SECTION 8
PERFORMANCE ASSESSMENT

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8.0 PERFORMANCE ASSESSMENT

8.1 Compliance with Performance Objectives

In developing the performance assessment section, the applicant is referred to the following U.S. Nuclear Regulatory Commission guidance documents: (1) NUREG-1200, "Standard Review Plan for the Review of a License Application for Low-Level Radioactive Waste Disposal Facility," January 1991; (2) NUREG-1573, "A Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities," October 2000; and (3) NUREG-1199, "Standard Format and Content of a license application for a Low-Level Radioactive Waste Disposal Facility," January 1991.

8.1.1 Meeting Performance Objectives

In meeting the performance objectives in 30 TAC §336.724 (relating to Protection of the General Population from Releases of Radioactivity), 30 TAC §336.725 (relating to Protection of Individuals from Inadvertent Intrusion), 30 TAC §336.726 (relating to Protection of Individuals during Operations), and 30 TAC §336.727 (relating to Stability of the Disposal Site after Closure), the applicant shall provide the following information:

(1) data used for demonstrating compliance with performance objectives;

(2) how data was collected;

(3) development of conceptual model(s);

(4) defining scenarios and pathways;

(5) selection of appropriate mathematical model(s) and code(s);

(6) calibration of the model(s)/code(s) and the data output from execution of the code(s);

(7) sensitivity and uncertainty analyses; and

(8) a determination of site adequacy in meeting the performance objectives.

The information and analyses provided in this License Application (LA) demonstrate that the facility satisfies the performance objectives in 30 TAC §336.724 through 727. These items are addressed as Principal Design Criteria in Section 3.1.2. This application includes all of the information recommended in the Texas Commission on Environmental Quality (TCEQ) Application Guidance and follows the recommendations of the TCEQ Guidance Document on Performance Assessment (TCEQ 2004). The performance assessment demonstrates compliance with dose limits for workers and members of the public.

Data Used for Demonstrating Compliance with Performance Objectives – The dose calculations rely on site characteristics, such as meteorology, geology, and hydrology data, which are found in Section 2.0. Design data for the facility, contained in Section 3.0, were used to represent the facility in the computer modeling. The performance assessment also used waste inventory information which is described in Section 8.2.

How Data were Collected – The collection of site data for the performance assessment input is described in Section 2.0. Data were collected as part of site geological investigations, ecological studies, the annual groundwater monitoring program, and the radiological environmental monitoring program (REMP). Meteorological data were collected from weather stations onsite and in nearby communities.

Development of the Conceptual Model – The hydrologic conceptual model for the Site is described in Section 2.5.8, and is consistent with the simplified cross section shown in Figure 8.1-1. The top 30 to 50 feet of material at the Site is alluvial material referred to as the Ogallala, Antlers, Gatuna (OAG) formation. Beneath it is a low-permeability clay formation known as the red beds, which extends to a depth of over 1,000 feet. The red beds contain interbeds of sandstone at various depths. The shallowest interbeds occur at depths of about 80, 125, and 180 feet. The sandstone layer at 125 feet is likely continuous across the WCS Site, but is unsaturated. The uppermost fully saturated sandstone layer is about 10 to 30 feet thick and is found at a depth of about 225 feet. The first usable aquifer is the lower Dockum aquifer, consisting of the Trujillo formation, at a depth of 600 feet, and the Santa Rosa formation at a depth of about 1,100 feet.

Waste disposal will be entirely within the red beds. After the disposal units are filled with waste, a low-permeability cover of red bed material will be constructed over the waste at the approximate elevation of the top of the red beds. The remainder of the excavation will be closed, from the bottom up, with clay fill material, a shotcrete barrier, a compacted clay [performance layer, a lateral sand drain layer extending horizontally to the OAG formation, additional clay fill material, a rock layer for erosion and bio-intrusion protection and a vegetated soil layer as shown in Figure 8.1-2. The conceptual model for radionuclide migration through the subsurface is discussed in the site conceptual model summarized in Section 8.3.2 and presented in more detail in Section 2.5.8. The conceptual model summarizes the features of the Site and the design that are important for determining its operational features and long-term performance, and for demonstrating compliance with the dose criteria for workers and members of the public.

Defining Scenarios and Pathways – Exposure scenarios and environmental pathways used in the dose calculations are given in Section 8.3. Appropriate scenarios and pathways are selected based on the site geology, hydrology, demography, design, and disposal site characteristics. The Texas regulations in 30 TAC §336.709 require that several environmental pathways be analyzed. The required pathways are air, soil, groundwater, surface water, plant uptake, and exhumation by burrowing animals. All of these pathways are included in the performance assessment. From the initial group of pathways, a site-specific list of pathways for the facility was developed, taking into account the site characteristics.

