This included a SOR criteria applied to $100m^2$ areas for COCs in surface and subsurface soil, interpreted as $DCGL_{emc}$ values. Additionally, total U concentrations had to be less than 600 pCi/g. SOR values were conservatively calculated for COCs listed in Table 1, with no adjustment being made for the background activity concentrations of each COC. Net concentrations of each COC were summed for comparison to a value of 1.0, which corresponded with the projects DCGLs. RODs for the Soils and Building 14 OUs both utilized the same DCGL values for soil. If a Class 1 sample did not meet DCGL values or the never-to-exceed total U activity concentration of 600 pCi/g, further remediation was performed until the area met these criteria. If a Class 2 or Class 3 sample exceeded DCGLs then the sample location was re-classified as a Class 1 area, requiring remediation.

FSS Evaluation of Building and Structure Surfaces

Because of the difficulty inherent in alpha measurements in the field, gross beta field measurements were used to demonstrate ROD compliance at the Linde Site. The following methodology was used to demonstrate that surface contamination levels were in accordance with ROD criteria:

- A one meter rectangular reference coordinate system was established (using a two-dimensional axis) for the survey unit to guide the selection of measurement locations and to provide a mechanism for relocating and reproducing a previous measurement.
- A triangular sampling pattern was used where feasible to establish the randomly selected systematic locations for direct measurements, providing a measurement density of at least one direct measurement per square meter.
- 100% surface scans were conducted using a plastic scintillator detector with a dual rate meter capable of detecting and identifying both alpha and beta particles.
- One-minute direct biased measurements were performed at the point of the highest observed count rate (biased measurement location) within each rectangular grid during the scan survey. The randomly selected survey locations within a survey unit were established using the guidance provided in MARSSIM subsection 5.5.2.5 "Determining Survey Locations." A one-minute direct measurement at each designated, pre-determined systematic measurement location was also performed.

For building structures, survey units were established such that each survey unit had similar building materials (i.e., concrete, ceiling tile, wallboard, etc.). DCGL documents were prepared for each survey unit and each survey area was evaluated independently to demonstrate compliance with surface contamination limits. Because of the difficulty inherent in α measurements in the field, β field measurements were used to demonstrate ROD compliance. A Total β never-to exceed limit ($DCGL_{emc}$) was developed to demonstrate compliance with the ROD. The surface activity remaining on structures could not result in a TEDE exceeding the benchmark dose limit of 8.8 mrem/yr as established for the cleanup of contaminated soil. The isotopic distribution used for external surface contamination was based on the gamma spectroscopy analyses associated with soil samples adjacent to the unit. A unit dose factor for each of the radionuclides of concern was calculated (receptor dose at time zero) based upon the unity source term for each radionuclide. The unit dose factor was then used to determine the derived surface activity limit (dpm per 100 cm^2) that corresponds to the benchmark dose of 8.8 mrem/year. The surface activity limit was converted to a surface beta (β) limit by correcting for the particle abundance.

The network of subsurface concrete utility tunnels were addressed as a whole utilizing a derived concentration guideline level – gross activity ($DCGL_{ga}$) limit of 2,000 surface beta/min/100cm^2. The $DCGL_{ga}$, developed in 2000 (IT 2000), was based on an isotopic average of soil samples from various locations around the site. The entire interior of the utility tunnel was surveyed in 2001 and exterior tunnel surfaces were surveyed throughout the project as they were exposed. As sections of the tunnels were addressed or removed, they were approached as individual units.

FSS Summary
The final FSS configuration (i.e. after the 1999-2010 and 2010-2013 soil and structure surface remedial actions and the 2004-2005 Building 14 OU remedial action) of the Linde Site consisted of 138 FSS units:

- 92 Class 1 soil SUs;
- 27 Class 2 soil SUs;
- 1 Class 3 soil SU;
- 16 Class 1 building and structure surface SUs; and
- 2 Class 2 building and structure surface SUs.

Table 8 provides a summary of the 138 survey units, MARSSIM classification, the contractor(s) responsible for collecting FSS data, and the contractor that completed each TDP.

Table 8 – Final Status Survey Unit Collection Summary

Survey Unit Number	MARSSIM Classification	Data Collection	Data Presentation
001	Class 2	Shaw	Shaw
002[a]	Class 2	Shaw	Shaw
003	Class 2	Shaw	Shaw
004	Class 3	Shaw	Shaw
005	Class 1	Shaw	Shaw
005A	Class 1 - Surfaces	Shaw	Shaw
005B-005F	Class 2 - Surfaces	Shaw	Shaw
006	Class 1	Shaw	Shaw
007	Class 1	Shaw	Shaw
008	Class 1	Shaw	Shaw
009	Class 1	Shaw	Shaw
010	Class 1	Shaw	Shaw
011	Class 1	Shaw	Shaw
011A, 014A & B[b]	Class 1 - Surfaces	Shaw	Shaw
012	Class 1	Shaw	Shaw
013	Class 1	Shaw	Shaw
014	Class 1	Shaw	Shaw
015	Class 2	Shaw	Shaw
016	Class 1	Shaw	Shaw
016A	Class 1 - Surfaces	Shaw	Shaw
017	Class 1	Shaw	Shaw
017 A, D[c]	Class 1 - Surfaces	Shaw	n/a
017 B, C	Class 1 - Surfaces	Shaw	Shaw
018	Class 1	Shaw	Shaw
019	Class 1	Shaw	Shaw
020	Class 1	Shaw	Shaw
020A[c]	Class 1 - Surfaces	Shaw	n/a
021	Class 2	Shaw	Shaw
022	Class 2	Shaw	Shaw
023	Class 1	Shaw	Shaw
024	Class 1	Shaw	Shaw
025	Class 2	Shaw	Shaw

Survey Unit Number	MARSSIM Classification	Data Collection	Data Presentation
026	Class 1	Shaw	Shaw
027	Class 1	Shaw	Shaw
028	Class 1	Shaw	Shaw
028A	Class 1 - surfaces	Shaw	Shaw
029	Class 2	Shaw	Shaw
030	Class 1	Shaw	Shaw
030A	Class 1 - surfaces	Shaw	Shaw
031	Class 1	Shaw	Shaw
032	Class 2	Shaw	Shaw
033	Class 1	Shaw	Shaw
033A	Class 2 - Surfaces	Shaw	Shaw
034	Class 1	Shaw	Shaw
035	Class 1	Shaw	Shaw
036	Class 1	Shaw	Shaw
037	Class 1	Shaw	Shaw
038	Class 1	Shaw	Shaw
039	Class 1	Shaw	Shaw
040	Class 1	Shaw	Shaw
041	Class 1	Shaw	Shaw
042	Class 1	Shaw	Shaw
043	Class 1	Shaw	Shaw
044	Class 1	Shaw	Shaw
045	Class 1	Shaw	Shaw
046	Class 1	Shaw	Shaw
047	Class 1	Shaw	Shaw
048	Class 1	Shaw	Shaw
049	Class 1	Shaw	Shaw
049A	Class 1 - Surfaces	Shaw	Shaw
050	Class 1	Shaw	Shaw
051	Class 1	Shaw	Shaw
052	Class 1	Shaw	Shaw
053	Class 1	Shaw	Shaw
054	Class 1	Shaw	Shaw
055	Class 1	Shaw	Shaw
056	Class 2	Shaw	Shaw
057	Class 1	Shaw	Shaw
058	Class 1	Shaw	Shaw
058A[c]	Class 1 - Surfaces	Shaw	n/a
059	Class 1	Shaw	Shaw
060	Class 1	Shaw	Shaw
060A & 060B	Class 1 - Surfaces	Shaw	Shaw
061	Class 1	Shaw	Shaw
062	Class 1	Shaw	Shaw
063	Class 1	Shaw	Shaw
064	Class 1	Shaw	Shaw
065	Class 1	Shaw	Shaw
066	Class 1	Shaw	Shaw

Survey Unit Number	MARSSIM Classification	Data Collection	Data Presentation
067	Class 1	Shaw	Shaw
068	Class 1	Shaw	Shaw
069	Class 2	Shaw	Shaw
070	Class 2	Shaw	Shaw
071	Class 1	Shaw	Shaw
071A, B and C[b]	Class 1 - Surfaces	Shaw	Shaw
072	Class 1	Shaw	Shaw
073	Class 1	Shaw	Shaw
074	Class 1	Shaw	Shaw
075	Class 1	Shaw	Shaw
076	Class 1	Shaw	Shaw
077	Class 1	Shaw	Shaw
078	Class 1	Shaw	Shaw
079	Class 1	Shaw	Shaw
080	Class 1	Shaw	Shaw
080A	Class 1 - Surfaces	Shaw	Shaw
081	Class 1	Shaw	Shaw
082	Class 1	Shaw	Shaw
082A, B and E	Class 1 - Surfaces	Shaw	Shaw
082C and D	Class 1 - Surfaces	Shaw	Shaw
083	Class 1	Shaw	Shaw
084	Class 1	Shaw	Shaw
085	Class 1	Shaw	Shaw
086	Class 1	Shaw	Shaw
87A[a]	Class 1 - Surfaces	Shaw/Cabrera	Cabrera
087 B-D[c]	Class 2 - Surfaces	Shaw	n/a
088	Class 1	Shaw	Shaw
089	Class 2	Shaw	Shaw
090	Class 2	Shaw	Shaw
091	Class 2	Shaw	Shaw
092	Class 2	Shaw	Shaw
093	Class 2	Shaw	Shaw
094	Class 1	Shaw	Shaw
095	Class 1	Shaw	Shaw
096	Class 2	Shaw	Shaw
097	Class 1	Shaw	Shaw
098	Class 1	Shaw	Shaw
099	Class 1	Shaw	Shaw
100	Class 2	Shaw	Shaw
101	Class 2	Shaw	Shaw
102	Class 2	Shaw	Shaw
103	Class 2	Shaw	Shaw
104A	Class 1 - Surfaces	Cabrera	Cabrera
104	Class 1	Cabrera	Cabrera
105	Class 1	Cabrera	Cabrera
106	Class 1	Cabrera	Cabrera
107	Class 1	Cabrera	Cabrera

Survey Unit Number	MARSSIM Classification	Data Collection	Data Presentation
108	Class 1	Cabrera	Cabrera
109	Class 1	Cabrera	Cabrera
110	Class 2	Shaw/Cabrera	Cabrera
111	Class 1	Cabrera	Cabrera
112	Class 2	Shaw/Cabrera	Cabrera
113	Class 2	Shaw/Cabrera	Cabrera
114	Class 2	Shaw/Cabrera	Cabrera
115	Class 2	Shaw/Cabrera	Cabrera
116	Class 1	Cabrera	Cabrera
117	Class 1	Cabrera	Cabrera
Bldg 14 OU - 001	Class 1	Shaw	Shaw
Bldg 14 OU - 002	Class 1	Shaw	Shaw
Bldg 14 OU - 003	Class 1	Shaw	Shaw
Bldg 14 OU - 004	Class 1	Shaw	Shaw
Bldg 14 OU - 005	Class 1 - Surfaces	Shaw	Shaw

n/a - not available

[a] A FSS was performed by Shaw. A subsequent remediation and new FSS was completed by Cabrera and is documented in its associated TDP.
[b] FSS units are grouped together as presented in their TDP. However, they were counted as separate FSS units in the Project Construction Report (Shaw 2010).
[c] A FSS was performed by Shaw. Subsequently, the unit was removed or is superseded by another FSS unit. There is no associated TDP available.

7.1 FINAL STATUS SURVEY SUMMARY (1999-2010)

From 1999 through 2010, remediation and FSS activities were performed by Shaw (i.e. IT and its successor Shaw) for soils and structure surfaces at the Linde Site. Shaw was responsible for evaluating 116 FSS units (listed in Table 8 and illustrated in Figure 5) where the FSS was satisfactorily completed (i.e. SUs were determined to meet ROD criteria). Additional subsurface direct push core sampling was performed by Shaw as an investigative measure in areas that were not addressed under the remediation contract. Those samples were utilized by Cabrera during the 2010-2013 remediation to close out Class 2 soil FSS units 110 and 112-115 at the end of the project.

A summary of FSS results for the 116 FSS units, addressed by Shaw, is found below. Some of these soil values may not represent current conditions since some FSS systematic samples collected by Shaw were later excavated by Cabrera.

- 78 Class 1, 22 Class 2, and 1 Class 3 soil SUs.
- 13 Class 1, and 2 Class 2 building and structure surface SUs.
- 38 hectares (95 acres) released under FSS [i.e. Class 1 – 8 hectares (21 acres), Class 2 – 15 hectares (37 acres), and Class 3 – 15 hectares (37 acres)].
- 1,343 FSS samples analyzed (excluding additional direct push core samples). 1,476 additional direct push core samples surveyed with the core scanner for Class 2 SU sampling.
- 2,088,096 gamma walkover survey data points collected (i.e. Class 1 – 1,464,906 data points, Class 2 – 615,989 data points, Class 3 – 8,885 data points).
- The site-wide average residual Ra-226, Th-230 and total U concentrations in soil were 1.00, 1.38, and 3.09 pCi/g, respectively.

- The average survey unit DCGL SOR value was 0.10.
- No individual FSS sample exhibited a DCGL SOR score greater than 1.0.

7.2 FINAL STATUS SURVEY SUMMARY (2004-2005)

From 2004 through 2005, remediation and FSS activities were performed by Shaw on Building 14 structure surfaces and underlying soils. Shaw was responsible for evaluating five FSS units (listed in Table 8 and illustrated in Figure 5) where the FSS was satisfactorily completed (i.e. SUs were determined to meet ROD criteria). The proposed limits of remediation included the soils within the footprint of the building. The entire Building 14 OU was excavated to a depth greater than 15 cm (6 in) below the ground surface.

A summary of FSS results for the five soil FSS units, addressed by Shaw, is found below.

- 4 Class 1 soil SUs.
- 1 Class 1 building and structure surface SU.
- 0.35 hectares (0.87 acres) released under FSS.
- 42 FSS samples analyzed and 193 surface scan points. 35 additional biased samples in support of gamma walkovers.
- 52,725 gamma walkover survey data points collected.
- The site-wide average residual Ra-226, Th-230 and total U concentrations in soil were 1.16, 1.17, and 7.18 pCi/g, respectively.
- The average survey unit DCGL SOR value was 0.11.
- No individual FSS sample exhibited a DCGL SOR score greater than 1.0.

7.3 FINAL STATUS SURVEY SUMMARY (2010-2013)

From 2010 through 2013, remediation and FSS activities were continued by Cabrera for the Soil OU at the Linde Site. Cabrera was responsible for evaluating 16 FSS units (listed in Table 8 and illustrated in Figure 5) where the FSS was satisfactorily completed (i.e. SUs were determined to meet ROD criteria). Additional subsurface direct push core scans and composite sampling was performed by Cabrera as a FSS measure to supplement investigative data collected by Shaw, in closing out Class 2 FSS units. A summary of FSS results for the 16 soil FSS units, addressed by Cabrera, is found below.

- 9 Class 1 soil SUs and 5 Class 2 soil SUs.
- 2 Class 1 building and structure surface SU.
- 5.0 hectares (12.4 acres) released under FSS.
- 196 FSS samples analyzed and 193 surface scan points.
- 895,686 gamma walkover survey data points collected.
- The site-wide average residual Ra-226, Th-230 and total U concentrations in soil were 0.79, 1.02, and 2.17 pCi/g, respectively.
- The average survey unit DCGL SOR value was 0.08.
- No individual FSS sample exhibited a DCGL SOR score greater than 1.0, except one characterization sample on the CSX property that exhibited a subsurface soil DCGL score greater than 1.0 and is documented in Section 7.5.

Table 9 summarizes the FSS units, data points, and samples collected during the 1999-2010 and 2010-2013 Soil OU remedial actions and the 2004-2005 Building 14 OU remedial action. Alpha and gamma spectroscopy were performed by off-site laboratories on all FSS and beneficial re-use samples, along with some FSS unit biased samples. A majority of FSS unit biased samples were analyzed on site using gamma spectroscopy. Class 2 FSS unit direct push soil cores were screened on site using a core scanner.

Table 10 summarizes the number of samples collected from each FSS unit, and the minimum (MIN), average (AVG), and maximum (MAX) FSS result (in pCi/g and inclusive of background contribution) for each FSS unit and FUSRAP-eligible COC. The average FSS unit SOR DCGL is also presented (SOR calculations subtract background). For building structure units, the average surface beta limit described in Section 7.0, is shown.

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Table 9 – Sampling Summary for each Final Status Survey Unit

FSS Unit	MARSSIM Classification	Area	Surface Area (m^2)	Gamma Walkover Survey Data Points	Number of Systematic Samples	Number of Quality Control Samples	Number of Biased Samples	Number of Core Composite Samples
001	Class 2	Bldg. 104	3,067	13,021	32	---	n/a	6
002[a]	Class 2	Bldg. 31	2,691	n/a - Concrete Floor	28	---	---	10
003	Class 2	Bldg. 90	7,816	n/a - ISOCS Surveyed	78	1	n/a	16
004	Class 3	n/a	150,550	8,885	20	2	8	21
005	Class 1	C	302	604	20	1	5	n/a
005A	Class 1 Surfaces	Bldg. 31	96	n/a - Concrete Walls	97 - Scan Points	---	7 - Scan Points	---
005B-005F	Class 2 Surfaces	Bldg. 31	706	n/a - Concrete Walls	150 - Scan Points	---	224 - Scan Points	---
006	Class 1	A	1,781	25,793	20	1	4	n/a
007	Class 1	A	1,588	23,310	20	1	2	n/a
008	Class 1	B	1,988	21,101	20	1	3	n/a
009	Class 1	B	1,980	14,618	20	1	1	n/a
010	Class 1	B	1,959	12,460	20	1	2	n/a
011	Class 1	B	1,563	14,591	16	1	4	n/a
011A, 014A & B[b]	Class 1 Surfaces	B	164	n/a - Concrete Walls	164 - Scan Points	---	164 - Scan Points	---
012	Class 1	D	1,862	24,688	19	1	4	n/a
013	Class 1	D	1,852	25,596	20	1	n/a	n/a
014	Class 1	B	651	1,376	10	1	1	n/a
015	Class 2	n/a	9,996	33,670	100	1	n/a	20
016	Class 1	D	1,996	24,369	20	1	n/a	n/a
016A	Class 1 Surfaces	D	42	n/a - Concrete Walls	42 - Scan Points	---	n/a	---
017	Class 1	M	1,909	31,843	20	1	n/a	n/a
017 B, C	Class 1 Surfaces	M	128	n/a - Concrete Walls	128 - Scan Points	---	128 - Scan Points	---
018	Class 1	E	1,640	26,402	17	1	2	n/a
019	Class 1	E	2,000	32,520	20	1	19	n/a
020	Class 1	M	280	4,202	6	3	2	n/a
021	Class 2	n/a	9,995	40,474	100	1	n/a	20
022	Class 2	n/a	9,980	63,573	100	1	9	20
023	Class 1	L	574	14,965	10	1	10	n/a
024	Class 1	E	2,000	48,061	20	1	1	n/a
025	Class 2	n/a	10,000	57,388	100	1	n/a	20
026	Class 1	I	1,398	41,470	14	1	20	n/a
027	Class 1	E	2,000	42,931	20	1	9	n/a
028	Class 1	D	1,866	43,296	19	1	16	n/a
028A	Class 1 Surfaces	D-1	77	n/a - Concrete Walls	77 - Scan Points	---	77 - Scan Points	---

FSS Unit	MARSSIM Classification	Area	Surface Area (m^2)	Gamma Walkover Survey Data Points	Number of Systematic Samples	Number of Quality Control Samples	Number of Biased Samples	Number of Core Composite Samples
029	Class 2	n/a	9,253	62,958	98	1	1	19
030	Class 1	J	233	4,483	10	1	4	n/a
030A	Class 1 Surfaces	J	8	n/a - Concrete Walls	16 - Scan Points	---	16 - Scan Points	---
031	Class 1	M	119	3,561	6	1	n/a	n/a
032	Class 2	n/a	4,634	29,961	47	2	n/a	10
033	Class 1	N	685	9,315	7	1	n/a	n/a
033A	Class 2 Surfaces	N	14	n/a - Concrete Walls	16 - Scan Points	---	24 - Scan Points	---
034	Class 1	E	1,628	25,383	17	1	15	n/a
035	Class 1	M	1,626	24,207	17	1	5	n/a
036	Class 1	E	488	8,789	6	1	2	n/a
037	Class 1	E	1,673	22,223	17	1	17	n/a
038	Class 1	M	1,123	20,590	12	1	18	n/a
039	Class 1	G-2	1,211	15,817	14	1	n/a	n/a
040	Class 1	D	1,756	35,219	18	1	13	n/a
041	Class 1	Q	1,085	16,328	11	1	n/a	n/a
042	Class 1	G-2	2,000	28,432	20	1	n/a	n/a
043	Class 1	O	17	1,051	4	1	n/a	n/a
044	Class 1	D	988	18,822	10	1	n/a	n/a
045	Class 1	Q	1,822	28,760	19	1	n/a	n/a
046	Class 1	G-2	812	8,279	10	1	n/a	n/a
047	Class 1	Q	1,226	12,832	13	1	n/a	n/a
048	Class 1	D	847	13,441	10	1	n/a	n/a
049	Class 1	Q	1,489	13,545	15	1	3	n/a
049A	Class 1 Surfaces	Q	19	n/a - Concrete Walls	24 - Scan Points	---	24 - Scan Points	---
050	Class 1	M	604	11,789	7	1	n/a	n/a
051	Class 1	G-2	1,650	26,642	16	1	11	n/a
052	Class 1	M	950	19,269	9	1	n/a	n/a
053	Class 1	M	755	10,488	6	n/a	n/a	6
054	Class 1	Q	434	6,926	6	1	n/a	n/a
055	Class 1	D	269	6,296	6	1	n/a	n/a
056	Class 2	n/a	5,310	42,364	56	1	16	11
057	Class 1	D	1,409	30,961	15	1	6	n/a
058	Class 1	D	898	23,667	10	1	1	n/a
59	Class 1	G-2	1,314	23,306	13	1	32	n/a
060	Class 1	D	1,165	25,444	13	1	n/a	n/a
060A & 060B	Class 1 Surfaces	D-2	31	n/a - Concrete Walls	32 - Scan Points	---	---	---
061	Class 1	D	1,424	32,629	13	1	2	n/a
062	Class 1	G-2	1,608	33,143	16	1	20	n/a
063	Class 1	I	1,952	48,890	20	1	3	n/a

FSS Unit	MARSSIM Classification	Area	Surface Area (m^2)	Gamma Walkover Survey Data Points	Number of Systematic Samples	Number of Quality Control Samples	Number of Biased Samples	Number of Core Composite Samples
064	Class 1	I	1,530	38,387	16	1	1	n/a
065	Class 1	J	110	3,057	6	1	2	n/a
066	Class 1	G-1	1,434	23,095	16	1	21	n/a
067	Class 1	J	281	7,020	6	1	2	n/a
068	Class 1	F	339	7,021	6	1	n/a	n/a
069	Class 2	n/a	3,196	3,657	31	1	21	10
070	Class 2	n/a	7,276	1,579	60	1	21	15
071	Class 1	D	421	7,077	6	1	2	n/a
071A, B and C[b]	Class 1 Surfaces	D-2	74	n/a - Concrete Walls	86 - Scan Points	---	---	---
072	Class 1	F	1,236	19,797	11	1	5	n/a
073	Class 1	G-1	968	19,932	11	1	34	n/a
074	Class 1	Q	1,468	25,970	17	1	n/a	n/a
075	Class 1	S	593	13,114	6	1	1	n/a
076	Class 1	I	423	10,108	6	1	n/a	n/a
077	Class 1	I	606	10,938	7	1	2	n/a
078	Class 1	H	1,145	37,724	11	1	2	n/a
079	Class 1	T	160	3,251	6	1	7	n/a
080	Class 1	K	91	3,443	3	1	n/a	n/a
080A	Class 1 Surfaces	F	24	n/a - Concrete Walls	29 - Scan Points	---	---	---
081	Class 1	E	858	18,457	9	1	2	n/a
082	Class 1	D	268	8,721	13	1	8	n/a
082C and D	Class 1 Surfaces	Bldg. 70	3	n/a - Concrete Walls	4 - Scan Points	---	4	---
082A, B and E	Class 1 Surfaces	Bldg. 70	31	n/a - Concrete Walls	34 - Scan Points	---	40	---
083	Class 1	R	761	14,478	10	1	12	n/a
084	Class 1	I	63	1,988	3	1	n/a	n/a
085	Class1	K	237	5,130	8	1	3	n/a
086	Class 1	R	108	1,955	3	1	5	n/a
87A[a]	Class 1 Surfaces	Bldg. 8 Tunnel	49	n/a - Concrete Wall	49 - Scan Points	---	---	---
088	Class 1	F	871	16	10	1	n/a	n/a
089	Class 2	n/a	4,638	27,442	46	1	11	10
090	Class 2	n/a	9,999	46,954	104	2	n/a	20
091	Class 2	n/a	10,000	51,299	94	2	6	20
092	Class 2	n/a	9,986	44,358	98	2	n/a	20
093	Class 2	n/a	7,417	34,791	79	2	6	15
094	Class 1	C	1,795	32,567	20	2	3	n/a
095	Class1	C	1,525	26,926	14	1	4	n/a

FSS Unit	MARSSIM Classification	Area	Surface Area (m^2)	Gamma Walkover Survey Data Points	Number of Systematic Samples	Number of Quality Control Samples	Number of Biased Samples	Number of Core Composite Samples
096	Class 2	n/a	9,491	37,461	99	2	12	19
097	Class 1	D	245	5,839	6	1	3	n/a
098	Class 1	H	632	13,509	6	1	n/a	n/a
099	Class1	E	636	14,027	7	1	n/a	n/a
100	Class 2	n/a	6,188	45,540	57	1	23	13
101	Class 2	Bldg. 70	8,498	n/a-concrete surface	70	2	39	17
102	Class 2	Bldg. 2	8,896	n/a-concrete surface	34	2	n/a	18
103	Class 2	Bldg. 2A/2B	4,975	n/a-concrete surface	41	2	16	10
104A	Class 1 Surfaces	Bldg. 8	49	n/a-concrete Wall	59	n/a	52	n/a
104	Class 1	Bldg. 8	994	68,574	9	2	8	n/a
105	Class 1	F	1,662	46,734	19	3	18	n/a
106	Class 1	Bldg. 90	1,999	115,831	21	2	n/a	n/a
107	Class 1	F	1,132	28,652	7	1	10	n/a
108	Class 1	G-2	145	4,713	9	1	15	n/a
109	Class 1	T	43	857	4	n/a	3	n/a
110	Class 2	n/a	6,408	17,800	100	2	32	20
111	Class 1	G-1	1,292	23,119	12	4	45	n/a
112	Class 2	n/a	8,726	69,905	80	1	11	20
113	Class 2	n/a	5,391	49,581	56	1	31	11
114	Class 2	n/a	9,753	136,369	95	1	67	20
115	Class 2	n/a	9,990	230,385	95	2	25	20
116	Class 1	D2 & M	2,070	81,777	21	7	12	20
117	Class 1	F	518	21,389	4	4	4	n/a
B-14 001	Class 1	Bldg. 14	147	3,600	6	1	2	n/a
B-14 002	Class 1	Bldg. 14	1,230	16,128	13	1	15	n/a
B-14 003	Class 1	Bldg. 14	1,335	17,276	14	1	16	n/a
B-14 004	Class 1	Bldg. 14	817	18,721	9	1	3	n/a
B-14 005	Class 1 - Surfaces	Bldg. 14	188	n/a-concrete surface	193 - Scan Points	---	240 - Scan Points	---
			Total	**3,055,056**	**3,185**	**147**	**978**	**477**

ISOCS - *in situ* object counting system n/a – not applicable

<u>Note</u>: Data presented in this table reflects that presented in TDPs. However, some information may not reflect current site conditions due to soil excavations conducted subsequent to the TDPs being issued. For example, Class 2 FSS unit number 002 was superseded by Class 1 FSS unit numbers 094 and 095 and two of the seven FSS samples for Class 1 FSS unit number 050 were later excavated and therefore, only five of the seven FSS samples for Class 1 FSS unit number 050 remain representative of current site conditions.

