DOE-FIU SCIENCE & TECHNOLOGY WORKFORCE DEVELOPMENT PROGRAM

STUDENT SUMMER INTERNSHIP TECHNICAL REPORT

June 21, 2010 to August 27, 2010

Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste

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ABSTRACT

This paper is intended to facilitate review of the Draft Environmental Impact Statement (EIS) for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste prepared by the U.S. Department of Energy (DOE). This document will describe the wastes and the proposed disposal alternatives to be analyzed in the Draft GTCC EIS, and provide a brief compilation of the major results of the analyses included in the impact statement. In addition, guidance is provided for locating more detailed information on specific topics in the full document. Informing the public and fostering public participation is an important goal throughout the EIS process. Stakeholders are the people or organizations who have an interest in or may be affected by the lack of disposal capability for these wastes and with activities at the various potential disposal sites for these wastes. Stakeholders include members of the general public, representatives of environmental groups, industry, educational groups, unions, and other organizations; and representatives of Congress, Federal agencies, American Indian Tribes, state agencies, and local governments. Readers interested primarily in the major issues and results presented in the Draft GTCC EIS should find their information needs met by this paper. Key information is presented about the purpose and need for agency action, the proposed action, the proposed alternatives, and the potential short- and long-term impacts of implementing each of the alternatives, uncertainties in the analyses, and public participation process for the EIS. A preferred alternative has not yet been identified but will be included in the Final GTCC EIS following public comment on the Draft GTCC EIS. Considerations for developing a preferred alternative are included in this report.

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1. INTRODUCTION

Greater-than-Class C (GTCC) low-level radioactive waste (LLRW) is defined by the U.S. Nuclear Regulatory Commission (NRC) as LLRW that has radionuclide concentrations exceeding the limits for Class C LLRW established in Title 10, Part 61, of the *Code of Federal Regulations* (10 CFR Part 61), "Licensing Requirements for Land Disposal of Radioactive Waste." In 10 CFR 61.55, the NRC classifies LLRW as A, B, and C according to the concentration of specific short- and long-lived radionuclides, with Class C having the highest radionuclide concentration limits. GTCC LLRW is generated by activities licensed by the NRC or Agreement States and cannot be disposed of in currently licensed commercial LLRW disposal facilities. Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA) assigned the responsibility for the disposal of GTCC LLRW to the federal government. The LLRWPAA specifies that GTCC LLRW covered under Section 3(b)(1)(D) is to be disposed of in a facility that is licensed by the NRC and that the NRC has determined is adequate for protecting public health and safety.

The U.S. Department of Energy (DOE) is the federal agency responsible for disposing of GTCC LLRW. Section 631 of the Energy Policy Act of 2005 requires the Secretary of Energy to:

1. Notify Congress of the DOE office responsible for completing the activities needed to provide for safe disposal of GTCC LLRW;
2. Submit to Congress a report containing an estimate of the cost and schedule to complete an environmental impact statement (EIS) and Record of Decision (ROD) for a permanent disposal facility for GTCC LLRW;
3. Submit to Congress a plan that ensures the continued recovery and storage of GTCC LLRW sealed sources that pose a security threat until a permanent disposal facility is available, and
4. Prior to issuing the ROD, submit to Congress a report that describes all alternatives considered in the EIS.

In response to these requirements, DOE designated its Office of Environmental Management (DOE-EM) as the lead organization responsible for developing GTCC LLRW disposal capability. In July 2006 and February 2006, DOE submitted the report and plan described in items 2 and 3, respectively, to Congress. Copies of these documents are available on the GTCC EIS Web site (http://www.gtcceis.anl.gov/). Consistent with NRC's and DOE's authorities under the Atomic Energy Act of 1954 (as amended), the NRC LLRW classification system does not apply to radioactive wastes generated or owned by DOE and disposed of in DOE facilities. However, DOE owns and generates both LLRW and potential non-defense-related transuranic (TRU) radioactive waste, which have characteristics similar to those of GTCC LLRW and for which there may be no path for disposal. DOE has included these wastes for evaluation in the EIS because their disposal requirements may be similar to those for GTCC LLRW, such that a common approach and/or facility could be used for these wastes. For the purposes of the EIS, DOE is referring to these wastes as GTCC-like waste. The use of the term "GTCC-like" does not have the effect of creating a new DOE classification of radioactive waste.

2. EXECUTIVE SUMMARY

This research work has been supported by the DOE-FIU Science and Technology Workforce Initiative, an innovative program developed by the U.S. Department of Energy's Environmental Management (DOE-EM) and Florida International University's Applied Research Center (FIU-ARC). During the summer of 2010, a DOE Fellow (Mr. Alexander Henao) spent 10 weeks during a summer internship at DOE Headquarters in Germantown, Maryland, under the supervision and guidance of Christine Gelles in EM-43 Division. The internship was initiated on June 19 and continued through August 27, 2010.

With the increasing need to find solutions to our waste problems, DOE is trying innovative ways to find a solution to the disposal of nuclear waste. Several types of waste are produced in the United States every year, some more dangerous than others. In this document, we are going to discuss waste that is greater than grade C, or GTCC as it is more commonly known. In this report, we are going to discuss several methods that could be used for the safe disposal of this waste. DOE has come up with 5 different methods that can potentially help with these issues. The first method they are considering is the No Action Method. Second is the disposal of the waste in the WIPP geologic repository and the other three methods would be to build a trench, a borehole or a vault disposal facility. Depending on the climate and soil conditions, one or two of these methods could be used at the designated DOE sites. Currently, the site where these new approaches could be deployed are as follow: the Waste Isolation Pilot Plant, the Hanford Site, Idaho National Laboratory, Los Alamos National Laboratory, the Nevada Test Site, the Oak Ridge Reservation and Savannah River National Laboratory. Several factors are going to be taken into consideration to determine which alternative works best for each site. Some of these factors includes: noise, air quality, waste management, cultural resources, etc. As we continue to evaluate possibilities, let's take into consideration that the preferred alternative could be a combination of two or more alternatives, based on the characteristics of the waste, its availability for disposal and other key factors. We will also analyze the long term effects of the engineered barriers related to the GTCC waste and possible future scenarios. Finally, we will discuss how modeling can help scientists estimate the endurance of these engineered barriers for the next 1000 years.

3. RESEARCH DESCRIPTIONS

3.1 Proposed Action

DOE proposes to construct and operate a new facility or facilities, or use an existing facility or facilities, for the disposal of GTCC LLRW and GTCC-like waste. DOE would then close the facility or facilities at the end of each facility's operational life. Institutional controls, including monitoring, would be employed for a period of time determined during the implementation phase. A combination of disposal methods and locations may be appropriate, depending on the characteristics of the waste and other factors.

The proposed action alternatives that are being analyzed include the following:

- Alternative 1: No Action
- Alternative 2: Disposal at the WIPP geologic repository
- Alternative 3: Disposal in a new borehole disposal facility
- Alternative 4: Disposal in a new trench disposal facility
- Alternative 5: Disposal in a new vault disposal facility

3.1.1 Alternative 1: No Action

Under the No Action Alternative, current practices for storing GTCC LLRW and GTCC-like waste would continue. The GTCC LLRW generated by the operation of commercial nuclear reactors (mainly activated metal waste) would continue to be stored at the various nuclear reactor sites that generated this waste or at other reactors owned by the same utility. Sealed sources would continue to be stored at interim storage and generator sites. Other waste would also remain stored and managed at the generator or interim storage sites. In a similar manner, all stored and projected GTCC-like waste would remain at current DOE storage and generator locations. Under this alternative, DOE would take no further action to develop disposal capability for these wastes, and current practices for managing these wastes would continue into the future. National security concerns over the lack of a disposal capability for GTCC sealed sources would not be addressed.

3.1.2 Alternative 2: Disposal at the WIPP geologic repository

This alternative involves the disposal of GTCC LLRW and GTCC-like waste at WIPP (Figure 1). The current operation at WIPP involves disposal of TRU waste generated by atomic energy defense activities by emplacement in underground disposal rooms that are mined as part of a panel and an access drift. Each mined panel consists of seven rooms. Contact handled (CH) TRU waste containers are emplaced on disposal room floors, and remote handled (RH) TRU waste containers are currently emplaced in horizontal boreholes in disposal room wall spaces. However, DOE has submitted a planned change request to use shielded containers for safe emplacement of selected RH TRU waste streams on the floor of the repository. The use of the shielded containers will enable DOE to significantly increase the efficiency of transportation and disposal operations for RH TRU waste at WIPP. Consistent with this planned change request, the EIS assumes all activated metal waste and Other Waste-RH would be packaged in shielded containers that would be emplaced on the floor of the mined panel rooms in a manner similar to that used for the emplacement of CH waste. The analysis discussed in the EIS assumes that current disposal procedures and practices at WIPP would continue, except for the emplacement of activated metal and Other

Waste-RH on room floors (not in wall spaces as is the current procedure). It is also assumed that all above-ground support facilities would be available for the disposal of GTCC LLRW and GTCC-like waste and that construction of additional above-ground facilities would not be required. However, the construction of up to 26 additional underground rooms would be required.