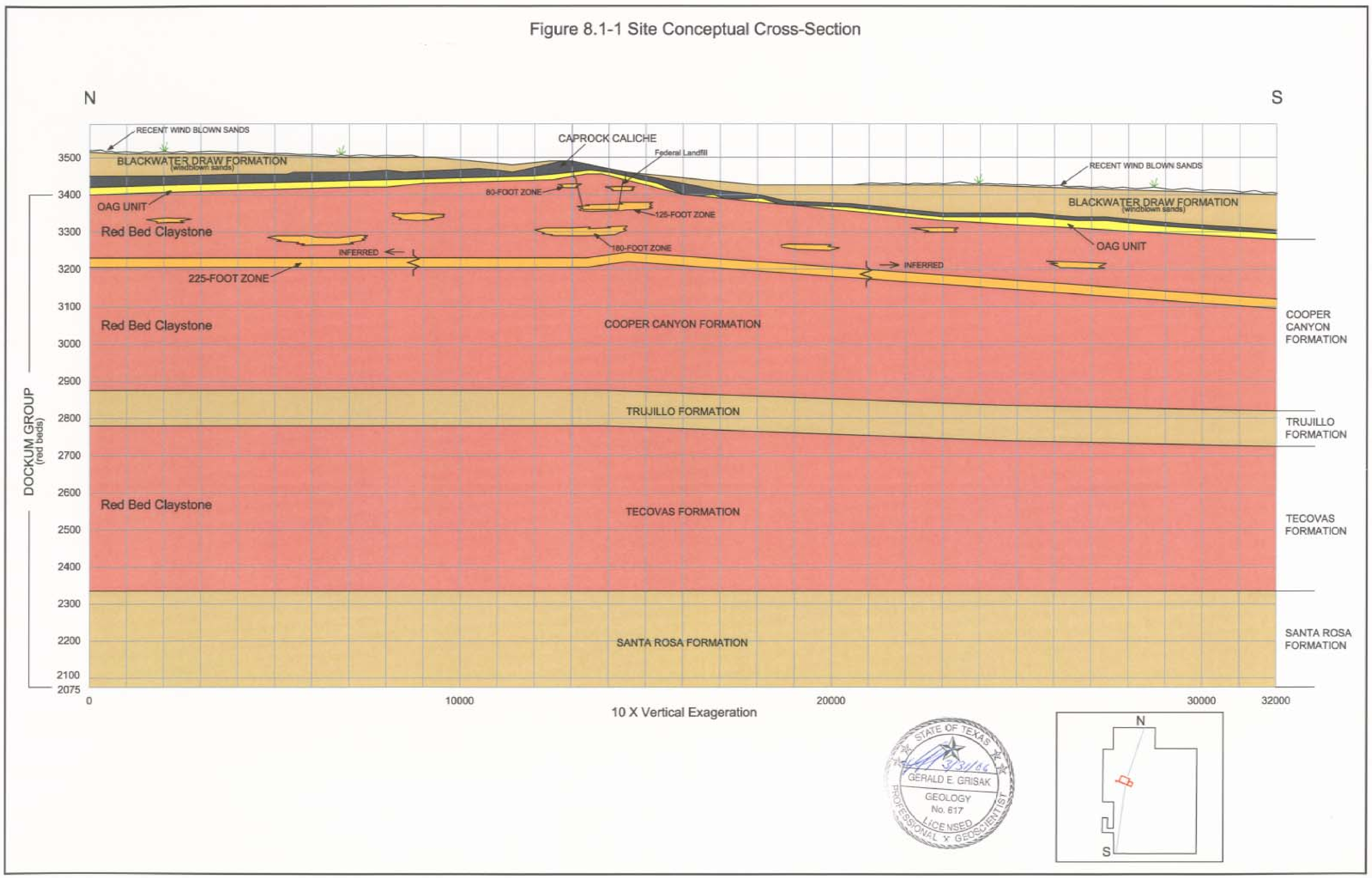


Figure 8.1-1. Site Conceptual Cross-Section

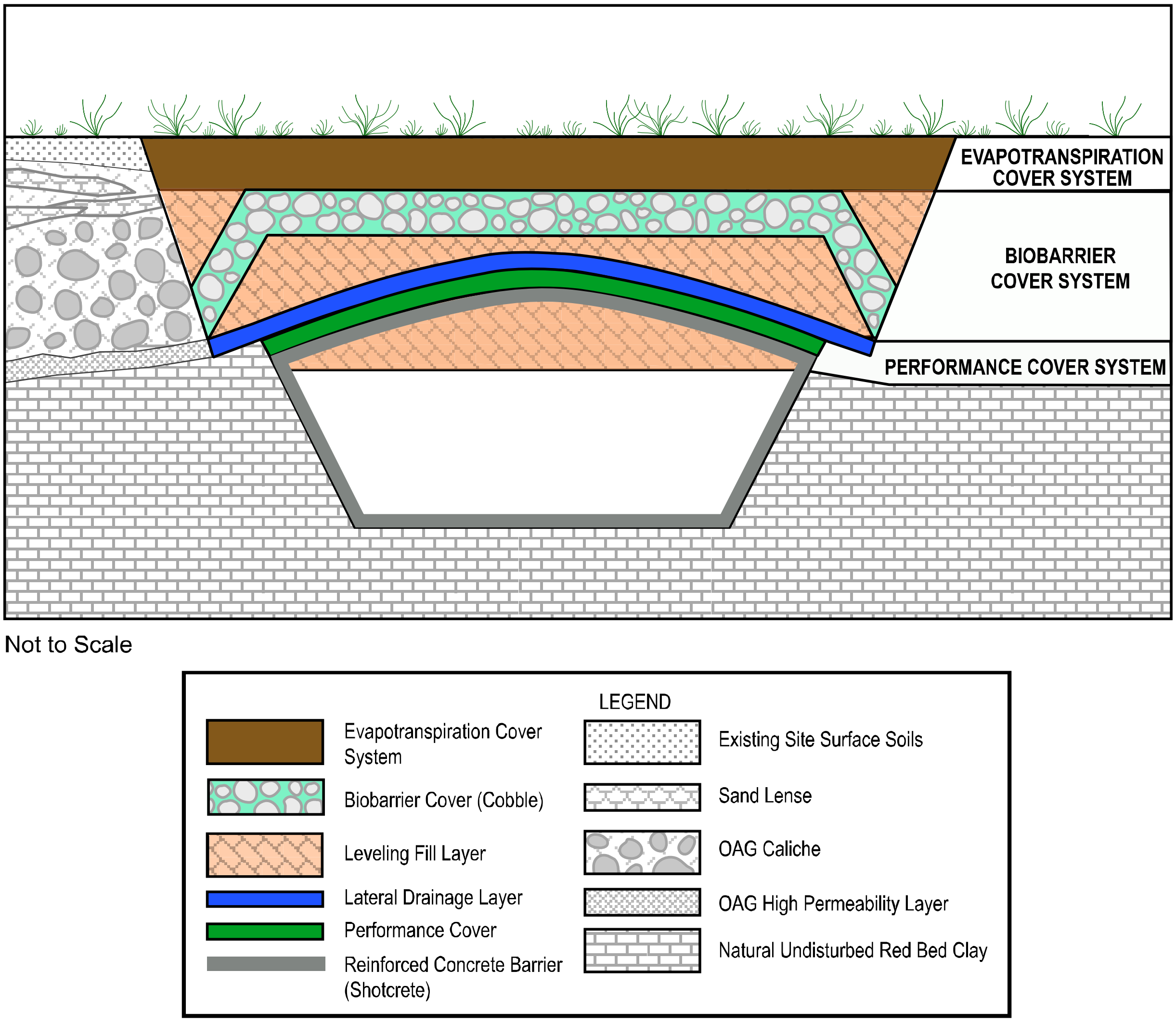


Figure 8.1-2. Disposal Unit Cross-Section

Selection of Appropriate Mathematical Models and Codes – Section 8.3 describes the selection of the mathematical models and computer codes used to determine compliance with the performance objectives. Computer codes were selected based on their capabilities to simulate the environmental pathways and exposure scenarios selected for the performance assessment. Computer codes were used to simulate water infiltration, erosion, radionuclide release and transport, human uptake of radionuclides, and external radiation exposure. Specific computer codes include the following:

- Hydrologic Evaluation of Landfill Performance (HELP) Version 3.07
- Soil Water Assessment Tool (SWAT 2000)
- MicroShield® Version 5
- Residual Radiation (RESRAD) Version 6.3

<u>Calibration of the Model(s)/Code(s) and the Data Output from Execution of the Code(s)</u> – Model calibration is the process of adjusting computer code input values so that the output matches current observed conditions at the Site. Calibration is usually required for complex multidimensional groundwater models. Calibration involves the adjustment of input values such as water table elevations, head values, hydraulic conductivity, boundary conditions, and leakage and storage factors. A successful model calibration brings the model calculations into agreement with observed groundwater conditions at the Site. After calibration, the model is used for predictive calculations of future conditions at the Site. Calibration is a means of increasing confidence in the model's predictions of future conditions.