[a] A FSS was performed by Shaw. A subsequent remediation and new FSS was completed by Cabrera and is documented in its associated TDP.
[b] FSS units are grouped together as presented in their TDP. However, they were counted as separate FSS units in the Project Construction Report (Shaw 2010).

Table 10 – Results Summary for Class 1, 2, and 3 Final Status Survey Units

FSS Unit	Number of FSS Samples	Ra-226[a,b]			Th-230[a,b]			Total U[a,b]			Average SOR DCGL[b]	Surface β/min/ 100 cm[2 e]
		MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX		
001	6	0.18	0.27	0.51	0.68	1.11	1.37	1.44	1.95	2.90	0.05	---
002[c]	10	0.11	0.43	1.43	1.06	2.49	7.42	1.54	5.87	22.07	0.09	---
003	16	0.17	0.39	0.66	1.54	2.56	3.36	2.77	6.17	18.88	0.09	---
004	20	0.69	1.10	1.47	0.58	1.13	1.62	1.06	1.13	2.56	0.10	---
005	20	0.21	0.39	0.74	0.86	1.65	4.35	1.23	3.54	13.11	0.07	---
005A	---	---	n/a	---	---	n/a	---	---	n/a	---	---	265.0
005B-F	---	---	n/a	---	---	n/a	---	---	n/a	---	---	-23.2
006	20	0.20	0.49	1.13	1.01	1.65	3.42	1.18	6.66	41.31	0.07	---
007	20	0.23	0.58	1.06	1.06	1.29	1.83	1.61	3.33	9.49	0.07	---
008	20	0.11	0.82	1.86	1.15	1.74	3.38	1.99	3.77	10.42	0.10	---
009	20	0.36	0.83	1.56	0.27	1.74	3.20	0.70	4.51	10.08	0.10	---
010	20	0.22	0.69	1.88	1.31	2.03	9.50	1.42	3.89	12.11	0.09	---
011	16	0.12	0.72	1.31	0.82	1.87	7.94	1.54	4.31	12.83	0.09	---
011A, 014A-B[d]	---	---	n/a	---	---	n/a	---	---	n/a	---	---	614.0
012	19	0.18	0.63	3.68	0.91	1.39	3.32	2.22	6.95	30.04	0.08	---
013	20	0.14	0.37	0.94	1.02	1.35	1.73	1.67	4.14	32.83	0.06	---
014	10	0.28	0.65	1.71	1.08	1.52	1.84	1.65	2.49	5.12	0.08	---
015	20	0.16	1.38	4.10	0.68	1.84	3.09	1.96	9.32	91.78	0.14	---
016	20	0.89	1.62	3.95	0.93	1.39	1.80	1.69	2.40	4.06	0.14	---
016A	---	---	n/a	---	---	n/a	---	---	n/a	---	---	143.0
017	20	0.75	1.32	1.63	0.95	1.21	1.35	0.82	2.01	2.81	0.12	---
017B-C	---	---	n/a	---	---	n/a	---	---	n/a	---	---	135.0
018	17	0.15	0.33	0.49	0.71	1.22	1.59	1.59	4.92	40.02	0.05	---
019	20	0.33	0.92	1.26	0.55	1.07	1.70	1.12	3.36	23.68	0.09	---
020	6	0.56	0.83	1.20	0.94	1.30	2.18	1.22	1.92	2.52	0.09	---
021	20	0.21	0.52	1.16	0.91	1.99	3.75	1.42	3.19	5.79	0.09	---
022	20	0.19	0.46	1.10	1.04	2.56	5.23	1.61	4.44	8.96	0.09	---
023	10	0.79	1.12	2.07	1.07	1.48	2.43	1.79	3.95	10.95	0.11	---
024	20	0.23	1.09	1.82	0.65	1.19	1.79	1.33	2.03	3.76	0.10	---
025	20	0.68	1.84	3.21	1.01	2.09	3.52	1.51	4.55	9.09	0.17	---
026	14	0.66	1.19	2.15	0.65	1.28	2.03	1.14	2.09	5.03	0.11	---
027	20	0.44	1.00	1.55	0.63	1.11	1.50	1.14	1.88	2.98	0.09	---
028	19	0.63	1.06	1.52	0.85	1.33	2.47	1.07	2.66	16.36	0.10	---
028A	---	---	n/a	---	---	n/a	---	---	n/a	---	---	-63.0
029	19	0.71	1.32	1.91	1.15	1.63	2.19	1.46	2.22	3.51	0.13	---
030	10	0.70	1.24	1.97	1.04	1.66	2.71	1.20	2.37	3.62	0.12	---
030A	---	---	n/a	---	---	n/a	---	---	n/a	---	---	56.0
031	6	0.85	1.14	1.47	0.83	1.27	1.76	0.69	1.82	2.28	0.11	---
032	10	0.65	1.27	1.80	1.12	1.37	1.58	1.52	1.97	2.62	0.12	---
033	7	0.60	0.80	1.13	0.77	1.21	1.89	0.70	1.33	1.81	0.08	---

FSS Unit	Number of FSS Samples	Ra-226[a,b]			Th-230[a,b]			Total U[a,b]			Average SOR DCGL[b]	Surface β/min/ 100 cm^2 [e]
		MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX		
033A	---	---	n/a	---	---	n/a	---	---	n/a	---	---	-16.0
034	17	0.65	1.14	1.88	0.48	1.38	3.43	0.60	2.03	6.30	0.11	---
035	17	0.52	1.01	2.23	0.52	1.13	2.96	1.08	2.45	11.37	0.09	---
036	6	0.67	1.37	2.49	1.14	2.38	4.99	0.66	2.45	4.10	0.15	---
037	17	0.54	0.96	1.69	1.19	1.61	2.10	1.29	1.75	2.37	0.10	---
038	12	0.61	0.91	1.28	0.78	1.10	1.44	1.22	1.97	3.40	0.09	---
039	14	0.64	0.93	1.17	0.82	1.21	1.56	1.47	2.01	3.51	0.09	---
040	18	0.56	0.90	1.44	0.77	1.32	1.92	1.49	3.78	22.41	0.09	---
041	11	0.86	1.20	1.77	0.85	1.21	1.77	0.42	3.00	15.62	0.11	---
042	20	0.60	1.04	1.82	0.35	1.13	2.15	1.38	1.95	3.17	0.10	---
043	4	0.74	0.92	1.04	0.55	1.17	1.49	1.62	2.03	2.83	0.09	---
044	10	0.66	1.08	1.71	0.96	1.27	1.48	1.36	2.24	4.10	0.10	---
045	19	0.60	1.22	2.28	0.70	1.37	3.41	1.14	3.28	16.51	0.11	---
046	10	0.69	0.94	1.45	0.56	1.13	1.65	1.50	1.88	2.26	0.11	---
047	13	0.62	0.95	1.33	0.73	1.10	1.79	1.04	2.01	3.72	0.09	---
048	10	0.07	0.64	1.22	0.55	0.96	1.34	0.80	1.88	2.81	0.06	---
049	15	-0.04	0.73	1.33	0.80	1.10	1.59	1.59	2.68	8.96	0.08	---
049A	---	---	n/a	---	---	na	---	---	na	---	---	186.0
050	7	-0.01	0.38	0.82	0.66	0.85	1.10	1.03	1.82	2.58	0.05	---
051	16	0.05	0.82	1.34	0.57	0.89	1.30	1.14	1.64	2.14	0.07	---
052	9	0.00	0.87	2.74	0.57	1.24	3.03	1.28	3.53	16.47	0.09	---
053	6	0.64	0.87	1.14	0.71	0.94	1.35	1.25	2.40	5.94	0.08	---
054	6	0.36	0.90	2.60	0.37	1.44	4.30	0.36	3.68	12.43	0.10	---
055	6	0.38	0.78	1.07	0.54	1.09	1.71	1.27	2.30	5.62	0.08	---
056	11	0.65	1.00	1.65	0.66	1.18	1.99	0.67	2.81	3.31	0.09	---
057	15	0.36	1.08	1.49	0.61	1.02	1.52	1.05	1.97	2.54	0.09	---
058	10	0.47	0.97	1.37	0.59	0.91	1.24	1.24	1.71	2.41	0.08	---
059	13	0.38	0.92	1.40	0.70	0.94	1.31	1.03	1.54	2.75	0.08	---
060	13	0.77	1.17	2.11	0.64	1.02	1.38	1.14	2.11	5.46	0.10	---
060A-B	---	---	n/a	---	---	n/a	---	---	n/a	---	---	206.0
061	13	0.42	0.99	1.37	0.78	1.01	1.34	1.21	2.01	3.76	0.09	---
062	16	0.68	1.03	1.37	0.54	1.22	4.86	1.19	1.84	2.88	0.10	---
063	20	0.78	1.22	2.67	0.38	1.17	2.48	0.76	2.41	7.78	0.11	---
064	16	0.62	1.10	1.91	0.51	0.94	1.49	0.63	1.71	3.76	0.10	---
065	6	1.01	1.42	1.78	0.79	1.28	2.10	1.69	3.17	6.87	0.13	---
066	16	0.82	1.50	4.02	0.70	1.10	1.53	0.92	1.97	2.88	0.12	---
067	6	0.74	1.00	1.27	0.32	0.94	1.80	0.98	2.92	6.89	0.09	---
068	6	0.61	1.30	1.85	0.63	3.02	11.40	1.58	11.10	18.60	0.16	---
069	10	0.96	1.32	1.80	0.94	1.80	2.57	0.73	2.50	4.10	0.13	---
070	15	0.37	1.28	2.38	0.98	1.60	3.38	1.29	2.81	4.46	0.13	---
071	6	0.72	1.24	1.94	0.92	1.67	4.50	1.44	1.86	2.62	0.12	---

FSS Unit	Number of FSS Samples	Ra-226[a,b]			Th-230[a,b]			Total U[a,b]			Average SOR DCGL[b]	Surface β/min/ 100 cm[2 e]
		MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX		
071A, B, and C[d]	---	---	n/a	---	---	n/a	---	---	n/a	---	---	125.8
072	11	0.71	1.14	1.70	0.84	1.70	5.32	1.44	3.78	16.53	0.12	---
073	11	0.85	1.19	1.95	0.92	1.23	1.84	1.28	2.01	2.75	0.11	---
074	17	0.25	1.15	1.75	0.13	1.02	1.70	0.48	2.14	6.93	0.10	---
075	6	0.99	1.39	2.45	0.45	1.15	2.55	1.16	3.76	13.72	0.12	---
076	6	0.91	1.17	1.55	0.74	1.05	1.22	0.93	2.11	2.83	0.10	---
077	7	0.59	1.64	4.05	0.93	1.32	1.74	1.61	2.14	2.81	0.14	---
078	11	0.72	1.25	1.93	0.45	1.08	2.76	0.93	2.20	8.63	0.11	---
079	6	0.72	1.23	1.57	0.52	0.97	1.27	1.54	2.07	2.60	0.11	---
080	3	1.06	1.23	1.40	0.88	1.01	1.12	0.73	1.63	2.37	0.10	---
080A	---	---	n/a	---	---	n/a	---	---	n/a	---	---	356.5
081	9	0.58	1.32	3.42	0.48	1.40	4.64	0.47	3.06	10.68	0.12	---
082	13	0.32	1.34	1.96	0.65	1.09	1.70	1.53	2.15	3.42	0.12	---
082C-D	---	---	n/a	---	---	n/a	---	---	n/a	---	---	794.0
082A, B and E	---	---	n/a	---	---	n/a	---	---	n/a	---	---	185.5
083	10	0.39	0.85	1.79	0.38	0.82	1.23	0.90	1.71	2.62	0.08	---
084	3	0.67	0.86	1.16	0.77	1.08	1.48	1.67	2.04	2.22	0.08	---
085	8	0.30	0.77	1.19	0.23	0.92	1.40	0.83	1.66	2.14	0.07	---
086	3	0.20	0.67	0.91	0.19	0.41	0.70	1.62	1.99	2.60	0.06	---
87A[c]	---	---	n/a	---	---	n/a	---	---	n/a	---	---	852.0
088	10	0.52	1.01	1.99	0.56	1.06	1.74	1.19	5.13	29.81	0.09	---
089	10	0.00	1.22	2.51	0.82	1.69	3.57	1.69	6.36	22.83	0.12	---
090	20	0.37	0.88	1.41	0.73	1.50	2.91	0.75	2.48	4.65	0.09	---
091	20	0.27	1.13	2.78	0.23	1.44	2.27	0.63	2.70	7.06	0.11	---
092	20	0.57	1.19	2.09	0.84	1.42	2.19	1.41	2.76	13.68	0.11	---
093	15	0.60	0.99	1.45	0.76	1.21	1.87	1.16	2.30	7.89	0.09	---
094	20	0.48	0.89	1.65	0.67	1.25	4.18	0.31	1.92	5.20	0.09	---
095	14	0.36	1.03	4.40	0.51	1.13	2.30	1.01	2.52	7.59	0.10	---
096	19	0.24	0.80	1.47	0.33	0.10	1.90	0.93	3.00	15.33	0.07	---
097	6	0.58	0.64	0.84	0.52	0.76	1.06	0.89	1.59	2.05	0.06	---
098	6	0.68	0.90	1.19	0.51	0.78	1.07	1.02	1.80	2.81	0.08	---
099	7	0.58	1.14	3.10	0.52	1.22	1.93	1.19	2.67	5.16	0.11	---
100	13	0.59	0.78	0.96	0.54	1.01	1.74	1.16	1.87	2.96	0.08	---
101	17	0.47	1.38	2.72	0.71	1.64	2.99	1.63	3.78	5.90	0.14	---
102	18	0.18	0.91	3.82	0.44	1.74	1.41	0.99	1.74	2.49	0.08	---
103	10	0.78	1.31	2.18	0.76	1.58	2.21	1.10	3.71	6.72	0.13	---
104A	---	---	n/a	---	---	n/a	---	---	n/a	---	n/a	---
104	9	0.54	0.69	0.88	0.70	0.80	0.85	1.31	1.54	1.95	0.06	---
105	19	0.49	1.00	1.36	0.70	1.06	3.28	0.74	0.96	8.90	0.09	---
106	21	0.46	0.87	1.38	0.80	1.06	1.27	1.52	4.11	46.93	0.08	---
107	7	0.39	0.75	0.99	0.78	0.84	0.89	1.56	1.65	1.75	0.07	---

FSS Unit	Number of FSS Samples	Ra-226[a,b]			Th-230[a,b]			Total U[a,b]			Average SOR DCGL[b]	Surface β/min/ 100 cm^2 [e]
		MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX		
108	9	0.63	0.94	1.44	0.79	0.98	1.16	1.44	1.64	1.82	0.08	---
109	4	0.87	1.45	2.78	1.08	1.52	2.20	1.71	1.87	2.07	0.13	---
110	20	0.10	0.31	0.49	0.54	0.96	1.27	1.27	1.98	2.63	0.04	---
111	12	0.42	0.75	1.26	0.88	1.02	1.18	1.18	2.67	8.60	0.07	---
112	20	0.44	0.88	1.66	0.61	0.89	1.23	1.17	1.73	2.55	0.08	---
113	11	0.17	0.36	0.74	0.83	1.06	1.53	1.75	3.60	14.38	0.05	---
114	20	0.49	0.97	1.43	0.45	1.28	3.64	0.94	2.90	8.05	0.10	---
115	20	0.66	0.91	1.26	0.69	1.08	1.56	1.58	2.60	5.42	0.08	---
116	21	0.35	0.70	1.09	0.69	0.87	1.10	1.40	1.65	2.14	0.07	---
117	4	0.28	0.53	0.82	0.80	0.81	0.83	1.29	1.51	1.73	0.05	---
B-14-001	6	0.78	1.22	1.59	0.68	1.18	1.72	1.14	2.33	3.72	0.11	---
B-14-002	13	0.67	1.24	2.06	0.50	1.33	2.49	1.43	14.46	122.20	0.12	---
B-14-003	14	0.66	1.02	1.48	0.70	1.13	2.04	1.55	9.57	41.86	0.10	---
B-14-004	9	0.75	1.14	1.80	0.68	1.02	1.56	1.14	2.35	6.30	0.10	---
B-14-005	---	---	---	---	---	---	---	---	---	---	---	131.8

[a] The average site background concentrations for Ra-226, Th-230, and total U were 1.1, 1.4, and 6.1 pCi/g, respectively.
[b] The MIN, AVG, and MAX Ra-226, Th-230, and total U concentrations, and average SOR DCGL values, presented were not incremental to background (i.e. it conservatively included contribution from background).
[c] A FSS was performed by Shaw. A subsequent remediation and new FSS was completed by Cabrera and is documented in its associated TDP.
[d] FSS units are grouped together as presented in their TDP. However, they were counted as separate FSS units in the Project Construction Report (Shaw 2010).
[e] The presented values meet derived surface contamination limits for each unit.

Note: Data presented in this table reflects that presented in TDPs. However, some information may not reflect current site conditions due to soil excavations conducted subsequent to the TDPs being issued. For example, Class 2 FSS unit number 002 was superseded by Class 1 FSS unit numbers 094 and 095 and two of the seven FSS samples for Class 1 FSS unit number 050 were later excavated and therefore, only five of the seven FSS samples for Class 1 FSS unit number 050 remain representative of current site conditions.

7.4 PLACEBACK SOILS

Overburden soil and construction debris, excavated to gain access to deposits of subsurface contamination or to maintain safe and stable remedial excavations, were stockpiled during remedial action for potential reuse as backfill.

For the Shaw remedial action (1999-2010), construction debris was segregated from soil and a biased composite sample was collected from each 15 m^3 (20 yd^3) stockpile using a gamma scan trigger level of 18,000 cpm on a sodium iodide detector. Samples were sent off site for radiological analysis by alpha spectroscopy and radon emanation methods. Analytical results were compared against the beneficial reuse criteria agreed upon between Praxair, NYSDEC, and USACE. The gross concentration of each radionuclide was evaluated against the surface DCGLs using background ranges prescribed by NYSDEC of 2 pCi/g, 2 pCi/g, and 5 pCi/g for Ra-226, Th-230, and U-238, respectively. Samples were also analyzed, as prescribed by NYSDEC, for the toxicity characteristic leaching procedure (TCLP) for metals, pesticides, herbicides, volatiles, and semivolatiles to ensure that the overburden soil met the NYSDEC beneficial use standard (6 NYCRR Part 360-1.15(b)(8)).

For the Cabrera remedial action (2010-2013), the correlation between gamma exposure rate and FUSRAP-eligible COC concentrations in soil was revised based on refined statistics from the hundreds of samples that the project collected and analyzed over the years. The revised gamma rate exposure threshold for disposal was set at 22,000 cpm with a new screening threshold for overburden soils being established for “gray” soils. The gray soils were materials exhibiting a gamma exposure rate from 18,000 cpm to 22,000 cpm. The management and evaluation techniques for various soils were as follows:

- Contaminated soils, with field screening exceeding 22,000 cpm, were transferred to a separate load-out pad for off-site disposal.
- “Clean” soils, with field screening below 18,000 cpm, were transferred to an evaluation area and isolated into approximately 92 m^3 to 382 m^3 (120 yd^3 to 500 yd^3) windrows. Each windrow was subjected to confirmatory composite radiological COC sampling.
- “Gray” soils, with field screening between 18,000 and 22,000 cpm, were transferred to an evaluation area and isolated in approximately 15 m^3 (20 yd^3) soil bins, spread to a thickness not to exceed 1 foot, and subjected to additional gamma walkover survey screening. Any identified “hot spots” (i.e., soils exceeding 22,000 cpm) were removed from each soil bin via precision excavation and discarded as radiological waste without biased sampling and analysis. Remaining soils were combined into approximately 92 m^3 to 382 m^3 (120 yd^3 to 500 yd^3) windrows and subjected to confirmatory composite radiological COC sampling.

Composite samples collected from “clean” and “gray” windrows were compared to the beneficial reuse COC criteria established during the 1999-2010 remedial action. Additionally, a minimum of three samples were collected for volatile organic compounds (VOCs) prior to aggregating each 92 m^3 to 382 m^3 (120 yd^3 to 500 yd^3) windrow into a final stockpile. Soils meeting the beneficial reuse COC and VOC criteria were aggregated into 3,822 m^3 (5,000 yd^3) stockpiles. Each stockpile was then composite sampled (10-node) and analyzed for TCLP metals, pesticides, herbicides, VOCs, and semi-volatiles to ensure the material met NYSDEC’s beneficial use standard (6 NYCRR Part 360-1.15(b)(8)).

7.4.1 Recycling

Concrete and metal debris from demolition activities was locally disposed or recycled as much as possible and/or practicable in an effort to reduce cost and minimize waste. These materials were power washed and visually inspected before receiving the required radiological screenings and surveys as described in Section 7.0. Petitions, along with the radiological screening and survey data, were provided to NYSDEC for local disposal or recycling concurrence. Table 11 summarizes recycled materials.

Table 11 – Reused and Recycled Materials

Remedial Action	Media	Reused or Recycled	Volume (tons)
1999-2010	Asphalt	Recycled	38
1999-2010	Concrete	Recycled	2,085
1999-2010	Metals	Recycled	416
1999-2010	Soils	Reused	24,840
2010-2013	Asphalt	Recycled	1,665
2010-2013	Concrete	Recycled	653
2010-2013	Concrete	Reused	4,100
2010-2013	Metals	Recycled	135
2010-2013	Soils	Reused	25,700
2004-2005	Mercury Debris	Recycled	0.7
			59,633

7.5 CSX RAIL LINE

The CSX main rail line borders FSS unit 111 to the east as shown in Figure 6. In correspondence with CSX prior to remedial actions in this area, CSX informed USACE that excavation was only permitted to within 3.7 m (12 ft) of the center line of the railroad track. FSS unit 111 was remediated to that boundary and biased samples were collected every 3.9 m (10 ft) along the eastern and southern boundaries of the unit to confirm areas outside of the FSS sample locations had been successfully remediated to below subsurface criteria. Fifty samples were collected at the point of highest gamma readings and the samples were sent off site for alpha spectroscopy analysis.