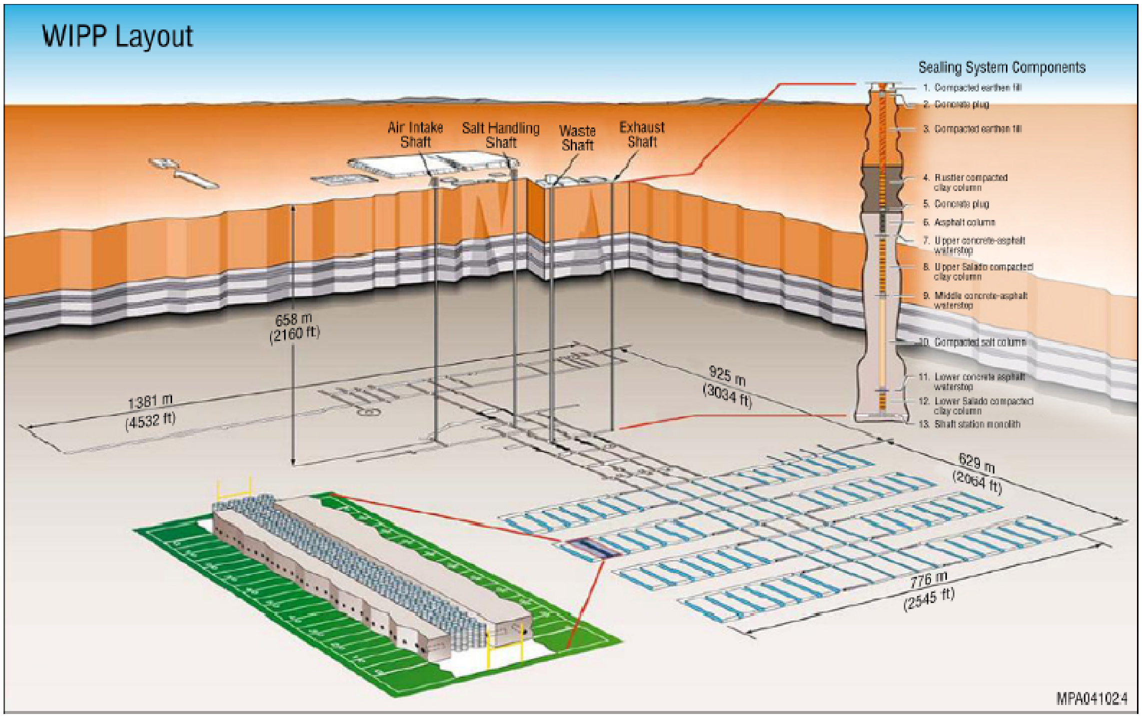

Figure 1. WIPP Layout.

3.1.3 Alternative 3: Disposal in a new borehole disposal facility

This alternative involves the construction, operation, and post-closure of a new borehole facility for the GTCC LLRW and GTCC-like waste inventory (Figure 2). Reference locations at the following five sites were evaluated for this alternative: the Hanford Site, INL, LANL, NTS, and the WIPP vicinity. Because of the shallow depth to groundwater at ORR and SRS, this alternative is not evaluated for these two sites. Of the four NRC regions considered for the generic commercial facility, only NRC Region IV was analyzed in the EIS as the depth to groundwater at the other three regions is considered too shallow for application of this method. For purposes of the draft EIS analysis, a borehole with a depth of 40 m (130 ft) was evaluated. To dispose of the entire inventory of GTCC LLRW and GTCC-like waste, the conceptual design indicates that about 44 ha (110 ac) of land would be required for the 930 boreholes needed to accommodate the waste packages of GTCC LLRW and GTCC-like waste. This acreage would include land required for supporting infrastructure, such as facilities or buildings for receiving and handling waste packages or containers, and space for a storm water retention pond. Less acreage and fewer boreholes would be required if a decision were made to only dispose of certain GTCC waste types in a borehole facility. The borehole method entails emplacement of waste in boreholes at depths below 30 m (100 ft.) but above 300 m (1,000 ft.) below ground surface (bgs). Boreholes can vary widely in diameter [from 0.3 to 3.7 m (1 to 12 ft.)], and the proximity of one borehole to another can vary depending on the design of the facility. After placement of the waste in the borehole, a reinforced concrete barrier would be added above the disposal containers to deter inadvertent drilling into the isolated waste during the post-closure period, and backfill would be added to the surface level.

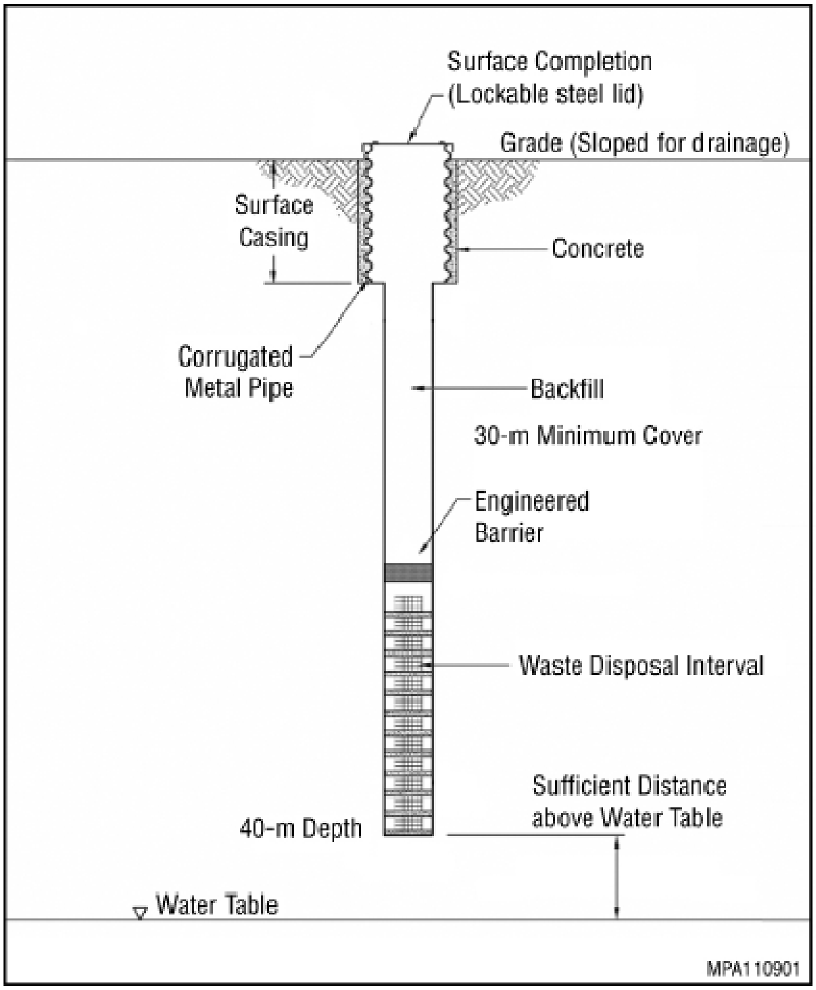

Figure 2. Borehole cross-section.

3.1.4 Alternative 4: Disposal in a new trench disposal facility

Alternative 4 involves the construction, operation, and post-closure performance of a new trench disposal facility (Figure 3). This alternative was evaluated for the Hanford Site, INL, LANL, NTS, SRS, and the WIPP vicinity. With regard to ORR, Alternative 4, like Alternative 3, is not evaluated because of the shallow depth to groundwater at that site. Alternative 4 is evaluated for the generic commercial location in NRC Regions II and IV in order to allow for a comparison with the federal sites in these two regions. A commercial trench facility could also be considered in Regions I and III. To dispose of the entire inventory of GTCC LLRW and GTCC-like waste, the conceptual design for the trench method includes 29 trenches occupying a footprint of about 20 ha (50 ac). This acreage includes land required for supporting infrastructure, such as facilities or buildings for receiving and handling waste packages or containers, and space for a storm water retention pond. Each trench would be approximately 3 m (10 ft.) wide, 11 m (36 ft.) deep, and 100 m (330 ft.) long. After waste was placed in the trench, a concrete layer would be placed on top, and backfill would be added to the surface level. The additional concrete layer would provide additional shielding during the operational period, and at some sites where the material through which drilling would be done is typically soft (e.g., sand or clay), the layer could deter inadvertent drilling into the buried waste during the post-closure period. Measures will be included in the designs of the facilities to reduce the likelihood for future inadvertent human intrusion. In addition to the concrete cover noted above, the conceptual design for the trench is deeper and narrower than conventional near surface LLRW disposal facilities to minimize this potential intrusion during the post-closure period. Additional intruder barriers would also be adopted for those sites in hard rock settings. Protecting against an inadvertent human intruder will be a key feature of the final facility design.

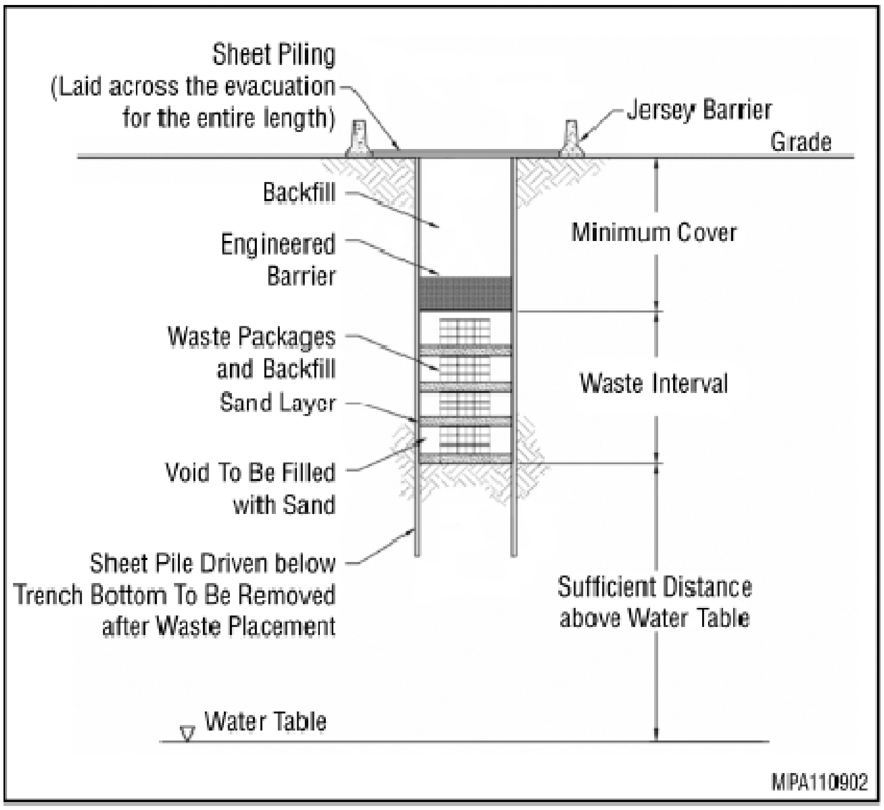

Figure 3. Trench cross-section.