Model calibration, in the sense it is used to calibrate complex groundwater models, is not necessary for the relatively simple computer models used in the performance assessment. The performance assessment documented in this section does not use any models that require calibration. However, the models were provided input parameter values that accurately reflect the current and expected conditions at the Site during and after disposal operations.

All input and output data from calculations and computer models are provided in the appendices to Section 8.0. Outputs are provided for all calculations, including spreadsheets, computer model outputs, and hand calculations.

<u>Sensitivity and Uncertainty Analyses</u> – As part of the computer calculations, sensitivity and uncertainty analyses were performed. The sensitivity analyses identified parameters whose variations had the greatest influence on the calculated results. These sensitive parameters were varied to quantify their potential effects on the outcome of the performance calculations.

The uncertainty analysis is discussed with the performance calculations in Section 8.3. The uncertainty analysis evaluates two general types of uncertainty: model uncertainty and parameter uncertainty. In addition to a discussion of model uncertainty, the sensitivity and uncertainty analysis includes deterministic calculations in which key parameter values are varied and a Monte Carlo uncertainty analysis.

<u>Determination of the Performance Objectives</u> – A wide range of site data was collected and analyzed to conclusively demonstrate that all regulatory performance objectives will be met. Radiation exposure to workers, the public, and intruders will below all applicable regulatory limits. The site characteristics, facility design, and operation will be protective of the surficial environment and groundwater.

Based on the results of the performance assessment, the Site meets the performance objectives of 30 TAC §336.724 through 727. The calculations and conclusions are documented in Sections 8.3, 8.4, and 8.5 and their associated appendices. Section 8.3 presents the performance assessment results and describes the scenarios and pathways analyzed. The pathway analysis demonstrates that doses to members of the public are within the limits specified in 30 TAC §336.724. The facility provides sufficient inadvertent intruder protection to satisfy the requirements of 30 TAC §336.725. Inadvertent intruder protection is ensured by the depth of waste burial and is supported by the dose analyses of intruder exposure pathways. Protection of individuals during operations is demonstrated, as required by 30 TAC §336.726, by the pathway analysis, the worker dose analysis, and the accident analysis, all of which are described in Section 8.3. The long-term site stability requirement of 30 TAC §336.727 is satisfied by the design features of the facility (e.g., concrete-in-concrete disposal), the site characteristics, and by the operational procedures for backfilling voids and minimizing the potential for settlement and subsidence. This and other aspects of long-term stability, such as erosion, are discussed in Section 8.4.

8.1.2 Other Activities/Facilities

Other Activities/Facilities – Demonstrate that the disposal site shall not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives of 30 TAC §336.723 or significantly mask the environmental monitoring program. If activities involving radioactive material were previously performed on the site, evaluate the contribution of those activities that may impact the ability of the site to meet performance objectives. [30 TAC §336.728(k)]

Other Facilities Considered – There are five non-WCS facilities and two WCS facilities within three miles of the proposed CWF and FWF. None of the facilities will affect the ability of the CWF or FWF to satisfy the performance objectives or mask their environmental monitoring systems. The nearby facilities include:

- Wallach Quarry
- Lea County Landfill
- Sundance, Inc.
- DD Landfarm
- National Enrichment Facility
- WCS RCRA landfill
- WCS 11e(2) byproduct material disposal facility

The Wallach Quarry is located about one mile west of the WCS property. The quarry produces crushed stone, sand, and gravel. No radioactive materials are handled at the facility. Because of the absence of radioactive materials, the quarry will have no impact on the ability of the proposed WCS facilities to meet the performance objectives. For the same reason the quarry will have no capacity to mask the environmental monitoring systems at the proposed facilities.

The Lea County (New Mexico) Landfill is located about one mile southwest of the WCS property. The landfill does not handle or dispose of radioactive materials. Because of the absence of radioactive materials, the landfill will not affect the ability of the proposed WCS facilities to meet the performance objectives nor will it mask the environmental monitoring systems.

Sundance, located about one mile west of the WCS property, is involved in oil recovery and solids disposal. The DD Landfarm is located about 2.5 miles west of the WCS facility and handles oil production wastes. Sundance and DD Landfarm may handle quantities of radioactively contaminated materials from oil production. If any airborne radionuclides were released from these facilities, the concentrations would be reduced by at least a factor of 150 before reaching the WCS property (see "Compliance with Dose Limits and Performance Objectives"). Because of their distance from the WCS property (at least one mile), these facilities will not mask the environmental monitoring systems and they will have no effect on the ability of the WCS facilities to meet the performance objectives.

The National Enrichment Facility, currently under construction, is located within one-half mile of the proposed WCS disposal facilities. The facility will operate gas centrifuges for the enrichment of uranium hexafluoride. Routine operation of the NEF is expected to result in minimal emissions to air, and chemical and radiological consequences from potential accident scenarios have been mitigated to levels that are below an intermediate consequence as defined in 10 CFR 70.61. All liquid effluents from the enrichment processes at the NEF will be treated to meet regulatory limits and discharged to a double-lined impoundment for evaporation (NEF 2004). The WCS radiological environmental monitoring system (Appendix 2.10.1-2, Addendum 1) includes a proposed air monitoring station to be located on WCS property in New Mexico, approximately ¼ mile west of the FWF and ¼ mile east of the NEF facility, which will allow identification of potential airborne releases from the NEF at the WCS LLRW disposal facility. Therefore, the facility will not affect the environmental monitoring systems or the ability of the WCS disposal facilities to meet the performance objectives.