Upon receipt of analytical data, an area of concern was identified along the eastern cut face of the SU. A sample (L-SL-SC-4377) had a subsurface SOR value of 1.41, in-between a sample (L-SL-SC-4375) with a SOR value of 0.91 and a sample (L-SL-SC-4378) with a SOR value of 0.94. The horizontal area between these three samples is approximately 12-m (40-ft) wide with a thin lens of contamination approximately 0.6 - 0.8 m (2 - 2.5 ft) below surface grade.

To determine whether the ROD criteria had been met, a 100 m^2 (1,076 ft^2) area (Figure 6) surrounding the elevated sample was examined, since the DCGLs (ROD criteria) apply over 100 m^2. Within this 100 m^2 (1,076 ft^2) area, there were seven biased and two FSS samples that had been collected previously. The concentrations of radionuclides within this 100 m^2 (1,076 ft^2) area from these nine samples were averaged and the SOR of the average radionuclide concentrations was determined. Because the average SOR within this 100 m^2 area is below 1, it was determined that the ROD criteria had been met in this area. Additionally, five direct push soil core samples to the east, north, and south of this area, which were collected in previous site investigation activities, were evaluated as bounding samples. None of the soil core samples exceeded the core scanner established threshold value. The biased and FSS sample locations are shown in Figure 6 and the sample analytical results are provided in Table 12 below.

Table 12 – Sample Results from the CSX Rail Line

Sample Location	Ra-226[a]	Th-230[a]	Total U[a]	Average SOR DCGL[b]
L-SL-SC-4373	0.93	0.92	2.30	0.00
L-SL-SC-4374	3.00	0.73	3.35	0.11
L-SL-SC-4375	10.6	13.4	7.73	0.91
L-SL-SC-4376	11.1	9.2	5.38	0.85
L-SL-SC-4377	13.3	27.2	9.01	**1.41**
L-SL-SC-4378	9.3	18.3	8.07	0.94
L-SL-SC-4379	1.27	2.76	2.83	0.04
L-FS111-003	0.79	0.93	0.90	0.07
L-FS111-004	0.58	0.96	0.89	0.06
Average	5.66	8.27	4.50	0.46

[a] Results include contribution from background (i.e. background is not subtracted).
[b] Samples exceeding a SOR of 1 are **bold**.

Since the average radionuclide concentrations across the 100 m^2 (1,076 ft^2) area resulted in a subsurface soil SOR value of 0.46 and none of the soil cores exhibited gamma emissions above investigation or sample thresholds, no further action is required in this area to satisfy the requirements of the ROD.

8.0 DEMONSTRATION OF CLEANUP QUALITY

USACE and the remediation contractors routinely performed many different quality assurance/quality control (QA/QC) activities. Contractor project QC was maintained through the implementation of project specific quality control plans and quality assurance project plans. Controlled copies of pertinent plans were available on site for the duration of the projects. The USACE QA process included having a USACE construction inspector and health physicist on site during the remediation to ensure that plans and proper procedures were implemented.

Upon completion of the FSS gamma walkover scans, a contractor QC review of the data was performed. The review included a verification of geographic position survey data, an instrument calibration check, review of standard operating procedures, and discussion of findings. Upon completion of the contractor QC process, USACE performed a QA review of the contractor data and conducted a verification gamma scan of the unit. Argonne performed an independent review of the contractor gamma walkover data including mapping and plotting verifications. NYSDEC also conducted verification gamma scans of the unit. USACE and NYSDEC gamma scans were based on professional judgment and the nature and extent of contamination that had existed in that area. Any anomalies, elevated areas or discrepancies in the data were investigated and resolved. Concurrence was received from all parties prior to USACE approval to backfill an excavation.

Field duplicates and QA splits were collected with FSS samples and compared to the original samples as a measure of precision. All samples used to close out FSS units were found to meet the required quality standards. USACE, Argonne, and the NYSDEC also performed QA reviews of the sample data and collected field split samples and biased samples as deemed necessary.

9.0 SUMMARY OF OPERATION AND MAINTENANCE

The applied remedial alternatives (building demolition and off-site disposal, complete soil excavation above ROD criteria and off-site disposal, and no action for groundwater) do not require operation and maintenance (O&M) actions at the Linde Site.

10.0 SUMMARY OF REMEDIAL COSTS

Table 13 presents a summary of remediation costs for the Linde Site. There are no O&M costs. The Contractors for the 1996-1997 and 1998-1999 non-time-critical removal actions and 1999-2010, 2004-2005, and 2010-2013 remedial actions were BNI, Radian, IT/Shaw, Shaw, and Cabrera, respectively.

Table 13 – Summary of Remedial Costs

Linde Removal/Remedial Actions	Estimate in EE/CA or ROD	Total Remediation Costs[a]
	(millions of dollars)	
Non-Time-Critical Removal Action (1996-1997) -Demolition of Building 38 (BNI)	$11.3 (EE/CA)[b]	**$25.0[c]**
Non-Time-Critical Removal Action (1998-1999) -Demolition of Building 30 (Radian)	$7.7 (EE/CA)[d]	**$12.4**
Remedial Action (1999-2010) -Soils OU (IT/Shaw)	$27.7 (ROD)[e]	**$246.3**
Remedial Action (2010-2013) -Soils OU (Cabrera)		
Remedial Action (2004-2005) -Building 14 OU (Shaw)	$9.8 (ROD)[f]	**$21.7**
Total	-	**$305.4**

[a] Total Remediation Costs include both contractor and government (DOE and USACE) costs.
[b] Total estimated present value cost for the DOE selected remedy in 1996 dollars. The EE/CA (DOE 1996a) underestimated the volume of Building 38 rubble and contaminated soil requiring disposal.
[c] Estimated DOE costs for the decontamination and demolition of Building 38, excavation and off-site disposal of contaminated soil stored near Bldg 90, and decontamination of Buildings 14 and 31.
[d] Total estimated present value cost for the selected remedy in 1996 dollars. The EE/CA (DOE 1996c) underestimated the volume of Building 30 rubble requiring disposal. The actual disposal volume of 6,778 m^3 (8,865 yd^3) was well in excess of the EE/CA estimate of 3,736 m^3 (4,486 yd^3).
[e] Total estimated present value cost for the selected remedy in 1999 dollars. The FS Addendum (USACE 1999a) underestimated the volume of soil requiring disposal. The actual disposal volume of 146,670 m^3 (191,834 yd^3) was well in excess of the 1999 soil volume estimate of 17,164 m^3 (22,450 yd^3). The ROD did not anticipate the need to excavate soils off the FUSRAP-designated Linde Site (i.e. onto the Mil-Sher, Carrier, and R.P. Adams properties) and around utility tunnels, or demolish Buildings 8 East Annex, 8A, 31, 58, 73A, and 90 to access contaminated soils underneath.
[f] Total estimated present value cost for the selected remedy in 2000 dollars. The Proposed Plan (USACE 2002) underestimated the volume of Building 14 rubble requiring disposal. The actual disposal volume of 10,858 m^3 (14,202 yd^3) was well in excess of the ROD estimate of 573 m^3 (750 yd^3).

11.0 FIVE-YEAR REVIEW

11.1 FIVE-YEAR REVIEW REPORT

USACE issued the *Five-Year Review Report for the Linde FUSRAP Site, Town of Tonawanda, Erie County, New York*, to determine the effectiveness of the selected remedial actions contained within the ROD (USACE 2000b). The trigger date for the five-year review was the initiation of soil excavation activities in September 2000. This first and only five-year review was due in September 2005, however, the five-year review report was not issued until August 2010. The report concluded that the excavation and off-site disposal remedy implemented for the soils OU at the Linde Site was expected to be protective of human health and the environment upon completion. In the interim, exposure pathways that would result in unacceptable risk were being controlled.

Two issues were identified during the five-year review. However, neither issue impacted the level of protectiveness of the soils OU remedial action. The first issue related to the need for improved outside project communication. The second issue was stakeholder concern that cleanup criteria identified in the ROD for the soils OU would allow FUSRAP-eligible contamination to remain at levels that would preclude unrestricted use of the land. However, this is no longer an issue since FUSRAP-eligible residuals at the Linde Site are at levels that allow for UU/UE. No additional five-year reviews are required.

11.2 FIVE-YEAR REVIEW REQUIREMENTS

The implemented remedy resulted in no FUSRAP-eligible COCs remaining in soil at the Linde Site above average background, as detailed in Section 6.9. Since FUSRAP-eligible residuals at the site are at levels that allow for UU/UE, five-year reviews are not required pursuant to Section 121(c) of CERCLA and Part 300.430(f)(4)(ii) of the NCP and the site is suitable for use without restrictions.

The ROD for the groundwater OU (USACE 2006b) indicated that no CERCLA action was warranted for groundwater at the Linde Site since there was no exposure pathways to human or environmental receptors. This No Action remedy also allowed for UU/UE conditions since the naturally occurring concentrations of constituents in groundwater at the Linde Site precluded its use without treatment, and the treatment to remove the naturally occurring constituents would also remove any of the FUSRAP-eligible constituents that may be present.

12.0 SITE TRANSFER FROM USACE TO DOE

12.1 GENERAL SITE TRANSFER PROCESS

Per the MOU between USACE and DOE (DOE and USACE 1999), USACE will employ the following process to transfer a completed FUSRAP site from USACE to DOE.

USACE will provide the DOE with a signed copy of the declaration of response action completion and Site Closeout Report, and any O&M and land use control implementation plans that may be required to ensure future protectiveness of the implemented remedy. USACE will also request and provide the DOE with any letters from regulators acknowledging that remedial action goals have been met, and provide the DOE with an estimate of annual out-year cost requirements, a general description of the remedial goals, and any restrictions remaining on the property.

Ninety days before the end of the two-year short-term operations and maintenance period for which USACE is responsible, USACE will notify the DOE with the effective date of site transfer to DOE for long-term stewardship. Accompanying this notification will be a complete electronic copy of the Administrative Record, the O&M plans and actual costs of O&M for the first two years, and a description of the long-term actions required by the DOE. In addition, USACE will provide the DOE with informational copies of the draft site-specific land use controls and implementation plans, and keep DOE informed of changes in completion schedules and other events/issues that might impact DOE's future responsibilities at the site.

12.2 SITE TRANSFER PROCESS FOR THE LINDE FUSRAP SITE

Per the MOU between USACE and DOE (DOE and USACE 1999), USACE will provide the DOE with a signed copy of the declaration of response action completion and Site Closeout Report for the Linde FUSRAP Site, once available. The signature date of this Linde SCOR officially starts the two-year short-term O&M period, for which USACE is responsible.

Ninety days before the end of the two-year short-term O&M period, USACE will notify the DOE with the effective date of transfer of the Linde FUSRAP Site to the DOE for long-term stewardship (i.e. two years from the signature date of this Linde SCOR). Accompanying this notification will be a complete electronic copy of the Administrative Record.

As discussed in Section 6.9, since residual Ra-226, Th-230, and total U in soil at the Linde Site are indistinguishable from background (i.e. naturally-occurring, non-impacted) radionuclide concentrations, no FUSRAP-eligible hazardous substances, pollutants, or contaminants remain at the Linde FUSRAP Site that would preclude UU/UE. In other words, the Linde Site is deemed protective for unrestricted use and no land use controls, O&M, or five-year reviews are required to ensure the protectiveness of the remedy. Therefore, long-term actions required by the DOE for the privately-owned Linde FUSRAP Site will be limited to records management.

During the two-year short-term O&M period, USACE will keep the DOE informed of changes in completion schedules and other events/issues that might impact the DOE's future responsibilities at the Linde FUSRAP Site.

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ATTACHMENT A

Figures

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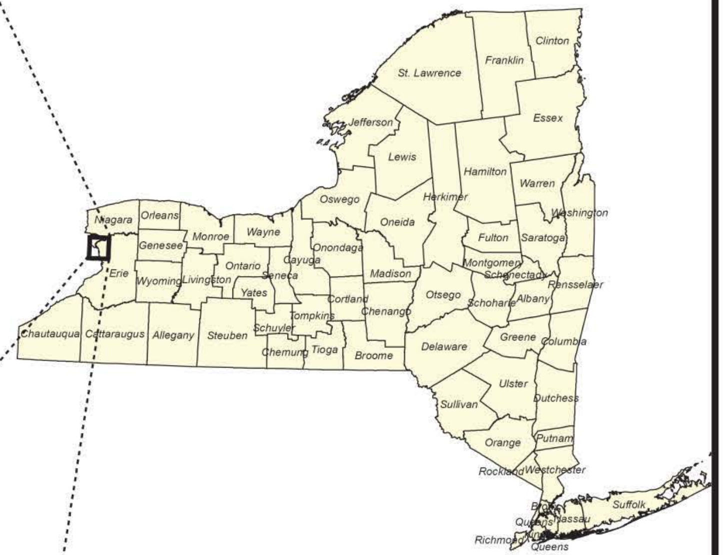

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS BUFFALO, NY	SITE LOCATION MAP	
Document Name: 160713_SiteLocation.mxd Drawn By: H5TDESPM Date Saved: 16 Jul 2013 Time Saved: 10:26:42 AM	LINDE FUSRAP SITE TONAWANDA, NEW YORK	FIGURE 1

Legend

- Former Injection Well
- Property Boundary
- Historic Buildings (with Building ID)
- Railroad

NOTES:
1) Aerial Photography Source: NAPP - Buffalo Quadrangle (1995).

0 225 450 900 Feet

US Army Corps of Engineers® Buffalo District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
BUFFALO, NY

HISTORIC SITE PLAN

Document Name: 050514_HistSitePlan.mxd
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Date Saved: 28 May 2014
Time Saved: 10:58:52 AM

LINDE FUSRAP SITE
TONAWANDA, NEW YORK

FIGURE 2

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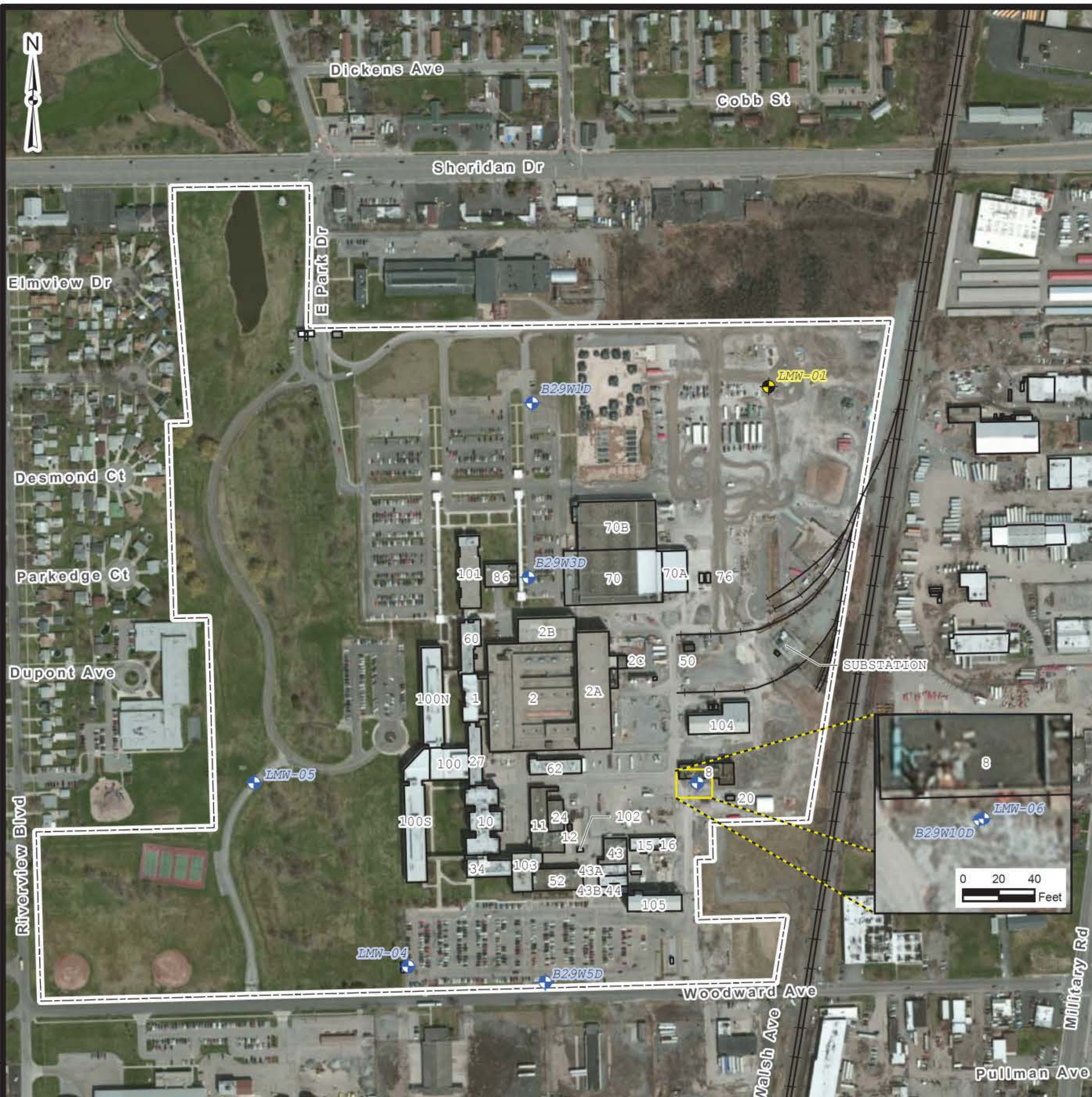

Legend

- Former Deep Monitoring Well
- Former Shallow Monitoring Well
- Property Boundary
- Existing Building (with Building ID)
- Railroad

NOTES:
1) No former injection wells remain onsite.
2) Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 225 450 900
Feet

US Army Corps of Engineers
Buffalo District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
BUFFALO, NY

CURRENT SITE PLAN

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LINDE FUSRAP SITE
TONAWANDA, NEW YORK

FIGURE 3

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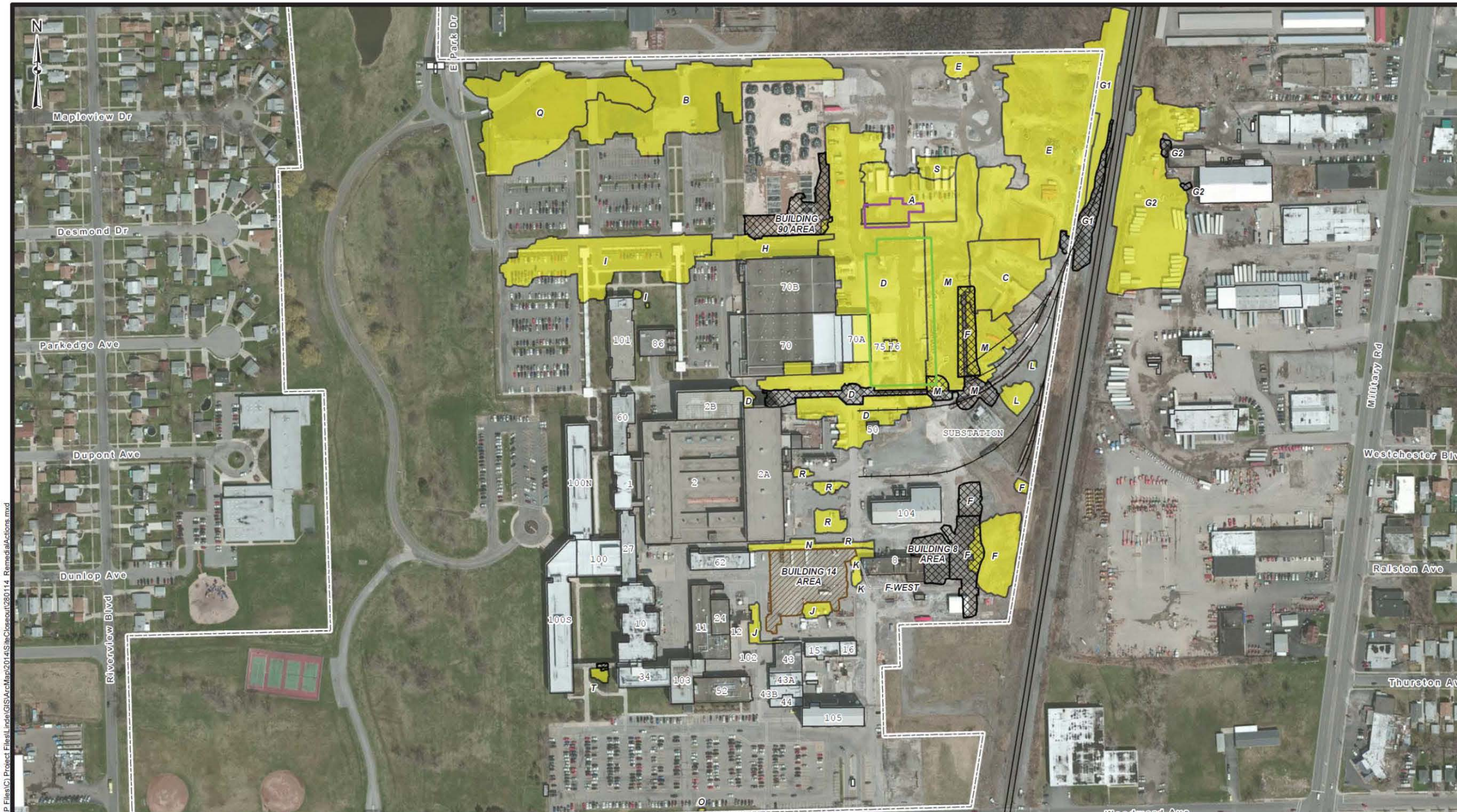

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Legend

- Property Boundary
- Excavation Area (2010 - 2013)
- Demolition of Building 14 (2004 - 2005)
- Excavation Area (1999 - 2010)

Non-Time Critical Removal Actions

- Demolition of Building 30 (1998-1999)
- Demolition of Building 38 (1996)
- Existing Building

0 125 250 500 Feet

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CORPS OF ENGINEERS
BUFFALO, NY

Document Name: 280114_RemedialActions.mxd
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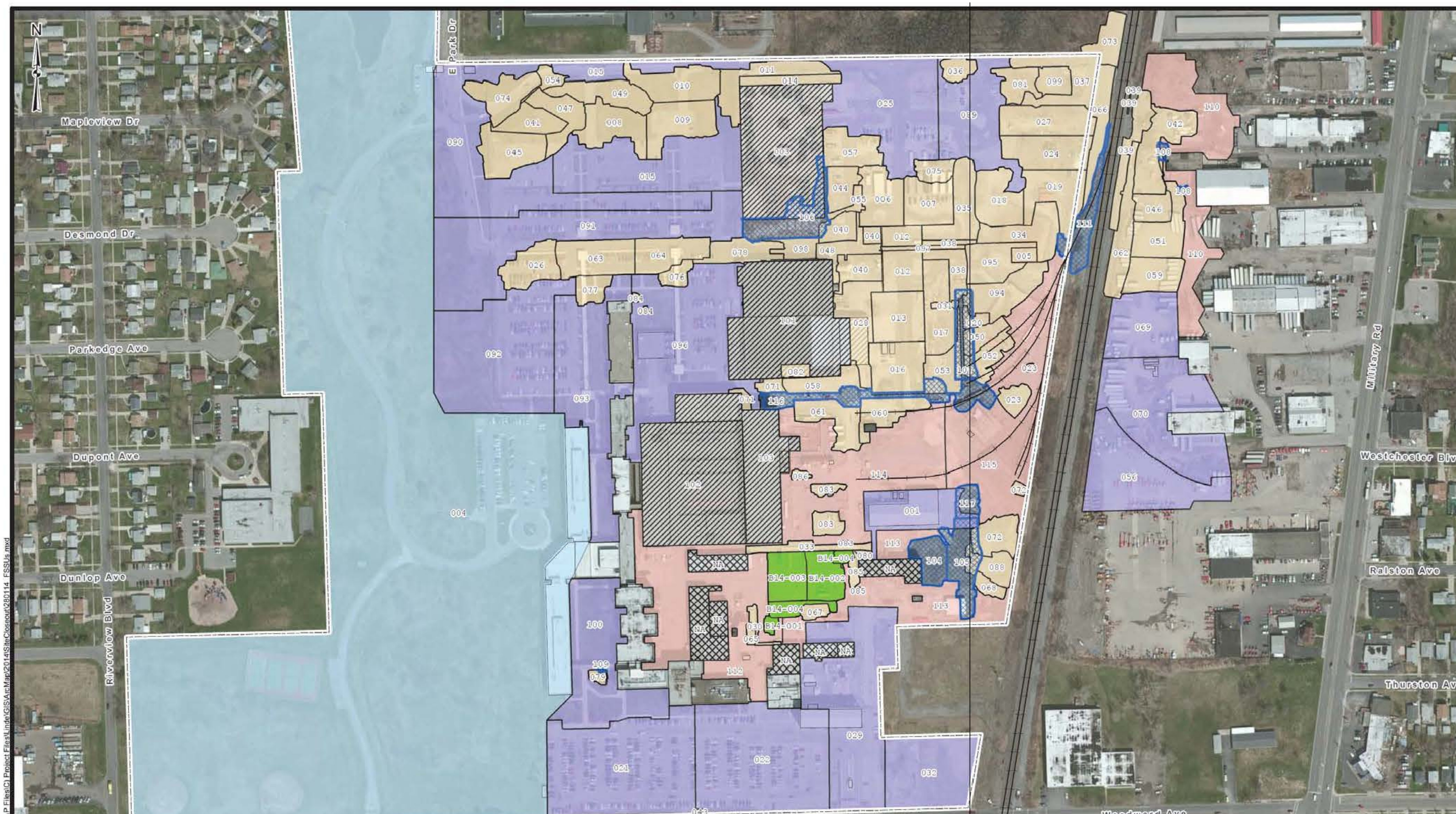
AERIAL EXTENT OF REMEDIAL ACTIONS
(1996 - 2013)