3.1.5 Alternative 5: Disposal in a new vault disposal facility

Alternative 5 involves the construction, operation, and post-closure performance of a new vault disposal facility at the Hanford Site, INL, LANL, NTS, ORR, SRS, and the WIPP vicinity. Alternative 5 was evaluated for a generic commercial location in all four NRC regions. The conceptual design for the vault disposal employs a reinforced concrete vault constructed near grade level, with the footings and floors of the vault situated in a slight excavation just below grade (Figure 4). The vault disposal facility to emplace the entire GTCC waste inventory would consist of 12 vaults (each with 11 vault cells) and occupy a footprint of about 24 ha (60 ac). Each vault would be about 11 m (36 ft.) wide, 94 m (310 ft.)

long, and 7.9 m (26 ft.) tall, with 12 vaults situated in a linear array. The interior cell would be 8.2 m (27 ft.) wide, 7.5 m (25 ft.) long, and 5.5 m (18 ft.) high, with an internal volume of 340 m^3 (12,000 ft^3) per cell. Double interior walls with an expansion joint would be included after every second cell. The thick concrete walls and earthen cover would minimize inadvertent intrusion into the vault.

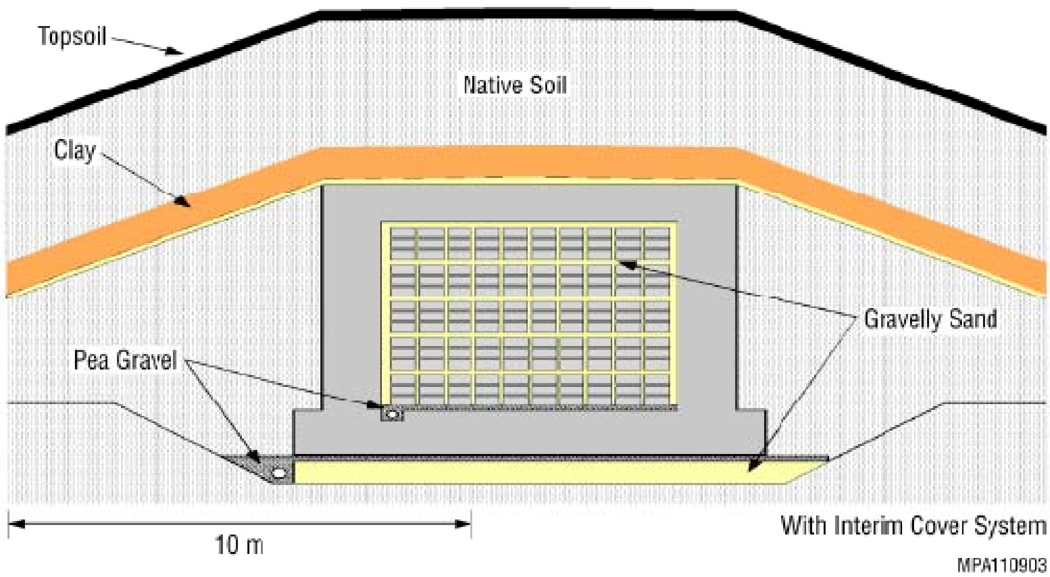

Figure 4. Trench cross-section.

3.2 Sites Considered for Disposal Locations

The sites being considered as disposal locations include:

- Waste Isolation Pilot Plant (WIPP)
- Hanford Site
- Idaho National Laboratory
- Los Alamos National Laboratory
- Nevada Test Site
- Oak Ridge Reservation
- Savannah River Site

3.2.1 Waste Isolation Pilot Plan

WIPP is a DOE facility that is the first underground deep geologic repository and is permitted by the U.S. Environmental Protection Agency (EPA) and the state of New Mexico to safely and permanently dispose of defense-related TRU radioactive waste. WIPP is located 42 km (26 mi) east of Carlsbad, New Mexico, in the Chihuahuan Desert in the southeast corner of the state (Figure 5). Project facilities include disposal rooms that are mined 655 m (2,150 ft.) under the ground in a salt formation (the Salado Formation) that is 610-m (2,000-ft) thick and has been stable for more than 200 million years. The WIPP facility sits in the approximate center of a 41-km^2 (16-mi^2) area that was withdrawn from the public domain and transferred to DOE. The facility footprint itself encompasses 14 fenced ha (35 fenced ac) of surface space and about 12 km (7.5 mi) of underground excavations in the Salado Formation. There are four shafts to the underground: the waste shaft, salt shaft, air intake shaft, and exhaust shaft. There are several miles of paved and unpaved roads in and around the WIPP site, and an 18-km–long (11-mi–long) access road runs north from the site to U.S. Highway (US) 62-180. The access road that is used to bring TRU waste shipments to WIPP is a wide, two-lane road with paved shoulders. Railroad access to the site is in place but is not currently in use. The initial construction of WIPP began in the 1980s. The first shipments of CH TRU and RH TRU waste were received at WIPP on March 26, 1999, and January 23, 2007, respectively. The total capacity for the disposal of TRU waste established under the WIPP LWA (Land Withdrawal Act) is 175,675 m^3 (6.2 million ft^3). The Consultation and Cooperative Agreement with the State of New Mexico (1981) established a total RH capacity of 7,080 m^3 (250,000 ft^3), with the remaining capacity for CH TRU at 168,500 m^3 (5.95 million ft^3). In addition, the WIPP LWA limits the total radioactivity of RH waste to 5.1 million curies. Current plans include receipt and emplacement of TRU waste in 10 waste disposal panels (there are seven rooms in each panel) through fiscal year (FY) 2030. As of FY 2010, waste emplacement in four panels was completed, and emplacement in the fifth panel and mining of the sixth panel had begun.

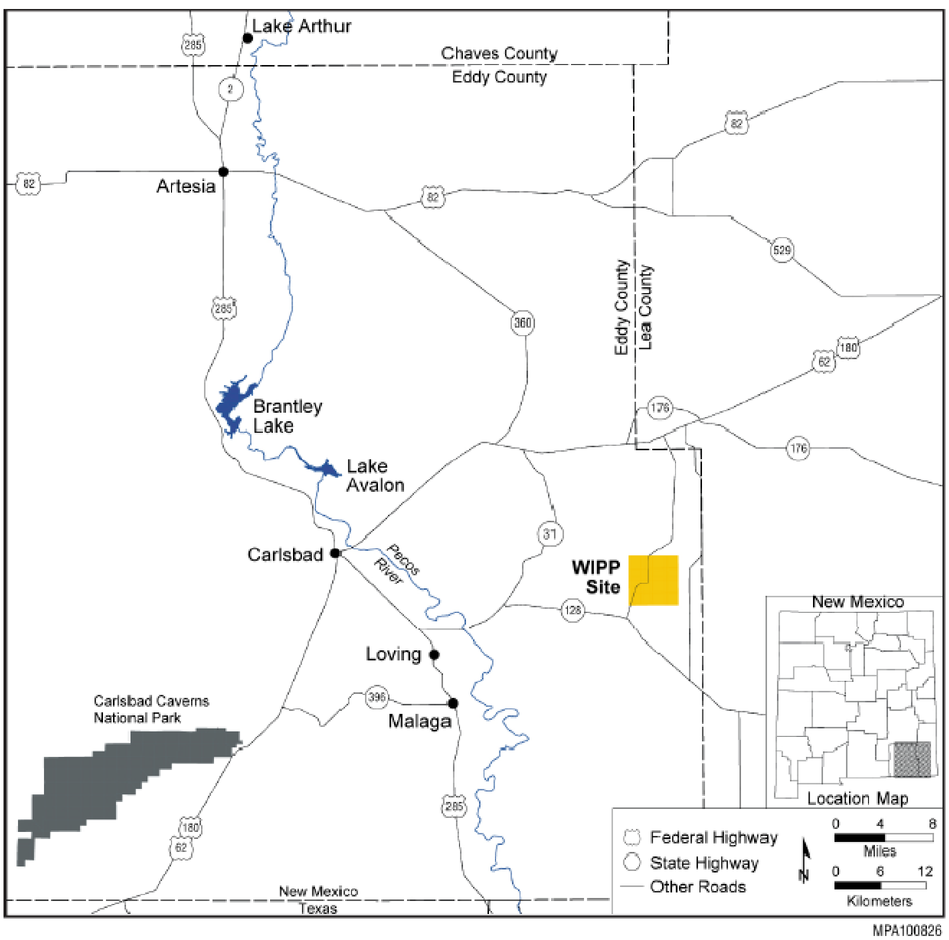

Figure 5. Location of WIPP site.