The WCS property encompasses two other disposal facilities in addition to the proposed CWF and FWF. These are the existing RCRA landfill and the proposed 11e(2) byproduct material facility. The RCRA disposal facility is located immediately southwest of the proposed FWF. It has accepted radionuclides at levels determined to be exempt from regulation as radioactive waste. The proposed 11e(2) byproduct material facility, which has a license application under review, would be located northwest of the FWF and would accept primarily soil-like materials containing natural radionuclides from the mining and milling of uranium and thorium ore. With regard to radioactive materials, there may be as many as four separate disposal facilities operating simultaneously on the WCS property. These are the CWF, the FWF, the RCRA facility, and the 11e(2) facility. All four must be considered when demonstrating that the dose limits stated in the performance objectives will be met.

The CWF will not be a source of dust emissions because all waste disposed in the CWF will be in canisters. In the distant future, the CWF will be a potential source of groundwater contamination. The groundwater will be monitored during operations and after closure.

The FWF will accept waste in canisters as well as bulk. The bulk waste will be a potential dust source, especially during unloading and waste placement in the FWF-NCDU. Canister waste will be disposed in the FWF-CDU and will not be a source of dust emissions. The FWF will also be a potential source of groundwater contamination in the distant future and will be monitored.

The RCRA disposal unit may accept and dispose exempt quantities of radioactive materials. The regulations allow disposal of exempt quantities of H-3, C-14, and I-125 in certain wastets (30 TAC 336.225). The RCRA disposal permit also authorizes the disposal of natural radionuclides of the uranium and thorium series. The RCRA facility may dispose of source material containing less than 0.05% thorium or uranium, rare earth ores and mixtures containing less than 0.25% thorium or uranium, and NORM waste containing less than 30 pCi/gm technologically enhanced radium or 150 pCi/gm of all other NORM isotopes. The radionuclides in the RCRA waste are a potential source of airborne and groundwater contamination.

A radionuclide inventory was developed for the RCRA facility based on the approved exempt materials disposed to date in the facility. The exempt radioactive materials disposed in the RCRA facility include:

- Radium at concentrations below 30 pCi/g
- Thorium and uranium at concentrations less than 0.05% by weight
- Depleted uranium
- Magnesium-thorium alloys
- Smoke detectors containing Am-241
- 20,000 curies of H-3 watch dials and faces
- Arc furnace dust contaminated with Cs-137 and Am-241

About half of the wastes disposed in the RCRA facility contain exempt radioactive materials. No scintillation media have been disposed in the facility. Based on past waste disposal, a conservatively high radionuclide inventory was developed for the entire RCRA facility at closure. The following conservative assumptions were used to estimate the inventory:

- The RCRA cell volume is 900,000 cubic yards.
- One half of the RCRA cell volume contains waste with exempt radioactive materials.
- All of the exempt material contains thorium-232 at the license limit of 0.05%.
- All of the exempt material contains uranium-238 at the license limit of 0.05%.
- All of the exempt material contains radium-226 at the license limit of 30 pCi/g.
- Smoke detectors, each containing 1 microcurie of americium-241 and weighing 200 grams, comprise 1% of the exempt material volume.
- The total H-3 inventory, which is contained in watch dials, is 20,000 curies.
- One curie of Cs-137 was included to represent contaminated arc furnace dust.

The resulting inventory for the RCRA facility is shown in Table 8.1.2-1. This inventory was used to model the potential radiological impacts from the RCRA facility.

Table 8.1.2-1. Estimated Inventory for RCRA Facility

Nuclide	Average Concentration in Facility (pCi/g)	Total Inventory (Ci)[a]
H-3	18,000	20,000
Cs-137	0.9	1
Ra-226 + decay products	15	17
Th-232 + decay products	28	30
U-238 + decay products	84	92
Am-241	25	28

(a) Based on facility volume of 900,000 cy and waste density of 1.6 g/cm3.

The 11e(2) disposal unit, which has an application now under review, will accept byproduct material from uranium and thorium mining and milling. Most of the waste will be disposed in bulk and will be a potential source of atmospheric emissions during disposal operations and a potential source of groundwater contamination for the long term. The inventory for the 11e(2) facility is shown in Table 8.1.2-2. The inventory is a maximum inventory based on the radionuclide concentrations in the Fernald silos, which are the highest known concentrations in this category of waste. These concentrations were used for the modeling in the 11e(2) application, even though the actual average concentrations to be disposed at the facility will be much lower.

Table 8.1.2-2. Estimated Inventory for 11e(2) Facility

Nuclide	Maximum Concentration (pCi/g)	Total Inventory (Ci)[(a)]
Ac-227	7,670	9,090
Pb-210	84,660	100,000
Po-210	84,660	100,000
Pa-231	4,041	4,790
Ra-224	128	152
Ra-226	84,660	100,000
Ra-228	128	152
Th-228	128	152
Th-230	12,560	14,900
Th-232	128	152
U-234	85.34	101
U-235	3.901	4.62
U-238	85.34	101

(a) Based on waste volume of 968,000 cy and waste density of 1.6 g/cm3.

The maximum credible radionuclide concentrations for the RCRA and 11e(2) facilities were used as input for RESRAD simulations to calculate the potential doses from these facilities. RESRAD was used to evaluate the groundwater pathway to the 225-foot zone, consistent with the performance assessment methodology described in Section 8.3 (pathway G3). The RESRAD site and environmental transport data were the same as the data used for the FWF and CWF performance assessments. The radionuclide concentrations were as shown in Tables 8.1.2-1 and 8.1.2-2, and the facility parameters were as shown in Table 8.1.2-3. The RESRAD simulations for the RCRA and 11e(2) facilities showed that there were no groundwater doses from either facility for the first 10,000 years, despite the highly overestimated radionuclide concentrations. Additional simulations for a 100,000-year time frame also showed no doses from either facility, because transport velocities in the subsurface are so slow that radionuclides cannot migrate a significant distance from the disposal cells. The RESRAD results are shown in Table 8.1.2-4.

Table 8.1.2-3. RESRAD Input Data for RCRA and 11e(2) Facilities

RESRAD Input Parameter[(a)]	RCRA Facility	11e(2) Facility
Waste disposal area (m^2)	46,400	90,000
Waste thickness (m)	15	8.23
Waste length parallel to aquifer (m)	215	300
Cover thickness (m)	5	9.1
Vertical distance from waste to aquifer (m)	54	51

(a) All other input parameters, except nuclide concentrations, are the same as for the FWF-NCDU.