LINDE FUSRAP SITE
TONAWANDA, NEW YORK

FIGURE 4



Legend

Class 1 Final Status Survey Units
- Completed by IT/SHAW (1999-2010)
- Completed by IT/SHAW (2004 - 2005)
- Completed by CABRERA (2010-2013)

Class 2 Final Status Survey Units
- Completed by IT/SHAW (1999-2010)
- Completed by CABRERA (2010-2013)
- Building Subsurface Soils Completed by IT/SHAW (1999-2010)
- Building Subsurface Soils Completed by CABRERA (2010-2013)

NA - No FSS Unit Number Designation

Class 3 Final Status Survey Units
- Completed by IT/SHAW (1999-2010)
- Property Boundary

0 125 250 500 Feet

US Army Corps of Engineers. Buffalo District

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CORPS OF ENGINEERS
BUFFALO, NY

MARSSIM FINAL STATUS SURVEY UNITS

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LINDE FUSRAP SITE
TONAWANDA, NEW YORK

FIGURE 5

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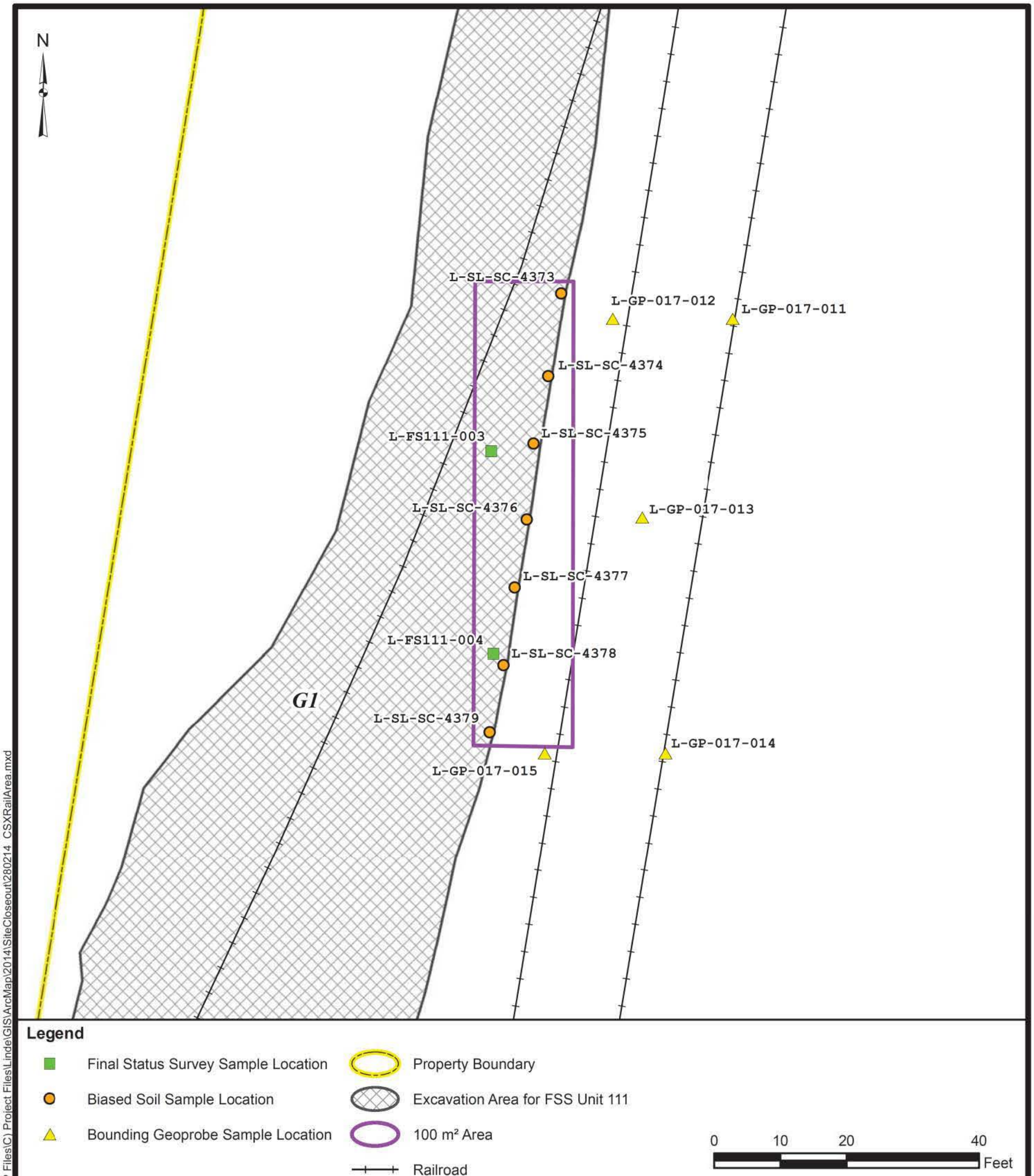

US Army Corps of Engineers
Buffalo District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
BUFFALO, NY

SOIL SAMPLE LOCATIONS FOR THE
CSX RAIL LINE

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Time Saved: 11:19:58 AM

LINDE FUSRAP SITE
TONAWANDA, NEW YORK

FIGURE 6

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ATTACHMENT B

Third-Party Post-Remediation Radiological Dose Assessment Report

for the Linde FUSRAP Site

Prepared by Argonne National Laboratory

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ANL/EVS-14/11

THIRD-PARTY POST-REMEDIATION RADIOLOGICAL DOSE ASSESSMENT REPORT FOR THE LINDE SITE, TONANWANDA, NY

MARCH 2015

U.S. Army Corps of Engineers
Formerly Utilized Sites Remedial Action Program

ANL/EVS-14/11

THIRD-PARTY POST-REMEDIATION RADIOLOGICAL DOSE ASSESSMENT REPORT FOR THE LINDE SITE, TONAWANDA, NY

MARCH 2015

Prepared by:
Argonne National Laboratory

Prepared for the:
U.S. Army Corps of Engineers

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CONTENTS

TABLES

GENERAL ACRONYMS AND ABBREVIATIONS

AC	Actinium
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
CFR	*Code of Federal Regulations*
COC	contaminant of concern
EPA	U.S. Environmental Protection Agency
FGR	Federal Guidance Report
FSSP	Final Status Survey Plan
FUSRAP	Formerly Utilized Sites Remedial Action Program
NRC	U.S. Nuclear Regulatory Commission
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MED	Manhattan Engineer District
Pa	Protactinium
Pb-210	Lead-210
Ra-226	Radium-226
ROD	Record of Decision
SOR	sum of the ratios
TEDE	total effective dose equivalent
Th-230	Thorium-230
U-234	Uranium-234
U-235	Uranium-235
U-238	Uranium-238
UMTRCA	Uranium Mill Tailings Radiation Control Act
USACE	U.S. Army Corps of Engineers
U_{total}	Total Uranium

UNITS OF MEASURE

cm^3	cubic centimeter(s)
d	day(s)
g	gram(s)
kg	kilogram(s)
L	liter(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
mol	mole(s)
mrem	millirem(s)
pCi	picocurie(s)
s	second(s)
yr	year(s)

METRIC CONVERSION CHART

To Convert to Metric			To Convert from Metric		
If You Know	Multiply By	To Get	If You Know	Multiply By	To Get
Length					
inches	2.54	centimeters	centimeters	0.3937	inches
feet	30.48	centimeters	centimeters	0.0328	feet
feet	0.3048	meters	meters	3.281	feet
yards	0.9144	meters	meters	1.0936	yards
miles	1.60934	kilometers	kilometers	0.6214	miles
Area					
square inches	6.4516	square centimeters	square centimeters	0.155	square inches
square feet	0.092903	square meters	square meters	10.7639	square feet
square yards	0.8361	square meters	square meters	1.196	square yards
acres	0.40469	hectares	hectares	2.471	acres
square miles	2.58999	square kilometers	square kilometers	0.3861	square miles
Volume					
fluid ounces	29.574	milliliters	milliliters	0.0338	fluid ounces
gallons	3.7854	liters	liters	0.26417	gallons
gallons	0.00378	cubic meters	cubic meters	264.55	gallons
cubic inches	16.3870	cubic centimeters	cubic centimeters	0.061023	cubic inches
cubic feet	0.028317	cubic meters	cubic meters	35.315	cubic feet
cubic yards	0.76455	cubic meters	cubic meters	1.308	cubic yards
Weight					
ounces	28,349,523	micrograms	micrograms	3.527396E-08	ounces
ounces	28.3495	grams	grams	0.03527	ounces
pounds	0.4536	kilograms	kilograms	2.2046	pounds
Radiation					
picocurie	0.037	Becquerel	Becquerel	27.027027	Picocuries
curie	3.70E+10	Becquerel	Becquerel	2.703E-11	Curies
Rem	0.01	sievert	sievert	100	rem

POST-REMEDIATION RADIOLOGICAL DOSE ASSESSMENT
LINDE SITE, TONAWANDA, NEW YORK

1 INTRODUCTION

A post-remediation radiological dose assessment was conducted for the Formerly Utilized Sites Remedial Action Program (FUSRAP) Linde Site by using the measured residual concentrations of the radionuclides of concern following the completion of the soils remedial action. The site's FUSRAP-related contaminants of concern (COCs) are radionuclides associated with uranium processing activities conducted by the Manhattan Engineer District (MED) in support of the Nation's early atomic energy and weapons program and include radium-226 (Ra-226), thorium-230 (Th-230), and total uranium (U_{total}). Remedial actions to address Linde Site soils and structures were conducted in accordance with the *Record of Decision for the Linde Site*, *Tonawanda, New York* (ROD) (USACE 2000a). In the ROD, the U.S. Army Corps of Engineers (USACE) determined that the cleanup standards found in Title 40, Part 192 of the *Code of Federal Regulations* (40 CFR Part 192), the standards for cleanup of uranium mill sites designated under the Uranium Mill Tailings Radiation Control Act (UMTRCA), and the Nuclear Regulatory Commission (NRC) standards for decommissioning of licensed uranium and thorium mills, found in 10 CFR Part 40, Appendix A, Criterion 6(6), are Applicable or Relevant and Appropriate Requirements (ARARs) for cleanup of MED-related contamination at the Linde Site. The major elements of this remedy will involve excavation of the soils with COCs above soil cleanup levels and placement of clean materials to meet the other criteria of 40 CFR Part 192.

Compliance with these standards required the USACE to remove MED-related soils with residual radionuclide concentrations averaged over a 100-square meter (m^2) area that exceeded unity for the sum of the ratios (SOR) of these radionuclide concentrations to the associated concentration limits, above background, of 554 pCi/g of U_{total}, 5 pCi/g of Ra-226, and 14 pCi/g of Th-230 for surface cleanups; and 3,021 pCi/g of U_{total}, 15 pCi/g of Ra-226, and 44 pCi/g of Th-230 for subsurface cleanups. In addition, prior to promulgation of the amendment to 10 CFR Part 40, Appendix A, Criterion 6(6), in June 1999, the USACE committed to remediate the Linde Site soils to ensure that no concentration of U_{total} exceeded 600 pCi/g above background.

In June 1999, regulations amending 10 CFR Part 40, Appendix A, Criterion 6(6) were promulgated to address areas contaminated with other radionuclides in addition to radium; the amended 10 CFR Part 40, Appendix A, Criterion 6(6) requires that radioactive contamination, considering all radionuclides including radium, remaining after remediation, will not result in a total effective dose equivalent (TEDE) to the average member of the critical group exceeding the benchmark dose after cleanup to the 40 CFR Part 192 standards of soils contaminated with radium only. This benchmark dose is used to establish allowable soil concentration levels for the various radionuclides present other than radium to be used in the SOR calculation. The USACE established the benchmark doses and associated radionuclide concentration limits for surface cleanups as well as subsurface cleanups for a commercial/industrial exposure scenario. A benchmark dose of 8.8 mrem/yr was derived for surface cleanups, and a benchmark dose of 4.1 mrem/yr was derived for subsurface cleanups (based on a cover depth of 6 inches) for a commercial/industrial worker scenario.

The USACE also completed the remediation of the Linde Building 14 Operable Unit located on the Linde site. The selected remedy required the demolition of Building 14 and removal of the building demolition debris from the site. The USACE determined that the soil cleanup standards would be the same as those implemented for the Linde Site soils (USACE 2003). The utility tunnel located beneath Building 14 was relocated to allow removal of contamination within and around the tunnel structure. Soils beneath and around the building were remediated to ensure the soil cleanup standards were met.

The effectiveness of the remedial actions performed at the site was evaluated through implementation of Final Status Survey Plans (FSSPs) (Shaw 2003, 2005; Cabrera 2010). Elements found in NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (EPA 2000), provided guidance for FSSP design and execution. The results of sampling and analytical testing performed in accordance with the FSSPs indicate that radiological contaminants are below specified limits. The residual radionuclide concentrations averaged over 100-m^2 areas met the ROD SOR threshold limits, above background, for surface and subsurface cleanups. All reported residual concentrations of U_{total} were less than 600 pCi/g.

A post-remediation radiological dose assessment was performed to determine the potential radiation doses under two scenarios, a commercial/industrial worker and a construction worker, consistent with the scenarios evaluated for the Linde Site and documented in the *Technical Memorandum: Linde Site Radiological Assessment Tonawanda, New York* (USACE 2000b).

2 APPROACH

The USACE conducted a soils remedial action at the Linde Site during July 1999 through May 2013. As outlined in the ROD (USACE 2000a), the remedial action required the removal and off-site disposal of MED-related soils with residual radionuclide concentrations averaged over a 100-m^2 area that exceeded unity for the SOR of the radionuclide concentrations to the associated concentration limits, above background. Table 1 gives the concentrations limits for the COCs. Also, the remedial action included the removal and off-site disposal of MED-related soils to ensure that no concentration of U_{total} exceeding 600 pCi/g above background remained in site soils.

The post-remediation radiological dose assessment consisted of defining a site-wide source term of the residual concentration in soil of the three COCs—Ra-226, Th-230, and U_{total}. The site-wide source term was established by calculating average activity concentrations of the COC results of the *in situ* systematic Class 1 and Class 2 final status survey samples. There were 1,528 *in situ* systematic final status survey samples from remaining unexcavated areas and excavated areas (prior to backfilling) that were used to calculate a site-wide average. A number of Class 2 *in situ* final status survey samples were excavated as part of a Class 1 survey unit; they were not used in the development of the source term since they no longer are representative of current site conditions. Several Class 1 units encroached on previously excavated Class 1 units, which resulted in replacement of older *in situ* final status survey samples with newer samples. Final status survey radionuclide activity concentrations with negative laboratory results were assigned values of zero prior to calculating the site-wide averages. The COC site-wide average activity concentrations and average background values are provided in Table 2.

For the site-wide source term, the average COC activity concentrations were all less than the average site background values. The source terms used in the post-remediation radiological dose assessment were the actual average COC activity concentrations as listed in Table 2; average background values were not subtracted. The area of the impacted zone for the source term was conservatively assumed to be 10,000 m^2

The RESRAD computer code (Version 6.5) was used to perform the post-remediation radiological dose assessment for the commercial/industrial worker scenario and the construction worker scenario (Yu et al. 2001). In general, the parameter values (including the site-specific and default values) for the commercial/industrial scenario and construction worker post-remediation radiological dose assessment were consistent with those used in the *Technical Memorandum: Linde Site Radiological Assessment, Tonawanda*, *New York* (USACE 2000b). Table 3 gives the input parameters for the commercial/industrial worker scenario and construction worker scenario.

3 RESULTS

The results of the dose assessments are provided in Table 4 for the commercial/industrial worker scenario and in Table 5 for the construction worker scenario. Appendices A and B provide the summary results from the RESRAD runs for the commercial/industrial worker scenario and construction worker scenario, respectively. The estimated annual radiation dose rate for the commercial/industrial worker is 2.03 mrem/yr and 0.50 mrem/yr for the construction worker, which meets the benchmark dose of 8.8 mrem/yr derived for surface cleanups and a benchmark dose of 4.1 mrem/yr derived for subsurface cleanups.

The maximum dose would occur at some time in the future for both scenarios (see Tables 4 and 5), predominantly from Th-230. For the commercial/industrial worker scenario, the majority of the radiation dose (96.6%) is from the external gamma exposure pathway. For the construction worker scenario, the majority of the radiation dose (86%) is also from the external gamma exposure pathway. Additional pathways contributing to this radiation dose include incidental soil ingestion (13%) and dust inhalation (< 1.0%).

On the basis of this post-remediation radiological dose assessment, it can be concluded that the Linde Site has been remediated consistent with the requirements identified in the ROD and all other supporting documentation. In addition, remedial actions have been completed in accordance with ALARA (As Low as Reasonably Achievable) considerations. The site-wide source term of the residual concentration in soil of the three COCs—Ra-226, Th-230 and U_{total}—were all less than their average background activity concentrations. The low residual concentrations of FUSRAP-related radionuclides at the site are comparable to ambient (background) levels and in accordance with site-specific ARARs.

4 REFERENCES

Cabrera (Cabrera Services, Inc.), 2010, *Final Status Survey Plan, Linde FUSRAP Site Remediation*, Tonawanda, June.

EPA (U.S. Environmental Protection Agency), 2000, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, EPA 402-R-97-016, Rev. 1, Aug.

EPA, 2011, *Exposure Factors Handbook*, EPA/600/R-090/052F.

Shaw (Shaw Environmental, Inc.), 2003, *Final Status Survey Plan for Building 14, Linde FUSRAP Site, Tonawanda, New York,* Oct.

Shaw, 2005, *Final Status Survey Plan Linde FUSRAP Site, Tonawanda, New York,* Dec.

USACE (U.S. Army Corps of Engineers), 2000a, *Record of Decision for the Linde Site, Tonawanda, New York,* March.

USACE, 2000b, *Technical Memorandum: Linde Site Radiological Assessment, Tonawanda, New York,* Feb.

USACE, 2003, *Record of Decision for the Building 14 Operable Unit Linde Site, Tonawanda, New York,* April.

USACE, 2006, *Record of Decision for the Groundwater Operable Unit Linde Site, Tonawanda, New York,* Dec.

Yu, C., et al., 2001, *User's Manual for RESRAD Version 6*, ANL/EAD-4, Argonne National Laboratory, Argonne, Ill., July.

Table 1 Site-Specific Soil Cleanup Goals and Average Background Activity Concentrations (pCi/g) for the Linde Site

	Surface[b]	Subsurface[b]	Background[c]
Ra-226[a]	5	15	1.1
Th-230	14	44	1.4
Total U[d]	554	3,021	6.1[d]

[a] Ra-226 criteria include Pb-210 contribution to dose.

[b] These cleanup goals represent residual radionuclide concentrations averaged over a 100-m^2 area that exceeds unity for the SOR of these radionuclide concentrations to the associated concentration limits, above background, of 554 pCi/g of U_{total}, 5 pCi/g of Ra-226, and 14 pCi/g of Th-230 for surface cleanups; and 3,021 pCi/g of U_{total}, 15 pCi/g of Ra-226, and 44 pCi/g of Th-230 for subsurface cleanups.

[c] Source for the average background activity concentrations: *Record of Decision for the Linde Site, Tonawanda, New York* (USACE 2000a).

[d] Total uranium background is the sum of the background values for uranium-234 (U-234), uranium-235 (U-235), and uranium-238 (U-238).

Table 2 Residual Radionuclide Site-Wide Average Concentrations

Radionuclide	Average Activity Concentration (pCi/g)	Average Activity Concentration Above Background (pCi/g)
Ra-226	0.97	<Bkg
Th-230	1.31	<Bkg
Total U	3.00	<Bkg

Table 3 RESRAD Input Parameters for the Commercial/Industrial Worker and Construction Worker Scenarios

RESRAD Input Parameter	RESRAD Default	Commercial/ Industrial	Construction	Note
Dose factor library	FGR 12	FGR 12	FGR 12	RESRAD default
Cut-off half-life (180 d or 30 d)	180	180	180	RESRAD default
Number of points (32, 64, 128, 256, 512, and 1,024)	32	32	32	RESRAD default
Linear spacing/log spacing	Log spacing	Log spacing	Log spacing	RESRAD default
Maximum no. of points for dose	17	17	17	RESRAD default
Maximum no. of points for risk	257	257	257	RESRAD default
Use line draw character (yes/no)	Yes	Yes	Yes	RESRAD default
Find peak pathway dose (yes/no)	Yes	Yes	Yes	RESRAD default
Calculation Parameters				
Basic radiation dose limit (mrem/yr)	25	25	25	RESRAD default
Times for calculation (yr)	1, 3, 10, 30, 100, 300,1000	1, 3, 10, 30, 100, 300, 1000, 10000	1, 3, 10, 30, 100, 300, 1000, 10000	Increased the time horizon of calculation to 10000 years
Source				
Nuclide concentrations (pCi/g)				
Ra-226	0	0.965	0.965	Site average
Th-230	0	1.31	1.31	Site average
U-234	0	1.466	1.466	Site average
U-235	0	0.067	0.067	Site average
U-238	0	1.466	1.466	Site average

Table 3 RESRAD Input Parameters for the Commercial/Industrial Worker and Construction Worker Scenarios (Cont.)

RESRAD Input Parameter	RESRAD Default	Commercial/ Industrial	Construction	Note
Transport Factors				
Distribution coefficient for all zones (cm^3/g)				
Pb	100	550	550	Decay progeny of Ra-226
Ra	70	9,100	9,100	USACE (2000b)
Th	60,000	5,800	5,800	USACE (2000b)
U	50	10	10	USACE (2000b)
Ac	20	2,400	2,400	Decay progeny of U-235
Pa	50	2,700	2,700	Decay progeny of U-235
Number of unsaturated zones	1	1	1	RESRAD default
Time since placement of material (yr)	0	0	0	RESRAD default
Groundwater concentration (pCi/L)	0	0	0	RESRAD default
Leach rate (1/yr)	0	0	0	RESRAD default
Solubility limit (mol/L)	0	0	0	RESRAD default
Use plant/soil ration (check box)	No	No	No	RESRAD default
Impacted Zone Parameters				
Area of impacted zone (m^2)[a]	10,000	10,000	10,000	RESRAD default
Thickness of impacted zone (m)	2	2	2	Changed to RESRAD default of 2 m from 3 m used in USACE (2000b). It is expected that after cleanup the depth of contamination will not exceed 2 m.
Length parallel to aquifer flow (m)	100	100	100	RESRAD default

Table 3 RESRAD Input Parameters for the Commercial/Industrial Worker and Construction Worker Scenarios (Cont.)

RESRAD Input Parameter	RESRAD Default	Commercial/ Industrial	Construction	Note
Does the initial contamination penetrate the water table?	No	No	No	RESRAD default
Cover and Impacted Zone Hydrological Data				
Cover depth (m)	0	0	0	Only one run with RESRAD default of 0 m instead of 0/0.15 m used in USACE (2000b)
Density of primary impacted zone (g/cm^3)	1.5	1.5	1.5	RESRAD default
Impacted zone erosion rate (m/yr)	1.00E-03	0	0	USACE (2000b)
Impacted zone total porosity	0.4	0.45	0.45	USACE (2000b)
Impacted zone field capacity	0.2	0.2	0.2	RESRAD default
Impacted zone hydraulic conductivity (m/yr)	10	123	123	USACE (2000b)
Impacted zone b parameter	5.3	5.3	5.3	RESRAD default
Evapotranspiration coefficient	0.5	0.46	0.46	USACE (2000b)
Wind speed (m/s)	2	2	2	RESRAD default
Precipitation rate (m/yr)	1	1.23	1.23	USACE (2000b)
Irrigation rate (m/yr)	0.2	0.2	0.2	Contaminated water is not used for irrigation (USACE 2006)
Irrigation mode (overhead/ditch)	Overhead	Overhead	Overhead	Contaminated water is not used for irrigation (USACE 2006)
Runoff coefficient	0.2	0.25	0.25	USACE (2000b)

Table 3 RESRAD Input Parameters for the Commercial/Industrial Worker and Construction Worker Scenarios (Cont.)