3.2.2 Hanford Site

The Hanford Site is located in south-central Washington State on 151,775 ha (375,040 ac) of land between the Cascade Range and the Rocky Mountains (Figure 6). The Columbia River flows through the northern portion of the site and forms part of its eastern boundary. Hanford has been operated by DOE and its predecessors [the Manhattan Engineer District, U.S. Atomic Energy Commission (AEC), and U.S. Energy Research and Development Administration] since it was created in 1943. Its primary mission was to produce nuclear materials in support of national defense and research. Operations associated with those programs used facilities for the fabrication of nuclear reactor fuel, reactors for nuclear materials production, chemical separation plants, nuclear material processing facilities, research laboratories, and waste management facilities. Current activities include research, environmental restoration, and waste management. The Hanford Reach National Monument (Monument) covers an area of 78,900 ha (195,000 ac) on DOE’s Hanford Reservation. Of this, the U.S. Fish and Wildlife Service (USFWS) manages approximately 66,773 ha (165,000 ac) through a DOE permit and other agreements with DOE. DOE directly manages approximately 11,736 ha (29,000 ac), and the Washington Department of Fish and Wildlife currently manages the remainder [approximately 324 ha (800 ac)] under a DOE permit. Because DOE is currently the underlying land holder, it retains approval authority over certain management aspects of the monument. Current waste management activities at the Hanford Site include the treatment and disposal of LLRW on site, the processing and certification of TRU waste pending its disposal at WIPP, and the storage of high-level radioactive waste on site pending its disposal in a geologic repository. The main areas where waste management activities occur are the 200 West Area and the 200 East Area, which are south of the Columbia River. These 200 Areas cover about 16 km^2 (6 mi^2). Activities at the 200 Areas include the operation of lined trenches for the disposal of LLRW and mixed LLRW and the operation of the Environmental Restoration Disposal Facility for the disposal of LLRW generated by environmental restoration activities that are being conducted at the Hanford Site to comply with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). US Ecology, Inc., operates a commercial LLRW disposal facility on a 40-ha (100-ac) site leased by the State of Washington near the 200 East Area. The facility is licensed by the NRC and the State of Washington. The GTCC reference location is immediately south of the Integrated Disposal Facility (IDF) site in the 200 East Area in the central portion of the Hanford Site. The 200 East and West Areas are located on a plateau about 11 and 8 km (7 and 5 mi), respectively, south of the Columbia River. Historically, these areas have been dedicated to fuel reprocessing and to waste management and disposal activities (Bunn et al. 2005).

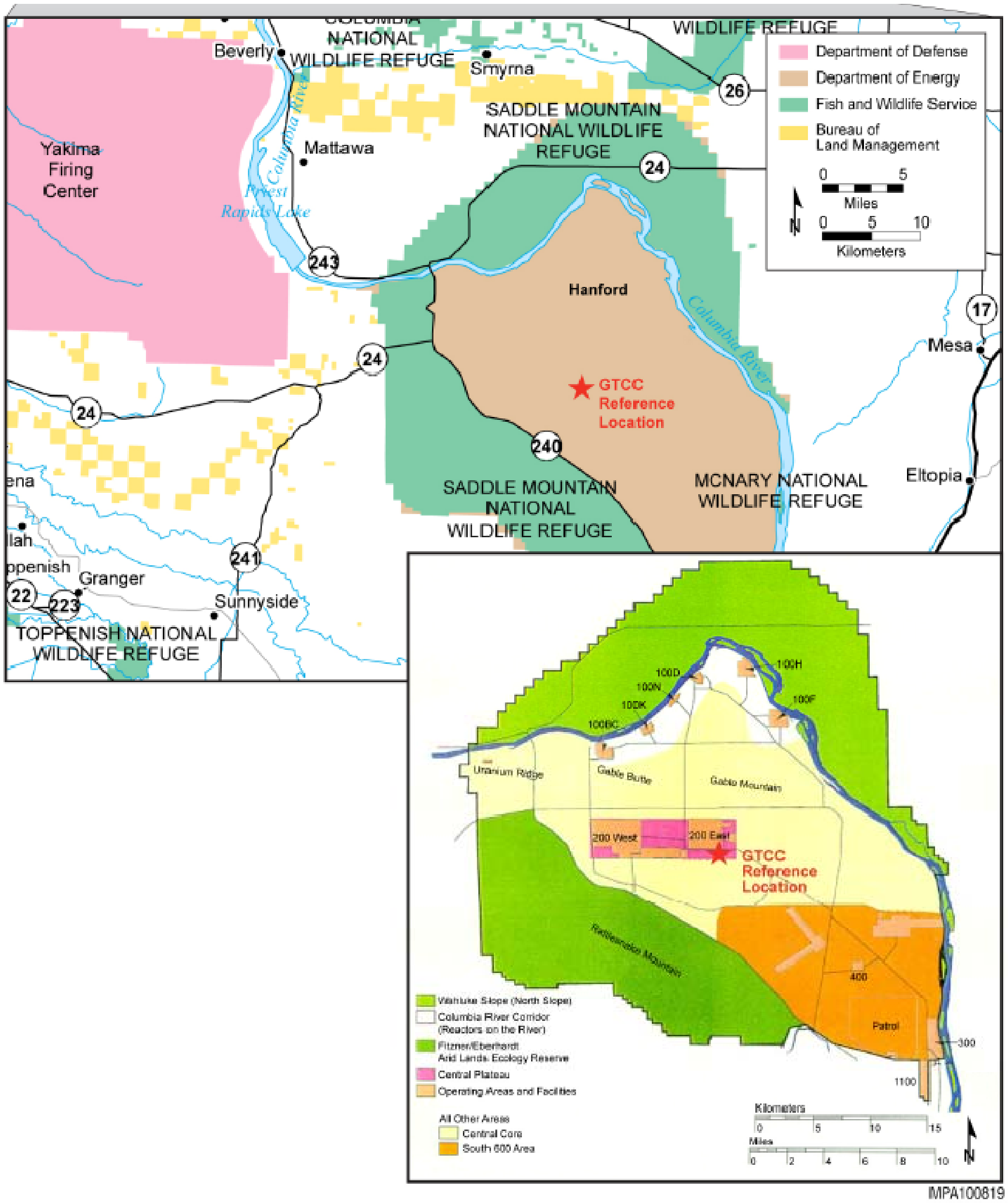

Figure 6. Location and layout of the Hanford Site and GTCC reference location.

3.2.3 Idaho National Laboratory

INL is located on 230,000 ha (580,000 ac) of relatively undisturbed DOE land in the upper Snake River Plain in southeastern Idaho (Figure 7). Basalt flows cover most of the plain, producing a rolling topography. The average elevation at the site is 1,500 m (4,900 ft). INL is bordered by mountain ranges on the north and by volcanic buttes and open plain on the south. Lands immediately adjacent to the INL site consist of open rangeland, foothills, and agricultural fields. About 60% of the site is open to livestock grazing. The laboratory was created by the AEC in 1949 to build and test nuclear power reactors. During the 1970s, its mission broadened to include areas such as biotechnology, energy and materials research, conservation, and renewable energy. In 2003, DOE announced that Idaho National Engineering and Environmental Laboratory and Argonne National Laboratory-West would be the lead laboratories for the development of the next generation of power reactors. In 2005, the two laboratories became INL (DOE 2006). Key facilities consist of clusters of buildings and structures that are typically less than a few square miles each, separated from each other by miles of gently rolling, sagebrush-covered, semi-arid desert. In addition to the INL site, DOE owns or leases laboratories and administrative offices in the city of Idaho Falls, about 40 km (25 mi) east of the INL site boundary. Current waste management activities at INL include the treatment and storage of mixed LLRW (waste containing hazardous constituents in addition to radionuclides) on site, the treatment of LLRW on site and its disposal on site or off site in DOE or commercial facilities, the storage of TRU waste on site, and the storage of high-level radioactive waste and spent nuclear fuel (SNF) on site pending the disposal of these last two materials. These wastes originate from DOE activities and from the on-site Naval Reactors Program. LLRW (RH waste) from INL site operations is disposed of at the Subsurface Disposal Area at the Radioactive Waste Management Complex (RWMC). CH waste is sent off site. TRU waste is also stored and treated at the RWMC and Idaho Nuclear Technology and Environmental Complex (INTEC) to prepare it for disposal at WIPP. The GTCC reference location is southwest of the Advanced Test Reactor (ATR) Complex (Reactor Technology Complex or RTC) in the south central portion of INL. The ATR is dedicated to research supporting DOE missions, including nuclear technology research.