An additional RESRAD simulation was conducted for a hypothetical scenario in which all of the RCRA waste and 11e(2) waste was disposed with the Federal waste in the FWF-NCDU. The FWF-NCDU is a deeper excavation than the RCRA or 11e(2) facilities, which places the disposed wastes closer to the 225-foot saturated zone. This simulation similarly showed no doses for the first 10,000 years. For the extended time frame of 100,000 years, the maximum dose was 3.4 mrem/yr at year 36,400. This is the same as the dose calculated for the FWF-NCDU waste alone. Therefore, in this hypothetical scenario, the RCRA and 11e(2) wastes have no net effect on the ability to meet the facility performance objectives. This also demonstrates that the RCRA and 11e(2) facilities have radionuclide containment capabilities similar to the FWF.

These results show that the performance objectives will be met for the expected scenario in which the RCRA, the 11e(2), the CWF, and the FWF (CDU and NCDU) operate simultaneously. The results also show that the performance objectives will be met for the hypothetical scenario in which all of the RCRA and 11e(2) waste is disposed in the FWF-NCDU. In either case, the RCRA and 11e(2) facilities do not adversely affect the ability to meet the performance objectives.

Table 8.1.2-4. RESRAD Results for RCRA and 11e(2) Facilities

Facility	Maximum Dose 10,000-yr simulation (mrem/yr)	Maximum dose 100,000-yr simulation (mrem/yr)
RCRA	0	0
11e(2)	0	0
Composite – RCRA & 11e(2) waste in FWF-NCDU	0	3.4

<u>Applicable Regulations</u> – Regulations for radioactive waste disposal impose limits on the dose to a member of the public. One of the long-term performance objectives states that effluents leaving the disposal site should not cause a dose that exceeds 25 mrem/yr to any member of the public. This includes releases through air, groundwater, surface water, soil, plant root intrusion, and burrowing animals. During disposal operations, the total effective dose equivalent to a member of the public must not exceed 100 mrem/yr (30 TAC 336.313(a)). The 25 mrem/yr dose limit is used for a member of the public during operations. A dose to an off-site individual through the air pathway should generally not exceed 10 mrem/yr.

In the case of the WCS facilities, as many as four different waste disposal facilities may be operating simultaneously (RCRA, 11e(2), CWF, and FWF (CDU and NCDU). The operational dose limits and the long-term performance objective apply to all facilities and potential sources at the WCS Site. For example, if four separate waste disposal facilities are operating, the combined dose from all four must satisfy the regulatory dose limits and the long term performance objectives. In order to show compliance with the dose limits and performance objectives, an aggregate dose must be computed that considers all potential sources of radionuclides.

In addition to the dose-based performance criteria, regulations also require that the facilities' environmental monitoring systems be able to detect radionuclide releases. In the case of multiple disposal facilities, the monitoring system for each facility must be capable of detecting releases without being masked by releases from other nearby facilities. That is, the monitoring system must be able to distinguish the source of any radionuclide releases.

In summary, there are two criteria to consider when licensing multiple facilities in the same general area:

- The same performance objectives and dose limits that apply to a single facility also apply to multiple facilities.
- Each facility's environmental monitoring system must be capable of detecting radionuclide releases without being masked by releases from adjacent facilities.

Compliance with Dose Limits and Performance Objectives – During operations, the dose limit to a member of the public is 100 mrem/yr total effective dose equivalent (30 TAC 336.313(a)). After closure, the Compact and Federal facilities are each subject to a 25-mrem/yr dose limit to a member of the public from radionuclides released from the disposal facility. The 25 mrem/yr limit is used in this assessment for members of the public during normal operations and after closure. These dose limits must consider the doses from other adjacent facilities whenever it is possible for the doses from multiple facilities to combine in such a way as to produce a higher dose than would result from each facility alone. The regulations in 30 TAC 336.728(k) require the performance assessment to consider all other waste disposal activities at or near the WCS Site that may impact the ability to meet the performance objectives.

For the groundwater pathway, there is no connection between the WCS facilities and the non-WCS facilities discussed at the beginning of Section 8.1.2. The groundwater doses from adjacent facilities cannot combine to produce a higher dose than that from a single facility. For the WCS facilities, the groundwater flow velocity in the 225-foot zone is only 0.007 ft/yr (see Appendix 8.0-6, Section 8.0-6.10). Groundwater contamination plumes from multiple facilities, if present, would have to travel tens or hundreds of feet to combine, which, at a velocity of 0.007 ft/yr, will not occur, even in a 10,000-year time frame. In addition, even if multiple groundwater plumes were to combine in the far-distant future, the radionuclide concentrations in the combined plume would not exceed the concentration of the highest contributing individual plume. In other words, the groundwater plume concentrations are not additive when mixed. Therefore, the groundwater pathway doses will never increase above the maximum dose from an individual facility. If the groundwater pathway doses from each individual facility meet the performance objective, then the dose from multiple facilities will also meet the performance objective.

For the intruder scenario, a basic assumption is that only one facility is intruded upon. The intruder is not assumed to disturb multiple waste facilities sequentially. Therefore, the inadvertent intruder doses have no additive effects among multiple facilities.

The only other significant dose pathway is atmospheric transport of dust. At the site boundary it is conceivable that a dose could be the result of dust emissions from multiple facilities. For example, under the conditions of a prevailing southerly wind, a location at the northern site boundary could potentially be affected by dust emissions from the RCRA facility, the 11e(2) facility, and the FWF-NCDU. There will be no contaminated dust emissions from the canister waste facilities (CWF and FWF-CDU).

The atmospheric pathway doses are limited by the 25 mrem/yr performance objective, but other regulations may also apply. An air pathway dose limit of 10 mrem/yr is commonly applied to facilities based on the EPA NESHAP rules for radionuclides. No air pathway doses are expected from the Compact facility because all of the waste will be in canisters.

Airborne emissions from present or future portions of the RCRA facility are expected to be negligible because of the very low concentrations. The maximum radionuclide concentrations allowed in the RCRA facility are shown in Table 8.1.2-1. None of the radionuclide concentrations exceed ten percent of the Class A concentration limits. Therefore, the dose-based performance objectives will not be significantly affected by the RCRA facility.

No airborne emissions are expected from the 11e(2) facility because of dust control practices that will be in effect. The disposal cells are below natural grade and dust control measures will prevent airborne releases of radionuclides. Under these conditions, the attainment of the performance objectives will be unaffected by waste disposed in the 11e(2) facility.

The FWF-NCDU is a potential source of airborne emissions. Dust emissions were evaluated in the performance assessment in Section 8.3. The FWF-NCDU meets all of the performance objectives.