RESRAD Input Parameter	RESRAD Default	Commercial/ Industrial	Construction	Note
Occupancy, Inhalation, and External Gamma Parameters				
Inhalation rate (m^3/yr)	8,400	8,400	8,400	USACE (2000b) and EPA (2011)
Mass loading for inhalation (g/m^3)	1.00E-04	1.00E-04	2.00E-04	RESRAD default USACE (2000b)
Exposure duration (yr)	30	25	9	USACE (2000b)
Indoor dust filtration factor	0.4	0.4	NU	RESRAD default
External gamma shielding factor	0.7	0.7	NU	RESRAD default
Indoor time fraction	0.5	0.2	0	USACE (2000b)
Outdoor time fraction	0.25	0.03	0.037	USACE (2000b)
Shape of impacted zone (circular/noncircular)	Circular	Circular	Circular	RESRAD default
Ingestion Pathway Dietary and Nondietary Data				
Soil ingestion (g/yr)	36.5	18.25	175.2	USACE (2000b)
Depth of soil mixing layer (m)	0.15	0	0	USACE (2000b)

[a] The 10,000 m^2 area of the impacted zone was selected to be representative of a site-wide area and is a conservative increase in comparison to the 2,000 m^2 area that was used in USACE (2000b).

Source: The parameter values are RESRAD defaults or selected from USACE (2000b), and USACE (2006), as noted in the table. The areas of the impacted zones and the nuclide concentrations in the impacted zones were developed for the specific post-remediation source terms. NU indicates that the parameter was not used in the dose assessment.

Table 4 Post-Remediation Radiological Dose Assessment: Estimated Maximum Dose Rates for the Commercial/Industrial Worker Scenario[a]

Pathway	Dose Rates (mrem/yr)
External gamma exposure	1.98
Dust inhalation (without radon)	6.48×10^{-3}
Soil ingestion	4.21×10^{-2}
Total	2.03

[a] Maximum dose rate will occur 2,756 years in the future.

[b]Maximum dose rate of 1.94 mrem/yr will occur in a 1,000 year evaluation period.

Table 5 Post-Remediation Radiological Dose Assessment: Estimated Maximum Dose Rates for the Construction Worker Scenario[a]

Pathway	Dose Rates (mrem/yr)
External gamma exposure	0.43
Dust inhalation (without radon)	4.36×10^{-3}
Soil ingestion	6.51×10^{-2}
Total	0.50

[a] Maximum dose rate will occur 2,732 years in the future.

[b]Maximum dose rate of 0.48 mrem/yr will occur in a 1,000 year evaluation period.

APPENDIX A:

RESRAD Summary Report for the Commercial/Industrial Worker Scenario

1RESRAD, Version 6.5   T« Limit = 180 days   06/18/2014 10:54 Page   1
Summary : Linde Site Industrial/Commercial
File   : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-INDUSTRIAL-10000-TIMEFRACTION_03-INH8400.RAD

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Part I: Mixture Sums and Single Radionuclide Guidelines
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1RESRAD, Version 6.5   T« Limit = 180 days   06/18/2014 10:54 Page   2
Summary : Linde Site Industrial/Commercial
File   : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-INDUSTRIAL-10000-TIMEFRACTION_03-INH8400.RAD

Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 12 & FGR 11

0 Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	Ac-227 (Source: FGR 12)	4.951E-04	4.951E-04	DCF1(1)
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(2)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(3)
A-1	Bi-211 (Source: FGR 12)	2.559E-01	2.559E-01	DCF1(4)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(5)
A-1	Fr-223 (Source: FGR 12)	1.980E-01	1.980E-01	DCF1(6)
A-1	Pa-231 (Source: FGR 12)	1.906E-01	1.906E-01	DCF1(7)
A-1	Pa-234 (Source: FGR 12)	1.155E+01	1.155E+01	DCF1(8)
A-1	Pa-234m (Source: FGR 12)	8.967E-02	8.967E-02	DCF1(9)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(10)
A-1	Pb-211 (Source: FGR 12)	3.064E-01	3.064E-01	DCF1(11)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(12)
A-1	Po-210 (Source: FGR 12)	5.231E-05	5.231E-05	DCF1(13)
A-1	Po-211 (Source: FGR 12)	4.764E-02	4.764E-02	DCF1(14)

A-1	Po-214 (Source: FGR 12)	5.138E-04	5.138E-04	DCF1(15)
A-1	Po-215 (Source: FGR 12)	1.016E-03	1.016E-03	DCF1(16)
A-1	Po-218 (Source: FGR 12)	5.642E-05	5.642E-05	DCF1(17)
A-1	Ra-223 (Source: FGR 12)	6.034E-01	6.034E-01	DCF1(18)
A-1	Ra-226 (Source: FGR 12)	3.176E-02	3.176E-02	DCF1(19)
A-1	Rn-219 (Source: FGR 12)	3.083E-01	3.083E-01	DCF1(20)
A-1	Rn-222 (Source: FGR 12)	2.354E-03	2.354E-03	DCF1(21)
A-1	Th-227 (Source: FGR 12)	5.212E-01	5.212E-01	DCF1(22)
A-1	Th-230 (Source: FGR 12)	1.209E-03	1.209E-03	DCF1(23)
A-1	Th-231 (Source: FGR 12)	3.643E-02	3.643E-02	DCF1(24)
A-1	Th-234 (Source: FGR 12)	2.410E-02	2.410E-02	DCF1(25)
A-1	Tl-207 (Source: FGR 12)	1.980E-02	1.980E-02	DCF1(26)
A-1	Tl-210 (Source: no data)	0.000E+00	-2.000E+00	DCF1(27)
A-1	U-234 (Source: FGR 12)	4.017E-04	4.017E-04	DCF1(28)
A-1	U-235 (Source: FGR 12)	7.211E-01	7.211E-01	DCF1(29)
A-1	U-238 (Source: FGR 12)	1.031E-04	1.031E-04	DCF1(30)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.724E+00	6.700E+00	DCF2(1)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(2)
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(3)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(4)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(5)
B-1	U-234	1.320E-01	1.320E-01	DCF2(6)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(7)
B-1	U-238	1.180E-01	1.180E-01	DCF2(8)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(9)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.410E-02	DCF3(1)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(2)
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(3)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(4)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(5)
D-1	U-234	2.830E-04	2.830E-04	DCF3(6)

Dose Conversion Factor (and Related) Parameter Summary (continued)
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-1	U-235+D	2.673E-04	2.660E-04	DCF3(7)
D-1	U-238	2.550E-04	2.550E-04	DCF3(8)
D-1	U-238+D	2.687E-04	2.550E-04	DCF3(9)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)

```
 D-34 ³ Ac-227+D  , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 2.000E-05 ³ 2.000E-05 ³ RTF(  1,3)
 D-34 ³                                                             ³           ³           ³
 D-34 ³ Pa-231    , plant/soil concentration ratio, dimensionless   ³ 1.000E-02 ³ 1.000E-02 ³ RTF(  2,1)
 D-34 ³ Pa-231    , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 5.000E-03 ³ 5.000E-03 ³ RTF(  2,2)
 D-34 ³ Pa-231    , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 5.000E-06 ³ 5.000E-06 ³ RTF(  2,3)
 D-34 ³                                                             ³           ³           ³
 D-34 ³ Pb-210+D  , plant/soil concentration ratio, dimensionless   ³ 1.000E-02 ³ 1.000E-02 ³ RTF(  3,1)
 D-34 ³ Pb-210+D  , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 8.000E-04 ³ 8.000E-04 ³ RTF(  3,2)
 D-34 ³ Pb-210+D  , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 3.000E-04 ³ 3.000E-04 ³ RTF(  3,3)
 D-34 ³                                                             ³           ³           ³
 D-34 ³ Ra-226+D  , plant/soil concentration ratio, dimensionless   ³ 4.000E-02 ³ 4.000E-02 ³ RTF(  4,1)
 D-34 ³ Ra-226+D  , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 1.000E-03 ³ 1.000E-03 ³ RTF(  4,2)
 D-34 ³ Ra-226+D  , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 1.000E-03 ³ 1.000E-03 ³ RTF(  4,3)
 D-34 ³                                                             ³           ³           ³
 D-34 ³ Th-230    , plant/soil concentration ratio, dimensionless   ³ 1.000E-03 ³ 1.000E-03 ³ RTF(  5,1)
 D-34 ³ Th-230    , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 1.000E-04 ³ 1.000E-04 ³ RTF(  5,2)
 D-34 ³ Th-230    , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 5.000E-06 ³ 5.000E-06 ³ RTF(  5,3)
 D-34 ³                                                             ³           ³           ³
 D-34 ³ U-234     , plant/soil concentration ratio, dimensionless   ³ 2.500E-03 ³ 2.500E-03 ³ RTF(  6,1)
 D-34 ³ U-234     , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 3.400E-04 ³ 3.400E-04 ³ RTF(  6,2)
 D-34 ³ U-234     , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 6.000E-04 ³ 6.000E-04 ³ RTF(  6,3)
 D-34 ³                                                             ³           ³           ³
 D-34 ³ U-235+D   , plant/soil concentration ratio, dimensionless   ³ 2.500E-03 ³ 2.500E-03 ³ RTF(  7,1)
 D-34 ³ U-235+D   , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 3.400E-04 ³ 3.400E-04 ³ RTF(  7,2)
 D-34 ³ U-235+D   , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 6.000E-04 ³ 6.000E-04 ³ RTF(  7,3)
 D-34 ³                                                             ³           ³           ³
 D-34 ³ U-238     , plant/soil concentration ratio, dimensionless   ³ 2.500E-03 ³ 2.500E-03 ³ RTF(  8,1)
 D-34 ³ U-238     , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 3.400E-04 ³ 3.400E-04 ³ RTF(  8,2)
 D-34 ³ U-238     , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 6.000E-04 ³ 6.000E-04 ³ RTF(  8,3)
 D-34 ³                                                             ³           ³           ³
 D-34 ³ U-238+D   , plant/soil concentration ratio, dimensionless   ³ 2.500E-03 ³ 2.500E-03 ³ RTF(  9,1)
 D-34 ³ U-238+D   , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 3.400E-04 ³ 3.400E-04 ³ RTF(  9,2)
 D-34 ³ U-238+D   , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 6.000E-04 ³ 6.000E-04 ³ RTF(  9,3)
      ³                                                             ³           ³           ³
 D-5  ³ Bioaccumulation factors, fresh water, L/kg:                 ³           ³           ³
 D-5  ³ Ac-227+D  , fish                                            ³ 1.500E+01 ³ 1.500E+01 ³ BIOFAC(  1,1)
 D-5  ³ Ac-227+D  , crustacea and mollusks                          ³ 1.000E+03 ³ 1.000E+03 ³ BIOFAC(  1,2)
 D-5  ³                                                             ³           ³           ³
 D-5  ³ Pa-231    , fish                                            ³ 1.000E+01 ³ 1.000E+01 ³ BIOFAC(  2,1)
 D-5  ³ Pa-231    , crustacea and mollusks                          ³ 1.100E+02 ³ 1.100E+02 ³ BIOFAC(  2,2)
 D-5  ³                                                             ³           ³           ³
 D-5  ³ Pb-210+D  , fish                                            ³ 3.000E+02 ³ 3.000E+02 ³ BIOFAC(  3,1)
 D-5  ³ Pb-210+D  , crustacea and mollusks                          ³ 1.000E+02 ³ 1.000E+02 ³ BIOFAC(  3,2)
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                    Dose Conversion Factor (and Related) Parameter Summary (continued)
                                      Dose Library: FGR 12 & FGR 11
0     ³                                                             ³  Current  ³   Base    ³  Parameter
 Menu ³                        Parameter                            ³   Value#  ³   Case*   ³    Name
```

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D-5  ³ Ra-226+D  , fish                                        ³ 5.000E+01 ³ 5.000E+01 ³ BIOFAC(  4,1)
D-5  ³ Ra-226+D  , crustacea and mollusks                      ³ 2.500E+02 ³ 2.500E+02 ³ BIOFAC(  4,2)
D-5  ³                                                         ³           ³           ³
D-5  ³ Th-230    , fish                                        ³ 1.000E+02 ³ 1.000E+02 ³ BIOFAC(  5,1)
D-5  ³ Th-230    , crustacea and mollusks                      ³ 5.000E+02 ³ 5.000E+02 ³ BIOFAC(  5,2)
D-5  ³                                                         ³           ³           ³
D-5  ³ U-234     , fish                                        ³ 1.000E+01 ³ 1.000E+01 ³ BIOFAC(  6,1)
D-5  ³ U-234     , crustacea and mollusks                      ³ 6.000E+01 ³ 6.000E+01 ³ BIOFAC(  6,2)
D-5  ³                                                         ³           ³           ³
D-5  ³ U-235+D   , fish                                        ³ 1.000E+01 ³ 1.000E+01 ³ BIOFAC(  7,1)
D-5  ³ U-235+D   , crustacea and mollusks                      ³ 6.000E+01 ³ 6.000E+01 ³ BIOFAC(  7,2)
D-5  ³                                                         ³           ³           ³
D-5  ³ U-238     , fish                                        ³ 1.000E+01 ³ 1.000E+01 ³ BIOFAC(  8,1)
D-5  ³ U-238     , crustacea and mollusks                      ³ 6.000E+01 ³ 6.000E+01 ³ BIOFAC(  8,2)
D-5  ³                                                         ³           ³           ³
D-5  ³ U-238+D   , fish                                        ³ 1.000E+01 ³ 1.000E+01 ³ BIOFAC(  9,1)
D-5  ³ U-238+D   , crustacea and mollusks                      ³ 6.000E+01 ³ 6.000E+01 ³ BIOFAC(  9,2)
ÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
#For DCF1(xxx) only, factors are for infinite depth & area.  See ETFG table in Ground Pathway of Detailed Report.
*Base Case means Default.Lib w/o Associate Nuclide contributions.
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                                         Site-Specific Parameter Summary
0     ³                                         ³   User    ³           ³          Used by RESRAD          ³  Parameter
 Menu ³                  Parameter              ³   Input   ³  Default  ³ (If different from user input) ³    Name
ÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 R011 ³ Area of contaminated zone (m**2)        ³ 1.000E+04 ³ 1.000E+04 ³               ---                ³ AREA
 R011 ³ Thickness of contaminated zone (m)      ³ 2.000E+00 ³ 2.000E+00 ³               ---                ³ THICK0
 R011 ³ Fraction of contamination that is submerged ³ 0.000E+00 ³ 0.000E+00 ³           ---                ³ SUBMFRACT
 R011 ³ Length parallel to aquifer flow (m)     ³ not used  ³ 1.000E+02 ³               ---                ³ LCZPAQ
 R011 ³ Basic radiation dose limit (mrem/yr)    ³ 2.500E+01 ³ 3.000E+01 ³               ---                ³ BRDL
 R011 ³ Time since placement of material (yr)   ³ 0.000E+00 ³ 0.000E+00 ³               ---                ³ TI
 R011 ³ Times for calculations (yr)             ³ 1.000E+00 ³ 1.000E+00 ³               ---                ³ T( 2)
 R011 ³ Times for calculations (yr)             ³ 3.000E+00 ³ 3.000E+00 ³               ---                ³ T( 3)
 R011 ³ Times for calculations (yr)             ³ 1.000E+01 ³ 1.000E+01 ³               ---                ³ T( 4)
 R011 ³ Times for calculations (yr)             ³ 3.000E+01 ³ 3.000E+01 ³               ---                ³ T( 5)
 R011 ³ Times for calculations (yr)             ³ 1.000E+02 ³ 1.000E+02 ³               ---                ³ T( 6)
 R011 ³ Times for calculations (yr)             ³ 3.000E+02 ³ 3.000E+02 ³               ---                ³ T( 7)
 R011 ³ Times for calculations (yr)             ³ 1.000E+03 ³ 1.000E+03 ³               ---                ³ T( 8)
 R011 ³ Times for calculations (yr)             ³ 1.000E+04 ³ 0.000E+00 ³               ---                ³ T( 9)
 R011 ³ Times for calculations (yr)             ³ not used  ³ 0.000E+00 ³               ---                ³ T(10)
      ³                                         ³           ³           ³                                  ³
 R012 ³ Initial principal radionuclide (pCi/g):  Ra-226 ³ 9.650E-01 ³ 0.000E+00 ³          ---             ³ S1(4)
 R012 ³ Initial principal radionuclide (pCi/g):  Th-230 ³ 1.310E+00 ³ 0.000E+00 ³          ---             ³ S1(5)
 R012 ³ Initial principal radionuclide (pCi/g):  U-234  ³ 1.466E+00 ³ 0.000E+00 ³          ---             ³ S1(6)
 R012 ³ Initial principal radionuclide (pCi/g):  U-235  ³ 6.700E-02 ³ 0.000E+00 ³          ---             ³ S1(7)
 R012 ³ Initial principal radionuclide (pCi/g):  U-238  ³ 1.466E+00 ³ 0.000E+00 ³          ---             ³ S1(8)
 R012 ³ Concentration in groundwater   (pCi/L):  Ra-226 ³ not used  ³ 0.000E+00 ³          ---             ³ W1( 4)
```

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R012	Concentration in groundwater (pCi/L): Th-230	not used	0.000E+00	---	W1(5)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(8)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	0.000E+00	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.500E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.230E+02	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	4.600E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.230E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.500E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ

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R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)

R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	9.100E+03	7.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.220E-05	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for Th-230				
R016	Contaminated zone (cm**3/g)	5.800E+03	6.000E+04	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	not used	6.000E+04	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.483E-05	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	1.000E+01	5.000E+01	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(6,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.980E-02	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for U-235				
R016	Contaminated zone (cm**3/g)	1.000E+01	5.000E+01	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(7,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.980E-02	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	1.000E+01	5.000E+01	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(8,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.980E-02	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)

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R016	Distribution coefficients for daughter Ac-227				
R016	Contaminated zone (cm**3/g)	2.400E+03	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	not used	2.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	not used	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	8.418E-05	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)

R016	Distribution coefficients for daughter Pa-231				
R016	Contaminated zone (cm**3/g)	2.700E+03	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	7.483E-05	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	5.500E+02	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.672E-04	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	2.500E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	2.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	3.000E-02	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)

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R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)

R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	1.825E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	0.000E+00	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)

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Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name

R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS

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Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	active

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Contaminated Zone Dimensions	
Area:	10000.00 square meters
Thickness:	2.00 meters
Cover Depth:	0.00 meters

Initial Soil Concentrations, pCi/g	
Ra-226	9.650E-01
Th-230	1.310E+00
U-234	1.466E+00
U-235	6.700E-02
U-238	1.466E+00

0

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03	1.000E+04
TDOSE(t):	1.795E+00	1.795E+00	1.795E+00	1.796E+00	1.796E+00	1.800E+00	1.836E+00	1.940E+00	1.623E+00
M(t):	7.179E-02	7.180E-02	7.180E-02	7.183E-02	7.185E-02	7.202E-02	7.342E-02	7.761E-02	6.493E-02

0Maximum TDOSE(t): 2.025E+00 mrem/yr   at t =   2756 ñ 6 years
0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)

As mrem/yr and Fraction of Total Dose At t = 2.756E+03 years
0 Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Ra-226	4.922E-01	0.2430	1.371E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.949E-03	0.0049
Th-230	1.484E+00	0.7326	6.328E-03	0.0031	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.217E-02	0.0159
U-234	7.487E-04	0.0004	3.223E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.624E-05	0.0000
U-235	1.959E-05	0.0000	6.915E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.887E-06	0.0000
U-238	1.063E-07	0.0000	4.621E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.308E-09	0.0000
Total	1.977E+00	0.9760	6.475E-03	0.0032	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.214E-02	0.0208

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.756E+03 years
0 Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.023E-01	0.2480
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.522E+00	0.7516
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.681E-04	0.0004
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.239E-05	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.091E-07	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.025E+00	1.0000

0*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
0 Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Ra-226	1.726E+00	0.9615	1.351E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.802E-03	0.0032
Th-230	7.656E-04	0.0004	6.680E-03	0.0037	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.015E-03	0.0017
U-234	9.559E-05	0.0001	2.997E-03	0.0017	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.724E-03	0.0010
U-235	8.136E-03	0.0045	1.277E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.448E-05	0.0000
U-238	3.532E-02	0.0197	2.680E-03	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.637E-03	0.0009
Total	1.770E+00	0.9861	1.262E-02	0.0070	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.225E-02	0.0068

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)

As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

0 Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.732E+00	0.9648
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.046E-02	0.0058
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.817E-03	0.0027
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.338E-03	0.0046
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.963E-02	0.0221
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.795E+00	1.0000

0*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)

As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

0 Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Ra-226	1.725E+00	0.9610	1.456E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.687E-03	0.0037
Th-230	1.780E-03	0.0010	6.680E-03	0.0037	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.018E-03	0.0017
U-234	9.372E-05	0.0001	2.939E-03	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.691E-03	0.0009
U-235	7.977E-03	0.0044	1.252E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.308E-05	0.0000
U-238	3.462E-02	0.0193	2.628E-03	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.605E-03	0.0009
Total	1.769E+00	0.9857	1.252E-02	0.0070	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.307E-02	0.0073

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)

As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

0 Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.732E+00	0.9648
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.148E-02	0.0064
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.723E-03	0.0026
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.175E-03	0.0046
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.886E-02	0.0216
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.795E+00	1.0000

0*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years
0 Water Independent Pathways (Inhalation excludes radon)

0	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-	ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ
Ra-226	1.723E+00	0.9600	1.656E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.375E-03	0.0047
Th-230	3.808E-03	0.0021	6.680E-03	0.0037	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.027E-03	0.0017
U-234	9.014E-05	0.0001	2.825E-03	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.625E-03	0.0009
U-235	7.667E-03	0.0043	1.204E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.038E-05	0.0000
U-238	3.328E-02	0.0185	2.526E-03	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.543E-03	0.0009
ÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ
Total	1.768E+00	0.9850	1.232E-02	0.0069	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.464E-02	0.0082

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years
0 Water Dependent Pathways

0	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-	ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.732E+00	0.9648
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.351E-02	0.0075
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.540E-03	0.0025
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.858E-03	0.0044
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.735E-02	0.0208
ÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.795E+00	1.0000

0*Sum of all water independent and dependent pathways.

1RESRAD, Version 6.5   T« Limit = 180 days   06/18/2014 10:54 Page 15
Summary : Linde Site Industrial/Commercial
File   : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-INDUSTRIAL-10000-TIMEFRACTION_03-INH8400.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
0 Water Independent Pathways (Inhalation excludes radon)

0	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-	ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
ÄÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ
Ra-226	1.718E+00	0.9567	2.262E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.350E-02	0.0075
Th-230	1.089E-02	0.0061	6.679E-03	0.0037	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.072E-03	0.0017
U-234	7.896E-05	0.0000	2.459E-03	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.415E-03	0.0008
U-235	6.676E-03	0.0037	1.052E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.180E-05	0.0000
U-238	2.897E-02	0.0161	2.199E-03	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.343E-03	0.0007
ÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ
Total	1.765E+00	0.9827	1.167E-02	0.0065	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.939E-02	0.0108

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)

```
                        As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
0                                         Water Dependent Pathways
0           Water              Fish              Radon              Plant              Meat               Milk           All Pathways*
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
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 Ra-226  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.732E+00 0.9644
 Th-230  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.064E-02 0.0115
 U-234   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  3.953E-03 0.0022
 U-235   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  6.843E-03 0.0038
 U-238   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  3.251E-02 0.0181
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 Total   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.796E+00 1.0000
0*Sum of all water independent and dependent pathways.
1RESRAD, Version 6.5      T« Limit = 180 days       06/18/2014  10:54  Page  16
 Summary : Linde Site Industrial/Commercial
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-INDUSTRIAL-10000-TIMEFRACTION_03-INH8400.RAD

             Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                        As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years
0                              Water Independent Pathways (Inhalation excludes radon)
0          Ground          Inhalation            Radon              Plant              Meat               Milk               Soil
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
 ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ
 Ra-226  1.703E+00 0.9479  3.397E-04 0.0002  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.310E-02 0.0129
 Th-230  3.099E-02 0.0173  6.676E-03 0.0037  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  3.290E-03 0.0018
 U-234   5.673E-05 0.0000  1.656E-03 0.0009  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  9.526E-04 0.0005
 U-235   4.497E-03 0.0025  7.245E-05 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.333E-05 0.0000
 U-238   1.950E-02 0.0109  1.480E-03 0.0008  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  9.039E-04 0.0005
 ÍÍÍÍÍÍÍ ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ
 Total   1.758E+00 0.9786  1.022E-02 0.0057  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.829E-02 0.0157
0
             Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                        As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years
0                                         Water Dependent Pathways
0           Water              Fish              Radon              Plant              Meat               Milk           All Pathways*
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
 ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ
 Ra-226  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.726E+00 0.9610
 Th-230  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.095E-02 0.0228
 U-234   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.665E-03 0.0015
 U-235   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.613E-03 0.0026
 U-238   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.188E-02 0.0122
 ÍÍÍÍÍÍÍ ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ
 Total   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.796E+00 1.0000
0*Sum of all water independent and dependent pathways.
1RESRAD, Version 6.5      T« Limit = 180 days       06/18/2014  10:54  Page  17
 Summary : Linde Site Industrial/Commercial
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-INDUSTRIAL-10000-TIMEFRACTION_03-INH8400.RAD
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
0 Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Ra-226	1.650E+00	0.9162	4.445E-04	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.209E-02	0.0178
Th-230	9.979E-02	0.0554	6.673E-03	0.0037	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.485E-03	0.0025
U-234	4.214E-05	0.0000	4.165E-04	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.396E-04	0.0001
U-235	1.141E-03	0.0006	2.413E-05	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.612E-05	0.0000
U-238	4.875E-03	0.0027	3.701E-04	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.261E-04	0.0001
Total	1.755E+00	0.9750	7.928E-03	0.0044	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.706E-02	0.0206

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
0 Water Dependent Pathways

Radio- Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.682E+00	0.9343
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.109E-01	0.0616
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.983E-04	0.0004
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.181E-03	0.0007
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.471E-03	0.0030
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.800E+00	1.0000

0*Sum of all water independent and dependent pathways.