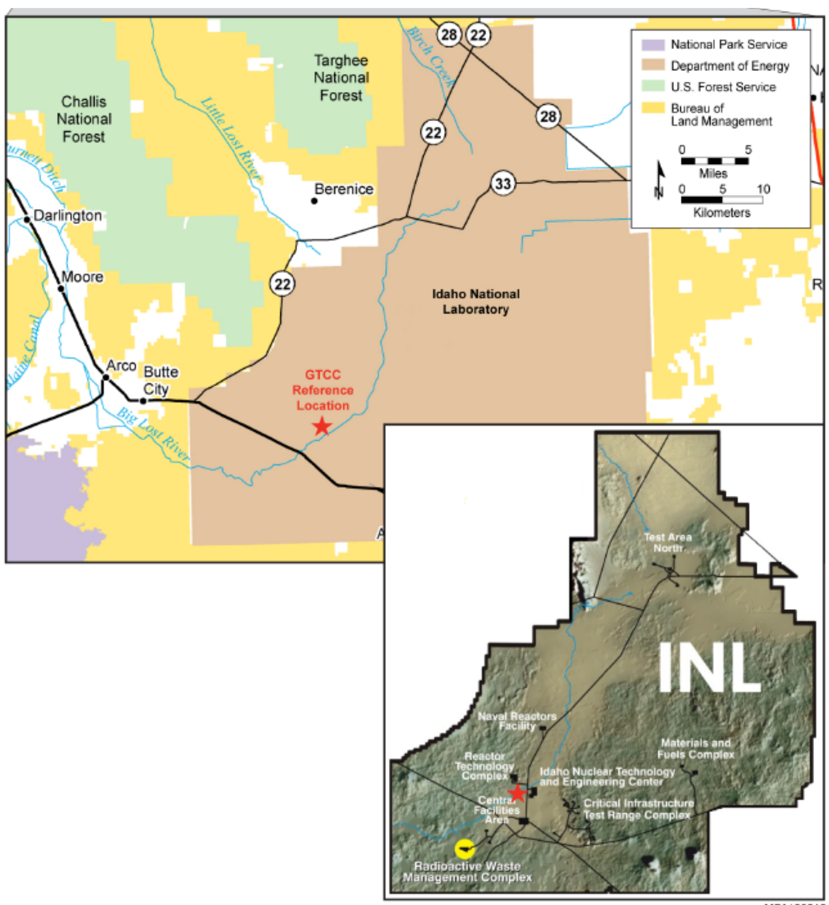

Figure 7. Location of Idaho National Laboratory.

3.2.4 Los Alamos National Laboratory

LANL is located in northern New Mexico, within Los Alamos County, on 10,360 ha (25,600 ac) of land owned by the U.S. Government and administered by DOE and the National Nuclear Security Administration (NNSA) (Figure 8). The site is situated on the eastern flank of the Jemez Mountains along an area known as the Pajarito Plateau. The terrain in the LANL area consists of mesa tops and canyon bottoms that trend in a west-to-east direction, with the canyons intersecting the Rio Grande River to the east of LANL. Elevations range from about 2,380 m (7,800 ft) at the highest elevation on the western side of the site to about 1,890 m (6,200 ft) at the lowest point along the eastern boundary at the Rio Grande. Laboratory operations are conducted in numerous facilities located in 48 designated technical areas (TAs) and at other leased properties located nearby. The laboratory's core mission since its creation in 1943 has been to maintain the effectiveness of the nation's nuclear deterrent. As one of the world's leading research institutions, it is also involved in hydrogen fuel cell development, supercomputing, and applied environmental research. There are more than 2,000 structures on the site, providing about 800,000 m^2 (8.6 million ft^2) of covered space. About half of the square footage at LANL is considered laboratory or production space; the remaining area is considered administrative, storage, service, or other space. Most of the site is undeveloped, which provides a buffer for security and safety and offers the possibility of expansion for future use. LANL is the largest institution in northern New Mexico and has more than 9,000 employees (LANL 2008). Current waste management activities at LANL include the storage of mixed LLRW, the disposal of LLRW on site, and the storage of TRU waste on site. Area G at Technical Area-54 (TA-54) currently accepts on-site LLRW for disposal; also, in special cases, off-site waste has been accepted from other DOE sites for disposal. Engineered shafts are actively used to dispose of RH LRW. The GTCC reference location is situated in three undeveloped and relatively undisturbed areas within TA-54, on Mesita del Buey: Zone 6, North Site, and North Site Expanded. Zone 6 is slightly less than 16 ha (40 ac) in area. It is not fenced, but access by road is controlled by a gate. The total area of the North Site is about 25 ha (63 ac), of which about 20 ha (50 ac) would be suitable for the development of disposal cells. The North Site Expanded section adds another suitable 23 ha (57 ac). The primary function of TA-54 is the management of radioactive and hazardous chemical wastes. Its northern border coincides with the boundary between LANL and the San Ildefonso Pueblo; its southeastern boundary borders the town of White Rock (LANL 2008).

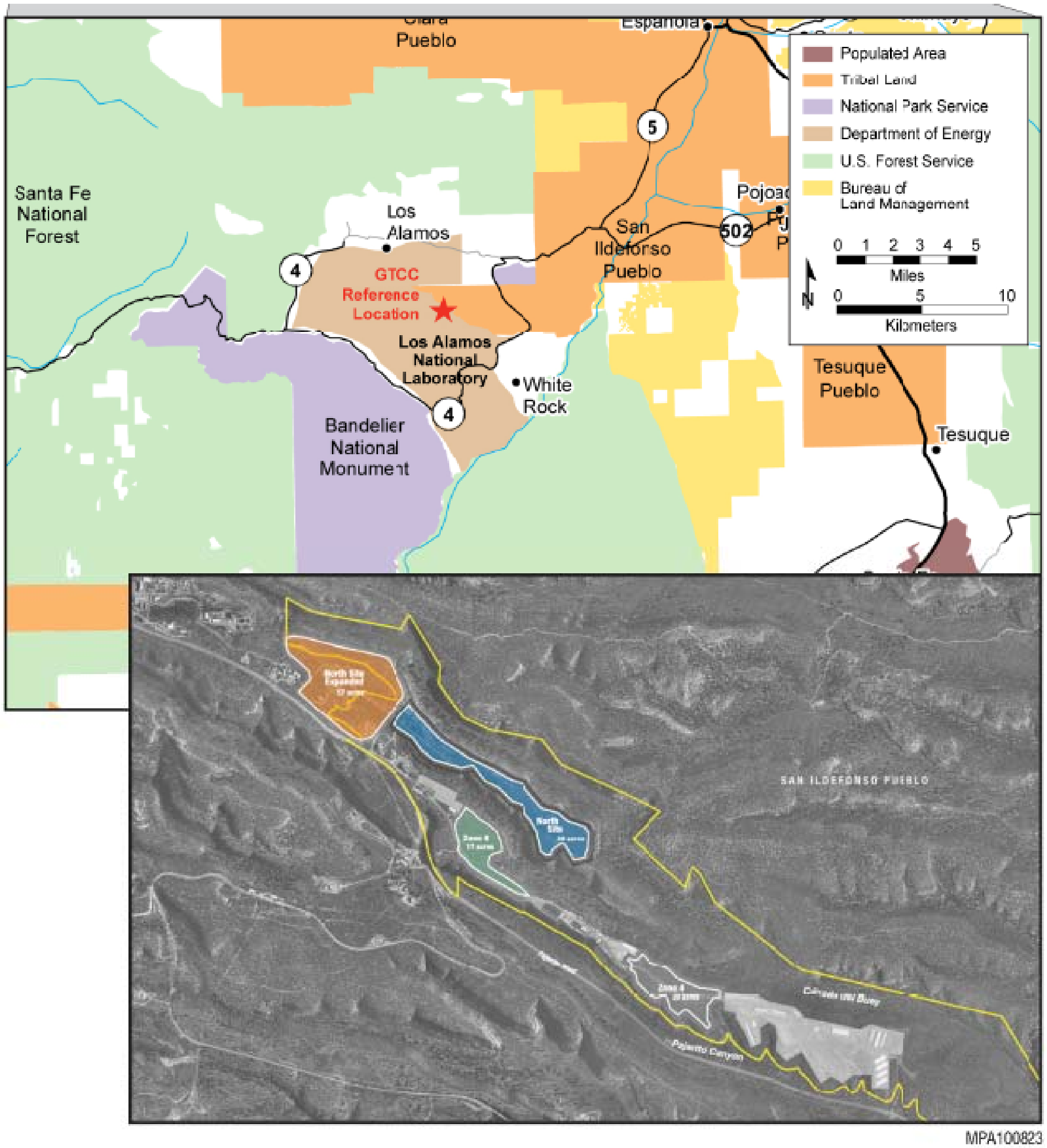

Figure 8. Location of Los Alamos National Laboratory and GTCC reference location.

3.2.5 Nevada Test Site

NTS is located about 105 km (65 mi) northwest of Las Vegas in southern Nevada on 356,125 ha (880,000 ac) of land managed by DOE (Figure 9). NTS is surrounded by federal installations with strictly controlled access and by federal lands that are open to the public. Its terrain is characterized by high relief, with elevations ranging from about 914 m (3,000 ft.) at Frenchman Flat in the southeastern portion of the site to about 2,260 m (7,400 ft.) on Rainier Mesa. Historically, the primary mission of NTS was to conduct nuclear weapons tests. The tests have altered the natural topography of NTS, creating craters in the Yucca Flat and Frenchman Flat basins and on the Pahute and Rainier Mesas. Since the moratorium on nuclear testing in the United States began in October 1992, the mission of NTS has been to maintain the readiness to conduct nuclear tests in the future. The site also supports DOE's waste management program, as well as other national-security-related research and development (R&D) and testing programs. NTS presently serves as a disposal site for LLRW and mixed LLRW generated by DOE defense-related facilities. It is also an interim storage site for a limited amount of TRU mixed wastes pending transfer to WIPP for disposal. Waste management activities are conducted in four primary NTS areas: Areas 3, 5, 6, and 11. Areas 3 and 5 are the two existing radioactive waste management sites at NTS. From 1984 through 1989, boreholes [at depths of 21 to 37 m (70 to 120 ft)] were used at the Area 5 facility to dispose of LLRW and TRU waste.