Environmental Monitoring – The vicinity of the CWF and FWF will be monitored for direct radiation and for radioactivity in groundwater, surface water, air, soil, plants, and animals. Sampling locations will be selected to allow the monitoring systems to determine the source of any radionuclides.

The groundwater monitoring system can easily determine the source of radionuclides detected in groundwater samples. The groundwater in the 225-foot zone will be monitored from wells located at the down-gradient edges of the various disposal cells. The flow velocity in the 225-foot zone is approximately 0.007 ft/yr to the south or southwest, so elevated readings in a particular well can be attributed to the nearest upgradient waste cell, rather than waste cells that are cross-gradient from the monitor well. The extremely low flow velocity will prevent commingling of radionuclides released from different disposal facilities.

Surface water from inside the disposal cells will be monitored when it is present. Since the disposal cells are below grade, any surface water that collects in a disposal cell will not be affected by radioactivity from any other nearby disposal facility.

The atmospheric monitoring system is designed to detect radionuclide releases from a particular facility. Perimeter sampling locations will detect radionuclides primarily from the nearest disposal facility. Atmospheric dispersion will reduce the concentrations of radionuclides from other facilities further upwind.

Two of the non-WCS facilities mentioned at the beginning of Section 8.1.2 are possible sources of airborne radionuclide emissions. Sundance and DD Landfarm may handle radioactive waste from oil production. Sundance is one mile west of the WCS property and DD Landfarm is 2.5 miles west. Radionuclide concentrations in waste at these facilities, if present, should not exceed the concentrations allowed at the FWF or RCRA facilities. Any airborne radionuclide releases from Sundance or DD Landfarm would be highly dispersed in the atmosphere before reaching the WCS property. The average annual wind frequency from the west is only 3 percent. The atmospheric dispersion parameter (X/Q), calculated using the conservative methodology of Appendix 8.0-6 (Section 8.0-6.1), yields values of 1.4E-5 s/m^3 and 9.4E-8 s/m^3, at distances of 100 meters and one mile, respectively. Thus, airborne dust transport for one mile reduces the concentration by at least 150 times (1.4E-5 / 9.4E-8). Therefore, any airborne releases from Sundance or DD Landfarm would be greatly reduced before reaching the WCS Site and would not mask air emissions from WCS facilities.

The predominant wind direction at the Site is from the south. When a southerly wind is blowing, an array of air samplers along the north sides of the CWF, FWF, and the 11e(2) facility will easily distinguish the source of any emissions. When the wind is blowing in other directions, air samplers at the perimeters of the facilities will detect radionuclides primarily from the immediately adjacent facility. While some mixing and cross-contamination may occur, the particular suite of radionuclides detected in the air samples will help determine their origin. Air monitors will be placed between facilities to allow sources of releases to be identified and to eliminate masking. Monitoring will also be able to distinguish releases from the treatment and storage facility.

Direct radiation will be monitored by TLDs placed in the disposal cells of each facility. The TLDs in the disposal cells will be below grade and will be unaffected by radiation from other nearby facilities. Additional TLDs will be placed at grade level on the fence at the disposal site boundaries to monitor external radiation levels. The external radiation monitoring systems in each facility will therefore not be masked by radiation from other facilities.

Monitoring of soil, plants, and animals near the disposal facilities will be less indicative of the source of the contamination. However, any radionuclides detected in the soil, plants, or animals are most likely to be detected nearest the facility from which they were released. Soil samples will be taken between facilities to minimize masking and help determine the source of any releases. Radionuclide analysis will likely indicate the source of the release by the suite of radionuclides present.

In summary, the environmental monitoring system will be capable of determining the sources of any radionuclide releases, both during operations and after closure. Any releases from the CWF, the FWF-CDU, or the FWF-NCDU will not be masked by releases from each another or from the RCRA or 11e(2) facilities.

8.2 Source Term

8.2.1 Types, Forms, and Quantities of Radioactive Waste

Describe the types, chemical and physical forms, quantities, classification, and specifications of the radioactive material proposed to be received, possessed, processed, and disposed of at the land disposal facility. Provide sufficient information about the wastes projected to be disposed of at the disposal site to allow for defendable modeling of potential radiological impacts associated with waste disposal. This description shall include any prior disposal containing radioactive material at the site. This description shall include performance criteria for form and packaging of the waste or radioactive material that has been previously received and will be received. [30 TAC §336.707(b), 305.45(a)(8)(B)(ii)] & [THSC §401.112(a)(8)]

The CWF will accept only low-level radioactive waste (LLRW) generated in the member states of the Texas Compact. The waste generators include nuclear electric utilities, industrial facilities, universities, hospitals, and the military. All of the LLRW accepted for disposal must be classified as Class A, B, or C according to the classification system in 30 TAC §336.362(a). The LLRW is characterized in terms of waste streams specific to each type of waste generator. Each waste stream is quantified and described in terms of the volume generated, its physical and chemical characteristics, and the individual radionuclide and chemical concentrations in the waste stream. The volumes of all waste streams are summed to estimate the total volume of waste for the CWF. The volumes and radionuclide concentrations of each waste stream are multiplied to calculate the total inventory of each radionuclide to be disposed. The individual radionuclide inventories are used in the long-term performance assessment calculations to verify compliance with the performance objectives in 30 TAC §336.724 through 336.727. The radionuclide inventory for the CWF is presented in detail in Appendix 8.0-1, “Texas Compact Inventory.” Summary information on the waste is presented below in Section 8.2.2.

The same methodology is used to determine the FWFCDU and FWF-NCDU inventories. Both the FWF-CDU and FWF NCDU will accept LLRW and mixed LLRW from U.S. Department of Energy (DOE) facilities across the country. Mixed LLRW is LLRW that contains hazardous listed chemicals or exhibits hazardous characteristics. Individual waste streams are characterized and combined to estimate the total inventory by radionuclide. The radionuclide inventory is used in the performance assessment calculations to demonstrate compliance with the performance objectives. The FWF-CDU and FWF-NCDU inventories are presented in detail in Appendix 8.0-2, “Federal Facility Inventory.” Summary information on the waste is presented in Section 8.2.2.

8.2.2 Waste During Operational Life

The following information on waste characteristics should be provided:

(1) A discussion of the potential for receipt of Compact and non-Compact waste, as well as the conditions for such waste receipt.

(2) An identification of the major individual waste streams that constitute the majority of the waste volume and activity.

(3) An identification of the waste streams that constitute the remaining waste volume and activity. These waste streams may be identified in terms of typical waste streams generated by a number of generators (e.g., a waste stream consisting of low-activity waste generated by hospitals).