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Summary : Linde Site Industrial/Commercial
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years
0 Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Ra-226	1.506E+00	0.8205	4.194E-04	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.044E-02	0.0166
Th-230	2.835E-01	0.1545	6.666E-03	0.0036	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.155E-03	0.0044
U-234	1.215E-04	0.0001	1.126E-05	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.215E-06	0.0000
U-235	4.603E-05	0.0000	9.034E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.609E-06	0.0000
U-238	9.288E-05	0.0001	7.055E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.310E-06	0.0000
Total	1.790E+00	0.9751	7.112E-03	0.0039	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.862E-02	0.0210

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)

```
                         As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years
0                                          Water Dependent Pathways
0           Water              Fish              Radon             Plant              Meat              Milk          All Pathways*
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
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 Ra-226  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.537E+00 0.8373
 Th-230  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.984E-01 0.1625
 U-234   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.410E-04 0.0001
 U-235   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  6.267E-05 0.0000
 U-238   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.042E-04 0.0001
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 Total   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.836E+00 1.0000
0*Sum of all water independent and dependent pathways.
1RESRAD, Version 6.5      T« Limit = 180 days       06/18/2014  10:54  Page  19
 Summary : Linde Site Industrial/Commercial
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-INDUSTRIAL-10000-TIMEFRACTION_03-INH8400.RAD

                      Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                         As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years
0                               Water Independent Pathways (Inhalation excludes radon)
0          Ground           Inhalation           Radon             Plant              Meat              Milk              Soil
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
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 Ra-226  1.095E+00 0.5643  3.049E-04 0.0002  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.213E-02 0.0114
 Th-230  7.974E-01 0.4110  6.610E-03 0.0034  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.847E-02 0.0095
 U-234   3.895E-04 0.0002  3.365E-06 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  9.071E-06 0.0000
 U-235   2.318E-05 0.0000  8.184E-06 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  6.968E-06 0.0000
 U-238   5.348E-08 0.0000  4.888E-10 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.255E-09 0.0000
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 Total   1.893E+00 0.9755  6.926E-03 0.0036  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.062E-02 0.0209
0
                      Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                         As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years
0                                          Water Dependent Pathways
0           Water              Fish              Radon             Plant              Meat              Milk          All Pathways*
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
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 Ra-226  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.117E+00 0.5759
 Th-230  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  8.224E-01 0.4239
 U-234   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.019E-04 0.0002
 U-235   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  3.834E-05 0.0000
 U-238   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  5.523E-08 0.0000
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 Total   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.940E+00 1.0000
0*Sum of all water independent and dependent pathways.
1RESRAD, Version 6.5      T« Limit = 180 days       06/18/2014  10:54  Page  20
 Summary : Linde Site Industrial/Commercial
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-INDUSTRIAL-10000-TIMEFRACTION_03-INH8400.RAD
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+04 years

0 Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Ra-226	1.817E-02	0.0112	5.059E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.673E-04	0.0002
Th-230	1.566E+00	0.9647	4.741E-03	0.0029	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.324E-02	0.0205
U-234	7.980E-04	0.0005	2.417E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.694E-05	0.0000
U-235	9.773E-06	0.0000	3.450E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.937E-06	0.0000
U-238	1.144E-07	0.0000	3.467E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.429E-09	0.0000
Total	1.585E+00	0.9764	4.752E-03	0.0029	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.362E-02	0.0207

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+04 years

0 Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.854E-02	0.0114
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.604E+00	0.9881
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.173E-04	0.0005
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.616E-05	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.172E-07	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.623E+00	1.0000

0*Sum of all water independent and dependent pathways.

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Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

DSR(j,t) At Time in Years (mrem/yr)/(pCi/g)

Parent (i)	Product (j)	Thread Fraction	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03	1.000E+04
Ra-226+D	Ra-226+D	1.000E+00	1.794E+00	1.793E+00	1.791E+00	1.786E+00	1.769E+00	1.714E+00	1.565E+00	1.138E+00	1.888E-02
Ra-226+D	Pb-210+D	1.000E+00	4.906E-04	1.451E-03	3.283E-03	8.844E-03	1.929E-02	2.920E-02	2.790E-02	2.028E-02	3.366E-04
Ra-226+D	äDSR(j)		1.794E+00	1.794E+00	1.795E+00	1.795E+00	1.789E+00	1.743E+00	1.593E+00	1.158E+00	1.921E-02
0Th-230	Th-230	1.000E+00	7.597E-03	7.596E-03	7.596E-03	7.593E-03	7.587E-03	7.564E-03	7.498E-03	7.271E-03	4.901E-03
Th-230	Ra-226+D	1.000E+00	3.886E-04	1.165E-03	2.718E-03	8.140E-03	2.353E-02	7.619E-02	2.168E-01	6.101E-01	1.198E+00
Th-230	Pb-210+D	1.000E+00	7.103E-08	4.927E-07	2.552E-06	2.125E-05	1.479E-04	9.378E-04	3.431E-03	1.046E-02	2.108E-02
Th-230	äDSR(j)		7.985E-03	8.762E-03	1.032E-02	1.575E-02	3.126E-02	8.469E-02	2.278E-01	6.278E-01	1.224E+00
0U-234	U-234	1.000E+00	3.286E-03	3.222E-03	3.096E-03	2.696E-03	1.814E-03	4.534E-04	8.634E-06	8.224E-12	0.000E+00
U-234	Th-230	1.000E+00	3.397E-08	1.010E-07	2.312E-07	6.481E-07	1.564E-06	2.973E-06	3.406E-06	3.312E-06	2.232E-06
U-234	Ra-226+D	1.000E+00	1.160E-09	8.075E-09	4.213E-08	3.599E-07	2.673E-06	1.973E-05	8.286E-05	2.663E-04	5.457E-04
U-234	Pb-210+D	1.000E+00	1.595E-13	2.366E-12	2.693E-11	6.539E-10	1.253E-08	2.112E-07	1.280E-06	4.556E-06	9.600E-06

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 U-234      äDSR(j)               3.286E-03 3.222E-03 3.097E-03 2.697E-03 1.818E-03 4.763E-04 9.618E-05 2.742E-04 5.575E-04
0U-235+D    U-235+D    1.000E+00  1.245E-01 1.220E-01 1.173E-01 1.021E-01 6.871E-02 1.718E-02 3.273E-04 3.124E-10 0.000E+00
 U-235+D    Pa-231     1.000E+00  1.000E-06 2.974E-06 6.805E-06 1.908E-05 4.602E-05 8.722E-05 9.899E-05 9.281E-05 3.912E-05
 U-235+D    Ac-227+D   1.000E+00  5.445E-08 3.756E-07 1.920E-06 1.526E-05 9.275E-05 3.679E-04 5.091E-04 4.794E-04 2.021E-04
 U-235+D    äDSR(j)               1.245E-01 1.220E-01 1.173E-01 1.021E-01 6.885E-02 1.763E-02 9.354E-04 5.722E-04 2.412E-04
0U-238      U-238      5.400E-05  1.569E-07 1.538E-07 1.478E-07 1.287E-07 8.660E-08 2.165E-08 4.125E-10 3.937E-16 0.000E+00
0U-238+D    U-238+D    9.999E-01  2.703E-02 2.650E-02 2.548E-02 2.218E-02 1.492E-02 3.732E-03 7.109E-05 6.785E-11 0.000E+00
 U-238+D    U-234      9.999E-01  4.642E-09 1.368E-08 3.071E-08 8.022E-08 1.568E-07 1.292E-07 7.358E-09 2.336E-14 0.000E+00
 U-238+D    Th-230     9.999E-01  3.199E-14 2.214E-13 1.141E-12 9.318E-12 6.088E-11 2.917E-10 4.810E-10 4.752E-10 3.203E-10
 U-238+D    Ra-226+D   9.999E-01  8.199E-16 1.219E-14 1.396E-13 3.455E-12 6.971E-11 1.347E-09 9.597E-09 3.651E-08 7.826E-08
 U-238+D    Pb-210+D   9.999E-01  9.028E-20 2.764E-18 6.778E-17 4.803E-15 2.585E-13 1.253E-11 1.437E-10 6.233E-10 1.377E-09
 U-238+D    äDSR(j)               2.703E-02 2.650E-02 2.548E-02 2.218E-02 1.492E-02 3.732E-03 7.111E-05 3.767E-08 7.996E-08
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 The DSR includes contributions from associated (half-life ó 180 days) daughters.
0
                                  Single Radionuclide Soil Guidelines G(i,t) in pCi/g
                                     Basic Radiation Dose Limit = 2.500E+01 mrem/yr
0Nuclide
   (i)    t= 0.000E+00   1.000E+00   3.000E+00   1.000E+01   3.000E+01   1.000E+02   3.000E+02   1.000E+03   1.000E+04
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 Ra-226      1.393E+01   1.393E+01   1.393E+01   1.393E+01   1.398E+01   1.434E+01   1.570E+01   2.159E+01   1.301E+03
 Th-230      3.131E+03   2.853E+03   2.423E+03   1.587E+03   7.997E+02   2.952E+02   1.098E+02   3.982E+01   2.042E+01
 U-234       7.608E+03   7.760E+03   8.073E+03   9.271E+03   1.375E+04   5.248E+04   2.599E+05   9.118E+04   4.484E+04
 U-235       2.009E+02   2.049E+02   2.132E+02   2.448E+02   3.631E+02   1.418E+03   2.673E+04   4.369E+04   1.037E+05
 U-238       9.247E+02   9.432E+02   9.813E+02   1.127E+03   1.675E+03   6.699E+03  *3.361E+05  *3.361E+05  *3.361E+05
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 *At specific activity limit
1RESRAD, Version 6.5      T« Limit = 180 days        06/18/2014  10:54  Page  22
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             Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
             and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
          at tmin = time of minimum single radionuclide soil guideline
      and at tmax = time of maximum total dose =    2756 ñ 6 years
0Nuclide  Initial         tmin       DSR(i,tmin) G(i,tmin) DSR(i,tmax) G(i,tmax)
   (i)    (pCi/g)       (years)                   (pCi/g)               (pCi/g)
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 Ra-226  9.650E-01     5.58 ñ 0.01    1.795E+00  1.393E+01  5.205E-01  4.803E+01
 Th-230  1.310E+00     5677 ñ *       1.359E+00  1.839E+01  1.162E+00  2.152E+01
 U-234   1.466E+00     0.000E+00      3.286E-03  7.608E+03  5.240E-04  4.771E+04
 U-235   6.700E-02     0.000E+00      1.245E-01  2.009E+02  4.834E-04  5.171E+04
 U-238   1.466E+00     0.000E+00      2.703E-02  9.247E+02  7.440E-08 *3.361E+05
 ÍÍÍÍÍÍÍ ÍÍÍÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ
 *At specific activity limit

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 File    : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-INDUSTRIAL-10000-TIMEFRACTION_03-INH8400.RAD

                                    Individual Nuclide Dose Summed Over All Pathways
```

Parent Nuclide and Branch Fraction Indicated

DOSE(j,t), mrem/yr

0Nuclide (j)	Parent (i)	THF(i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03	1.000E+04
Ra-226	Ra-226	1.000E+00	1.731E+00	1.730E+00	1.729E+00	1.723E+00	1.708E+00	1.654E+00	1.510E+00	1.098E+00	1.822E-02
Ra-226	Th-230	1.000E+00	5.090E-04	1.527E-03	3.561E-03	1.066E-02	3.082E-02	9.981E-02	2.841E-01	7.992E-01	1.570E+00
Ra-226	U-234	1.000E+00	1.701E-09	1.184E-08	6.176E-08	5.276E-07	3.919E-06	2.892E-05	1.215E-04	3.904E-04	8.000E-04
Ra-226	U-238	9.999E-01	1.202E-15	1.788E-14	2.046E-13	5.065E-12	1.022E-10	1.975E-09	1.407E-08	5.352E-08	1.147E-07
Ra-226	äDOSE(j)		1.732E+00	1.732E+00	1.732E+00	1.734E+00	1.738E+00	1.754E+00	1.794E+00	1.897E+00	1.589E+00
0Pb-210	Ra-226	1.000E+00	4.734E-04	1.400E-03	3.168E-03	8.534E-03	1.862E-02	2.818E-02	2.692E-02	1.957E-02	3.248E-04
Pb-210	Th-230	1.000E+00	9.305E-08	6.454E-07	3.343E-06	2.784E-05	1.938E-04	1.229E-03	4.494E-03	1.370E-02	2.762E-02
Pb-210	U-234	1.000E+00	2.338E-13	3.468E-12	3.948E-11	9.586E-10	1.837E-08	3.096E-07	1.877E-06	6.679E-06	1.407E-05
Pb-210	U-238	9.999E-01	1.324E-19	4.053E-18	9.937E-17	7.042E-15	3.790E-13	1.838E-11	2.107E-10	9.138E-10	2.018E-09
Pb-210	äDOSE(j)		4.735E-04	1.401E-03	3.171E-03	8.562E-03	1.881E-02	2.941E-02	3.142E-02	3.328E-02	2.796E-02
0Th-230	Th-230	1.000E+00	9.952E-03	9.951E-03	9.951E-03	9.947E-03	9.939E-03	9.908E-03	9.822E-03	9.525E-03	6.420E-03
Th-230	U-234	1.000E+00	4.980E-08	1.481E-07	3.389E-07	9.501E-07	2.293E-06	4.358E-06	4.994E-06	4.855E-06	3.273E-06
Th-230	U-238	9.999E-01	4.690E-14	3.246E-13	1.673E-12	1.366E-11	8.925E-11	4.277E-10	7.052E-10	6.966E-10	4.695E-10
Th-230	äDOSE(j)		9.952E-03	9.952E-03	9.951E-03	9.948E-03	9.941E-03	9.913E-03	9.827E-03	9.530E-03	6.423E-03
0U-234	U-234	1.000E+00	4.817E-03	4.723E-03	4.539E-03	3.952E-03	2.659E-03	6.647E-04	1.266E-05	1.206E-11	0.000E+00
U-234	U-238	9.999E-01	6.805E-09	2.006E-08	4.502E-08	1.176E-07	2.299E-07	1.894E-07	1.079E-08	3.424E-14	0.000E+00
U-234	äDOSE(j)		4.817E-03	4.723E-03	4.539E-03	3.952E-03	2.659E-03	6.649E-04	1.267E-05	1.209E-11	0.000E+00
0U-235	U-235	1.000E+00	8.338E-03	8.175E-03	7.857E-03	6.840E-03	4.603E-03	1.151E-03	2.193E-05	2.093E-11	0.000E+00
0Pa-231	U-235	1.000E+00	6.700E-08	1.992E-07	4.560E-07	1.278E-06	3.083E-06	5.844E-06	6.632E-06	6.218E-06	2.621E-06
0Ac-227	U-235	1.000E+00	3.648E-09	2.516E-08	1.286E-07	1.023E-06	6.215E-06	2.465E-05	3.411E-05	3.212E-05	1.354E-05
0U-238	U-238	5.400E-05	2.300E-07	2.254E-07	2.167E-07	1.886E-07	1.269E-07	3.174E-08	6.047E-10	5.772E-16	0.000E+00
U-238	U-238	9.999E-01	3.963E-02	3.886E-02	3.735E-02	3.251E-02	2.188E-02	5.470E-03	1.042E-04	9.947E-11	0.000E+00
U-238	äDOSE(j)		3.963E-02	3.886E-02	3.735E-02	3.251E-02	2.188E-02	5.470E-03	1.042E-04	9.947E-11	0.000E+00

THF(i) is the thread fraction of the parent nuclide.

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Individual Nuclide Soil Concentration

Parent Nuclide and Branch Fraction Indicated

S(j,t), pCi/g

0Nuclide (j)	Parent (i)	THF(i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03	1.000E+04
Ra-226	Ra-226	1.000E+00	9.650E-01	9.646E-01	9.637E-01	9.606E-01	9.519E-01	9.220E-01	8.418E-01	6.120E-01	1.015E-02
Ra-226	Th-230	1.000E+00	0.000E+00	5.674E-04	1.701E-03	5.661E-03	1.690E-02	5.536E-02	1.581E-01	4.453E-01	8.750E-01
Ra-226	U-234	1.000E+00	0.000E+00	2.839E-09	2.521E-08	2.674E-07	2.120E-06	1.600E-05	6.758E-05	2.175E-04	4.459E-04
Ra-226	U-238	9.999E-01	0.000E+00	2.674E-15	7.078E-14	2.446E-12	5.445E-11	1.089E-09	7.823E-09	2.981E-08	6.394E-08
Ra-226	äS(j):		9.650E-01	9.651E-01	9.654E-01	9.663E-01	9.688E-01	9.774E-01	9.999E-01	1.057E+00	8.856E-01
0Pb-210	Ra-226	1.000E+00	0.000E+00	2.952E-02	8.581E-02	2.567E-01	5.779E-01	8.830E-01	8.441E-01	6.137E-01	1.018E-02
Pb-210	Th-230	1.000E+00	0.000E+00	8.727E-06	7.690E-05	7.950E-04	5.903E-03	3.825E-02	1.406E-01	4.292E-01	8.658E-01
Pb-210	U-234	1.000E+00	0.000E+00	2.924E-11	7.693E-10	2.607E-08	5.511E-07	9.608E-06	5.872E-05	2.093E-04	4.412E-04
Pb-210	U-238	9.999E-01	0.000E+00	2.069E-17	1.629E-15	1.821E-13	1.119E-11	5.680E-10	6.587E-09	2.863E-08	6.327E-08
Pb-210	äS(j):		0.000E+00	2.953E-02	8.589E-02	2.575E-01	5.838E-01	9.212E-01	9.848E-01	1.043E+00	8.764E-01
0Th-230	Th-230	1.000E+00	1.310E+00	1.310E+00	1.310E+00	1.309E+00	1.308E+00	1.304E+00	1.293E+00	1.254E+00	8.451E-01
Th-230	U-234	1.000E+00	0.000E+00	1.307E-05	3.843E-05	1.197E-04	2.983E-04	5.727E-04	6.573E-04	6.391E-04	4.308E-04
Th-230	U-238	9.999E-01	0.000E+00	1.846E-11	1.618E-10	1.641E-09	1.144E-08	5.604E-08	9.281E-08	9.170E-08	6.180E-08

Th-230	äS(j):		1.310E+00	1.310E+00	1.310E+00	1.310E+00	1.309E+00	1.305E+00	1.294E+00	1.254E+00	8.455E-01
0U-234	U-234	1.000E+00	1.466E+00	1.437E+00	1.381E+00	1.203E+00	8.093E-01	2.023E-01	3.852E-03	3.669E-09	0.000E+00
U-234	U-238	9.999E-01	0.000E+00	4.074E-06	1.175E-05	3.409E-05	6.883E-05	5.735E-05	3.277E-06	1.042E-11	0.000E+00
U-234	äS(j):		1.466E+00	1.437E+00	1.381E+00	1.203E+00	8.093E-01	2.023E-01	3.855E-03	3.679E-09	0.000E+00
0U-235	U-235	1.000E+00	6.700E-02	6.569E-02	6.314E-02	5.496E-02	3.699E-02	9.248E-03	1.762E-04	1.682E-10	0.000E+00
0Pa-231	U-235	1.000E+00	0.000E+00	1.404E-06	4.128E-06	1.285E-05	3.202E-05	6.132E-05	6.970E-05	6.535E-05	2.755E-05
0Ac-227	U-235	1.000E+00	0.000E+00	2.218E-08	1.929E-07	1.903E-06	1.234E-05	5.000E-05	6.943E-05	6.537E-05	2.756E-05
0U-238	U-238	5.400E-05	7.916E-05	7.761E-05	7.460E-05	6.494E-05	4.370E-05	1.093E-05	2.082E-07	1.987E-13	0.000E+00
U-238	U-238	9.999E-01	1.466E+00	1.437E+00	1.381E+00	1.203E+00	8.093E-01	2.023E-01	3.855E-03	3.679E-09	0.000E+00
U-238	äS(j):		1.466E+00	1.437E+00	1.381E+00	1.203E+00	8.093E-01	2.023E-01	3.855E-03	3.679E-09	0.000E+00
ÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ

THF(i) is the thread fraction of the parent nuclide.

0RESCALC.EXE execution time = 1.81 seconds

APPENDIX B:

RESRAD Summary Report for the Construction Worker Scenario

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Summary : Linde Site Industrial\Commercial
File   : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-CONSTRUCTION-10000-INH8400.RAD

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Part I: Mixture Sums and Single Radionuclide Guidelines
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1RESRAD, Version 6.5   T« Limit = 180 days   06/18/2014 10:41 Page   2
Summary : Linde Site Industrial/Commercial
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Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 12 & FGR 11