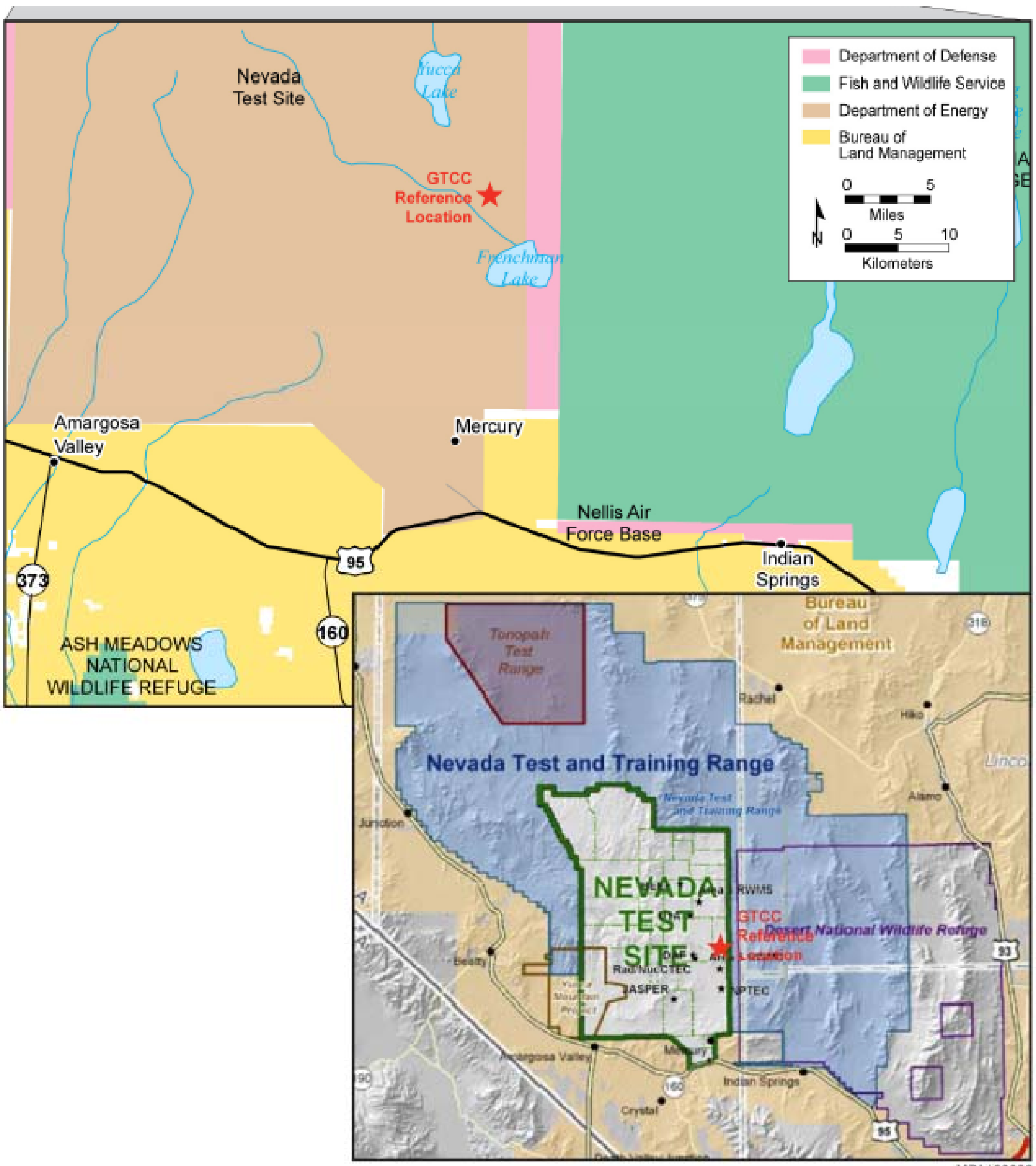

Figure 9. Location of Nevada Test Site and GTCC reference location.

3.2.6 Oak Ridge Reservation

ORR is located in eastern Tennessee, in Roane and Anderson Counties, on 13,640 ha (33,700 ac) of mostly contiguous land owned by DOE (Figure 10). The terrain is characterized by a series of parallel valleys and ridges with a northeast-southwest trend caused by the differential weathering of interstratified formations exposed at the surface. The topographic relief between valley floors and ridge crests is generally about 92 to 110 m (300 to 350 ft). The majority of ORR lies within the corporate limits of the city of Oak Ridge. The residential section of Oak Ridge forms ORR's northern and eastern boundaries; the Tennessee Valley Authority's Melton Hill and Watts Bar Reservoirs on the Clinch and Tennessee Rivers form the southern and western boundaries. Except for the city of Oak Ridge, the land within 8 km (5 mi) of ORR is semirural and used primarily for residences, small farms, and cattle pasture. Recreational fishing, boating, water skiing, and swimming are popular in the area. Following its acquisition in the early 1940s, much of the land that makes up ORR served as a buffer for three primary facilities: (1) the X-10 nuclear research facility currently known as ORNL; (2) the first uranium enrichment facility, or Y-12, currently known as the Y-12 National Security Complex; and (3) a gaseous diffusion enrichment facility currently known as East Tennessee Technology Park (ETTP). Over the past 60 years, the relatively undisturbed area has evolved into an eastern deciduous forest ecosystem of streams and reservoirs, hardwood forests, and extensive upland mixed forests (DOE 2004). The GTCC reference location is in Western Bear Creek Valley, just south of White Wing Scrap Yard and to the west of the Y-12 Complex. The area is relatively flat and bisected by a creek running perpendicular to the valley's trend. Current waste management activities at ORR include the treatment and storage of mixed LLRW on site, the treatment and disposal of LLRW on site, the management of TRU waste on site pending transfer off site for disposal, and the treatment of hazardous waste on site.

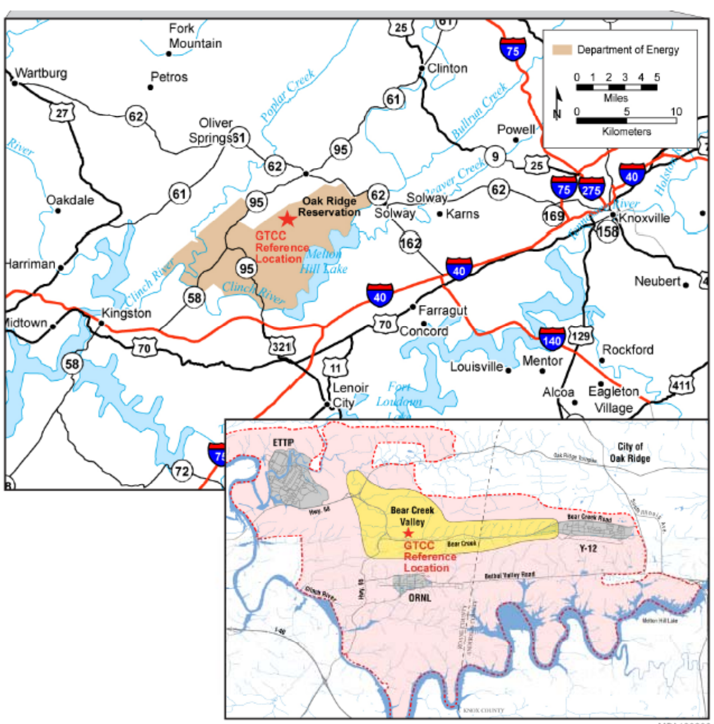

Figure 10. Location of the Oak Ridge Reservation and GTCC reference location.

3.2.7 Savannah River Site

SRS occupies 80,130 ha (198,000 ac) in Aiken, Allendale, and Barnwell Counties in South Carolina (Figure 11). SRS is approximately 19 km (12 mi) south of Aiken, South Carolina, and 24 km (15 mi) southeast of Augusta, Georgia. It is bounded on the southwest by the Savannah River. The AEC established SRS in the early 1950s, and until the early 1990s, its primary mission was the production of nuclear materials to support national programs. The Savannah River National Laboratory was so designated in 2004. Currently the site's missions are environmental management, which includes the treatment, storage, and disposal of radioactive waste; defense programs, which include tritium services to meet stockpile stewardship requirements; and nuclear nonproliferation, which includes the construction of the Mixed Oxide Fuel Fabrication Facility. The SRS management and operations contractor is currently Savannah River Nuclear Solutions, LLC, while Savannah River Remediation operates the liquid radioactive waste program. SRS currently manages high-level waste, TRU waste, LLRW, and mixed LLRW. High level waste is vitrified at the Defense Waste Processing Facility and stored on site pending disposal in a geologic repository. TRU waste is stored, prepared for shipment, and shipped to WIPP for disposal. LLRW is treated and disposed of on site, or it is prepared for shipment to be disposed of at other DOE sites (e.g., NTS) or commercial facilities. On-site facilities for LLRW disposal included engineered trenches and vaults. The GTCC reference location at SRS is on an upland ridge above Tinker Creek, to the northeast of Z Area in the north-central portion of SRS. The area is not currently being used for waste management.