(4) Information on the physical, chemical, and radiological characteristics of each waste stream so identified in items 2 and 3 above. This information should include:

(a) annual volumes,

(b) waste class,

(c) average concentrations of the principal radionuclides constituting the waste stream,

(d) the chemical and physical form,

(e) the presence of chelating agents,

(f) packaging characteristics (e.g., whether the waste will be disposed in a high-integrity container), and

(g) solidification agent. Descriptions of the chemical and physical form should provide information important to an estimation of release rates (e.g., whether the waste stream consists of activated metals, sealed sources, and ion-exchange resins).

(5) For the information discussed above on waste volumes, an estimate of trends, for example, whether the waste stream will be generated at a constant annual rate, or only occasionally. Waste streams only expected to be generated at a future time (e.g., waste streams associated with decommissioning of a nuclear power plant) should be specifically identified.

(6) For major generators, any plans to alter waste generation rates (e.g., in volume reduction, decommissioning plans) over the first 5 years of the operational life of the disposal facility.

(7) A presentation and discussion of any limitations that will be imposed on waste receipt, form, packaging, or other characteristics that would influence assessments of disposal facility performance. Such limitations could potentially include limitations on total site inventories of radionuclides of concern (e.g., C-14, H-3, Tc-99, or I-129), or requirements on the structural stability of certain Class A wastes. These proposed limitations will be incorporated into the land disposal facility licenses as conditions of operation.

(8) A summary of the total projected waste volume and activity for each year of the operational life.

Conditions of Waste Receipt – The CWF license will only allow the disposal of commercial LLRW from party states to the Texas Compact or LLRW approved by the Texas Low-Level Radioactive Waste Disposal Compact Commission (the Commission). The Commission has the authority to grant exemptions or enter into contracts with other states or allow new states to join the Texas Compact. Waste that is handled through waste brokers or processors must be documented as waste from Texas Compact generators in order to acceptable for disposal. Mixed LLRW will not be accepted at the CWF.

The adjacent FWF is expected to receive waste primarily from U.S. Department of Energy sites. The FWF consists of two separate disposal units. The FWF-CDU will accept Class C, Class B, containerized Class A and unstable Class A wastes. All wastes at the FWF-CDU will be disposed in concrete canisters. The other disposal unit, the FWF-NCDU, will accept Class A waste in bulk form, provided the waste can be compacted to a stable form in the trench. Federal waste is defined in Texas law as waste whose disposal is the responsibility of the Federal government under the Low-Level Radioactive Waste (LLRW) Policy Act. LLRW generated by U.S. Nuclear Regulatory Commission (NRC) licensees is a state disposal responsibility. The FWF license is expected to accept Federal LLRW and mixed LLRW from generators without regard to whether they are in the Texas Compact states. No intermingling or transferring of waste between the CWF and the FWF will be allowed.

Compact Facility Waste Streams – The Texas Compact waste inventory and generators are described in Appendix 8.0-1. The volume and activity were estimated for a 35-year waste disposal period, which encompasses the operational and decommissioning waste from all of the nuclear electric utilities in the Texas Compact, in addition to wastes from non-utility generators. A total of 38 waste streams are identified, with a total waste volume estimated at 102,000 yd^3 (2.8 million ft^3) and a total activity estimated at 4.7 million curies. Individual generators, waste streams, and volumes are described in detail in the Appendix 8.0-1. The appendix also contains summary information of the volumes and activities to be disposed for each year of operation of the CWF, as well as the total inventory, by radionuclide, for the entire waste disposal period. Appendix 8.0-1, Section 2.1, also lists prohibited waste forms for the CWF. Table 8.2-1 summarizes the CWF waste streams. The table shows fewer than 38 waste streams because some similar waste streams were combined. Appendix 8.0-1 gives the full details on all 38 waste streams.

Table 8.2-1. Waste Stream Summary for the CWF

Waste Stream		Class A		Class B		Class C	
		Ft^3	Ci	Ft^3	Ci	Ft^3	Ci
Major Waste Streams							
D&D	Reactor Decommissioning Wastes	1.69E+06	3.31E+04	2.13E+05	9.91E+05	5.10E+03	2.22E+06
NCTRASH	Non-compactible trash	5.83E+05	3.28E+03	2.04E+03	5.10E+02		
Remaining Waste Streams							
ABSLIQD	Absorbed liquids	2.24E+04	5.47E+03				
BIOWAST	Biological waste	9.47E+03	4.82E+01				

Table 8.2-1. Waste Stream Summary for the CWF

Waste Stream		Class A		Class B		Class C	
		Ft^3	Ci	Ft^3	Ci	Ft^3	Ci
CONDFSL	Condensate phase separator filter sludge	3.69E+04	3.84E+02	2.76E+03	1.77E+02		
COTRASH	Compactible trash	8.50E+04	7.38E+02				
DECONRS	Decontamination resins	1.34E+03	1.28E+03				
FLDRFSL	Floor drain filter sludge	3.30E+03	2.11E-01				
FPFILSL	Fuel pool skimmer filter sludge	2.27E+02	2.62E+01			4.58E+02	1.66E+02
HIGHACT	High activity wastes	5.63E+03	3.77E+02				
LOWASTE	Low activity waste	6.16E+03	1.03E+01				
NFRCOMP	Non-fuel reactor components					2.54E+03	1.34E+06
PROCFIL	Process filters					1.93E+04	5.58E+04
RWCUPRS	Reactor water cleanup resins			1.75E+02	6.30E+01		
RWDMRES	Reactor water demineralization resins	1.16E+04	3.19E+03	2.46E+04	3.69E+04		
SOURCES	Sealed radioactive sources	1.07E+04	9.70E+03	2.05E+03	2.34E+03	4.62E+03	2.56E+04
SSYSRES	Secondary system resins	2.39E+04	4.79E-05				
Totals by Class and Activity		**2.49E+06**	**5.76E+04**	**2.44E+05**	**1.03E+06**	**3.20E+04**	**3.64E+06**
Total Cubic Feet for CWF		2.8E+06					
Total Curies for CWF		4.7E+06					