0 Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	Ac-227 (Source: FGR 12)	4.951E-04	4.951E-04	DCF1(1)
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(2)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(3)
A-1	Bi-211 (Source: FGR 12)	2.559E-01	2.559E-01	DCF1(4)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(5)
A-1	Fr-223 (Source: FGR 12)	1.980E-01	1.980E-01	DCF1(6)
A-1	Pa-231 (Source: FGR 12)	1.906E-01	1.906E-01	DCF1(7)
A-1	Pa-234 (Source: FGR 12)	1.155E+01	1.155E+01	DCF1(8)
A-1	Pa-234m (Source: FGR 12)	8.967E-02	8.967E-02	DCF1(9)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(10)
A-1	Pb-211 (Source: FGR 12)	3.064E-01	3.064E-01	DCF1(11)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(12)

```
 A-1  ³ Po-210   (Source: FGR 12)                                 ³ 5.231E-05 ³ 5.231E-05 ³ DCF1( 13)
 A-1  ³ Po-211   (Source: FGR 12)                                 ³ 4.764E-02 ³ 4.764E-02 ³ DCF1( 14)
 A-1  ³ Po-214   (Source: FGR 12)                                 ³ 5.138E-04 ³ 5.138E-04 ³ DCF1( 15)
 A-1  ³ Po-215   (Source: FGR 12)                                 ³ 1.016E-03 ³ 1.016E-03 ³ DCF1( 16)
 A-1  ³ Po-218   (Source: FGR 12)                                 ³ 5.642E-05 ³ 5.642E-05 ³ DCF1( 17)
 A-1  ³ Ra-223   (Source: FGR 12)                                 ³ 6.034E-01 ³ 6.034E-01 ³ DCF1( 18)
 A-1  ³ Ra-226   (Source: FGR 12)                                 ³ 3.176E-02 ³ 3.176E-02 ³ DCF1( 19)
 A-1  ³ Rn-219   (Source: FGR 12)                                 ³ 3.083E-01 ³ 3.083E-01 ³ DCF1( 20)
 A-1  ³ Rn-222   (Source: FGR 12)                                 ³ 2.354E-03 ³ 2.354E-03 ³ DCF1( 21)
 A-1  ³ Th-227   (Source: FGR 12)                                 ³ 5.212E-01 ³ 5.212E-01 ³ DCF1( 22)
 A-1  ³ Th-230   (Source: FGR 12)                                 ³ 1.209E-03 ³ 1.209E-03 ³ DCF1( 23)
 A-1  ³ Th-231   (Source: FGR 12)                                 ³ 3.643E-02 ³ 3.643E-02 ³ DCF1( 24)
 A-1  ³ Th-234   (Source: FGR 12)                                 ³ 2.410E-02 ³ 2.410E-02 ³ DCF1( 25)
 A-1  ³ Tl-207   (Source: FGR 12)                                 ³ 1.980E-02 ³ 1.980E-02 ³ DCF1( 26)
 A-1  ³ Tl-210   (Source: no data)                                ³ 0.000E+00 ³-2.000E+00 ³ DCF1( 27)
 A-1  ³ U-234    (Source: FGR 12)                                 ³ 4.017E-04 ³ 4.017E-04 ³ DCF1( 28)
 A-1  ³ U-235    (Source: FGR 12)                                 ³ 7.211E-01 ³ 7.211E-01 ³ DCF1( 29)
 A-1  ³ U-238    (Source: FGR 12)                                 ³ 1.031E-04 ³ 1.031E-04 ³ DCF1( 30)
      ³                                                           ³           ³           ³
 B-1  ³ Dose conversion factors for inhalation, mrem/pCi:         ³           ³           ³
 B-1  ³ Ac-227+D                                                  ³ 6.724E+00 ³ 6.700E+00 ³ DCF2(  1)
 B-1  ³ Pa-231                                                    ³ 1.280E+00 ³ 1.280E+00 ³ DCF2(  2)
 B-1  ³ Pb-210+D                                                  ³ 2.320E-02 ³ 1.360E-02 ³ DCF2(  3)
 B-1  ³ Ra-226+D                                                  ³ 8.594E-03 ³ 8.580E-03 ³ DCF2(  4)
 B-1  ³ Th-230                                                    ³ 3.260E-01 ³ 3.260E-01 ³ DCF2(  5)
 B-1  ³ U-234                                                     ³ 1.320E-01 ³ 1.320E-01 ³ DCF2(  6)
 B-1  ³ U-235+D                                                   ³ 1.230E-01 ³ 1.230E-01 ³ DCF2(  7)
 B-1  ³ U-238                                                     ³ 1.180E-01 ³ 1.180E-01 ³ DCF2(  8)
 B-1  ³ U-238+D                                                   ³ 1.180E-01 ³ 1.180E-01 ³ DCF2(  9)
      ³                                                           ³           ³           ³
 D-1  ³ Dose conversion factors for ingestion, mrem/pCi:          ³           ³           ³
 D-1  ³ Ac-227+D                                                  ³ 1.480E-02 ³ 1.410E-02 ³ DCF3(  1)
 D-1  ³ Pa-231                                                    ³ 1.060E-02 ³ 1.060E-02 ³ DCF3(  2)
 D-1  ³ Pb-210+D                                                  ³ 7.276E-03 ³ 5.370E-03 ³ DCF3(  3)
 D-1  ³ Ra-226+D                                                  ³ 1.321E-03 ³ 1.320E-03 ³ DCF3(  4)
 D-1  ³ Th-230                                                    ³ 5.480E-04 ³ 5.480E-04 ³ DCF3(  5)
 D-1  ³ U-234                                                     ³ 2.830E-04 ³ 2.830E-04 ³ DCF3(  6)
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                    Dose Conversion Factor (and Related) Parameter Summary (continued)
                                  Dose Library: FGR 12 & FGR 11
0     ³                                                           ³  Current  ³   Base    ³  Parameter
 Menu ³                        Parameter                          ³   Value#  ³   Case*   ³    Name
 ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 D-1  ³ U-235+D                                                   ³ 2.673E-04 ³ 2.660E-04 ³ DCF3(  7)
 D-1  ³ U-238                                                     ³ 2.550E-04 ³ 2.550E-04 ³ DCF3(  8)
 D-1  ³ U-238+D                                                   ³ 2.687E-04 ³ 2.550E-04 ³ DCF3(  9)
      ³                                                           ³           ³           ³
 D-34 ³ Food transfer factors:                                    ³           ³           ³
```

```
D-34 ³ Ac-227+D  , plant/soil concentration ratio, dimensionless   ³ 2.500E-03 ³ 2.500E-03 ³ RTF(  1,1)
D-34 ³ Ac-227+D  , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 2.000E-05 ³ 2.000E-05 ³ RTF(  1,2)
D-34 ³ Ac-227+D  , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 2.000E-05 ³ 2.000E-05 ³ RTF(  1,3)
D-34 ³                                                             ³           ³           ³
D-34 ³ Pa-231    , plant/soil concentration ratio, dimensionless   ³ 1.000E-02 ³ 1.000E-02 ³ RTF(  2,1)
D-34 ³ Pa-231    , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 5.000E-03 ³ 5.000E-03 ³ RTF(  2,2)
D-34 ³ Pa-231    , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 5.000E-06 ³ 5.000E-06 ³ RTF(  2,3)
D-34 ³                                                             ³           ³           ³
D-34 ³ Pb-210+D  , plant/soil concentration ratio, dimensionless   ³ 1.000E-02 ³ 1.000E-02 ³ RTF(  3,1)
D-34 ³ Pb-210+D  , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 8.000E-04 ³ 8.000E-04 ³ RTF(  3,2)
D-34 ³ Pb-210+D  , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 3.000E-04 ³ 3.000E-04 ³ RTF(  3,3)
D-34 ³                                                             ³           ³           ³
D-34 ³ Ra-226+D  , plant/soil concentration ratio, dimensionless   ³ 4.000E-02 ³ 4.000E-02 ³ RTF(  4,1)
D-34 ³ Ra-226+D  , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 1.000E-03 ³ 1.000E-03 ³ RTF(  4,2)
D-34 ³ Ra-226+D  , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 1.000E-03 ³ 1.000E-03 ³ RTF(  4,3)
D-34 ³                                                             ³           ³           ³
D-34 ³ Th-230    , plant/soil concentration ratio, dimensionless   ³ 1.000E-03 ³ 1.000E-03 ³ RTF(  5,1)
D-34 ³ Th-230    , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 1.000E-04 ³ 1.000E-04 ³ RTF(  5,2)
D-34 ³ Th-230    , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 5.000E-06 ³ 5.000E-06 ³ RTF(  5,3)
D-34 ³                                                             ³           ³           ³
D-34 ³ U-234     , plant/soil concentration ratio, dimensionless   ³ 2.500E-03 ³ 2.500E-03 ³ RTF(  6,1)
D-34 ³ U-234     , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 3.400E-04 ³ 3.400E-04 ³ RTF(  6,2)
D-34 ³ U-234     , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 6.000E-04 ³ 6.000E-04 ³ RTF(  6,3)
D-34 ³                                                             ³           ³           ³
D-34 ³ U-235+D   , plant/soil concentration ratio, dimensionless   ³ 2.500E-03 ³ 2.500E-03 ³ RTF(  7,1)
D-34 ³ U-235+D   , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 3.400E-04 ³ 3.400E-04 ³ RTF(  7,2)
D-34 ³ U-235+D   , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 6.000E-04 ³ 6.000E-04 ³ RTF(  7,3)
D-34 ³                                                             ³           ³           ³
D-34 ³ U-238     , plant/soil concentration ratio, dimensionless   ³ 2.500E-03 ³ 2.500E-03 ³ RTF(  8,1)
D-34 ³ U-238     , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 3.400E-04 ³ 3.400E-04 ³ RTF(  8,2)
D-34 ³ U-238     , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 6.000E-04 ³ 6.000E-04 ³ RTF(  8,3)
D-34 ³                                                             ³           ³           ³
D-34 ³ U-238+D   , plant/soil concentration ratio, dimensionless   ³ 2.500E-03 ³ 2.500E-03 ³ RTF(  9,1)
D-34 ³ U-238+D   , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 3.400E-04 ³ 3.400E-04 ³ RTF(  9,2)
D-34 ³ U-238+D   , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 6.000E-04 ³ 6.000E-04 ³ RTF(  9,3)
     ³                                                             ³           ³           ³
D-5  ³ Bioaccumulation factors, fresh water, L/kg:                 ³           ³           ³
D-5  ³ Ac-227+D  , fish                                            ³ 1.500E+01 ³ 1.500E+01 ³ BIOFAC(  1,1)
D-5  ³ Ac-227+D  , crustacea and mollusks                          ³ 1.000E+03 ³ 1.000E+03 ³ BIOFAC(  1,2)
D-5  ³                                                             ³           ³           ³
D-5  ³ Pa-231    , fish                                            ³ 1.000E+01 ³ 1.000E+01 ³ BIOFAC(  2,1)
D-5  ³ Pa-231    , crustacea and mollusks                          ³ 1.100E+02 ³ 1.100E+02 ³ BIOFAC(  2,2)
D-5  ³                                                             ³           ³           ³
D-5  ³ Pb-210+D  , fish                                            ³ 3.000E+02 ³ 3.000E+02 ³ BIOFAC(  3,1)
D-5  ³ Pb-210+D  , crustacea and mollusks                          ³ 1.000E+02 ³ 1.000E+02 ³ BIOFAC(  3,2)
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                    Dose Conversion Factor (and Related) Parameter Summary (continued)
                                      Dose Library: FGR 12 & FGR 11
```

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0     ³                                                                  ³  Current  ³   Base    ³  Parameter
 Menu ³                           Parameter                              ³   Value#  ³   Case*   ³    Name
 ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 D-5  ³ Ra-226+D  , fish                                                 ³ 5.000E+01 ³ 5.000E+01 ³ BIOFAC(  4,1)
 D-5  ³ Ra-226+D  , crustacea and mollusks                               ³ 2.500E+02 ³ 2.500E+02 ³ BIOFAC(  4,2)
 D-5  ³                                                                  ³           ³           ³
 D-5  ³ Th-230    , fish                                                 ³ 1.000E+02 ³ 1.000E+02 ³ BIOFAC(  5,1)
 D-5  ³ Th-230    , crustacea and mollusks                               ³ 5.000E+02 ³ 5.000E+02 ³ BIOFAC(  5,2)
 D-5  ³                                                                  ³           ³           ³
 D-5  ³ U-234     , fish                                                 ³ 1.000E+01 ³ 1.000E+01 ³ BIOFAC(  6,1)
 D-5  ³ U-234     , crustacea and mollusks                               ³ 6.000E+01 ³ 6.000E+01 ³ BIOFAC(  6,2)
 D-5  ³                                                                  ³           ³           ³
 D-5  ³ U-235+D   , fish                                                 ³ 1.000E+01 ³ 1.000E+01 ³ BIOFAC(  7,1)
 D-5  ³ U-235+D   , crustacea and mollusks                               ³ 6.000E+01 ³ 6.000E+01 ³ BIOFAC(  7,2)
 D-5  ³                                                                  ³           ³           ³
 D-5  ³ U-238     , fish                                                 ³ 1.000E+01 ³ 1.000E+01 ³ BIOFAC(  8,1)
 D-5  ³ U-238     , crustacea and mollusks                               ³ 6.000E+01 ³ 6.000E+01 ³ BIOFAC(  8,2)
 D-5  ³                                                                  ³           ³           ³
 D-5  ³ U-238+D   , fish                                                 ³ 1.000E+01 ³ 1.000E+01 ³ BIOFAC(  9,1)
 D-5  ³ U-238+D   , crustacea and mollusks                               ³ 6.000E+01 ³ 6.000E+01 ³ BIOFAC(  9,2)
 ÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
 #For DCF1(xxx) only, factors are for infinite depth & area.  See ETFG table in Ground Pathway of Detailed Report.
 *Base Case means Default.Lib w/o Associate Nuclide contributions.
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                                                         Site-Specific Parameter Summary
0     ³                                                  ³   User    ³           ³            Used by RESRAD            ³  Parameter
 Menu ³                      Parameter                   ³   Input   ³  Default  ³ (If different from user input) ³    Name
 ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 R011 ³ Area of contaminated zone (m**2)                 ³ 1.000E+04 ³ 1.000E+04 ³              ---                 ³ AREA
 R011 ³ Thickness of contaminated zone (m)               ³ 2.000E+00 ³ 2.000E+00 ³              ---                 ³ THICK0
 R011 ³ Fraction of contamination that is submerged      ³ 0.000E+00 ³ 0.000E+00 ³              ---                 ³ SUBMFRACT
 R011 ³ Length parallel to aquifer flow (m)              ³ not used  ³ 1.000E+02 ³              ---                 ³ LCZPAQ
 R011 ³ Basic radiation dose limit (mrem/yr)             ³ 2.500E+01 ³ 3.000E+01 ³              ---                 ³ BRDL
 R011 ³ Time since placement of material (yr)            ³ 0.000E+00 ³ 0.000E+00 ³              ---                 ³ TI
 R011 ³ Times for calculations (yr)                      ³ 1.000E+00 ³ 1.000E+00 ³              ---                 ³ T( 2)
 R011 ³ Times for calculations (yr)                      ³ 3.000E+00 ³ 3.000E+00 ³              ---                 ³ T( 3)
 R011 ³ Times for calculations (yr)                      ³ 1.000E+01 ³ 1.000E+01 ³              ---                 ³ T( 4)
 R011 ³ Times for calculations (yr)                      ³ 3.000E+01 ³ 3.000E+01 ³              ---                 ³ T( 5)
 R011 ³ Times for calculations (yr)                      ³ 1.000E+02 ³ 1.000E+02 ³              ---                 ³ T( 6)
 R011 ³ Times for calculations (yr)                      ³ 3.000E+02 ³ 3.000E+02 ³              ---                 ³ T( 7)
 R011 ³ Times for calculations (yr)                      ³ 1.000E+03 ³ 1.000E+03 ³              ---                 ³ T( 8)
 R011 ³ Times for calculations (yr)                      ³ 1.000E+04 ³ 0.000E+00 ³              ---                 ³ T( 9)
 R011 ³ Times for calculations (yr)                      ³ not used  ³ 0.000E+00 ³              ---                 ³ T(10)
      ³                                                  ³           ³           ³                                  ³
 R012 ³ Initial principal radionuclide (pCi/g):  Ra-226  ³ 9.650E-01 ³ 0.000E+00 ³              ---                 ³ S1(4)
 R012 ³ Initial principal radionuclide (pCi/g):  Th-230  ³ 1.310E+00 ³ 0.000E+00 ³              ---                 ³ S1(5)
 R012 ³ Initial principal radionuclide (pCi/g):  U-234   ³ 1.466E+00 ³ 0.000E+00 ³              ---                 ³ S1(6)
 R012 ³ Initial principal radionuclide (pCi/g):  U-235   ³ 6.700E-02 ³ 0.000E+00 ³              ---                 ³ S1(7)
```

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R012	Initial principal radionuclide (pCi/g): U-238	1.466E+00	0.000E+00	---	S1(8)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(4)
R012	Concentration in groundwater (pCi/L): Th-230	not used	0.000E+00	---	W1(5)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(8)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	0.000E+00	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.500E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.230E+02	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	4.600E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.230E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.500E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ

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0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)

```
 R015 ³ Unsat. zone 1, field capacity                    ³ not used  ³ 2.000E-01 ³          ---            ³ FCUZ(1)
 R015 ³ Unsat. zone 1, soil-specific b parameter         ³ not used  ³ 5.300E+00 ³          ---            ³ BUZ(1)
 R015 ³ Unsat. zone 1, hydraulic conductivity (m/yr)     ³ not used  ³ 1.000E+01 ³          ---            ³ HCUZ(1)
      ³                                                  ³           ³           ³                         ³
 R016 ³ Distribution coefficients for Ra-226             ³           ³           ³                         ³
 R016 ³   Contaminated zone (cm**3/g)                    ³ 9.100E+03 ³ 7.000E+01 ³          ---            ³ DCNUCC( 4)
 R016 ³   Unsaturated zone 1 (cm**3/g)                   ³ not used  ³ 7.000E+01 ³          ---            ³ DCNUCU( 4,1)
 R016 ³   Saturated zone (cm**3/g)                       ³ not used  ³ 7.000E+01 ³          ---            ³ DCNUCS( 4)
 R016 ³   Leach rate (/yr)                               ³ 0.000E+00 ³ 0.000E+00 ³       2.220E-05         ³ ALEACH( 4)
 R016 ³   Solubility constant                            ³ 0.000E+00 ³ 0.000E+00 ³       not used          ³ SOLUBK( 4)
      ³                                                  ³           ³           ³                         ³
 R016 ³ Distribution coefficients for Th-230             ³           ³           ³                         ³
 R016 ³   Contaminated zone (cm**3/g)                    ³ 5.800E+03 ³ 6.000E+04 ³          ---            ³ DCNUCC( 5)
 R016 ³   Unsaturated zone 1 (cm**3/g)                   ³ not used  ³ 6.000E+04 ³          ---            ³ DCNUCU( 5,1)
 R016 ³   Saturated zone (cm**3/g)                       ³ not used  ³ 6.000E+04 ³          ---            ³ DCNUCS( 5)
 R016 ³   Leach rate (/yr)                               ³ 0.000E+00 ³ 0.000E+00 ³       3.483E-05         ³ ALEACH( 5)
 R016 ³   Solubility constant                            ³ 0.000E+00 ³ 0.000E+00 ³       not used          ³ SOLUBK( 5)
      ³                                                  ³           ³           ³                         ³
 R016 ³ Distribution coefficients for U-234              ³           ³           ³                         ³
 R016 ³   Contaminated zone (cm**3/g)                    ³ 1.000E+01 ³ 5.000E+01 ³          ---            ³ DCNUCC( 6)
 R016 ³   Unsaturated zone 1 (cm**3/g)                   ³ not used  ³ 5.000E+01 ³          ---            ³ DCNUCU( 6,1)
 R016 ³   Saturated zone (cm**3/g)                       ³ not used  ³ 5.000E+01 ³          ---            ³ DCNUCS( 6)
 R016 ³   Leach rate (/yr)                               ³ 0.000E+00 ³ 0.000E+00 ³       1.980E-02         ³ ALEACH( 6)
 R016 ³   Solubility constant                            ³ 0.000E+00 ³ 0.000E+00 ³       not used          ³ SOLUBK( 6)
      ³                                                  ³           ³           ³                         ³
 R016 ³ Distribution coefficients for U-235              ³           ³           ³                         ³
 R016 ³   Contaminated zone (cm**3/g)                    ³ 1.000E+01 ³ 5.000E+01 ³          ---            ³ DCNUCC( 7)
 R016 ³   Unsaturated zone 1 (cm**3/g)                   ³ not used  ³ 5.000E+01 ³          ---            ³ DCNUCU( 7,1)
 R016 ³   Saturated zone (cm**3/g)                       ³ not used  ³ 5.000E+01 ³          ---            ³ DCNUCS( 7)
 R016 ³   Leach rate (/yr)                               ³ 0.000E+00 ³ 0.000E+00 ³       1.980E-02         ³ ALEACH( 7)
 R016 ³   Solubility constant                            ³ 0.000E+00 ³ 0.000E+00 ³       not used          ³ SOLUBK( 7)
      ³                                                  ³           ³           ³                         ³
 R016 ³ Distribution coefficients for U-238              ³           ³           ³                         ³
 R016 ³   Contaminated zone (cm**3/g)                    ³ 1.000E+01 ³ 5.000E+01 ³          ---            ³ DCNUCC( 8)
 R016 ³   Unsaturated zone 1 (cm**3/g)                   ³ not used  ³ 5.000E+01 ³          ---            ³ DCNUCU( 8,1)
 R016 ³   Saturated zone (cm**3/g)                       ³ not used  ³ 5.000E+01 ³          ---            ³ DCNUCS( 8)
 R016 ³   Leach rate (/yr)                               ³ 0.000E+00 ³ 0.000E+00 ³       1.980E-02         ³ ALEACH( 8)
 R016 ³   Solubility constant                            ³ 0.000E+00 ³ 0.000E+00 ³       not used          ³ SOLUBK( 8)
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                                          Site-Specific Parameter Summary (continued)
0     ³                                                  ³   User    ³           ³     Used by RESRAD      ³  Parameter
 Menu ³                    Parameter                     ³   Input   ³  Default  ³ (If different from user input) ³    Name
 ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 R016 ³ Distribution coefficients for daughter Ac-227    ³           ³           ³                         ³
 R016 ³   Contaminated zone (cm**3/g)                    ³ 2.400E+03 ³ 2.000E+01 ³          ---            ³ DCNUCC( 1)
 R016 ³   Unsaturated zone 1 (cm**3/g)                   ³ not used  ³ 2.000E+01 ³          ---            ³ DCNUCU( 1,1)
 R016 ³   Saturated zone (cm**3/g)                       ³ not used  ³ 2.000E+01 ³          ---            ³ DCNUCS( 1)
 R016 ³   Leach rate (/yr)                               ³ 0.000E+00 ³ 0.000E+00 ³       8.418E-05         ³ ALEACH( 1)
```

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Pa-231				
R016	Contaminated zone (cm**3/g)	2.700E+03	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	7.483E-05	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	5.500E+02	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.672E-04	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	2.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	9.000E+00	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E+00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	3.700E-02	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)

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0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)

R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	1.752E+02	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	0.000E+00	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)

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Site-Specific Parameter Summary (continued)

0		User		Used by RESRAD	Parameter

Menu	Parameter	Input	Default	(If different from user input)	Name
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)

```
      ³                                                  ³           ³           ³                                 ³
 TITL ³ Number of graphical time points                  ³     32    ³    ---    ³              ---                ³ NPTS
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                                                 Site-Specific Parameter Summary (continued)
0     ³                                                  ³   User    ³           ³         Used by RESRAD          ³  Parameter
 Menu ³                     Parameter                    ³   Input   ³  Default  ³ (If different from user input) ³    Name
 ÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 TITL ³ Maximum number of integration points for dose    ³     17    ³    ---    ³              ---                ³ LYMAX
 TITL ³ Maximum number of integration points for risk    ³    257    ³    ---    ³              ---                ³ KYMAX
 ÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÍÍÍ



                      Summary of Pathway Selections

                     Pathway              ³   User Selection
           ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
              1 -- external gamma         ³       active
              2 -- inhalation (w/o radon) ³       active
              3 -- plant ingestion        ³     suppressed
              4 -- meat ingestion         ³     suppressed
              5 -- milk ingestion         ³     suppressed
              6 -- aquatic foods          ³     suppressed
              7 -- drinking water         ³     suppressed
              8 -- soil ingestion         ³       active
              9 -- radon                  ³     suppressed
              Find peak pathway doses     ³       active
           ÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
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      Contaminated Zone Dimensions            Initial Soil Concentrations, pCi/g
      ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ            ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
        Area:  10000.00 square meters                Ra-226     9.650E-01
   Thickness:      2.00 meters                       Th-230     1.310E+00
 Cover Depth:      0.00 meters                       U-234      1.466E+00
                                                     U-235      6.700E-02
                                                     U-238      1.466E+00
0
                                                 Total Dose TDOSE(t), mrem/yr
                                           Basic Radiation Dose Limit = 2.500E+01 mrem/yr
                    Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)
                    ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
    t (years):  0.000E+00  1.000E+00  3.000E+00  1.000E+01  3.000E+01  1.000E+02  3.000E+02  1.000E+03  1.000E+04
     TDOSE(t):  4.126E-01  4.137E-01  4.157E-01  4.218E-01  4.331E-01  4.446E-01  4.540E-01  4.793E-01  4.001E-01
         M(t):  1.650E-02  1.655E-02  1.663E-02  1.687E-02  1.733E-02  1.779E-02  1.816E-02  1.917E-02  1.600E-02
0Maximum TDOSE(t):  4.996E-01 mrem/yr   at t =    2732 ñ 5 years
```