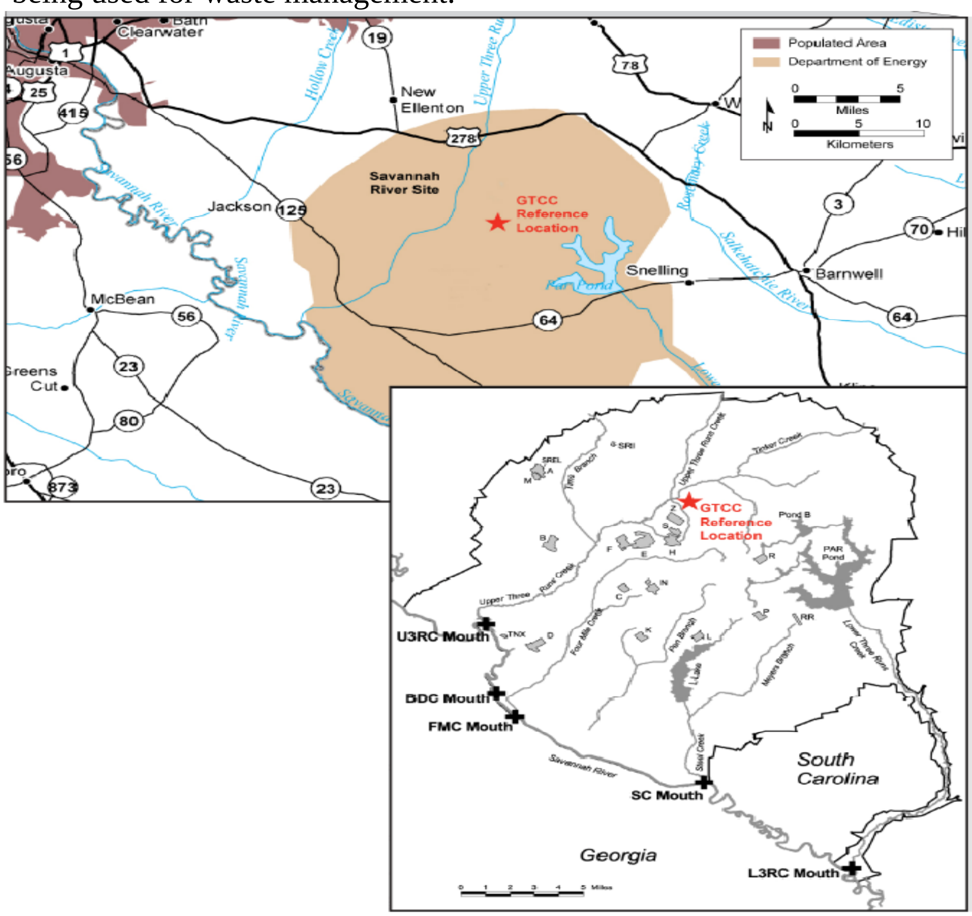

Figure 11. Location of the Savannah River site and GTCC reference location.

4. RESULTS AND ANALYSIS

This section summarizes the methodologies used in evaluating the various environmental resource areas discussed in the environmental impact statement (EIS). The environmental resource areas evaluated are as follows:

- Climate, air quality, and noise;
- Geology and soils;
- Water resources;
- Human health (including accidents and intentional destructive acts);
- Ecological resources;
- Socioeconomics;
- Environmental justice;
- Land use;
- Transportation (including accidents);
- Cultural resources;
- Waste management; and
- Cumulative impacts.

4.1 Air Quality

Potential air quality impacts under each alternative were evaluated by estimating potential air pollutant emissions from the activities associated with facility construction and operations. Air emissions of criteria pollutants, volatile organic compounds (VOCs), and carbon dioxide (CO_2, a primary greenhouse gas) that would result from the activities associated with construction (e.g., engine exhaust and fugitive dust emissions from heavy equipment and vehicles) and operations (e.g., boiler and emergency generator stack emissions) were estimated by using emission factors available in the standard reference and by using activity-level data. Information previously developed for other similar projects was also obtained and used to the extent possible. The significance of project-related emissions to overall air quality was determined by comparing the estimated project-related emissions with the site wide/countywide emissions or statewide/worldwide emissions of CO_2.

4.2 Noise

Potential noise impacts under each alternative were assessed by estimating the noise levels from noise-emitting sources associated with facility construction and operations, then performing noise propagation modeling. First, all potential noise-emitting sources were identified. Examples of noise-emitting sources include heavy equipment used in earth-moving activities during construction, process equipment, emergency generators used during operations, and both the on-site and off-site vehicles used throughout the project. Sound power or sound pressure levels of individual noise sources were obtained from the literature. Potential noise impacts at the nearest sensitive receptors (e.g., residences) were estimated by using a simple noise propagation formula (e.g., considering geometric spreading of sound energy and ground effects only). Estimated potential noise levels were assessed by comparing them to the U.S. Environmental Protection Agency (EPA) noise guideline, which is more stringent than the state or local guidelines. In addition, a ground borne vibration impact analysis was performed in the same way as was the noise impact analysis. Common ground borne vibration sources include construction and operational activities (e.g., use of heavy equipment). The distances at which vibration levels are below the threshold of perception for humans and interference with vibration-sensitive activities were estimated

4.3 Geology and Soils

The main elements considered when measuring impacts on geologic and soil resources at the greater-than-Class C (GTCC) reference locations were the location and extent of land disturbed during construction and operations. Activities that could result in land disturbance include excavating for the trench and vault facilities, drilling for boreholes, and staging of equipment in designated areas. Geologic and soil conditions within each of the GTCC reference locations were researched and are described in the affected environment section. Surveys in the vicinity of the candidate sites, including soil surveys, topographic surveys, and geologic and seismic hazard maps, were reviewed as an initial step in the assessment. Well log data from on-site (or near-site) wells and boreholes were also reviewed. The impact analysis for geologic resources evaluated effects on critical geologic attributes, including access to mineral or energy resources, destruction of unique geologic features, and mass movement induced by construction. The impact analysis also evaluated regional geologic conditions, such as earthquake potential. The impact analysis for soil resources evaluated effects on specific soil attributes, including the potential for soil erosion and compaction by construction activities. The determination of the relative magnitude of an impact for each evaluated site was based on an analysis of both the context of the action and the intensity of the impact on a particular resource.

4.4 Water Resources

Water resources that could be affected by the GTCC waste disposal facility include rivers, streams, and groundwater. Hydrologic conditions [including hydrologic parameters, such as flow volumes (surface water) and hydraulic conductivity (groundwater)] in the vicinity of each GTCC reference location were researched and are described in the affected environment section of the EIS. Impacts on surface water were evaluated in terms of runoff and water quality. Changes in runoff were assessed by comparing runoff conditions with and without the GTCC waste disposal facility. The potential for impacts on surface water quality was assessed on the basis of the site’s location relative to rivers and streams, local runoff rates, and groundwater discharge. The impact analysis for groundwater resources evaluated effects on underlying aquifers in terms of changes in groundwater depth, direction of groundwater flow, groundwater quality, and recharge rates. Impacts on groundwater depth and direction of flow were assessed by comparing existing water use with water demand under the proposed action. The RESRAD OFFSITE model was used to estimate the concentrations and migration rates of contaminants from source areas to groundwater (i.e., changes in groundwater quality over time). Changes in recharge rates were assessed by estimating the impermeable area that would result from GTCC waste disposal facility construction and operations and comparing it to the recharge area currently available at each of the reference locations

4.5 Ecological Resources

This section describes the methodology used to determine the potential impacts of the GTCC disposal options on ecological resources. Impacts on ecological resources consider the effects of facility construction, operation, decommissioning, and post-closure on terrestrial, wetland, aquatic, and special status species and their habitats at and in the vicinity of each GTCC reference location or disposal facility site. Special attention was paid to resources protected by regulations (e.g., federally listed species, migratory birds, bald and golden eagles, and wetlands). Direct and indirect impacts on ecological resources are evaluated on the basis of the:

- Nature and quality of habitats within and adjacent to the construction footprint,
- Potential magnitude of changes to habitat quality and quantity,
- Temporal characteristics of when impacts could occur,
- Expected duration of impacts,
- Sensitivity of biological resources that could be affected by changes in habitat quality or quantity,
- Rarity and importance of affected resources, and
- Regulatory requirements (wetlands, threatened and endangered species, migratory birds).

Factors considered in evaluating impacts from the GTCC disposal facility include:

- Habitat loss, modification, and fragmentation
- Barriers to movement
- Changes in hydrology and water quality
- Erosion and sedimentation
- Air quality and fugitive dust
- Introduction of invasive species
- Exposure to contaminants (including radionuclides)
- Mortality and injury
- Noise and disturbance

A quantitative assessment of the impacts on the large number of species found at each alternative site was not practical. The approach used for the EIS consisted of gathering land use and land cover data to identify areas of potential habitat and how it would be affected. Thus, impacts on plants and wildlife primarily addressed the effects of facility construction on habitat loss and fragmentation. The potential impacts on wetlands were based on the direct impacts that could result from construction (e.g., filling) or indirect impacts (e.g., changes in water quality, hydrologic regime, or soil compaction and runoff). Impacts on threatened and endangered species were investigated by using a species-specific approach. Consultations with regulatory agencies [e.g., U.S. Fish and Wildlife Service (USFWS) and state fish and game departments] were undertaken to assist with the identification of threatened, endangered and other special status species to be considered at each site.

4.6 Socioeconomics

The analysis of socioeconomic impacts from the construction of additional rooms and waste disposal operations at WIPP and the construction and waste disposal operations at the land disposal facilities assesses impacts in a region of influence (ROI) at each of the sites evaluated in the EIS. The ROI includes the counties in which the majority, up to 90%, of employees resides at each of the sites. The ROI includes county governments, city governments, and school districts. Within the ROI at each site, there are also various jurisdictions that could be affected by GTCC waste disposal facility construction and operations. The assessment of the impacts from GTCC waste disposal facilities covers impacts on employment, income, population, housing, community services, and traffic.

4.7 Environmental Justice

Executive Order 12898 (February 16, 1994) formally requires federal agencies to incorporate environmental justice as part of their missions. Specifically, it directs them to address, as appropriate, any disproportionately high and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations. The analysis of the impacts of a GTCC waste disposal facility on environmental justice issues follows guidelines described in *Environmental Justice Guidance under the National Environmental Policy Act*. The analysis method has three parts:

1. A description of the geographic distribution of low-income and minority populations in the affected area;
2. An assessment of whether the impacts of construction and operations would be high and adverse; and
3. If impacts are high and adverse, a determination of whether these impacts would disproportionately affect minority and low-income populations.