```
0
                      Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                                   As mrem/yr and Fraction of Total Dose At t = 2.732E+03 years
0                                     Water Independent Pathways (Inhalation excludes radon)
0             Ground           Inhalation             Radon               Plant               Meat                Milk                Soil
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
 Nuclide
 ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ
 Ra-226  1.083E-01 0.2167  9.321E-05 0.0002  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.553E-02 0.0311
 Th-230  3.217E-01 0.6440  4.260E-03 0.0085  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.951E-02 0.0991
 U-234   1.623E-04 0.0003  2.170E-06 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.500E-05 0.0001
 U-235   4.273E-06 0.0000  4.663E-06 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  9.113E-06 0.0000
 U-238   2.304E-08 0.0000  3.111E-10 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  3.551E-09 0.0000
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 Total   4.302E-01 0.8610  4.360E-03 0.0087  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  6.508E-02 0.1303
0
                      Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                                   As mrem/yr and Fraction of Total Dose At t = 2.732E+03 years
0                                                    Water Dependent Pathways
0              Water               Fish               Radon               Plant               Meat                Milk          All Pathways*
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
 Nuclide
 ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ
 Ra-226  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.239E-01 0.2480
 Th-230  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  3.755E-01 0.7516
 U-234   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.895E-04 0.0004
 U-235   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.805E-05 0.0000
 U-238   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.691E-08 0.0000
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 Total   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.996E-01 1.0000
0*Sum of all water independent and dependent pathways.
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                      Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                                   As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
0                                     Water Independent Pathways (Inhalation excludes radon)
0             Ground           Inhalation             Radon               Plant               Meat                Milk                Soil
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
 ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ
 Ra-226  3.756E-01 0.9102  9.088E-05 0.0002  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  8.961E-03 0.0217
 Th-230  1.666E-04 0.0004  4.494E-03 0.0109  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.656E-03 0.0113
 U-234   2.080E-05 0.0001  2.016E-03 0.0049  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.663E-03 0.0065
 U-235   1.771E-03 0.0043  8.588E-05 0.0002  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.150E-04 0.0003
 U-238   7.686E-03 0.0186  1.803E-03 0.0044  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.528E-03 0.0061
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 Total   3.852E-01 0.9336  8.490E-03 0.0206  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.892E-02 0.0459
```

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

0 Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.846E-01	0.9321
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.317E-03	0.0226
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.700E-03	0.0114
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.972E-03	0.0048
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.202E-02	0.0291
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.126E-01	1.0000

0*Sum of all water independent and dependent pathways.

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Summary : Linde Site Industrial/Commercial

File : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-CONSTRUCTION-10000-INH8400.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

0 Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Ra-226	3.754E-01	0.9074	9.793E-05	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.033E-02	0.0250
Th-230	3.874E-04	0.0009	4.494E-03	0.0109	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.662E-03	0.0113
U-234	2.040E-05	0.0000	1.977E-03	0.0048	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.611E-03	0.0063
U-235	1.736E-03	0.0042	8.422E-05	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.129E-04	0.0003
U-238	7.536E-03	0.0182	1.768E-03	0.0043	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.479E-03	0.0060
Total	3.851E-01	0.9308	8.421E-03	0.0204	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.019E-02	0.0488

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

0 Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.858E-01	0.9326
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.543E-03	0.0231
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.608E-03	0.0111
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.933E-03	0.0047
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.178E-02	0.0285
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.137E-01	1.0000

0*Sum of all water independent and dependent pathways.

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Summary : Linde Site Industrial/Commercial
File : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-CONSTRUCTION-10000-INH8400.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years
0 Water Independent Pathways (Inhalation excludes radon)

0 Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Ra-226	3.751E-01	0.9022	1.114E-04	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.293E-02	0.0311
Th-230	8.287E-04	0.0020	4.494E-03	0.0108	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.675E-03	0.0112
U-234	1.962E-05	0.0000	1.900E-03	0.0046	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.509E-03	0.0060
U-235	1.669E-03	0.0040	8.100E-05	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.087E-04	0.0003
U-238	7.243E-03	0.0174	1.699E-03	0.0041	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.383E-03	0.0057
Total	3.848E-01	0.9257	8.285E-03	0.0199	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.261E-02	0.0544

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years
0 Water Dependent Pathways

0 Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.881E-01	0.9336
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.997E-03	0.0240
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.429E-03	0.0107
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.858E-03	0.0045
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.132E-02	0.0272
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.157E-01	1.0000

0*Sum of all water independent and dependent pathways.
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Summary : Linde Site Industrial/Commercial
File : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-CONSTRUCTION-10000-INH8400.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
0 Water Independent Pathways (Inhalation excludes radon)

0 Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Ra-226	3.739E-01	0.8864	1.522E-04	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.084E-02	0.0494
Th-230	2.370E-03	0.0056	4.493E-03	0.0107	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.743E-03	0.0112
U-234	1.719E-05	0.0000	1.655E-03	0.0039	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.185E-03	0.0052
U-235	1.453E-03	0.0034	7.077E-05	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.544E-05	0.0002
U-238	6.305E-03	0.0149	1.479E-03	0.0035	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.074E-03	0.0049
Total	3.841E-01	0.9104	7.850E-03	0.0186	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.994E-02	0.0710

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

0 Water Dependent Pathways

0 Radio- Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.949E-01	0.9361
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.161E-02	0.0275
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.857E-03	0.0091
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.619E-03	0.0038
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.859E-03	0.0234
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.218E-01	1.0000

0*Sum of all water independent and dependent pathways.

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Summary : Linde Site Industrial/Commercial

File : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-CONSTRUCTION-10000-INH8400.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

0 Water Independent Pathways (Inhalation excludes radon)

0 Radio- Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Ra-226	3.706E-01	0.8556	2.285E-04	0.0005	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.567E-02	0.0824
Th-230	6.744E-03	0.0156	4.491E-03	0.0104	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.081E-03	0.0117
U-234	1.235E-05	0.0000	1.114E-03	0.0026	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.471E-03	0.0034
U-235	9.787E-04	0.0023	4.874E-05	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.691E-05	0.0002
U-238	4.243E-03	0.0098	9.955E-04	0.0023	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.396E-03	0.0032
Total	3.826E-01	0.8833	6.878E-03	0.0159	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.369E-02	0.1009

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

0 Water Dependent Pathways

0 Radio- Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.065E-01	0.9385
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.632E-02	0.0377
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.598E-03	0.0060
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.094E-03	0.0025
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.635E-03	0.0153
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.331E-01	1.0000

0*Sum of all water independent and dependent pathways.

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 Summary : Linde Site Industrial/Commercial
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-CONSTRUCTION-10000-INH8400.RAD

                        Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                                     As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
0                                       Water Independent Pathways (Inhalation excludes radon)
0            Ground           Inhalation           Radon             Plant              Meat              Milk              Soil
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
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 Ra-226   3.590E-01 0.8075  2.990E-04 0.0007  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.956E-02 0.1115
 Th-230   2.172E-02 0.0488  4.489E-03 0.0101  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  6.926E-03 0.0156
 U-234    9.171E-06 0.0000  2.802E-04 0.0006  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  3.701E-04 0.0008
 U-235    2.484E-04 0.0006  1.623E-05 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.490E-05 0.0001
 U-238    1.061E-03 0.0024  2.490E-04 0.0006  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  3.491E-04 0.0008
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 Total    3.821E-01 0.8593  5.333E-03 0.0120  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  5.723E-02 0.1287
0
                        Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                                     As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
0                                                      Water Dependent Pathways
0             Water              Fish              Radon             Plant              Meat              Milk          All Pathways*
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
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 Ra-226   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.089E-01 0.9196
 Th-230   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  3.313E-02 0.0745
 U-234    0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  6.595E-04 0.0015
 U-235    0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.895E-04 0.0007
 U-238    0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.659E-03 0.0037
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 Total    0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.446E-01 1.0000
0*Sum of all water independent and dependent pathways.
1RESRAD, Version 6.5      T« Limit = 180 days        06/18/2014  10:41  Page  18
 Summary : Linde Site Industrial/Commercial
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-CONSTRUCTION-10000-INH8400.RAD

                        Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                                     As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years
0                                       Water Independent Pathways (Inhalation excludes radon)
0            Ground           Inhalation           Radon             Plant              Meat              Milk              Soil
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
 ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ
 Ra-226   3.278E-01 0.7220  2.821E-04 0.0006  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.701E-02 0.1036
 Th-230   6.171E-02 0.1359  4.484E-03 0.0099  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.259E-02 0.0277
 U-234    2.645E-05 0.0001  7.573E-06 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.269E-05 0.0000
 U-235    1.002E-05 0.0000  6.078E-06 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  1.175E-05 0.0000
 U-238    2.022E-05 0.0000  4.746E-06 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  6.656E-06 0.0000
 ÍÍÍÍÍÍÍ ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ
 Total    3.896E-01 0.8581  4.785E-03 0.0105  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  5.964E-02 0.1314
```

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

0 Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.751E-01	0.8262
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.879E-02	0.1736
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.671E-05	0.0001
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.785E-05	0.0001
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.162E-05	0.0001
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.540E-01	1.0000

0*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

0 Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Ra-226	2.383E-01	0.4972	2.051E-04	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.418E-02	0.0713
Th-230	1.735E-01	0.3621	4.446E-03	0.0093	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.852E-02	0.0595
U-234	8.477E-05	0.0002	2.263E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.401E-05	0.0000
U-235	5.046E-06	0.0000	5.506E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.076E-05	0.0000
U-238	1.164E-08	0.0000	3.288E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.939E-09	0.0000
Total	4.119E-01	0.8594	4.659E-03	0.0097	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.273E-02	0.1309

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

0 Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.727E-01	0.5689
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.065E-01	0.4308
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.010E-04	0.0002
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.131E-05	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.391E-08	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.793E-01	1.0000

0*Sum of all water independent and dependent pathways.

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 Summary : Linde Site Industrial/Commercial
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                       Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                                    As mrem/yr and Fraction of Total Dose At t = 1.000E+04 years
0                                      Water Independent Pathways (Inhalation excludes radon)
0            Ground           Inhalation            Radon              Plant              Meat               Milk               Soil
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
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 Ra-226  3.954E-03 0.0099  3.404E-06 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  5.672E-04 0.0014
 Th-230  3.408E-01 0.8519  3.190E-03 0.0080  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  5.133E-02 0.1283
 U-234   1.737E-04 0.0004  1.626E-06 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.616E-05 0.0001
 U-235   2.127E-06 0.0000  2.321E-06 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.536E-06 0.0000
 U-238   2.491E-08 0.0000  2.333E-10 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  3.751E-09 0.0000
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 Total   3.450E-01 0.8622  3.197E-03 0.0080  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  5.193E-02 0.1298
0
                       Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                                    As mrem/yr and Fraction of Total Dose At t = 1.000E+04 years
0                                                     Water Dependent Pathways
0             Water             Fish              Radon              Plant              Meat               Milk          All Pathways*
 Radio-  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
 ÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄ
 Ra-226  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.525E-03 0.0113
 Th-230  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  3.953E-01 0.9882
 U-234   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.015E-04 0.0005
 U-235   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  8.984E-06 0.0000
 U-238   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  2.889E-08 0.0000
 ÍÍÍÍÍÍÍ ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ  ÍÍÍÍÍÍÍÍÍ ÍÍÍÍÍÍ
 Total   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  4.001E-01 1.0000
0*Sum of all water independent and dependent pathways.
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                                       Dose/Source Ratios Summed Over All Pathways
                             Parent and Progeny Principal Radionuclide Contributions Indicated
0  Parent     Product    Thread                       DSR(j,t) At Time in Years   (mrem/yr)/(pCi/g)
    (i)         (j)      Fraction    0.000E+00 1.000E+00 3.000E+00 1.000E+01 3.000E+01 1.000E+02 3.000E+02 1.000E+03 1.000E+04
 ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ
 Ra-226+D   Ra-226+D   1.000E+00  3.978E-01 3.977E-01 3.973E-01 3.960E-01 3.924E-01 3.801E-01 3.470E-01 2.523E-01 4.186E-03
 Ra-226+D   Pb-210+D   1.000E+00  7.324E-04 2.166E-03 4.901E-03 1.320E-02 2.880E-02 4.360E-02 4.165E-02 3.028E-02 5.025E-04
 Ra-226+D   äDSR(j)               3.986E-01 3.998E-01 4.022E-01 4.092E-01 4.212E-01 4.237E-01 3.887E-01 2.826E-01 4.689E-03
0Th-230     Th-230     1.000E+00  7.026E-03 7.025E-03 7.025E-03 7.023E-03 7.017E-03 6.995E-03 6.934E-03 6.724E-03 4.532E-03
 Th-230     Ra-226+D   1.000E+00  8.618E-05 2.585E-04 6.028E-04 1.805E-03 5.218E-03 1.690E-02 4.809E-02 1.353E-01 2.658E-01
 Th-230     Pb-210+D   1.000E+00  1.060E-07 7.356E-07 3.810E-06 3.173E-05 2.208E-04 1.400E-03 5.122E-03 1.561E-02 3.148E-02
 Th-230     äDSR(j)               7.112E-03 7.285E-03 7.632E-03 8.860E-03 1.246E-02 2.529E-02 6.015E-02 1.576E-01 3.018E-01
0U-234      U-234      1.000E+00  3.206E-03 3.143E-03 3.021E-03 2.630E-03 1.770E-03 4.424E-04 8.424E-06 8.024E-12 0.000E+00
 U-234      Th-230     1.000E+00  3.142E-08 9.342E-08 2.138E-07 5.994E-07 1.447E-06 2.749E-06 3.150E-06 3.063E-06 2.065E-06
```

U-234	Ra-226+D	1.000E+00	2.573E-10	1.791E-09	9.344E-09	7.982E-08	5.929E-07	4.375E-06	1.838E-05	5.906E-05	1.210E-04
U-234	Pb-210+D	1.000E+00	2.381E-13	3.532E-12	4.021E-11	9.762E-10	1.871E-08	3.153E-07	1.912E-06	6.802E-06	1.433E-05
U-234	äDSR(j)		3.206E-03	3.143E-03	3.021E-03	2.631E-03	1.772E-03	4.498E-04	3.186E-05	6.893E-05	1.374E-04
0U-235+D	U-235+D	1.000E+00	2.943E-02	2.885E-02	2.773E-02	2.414E-02	1.625E-02	4.062E-03	7.739E-05	7.386E-11	0.000E+00
U-235+D	Pa-231	1.000E+00	9.338E-07	2.777E-06	6.354E-06	1.781E-05	4.297E-05	8.144E-05	9.243E-05	8.666E-05	3.653E-05
U-235+D	Ac-227+D	1.000E+00	2.629E-08	1.813E-07	9.270E-07	7.368E-06	4.478E-05	1.776E-04	2.458E-04	2.314E-04	9.756E-05
U-235+D	äDSR(j)		2.943E-02	2.885E-02	2.774E-02	2.417E-02	1.633E-02	4.321E-03	4.156E-04	3.181E-04	1.341E-04
0U-238	U-238	5.400E-05	1.550E-07	1.519E-07	1.460E-07	1.271E-07	8.556E-08	2.139E-08	4.076E-10	3.890E-16	0.000E+00
0U-238+D	U-238+D	9.999E-01	8.198E-03	8.037E-03	7.725E-03	6.725E-03	4.526E-03	1.131E-03	2.156E-05	2.057E-11	0.000E+00
U-238+D	U-234	9.999E-01	4.529E-09	1.335E-08	2.996E-08	7.827E-08	1.530E-07	1.261E-07	7.179E-09	2.279E-14	0.000E+00
U-238+D	Th-230	9.999E-01	2.959E-14	2.048E-13	1.055E-12	8.618E-12	5.631E-11	2.698E-10	4.449E-10	4.395E-10	2.962E-10
U-238+D	Ra-226+D	9.999E-01	1.818E-16	2.704E-15	3.095E-14	7.663E-13	1.546E-11	2.988E-10	2.128E-09	8.096E-09	1.736E-08
U-238+D	Pb-210+D	9.999E-01	1.348E-19	4.127E-18	1.012E-16	7.172E-15	3.860E-13	1.871E-11	2.146E-10	9.306E-10	2.056E-09
U-238+D	äDSR(j)		8.198E-03	8.037E-03	7.725E-03	6.725E-03	4.526E-03	1.132E-03	2.157E-05	9.487E-09	1.971E-08

The DSR includes contributions from associated (half-life ó 180 days) daughters.

0

Single Radionuclide Soil Guidelines G(i,t) in pCi/g

Basic Radiation Dose Limit = 2.500E+01 mrem/yr

0Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03	1.000E+04
Ra-226	6.272E+01	6.253E+01	6.216E+01	6.109E+01	5.935E+01	5.900E+01	6.432E+01	8.847E+01	5.332E+03
Th-230	3.515E+03	3.432E+03	3.276E+03	2.822E+03	2.007E+03	9.884E+02	4.157E+02	1.586E+02	8.284E+01
U-234	7.798E+03	7.953E+03	8.274E+03	9.503E+03	1.411E+04	5.557E+04	7.846E+05	3.627E+05	1.819E+05
U-235	8.495E+02	8.664E+02	9.013E+02	1.034E+03	1.531E+03	5.786E+03	6.015E+04	7.859E+04	1.864E+05
U-238	3.050E+03	3.111E+03	3.236E+03	3.717E+03	5.524E+03	2.209E+04	*3.361E+05	*3.361E+05	*3.361E+05

*At specific activity limit

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Summary : Linde Site Industrial/Commercial

File   : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-CONSTRUCTION-10000-INH8400.RAD

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 2732 ñ 5 years

0Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Ra-226	9.650E-01	63.9 ñ 0.1	4.265E-01	5.862E+01	1.284E-01	1.947E+02
Th-230	1.310E+00	5653 ñ *	3.354E-01	7.454E+01	2.867E-01	8.721E+01
U-234	1.466E+00	0.000E+00	3.206E-03	7.798E+03	1.293E-04	1.934E+05
U-235	6.700E-02	0.000E+00	2.943E-02	8.495E+02	2.694E-04	9.281E+04
U-238	1.466E+00	0.000E+00	8.198E-03	3.050E+03	1.835E-08	*3.361E+05

*At specific activity limit

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Summary : Linde Site Industrial/Commercial

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                                    Individual Nuclide Dose Summed Over All Pathways
                                      Parent Nuclide and Branch Fraction Indicated
0Nuclide Parent   THF(i)                                          DOSE(j,t), mrem/yr
   (j)     (i)             t= 0.000E+00 1.000E+00 3.000E+00 1.000E+01 3.000E+01 1.000E+02 3.000E+02 1.000E+03 1.000E+04
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 Ra-226  Ra-226  1.000E+00    3.839E-01 3.837E-01 3.834E-01 3.822E-01 3.787E-01 3.668E-01 3.349E-01 2.435E-01 4.040E-03
 Ra-226  Th-230  1.000E+00    1.129E-04 3.386E-04 7.897E-04 2.365E-03 6.836E-03 2.214E-02 6.300E-02 1.773E-01 3.482E-01
 Ra-226  U-234   1.000E+00    3.772E-10 2.625E-09 1.370E-08 1.170E-07 8.691E-07 6.413E-06 2.694E-05 8.658E-05 1.774E-04
 Ra-226  U-238   9.999E-01    2.666E-16 3.965E-15 4.538E-14 1.123E-12 2.267E-11 4.381E-10 3.120E-09 1.187E-08 2.544E-08
 Ra-226  äDOSE(j)             3.840E-01 3.841E-01 3.842E-01 3.845E-01 3.855E-01 3.890E-01 3.979E-01 4.208E-01 3.524E-01
0Pb-210  Ra-226  1.000E+00    7.068E-04 2.091E-03 4.729E-03 1.274E-02 2.779E-02 4.208E-02 4.019E-02 2.922E-02 4.849E-04
 Pb-210  Th-230  1.000E+00    1.389E-07 9.636E-07 4.991E-06 4.156E-05 2.893E-04 1.834E-03 6.710E-03 2.045E-02 4.124E-02
 Pb-210  U-234   1.000E+00    3.490E-13 5.178E-12 5.894E-11 1.431E-09 2.742E-08 4.623E-07 2.803E-06 9.972E-06 2.101E-05
 Pb-210  U-238   9.999E-01    1.976E-19 6.051E-18 1.484E-16 1.051E-14 5.659E-13 2.744E-11 3.146E-10 1.364E-09 3.014E-09
 Pb-210  äDOSE(j)             7.069E-04 2.092E-03 4.734E-03 1.278E-02 2.808E-02 4.391E-02 4.691E-02 4.969E-02 4.174E-02
0Th-230  Th-230  1.000E+00    9.204E-03 9.203E-03 9.203E-03 9.200E-03 9.192E-03 9.164E-03 9.084E-03 8.809E-03 5.937E-03
 Th-230  U-234   1.000E+00    4.605E-08 1.370E-07 3.134E-07 8.787E-07 2.121E-06 4.030E-06 4.618E-06 4.490E-06 3.027E-06
 Th-230  U-238   9.999E-01    4.338E-14 3.002E-13 1.547E-12 1.263E-11 8.255E-11 3.955E-10 6.522E-10 6.442E-10 4.342E-10
 Th-230  äDOSE(j)             9.204E-03 9.204E-03 9.203E-03 9.201E-03 9.194E-03 9.168E-03 9.088E-03 8.814E-03 5.940E-03
0U-234   U-234   1.000E+00    4.700E-03 4.608E-03 4.429E-03 3.856E-03 2.595E-03 6.486E-04 1.235E-05 1.176E-11 0.000E+00
 U-234   U-238   9.999E-01    6.640E-09 1.957E-08 4.392E-08 1.147E-07 2.243E-07 1.848E-07 1.052E-08 3.341E-14 0.000E+00
 U-234   äDOSE(j)             4.700E-03 4.608E-03 4.429E-03 3.856E-03 2.595E-03 6.488E-04 1.236E-05 1.180E-11 0.000E+00
0U-235   U-235   1.000E+00    1.972E-03 1.933E-03 1.858E-03 1.617E-03 1.089E-03 2.721E-04 5.185E-06 4.949E-12 0.000E+00
0Pa-231  U-235   1.000E+00    6.256E-08 1.860E-07 4.258E-07 1.193E-06 2.879E-06 5.457E-06 6.193E-06 5.806E-06 2.447E-06
0Ac-227  U-235   1.000E+00    1.761E-09 1.215E-08 6.211E-08 4.937E-07 3.000E-06 1.190E-05 1.647E-05 1.551E-05 6.536E-06
0U-238   U-238   5.400E-05    2.272E-07 2.228E-07 2.141E-07 1.864E-07 1.254E-07 3.136E-08 5.975E-10 5.703E-16 0.000E+00
 U-238   U-238   9.999E-01    1.202E-02 1.178E-02 1.132E-02 9.859E-03 6.634E-03 1.659E-03 3.160E-05 3.016E-11 0.000E+00
 U-238   äDOSE(j)             1.202E-02 1.178E-02 1.132E-02 9.859E-03 6.635E-03 1.659E-03 3.160E-05 3.016E-11 0.000E+00
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 THF(i) is the thread fraction of the parent nuclide.
1RESRAD, Version 6.5      T« Limit = 180 days        06/18/2014  10:41  Page  24
 Summary : Linde Site Industrial/Commercial
 File    : C:\RESRAD_FAMILY\RESRAD\6.5\LINDE-CONSTRUCTION-10000-INH8400.RAD

                                         Individual Nuclide Soil Concentration
                                      Parent Nuclide and Branch Fraction Indicated
0Nuclide Parent   THF(i)                                            S(j,t), pCi/g
   (j)     (i)             t= 0.000E+00 1.000E+00 3.000E+00 1.000E+01 3.000E+01 1.000E+02 3.000E+02 1.000E+03 1.000E+04
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 Ra-226  Ra-226  1.000E+00    9.650E-01 9.646E-01 9.637E-01 9.606E-01 9.519E-01 9.220E-01 8.418E-01 6.120E-01 1.015E-02
 Ra-226  Th-230  1.000E+00    0.000E+00 5.674E-04 1.701E-03 5.661E-03 1.690E-02 5.536E-02 1.581E-01 4.453E-01 8.750E-01
 Ra-226  U-234   1.000E+00    0.000E+00 2.839E-09 2.521E-08 2.674E-07 2.120E-06 1.600E-05 6.758E-05 2.175E-04 4.459E-04
 Ra-226  U-238   9.999E-01    0.000E+00 2.674E-15 7.078E-14 2.446E-12 5.445E-11 1.089E-09 7.823E-09 2.981E-08 6.394E-08
 Ra-226  äS(j):               9.650E-01 9.651E-01 9.654E-01 9.663E-01 9.688E-01 9.774E-01 9.999E-01 1.057E+00 8.856E-01
0Pb-210  Ra-226  1.000E+00    0.000E+00 2.952E-02 8.581E-02 2.567E-01 5.779E-01 8.830E-01 8.441E-01 6.137E-01 1.018E-02
 Pb-210  Th-230  1.000E+00    0.000E+00 8.727E-06 7.690E-05 7.950E-04 5.903E-03 3.825E-02 1.406E-01 4.292E-01 8.658E-01
 Pb-210  U-234   1.000E+00    0.000E+00 2.924E-11 7.693E-10 2.607E-08 5.511E-07 9.608E-06 5.872E-05 2.093E-04 4.412E-04
 Pb-210  U-238   9.999E-01    0.000E+00 2.069E-17 1.629E-15 1.821E-13 1.119E-11 5.680E-10 6.587E-09 2.863E-08 6.327E-08
 Pb-210  äS(j):               0.000E+00 2.953E-02 8.589E-02 2.575E-01 5.838E-01 9.212E-01 9.848E-01 1.043E+00 8.764E-01
0Th-230  Th-230  1.000E+00    1.310E+00 1.310E+00 1.310E+00 1.309E+00 1.308E+00 1.304E+00 1.293E+00 1.254E+00 8.451E-01
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 Th-230  U-234   1.000E+00    0.000E+00 1.307E-05 3.843E-05 1.197E-04 2.983E-04 5.727E-04 6.573E-04 6.391E-04 4.308E-04
 Th-230  U-238   9.999E-01    0.000E+00 1.846E-11 1.618E-10 1.641E-09 1.144E-08 5.604E-08 9.281E-08 9.170E-08 6.180E-08
 Th-230  äS(j):               1.310E+00 1.310E+00 1.310E+00 1.310E+00 1.309E+00 1.305E+00 1.294E+00 1.254E+00 8.455E-01
0U-234   U-234   1.000E+00    1.466E+00 1.437E+00 1.381E+00 1.203E+00 8.093E-01 2.023E-01 3.852E-03 3.669E-09 0.000E+00
 U-234   U-238   9.999E-01    0.000E+00 4.074E-06 1.175E-05 3.409E-05 6.883E-05 5.735E-05 3.277E-06 1.042E-11 0.000E+00
 U-234   äS(j):               1.466E+00 1.437E+00 1.381E+00 1.203E+00 8.093E-01 2.023E-01 3.855E-03 3.679E-09 0.000E+00
0U-235   U-235   1.000E+00    6.700E-02 6.569E-02 6.314E-02 5.496E-02 3.699E-02 9.248E-03 1.762E-04 1.682E-10 0.000E+00
0Pa-231  U-235   1.000E+00    0.000E+00 1.404E-06 4.128E-06 1.285E-05 3.202E-05 6.132E-05 6.970E-05 6.535E-05 2.755E-05
0Ac-227  U-235   1.000E+00    0.000E+00 2.218E-08 1.929E-07 1.903E-06 1.234E-05 5.000E-05 6.943E-05 6.537E-05 2.756E-05
0U-238   U-238   5.400E-05    7.916E-05 7.761E-05 7.460E-05 6.494E-05 4.370E-05 1.093E-05 2.082E-07 1.987E-13 0.000E+00
 U-238   U-238   9.999E-01    1.466E+00 1.437E+00 1.381E+00 1.203E+00 8.093E-01 2.023E-01 3.855E-03 3.679E-09 0.000E+00
 U-238   äS(j):               1.466E+00 1.437E+00 1.381E+00 1.203E+00 8.093E-01 2.023E-01 3.855E-03 3.679E-09 0.000E+00
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 THF(i) is the thread fraction of the parent nuclide.
0RESCALC.EXE execution time =    1.34 seconds
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