Construction and operations of a GTCC waste disposal facility would affect environmental justice if any adverse health and environmental impacts were significantly high and if these impacts disproportionately affected minority and low-income populations. If the analysis determines that health and environmental impacts would not be significant, there could then be no disproportionate impacts on minority and low-income populations. If the impacts would be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations. The analysis of environmental justice issues considers impacts in an 80-km (50-mi) buffer around the site in order to include any potential adverse human health or socioeconomic impacts related to the GTCC waste disposal facility construction and operations. Accidental radiological releases, for example, could affect minority and low-income population groups located some distance from the site, depending on the size and nature of potential releases and on the meteorological conditions. Any accidental release to the environment could also affect fish and other natural resources that might be used for subsistence by low-income and minority population groups some distance from the site, the extent of which also would depend on the size and nature of any potential release at the site.

4.8 Land Use

Land use impacts are identified changes in land use categories and alternative or conflicting uses caused by a proposed action. Potential impacts on land use were evaluated for each alternative site by examining the characteristics and size of the land designated for the GTCC reference location and the compatibility of current land use designations with the GTCC waste disposal facility. The analyses considered potential land use impacts that could be incurred during the construction, operation, decommissioning, and post-closure phases of the project at each alternative site. An impact on land use would occur if the facility would change land use in the area in which the facility was located (i.e., the facility would not conform to existing DOE land use plans and policies) or in surrounding areas. Therefore, the GTCC waste disposal facility was considered to have a potential impact on land use only if it would:

- Conflict with existing land use plans;
- Conflict with existing recreational, educational, scientific, or other uses of the area;
- Conflict with existing conservation goals for the area; or
- Require a conversion from existing commercial land use of the area (e.g., timber harvest, mineral extraction, livestock grazing).

4.9 Transportation Risk Analysis

This section of the EIS provides the methodology and key input parameters used for the transportation risk analysis performed in support of the GTCC EIS. The analysis evaluated the transportation of the waste from its assumed or known location of generation or storage to each of the proposed disposal facility locations. Transportation impacts were estimated for shipment by both truck and rail modes for the three GTCC LLRW and GTCC-like waste types.

4.10 Cultural Resources

Cultural resources are the physical remains of past human activity or natural features that have significant historical or cultural meaning. These resources include archaeological sites, historic structures, cultural landscapes, and traditional cultural properties. The analysis of impacts on cultural resources relied on similar types of information for each site and alternative. The area potentially affected was determined for each site and included the areas needed for both construction and operation. To the extent possible, these areas included some buffer to allow for any minor changes during implementation. Information on the presence of cultural resources within the area that might be affected was compiled. This task relied on cultural and historical background data that provided an overarching context for the types of cultural resources that could be present in each region. Previous cultural resource studies were reviewed to determine if specific resources exist within the area potentially affected. A records search was done to determine if any of the cultural resources that are present are eligible for listing on the *National Register of Historic Places* (NRHP). Once the baseline for the types of cultural resources present was established, the assessment considered the activities that would be required for the proposed action and its potential for affecting cultural resources. Of greatest concern were activities that would require ground disturbance because these activities would have the greatest impact on cultural resources. If archeological surveys had not been completed for the project area, the analysis assumed that the distribution of resources was the same as the distribution known for the surrounding region. Once the potential for impacts from each alternative was determined, the effects of each alternative were compared.

4.11 Waste Management

Potential impacts on waste management programs at the various sites considered in the EIS were evaluated. Wastes that could be generated from the construction of the land disposal options evaluated in the EIS include small quantities of hazardous solids, nonhazardous solids (concrete and steel spoilage, excavated materials), hazardous liquids, and nonhazardous (sanitary waste) liquids. Wastes that could be generated from the operation of the land disposal methods include small quantities of solid low-level radioactive waste (LLRW), such as spent HEPA filters, and nonhazardous solid waste (including recyclable wastes). Some liquid LLRW would also be generated from truck wash down water An initial construction period of 3.4 years was assumed in the derivation. At all the sites evaluated for the land disposal options, the waste management programs for the waste categories generated were reviewed to determine potential impacts from the additional waste that could be generated. All the waste categories are routinely handled at all the DOE sites evaluated. Waste generated at the WIPP vicinity could be sent off-site for disposal; commercial disposal options are available for the waste categories that would be generated. The construction of underground rooms at WIPP would generate primarily slats or muck, which could be managed at WIPP by using existing procedures. Disposal operations would generate types of waste similar to those currently generated; it is expected that existing handling procedures and capacities would accommodate the additional waste.

4.12 Cumulative Impacts

Cumulative effects or impacts result from the incremental impact of the action alternatives when added to other past, present, and reasonably foreseeable future actions, regardless of what government agency or private entity undertakes such actions. Cumulative effects may result from impacts that are minor individually but that, when viewed collectively over space and time, can produce significant impacts. The approach used for cumulative impacts analysis in the EIS was based on the principles outlined by the Council on Environmental Quality and on the guidance developed by the EPA for independent reviewers of EISs. The cumulative impact analysis for the EIS was not meant to be a review of all potential environmental impacts at and near a site, nor was it meant to be a site wide impact analysis. For the EIS, past and present impacts at a given site are generally addressed in the affected environment discussion for each resource area. Reasonably foreseeable future actions at a given site were gleaned primarily from a review of various National Environmental Policy Act (NEPA) documents available for the site. In addition, the latest EIS (draft or final, as appropriate) available for the site was reviewed to identify total cumulative impact values reported for the site (with the reasonably foreseeable future actions considered). The potential impacts from the EIS were then compared to those reported values in order to gain perspective on the potential contribution from the GTCC EIS alternatives to overall cumulative impacts at the sites. This approach was taken since the potential impacts described in the EIS are relatively small and are not expected to contribute substantially to the cumulative impacts at the sites evaluated.

4.13 Engineered Barrier Performance

In order to understand which of the proposed alternative for the disposal of the waste works better or is more efficient, DOE looked into lesson learned and experiences from other agencies located all around the United States, to have a better understanding of how these engineered barriers performed. A number of these barriers are located in the same states that the current sites are located. At the same time, proposed longevity factors of the barriers were evaluated to determine if they would last for a long period of time.

The following states participated in this study:

- Texas
- Utah
- Colorado
- New York

4.13.1 Texas

The state of Texas has been experimenting with a multi-layered engineer cover and a cover with both geo-synthetic and clay components. Each of these units also has a leachate collection system and a system to monitor the groundwater in both the unsaturated and saturated porous media. Currently, the Texas Waste Disposal Facility has a heavy reliance on modeling and engineering analysis to help predict the performance of the site in order to receive a full license. With the modeling, they have reached agreement that there are some uncertainties when they model for more than 500 years and also that more data is needed to make better predictions.

4.13.2 Utah

In the state of Utah, two different monitoring activities are being conducted: short-term monitoring and long-term monitoring. With short-term monitoring, scientists are using a system of pan lysimeters and a cover test cell (CTC). For the long-term monitoring, they are using several different systems. One of these systems is the shallow aquifer monitoring well. Another method currently used is the nested monitoring well pair. A third method uses hydraulic gradient monitoring and a fourth uses shallow ground water quality monitoring. According to scientists and the different scientific models, they do not have 100% agreement with the long-term monitoring data; yet, the data shown with the short-term monitoring methods seem to have very comparable numbers.

4.13.3 Colorado

The state of Colorado is currently testing the use of water balance covers and actively discourages the use of near-surface engineered barriers for all programs, where applicable. As with most engineered barriers, inspections and maintenance at regular intervals is a must in order to conserve the stability and integrity of the engineered barrier. Multiple studies and investigations have shown that unwanted vegetation will quickly become established between the rock and the engineered barrier. This raises some concern as to how long the barrier will last without care. Some estimates proposed that they would need to change the barriers in about 200 to 300 years.

4.14.4 New York

Most of New York experience with monitoring and performance assessments of modern landfill liner systems has been associated with solid waste that is required to be double lined and are closely monitored on an ongoing and routine basis. Some of these barriers are located within a bedrock layer, where water can be store; thus, the growth of vegetation is a serious problem with this engineered barrier. Constant monitoring is to be employed so the stability and longevity of the barrier is achieved. According to the models, there might be some uncertainties after 200 years; repair and liner replacement will extend the life of the engineer barrier.

5. CONCLUSION

To date, there has been a heavy reliance on modeling and engineering analysis to help predict performance of the sites. As of now, some of the initial licenses are being supported by a variety of computer codes, including some with identified shortcomings. However, DOE will require demonstration that the acceptable dose to the general public has been evaluated to the peak dose or for a minimum of 10,000 years.

The department has evaluated years of monitoring data, sustaining that the performance of the doubled-lined landfills are capable of containing the waste without impacting groundwater quality. However, based on past experiences, we have to acknowledge that these are not passive containment systems. Over time, these systems tend to degrade and natural or manmade events can cause them to fail. A significant level of maintenance is needed to ensure that the containment systems continue to function properly. This level of maintenance will diminish if the facility ceases to operate and/or upon closure, but will not disappear completely. Containment system monitoring needs to be a key component for the post-closure period and some level of continue maintenance will always be necessary.

Experience with older generation disposal sites and the modern alternatives available today has shown that disposal sites will require ongoing monitoring and maintenance and possible remedial actions when determined necessary to protect the public health and the groundwater resources as long as the waste materials remain a threat to public health and the environment

Another important point is that the data collected is not enough to support what the computer models are currently showing. We only have data for the last 40 to 50 years and we are extrapolating data to show us scenarios that are 10,000 years in the future. The landscape will for sure be completely different and climate change will have a big impact on how the different alternatives will hold up. For now, only time will tell us what to expect.

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