Federal Facility Waste Streams – The FWF inventory is described in Appendix 8.0-2. Separate inventories are given for the FWF-CDU and the FWF-NCDU. The FWF was assumed to have a 35-year operational life. However, the volume and activity projections were based on a 70-year estimate of waste from the DOE complex and the assumption that an accelerated cleanup schedule would be implemented by DOE. The majority of the waste volume was from environmental restoration (ER) activities to be conducted at DOE facilities to clean up formerly used sites, while the remainder is from waste management (WM) activities. The FWF inventory identifies 69 waste streams with a total volume of 2.1 million yd^3 (57 million ft^3, 1.61 million m^3) of waste and a total activity of 16.4 million curies. DOE identifies commercial disposal as the preferred option for the majority of Class A, B, and C wastes. For the some of the wastes, DOE has not yet identified a disposal preference and these wastes are denoted “to be determined,” or TBD. Details of waste generators, waste streams, cleanup locations, and volumes are presented in detail in the Appendix 8.0-2. The appendix also contains summary information of the volumes and activities to be disposed for each year of operation of the FWF-CDU and FWF-NCDU, as well as the total inventories, by radionuclide, for each disposal trench. Appendix 8.0-2, Section 3.0, also lists prohibited waste forms for the Federal facilities. Table 8.2-2 summarizes the FWF waste streams. The table presents groupings of waste streams by class and waste type (i.e., low-level or mixed). Appendix 8.0-2 gives the full details on all 69 waste streams.

The combined capacity of the FWF-CDU and FWF-NCDU is limited by law to no more than 6 million yd^3. The current projected inventory of 2.1 million yd^3 represents the “as disposed” waste volume that arrives at the facility for disposal. Additional volume will be occupied by concrete canisters, grout backfill in canisters, and sand backfill between canisters in the FWF-CDU.

Table 8.2-2. Waste Stream Summary for FWF-CDU and FWF-NCDU

Waste Type	Class A		Class B/C	
	Volume (ft3)	Activity (Ci)	Volume (ft3)	Activity (Ci)
FWF-CDU				
Low-Level	5.74E+06	3.15E+04	1.57E+07	1.46E+07
Mixed	2.64E+06	4.47E+04	2.26E+05	1.80E+06
Total Volume ft3	2.43E+07			
Total Activity (Ci)	1.64E+07			
FWF-NCDU				
Low-Level	3.14E+07	6.84E+03	---	---
Mixed	1.19E+06	6.54E+02	---	---
Total Volume (ft3)	3.26E+07			
Total Activity (Ci)	7.50E+03			

Waste Stream Characteristics – Annual volumes, activities, waste classes, and waste streams for the CWF are presented in Table 8.2-3. The same information for the FWF-CDU and FWF-NCDU is shown in Table 8.2-4. More detailed information on the CWF and FWF waste streams is presented in Appendix 8.0-1 and 8.0-2, respectively. The appendices address the average radionuclide concentrations in the waste, chemical and physical characteristics, sources of the waste, and all waste properties necessary to support the performance assessment modeling.

Chelating agents are expected only in the DECONRS and RWDMRES waste streams. Decontamination and reactor water demineralization resins are used to remove radioactive deposits from the primary coolant systems of reactors. The resins are made of various polymers and are in the form of granules or small beads approximately 1 mm in diameter. The decontamination resins are used periodically to remove radioactive mineral deposits from the primary coolant system of the reactor and, thereby, reduce occupational exposures to workers in the vicinity of the pipes, valves, and pumps that carry the primary coolant. When the primary system is periodically decontaminated, chelating agents (e.g., EDTA or certain organic acids) and other chemicals are circulated through the reactor cooling system and through resins, which trap the chelating agents and other contaminants. Following decontamination, the resins contain the chelating agents and radionuclides from the coolant system. Before disposal, the resins must be dewatered or solidified. The DECONRS Class A waste stream is expected to be generated from 2010 through 2012, while the RWDMRES Class A and B waste streams are expected to be generated from 2010 through 2032. Conservative modeling parameters, such as low K_d values, are used in the performance assessment to account for the presence of chelating agents. The effects of chelating agents are also addressed in the RESRAD sensitivity analysis in Appendix 8.0-6.

All waste (except bulk waste in the FWF-NCDU) must be properly packaged and, for some waste streams, stabilized or solidified by the generators prior to being shipped for disposal.

Packaging and solidification methods must meet the site waste acceptance criteria and TCEQ regulations. Waste streams that will likely need to be stabilized or solidified include resins from nuclear utilities and absorbed liquids from non-utility generators. Waste may contain no more than one percent free liquids. Waste packages that do not meet the acceptance criteria will be deferred and the generator/shipper contacted for further action.

Section 3.0 addresses the details of disposal arrays used in the CWF, FWF-CDU, and FWF-NCDU. Non-bulk wastes will be placed in concrete canisters, grouted inside the canisters, backfilled between canisters and covered with red bed clay. Bulk Class A waste will be compacted in place in the FWF-NCDU and covered with red bed clay.

Table 8.2-3. Annual Volumes and Waste Streams for the CWF

		Non Utility Waste Streams Cubic Feet										Utility Waste Streams Cubic Feet																	
		ABSLIQD	BIOWAST	COTRASH	HIGHACT	LOWASTE	NCTRASH	NCTRASH	SOURCES	SOURCES	SOURCES	CONFDSL	CONFDSL	COTRASH	DECONRS	FLDRFSL	FPFILSL	FPFILSL	NCTRASH	NFRCOMP	PROCFIL	RWCUPRS	RWDMRES	RWDMRES	SSYSRES	D&D	D&D	D&D	Forecast Cubic Feet
Class		A	A	A	A	A	A	B	A	B	C	A	B	A	A	A	A	C	A	C	C	B	A	B	A	A	B	C	
Operational Year	2010	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02	1.2E+04	9.2E+03	1.4E+04	4.5E+02	2.7E+02	7.6E+01	1.5E+02	5.3E+04	8.5E+02	1.8E+03	5.8E+01	1.1E+03	2.2E+03	2.3E+03				9.5E+04
	2011	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02	1.2E+04	9.2E+03	1.4E+04	4.5E+02	2.7E+02	7.6E+01	1.5E+02	5.3E+04	8.5E+02	1.8E+03	5.8E+01	1.1E+03	2.2E+03	2.3E+03				9.5E+04
	2012	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02	1.2E+04	9.2E+03	1.4E+04	4.5E+02	2.7E+02	7.6E+01	1.5E+02	5.3E+04	8.5E+02	1.8E+03	5.8E+01	1.1E+03	2.2E+03	2.3E+03				9.5E+04
	2013	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+03		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03	1.3E+04	9.5E+02	2.2E+02	4.3E+04
	2014	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03	1.3E+04	9.5E+02	2.2E+02	4.3E+04
	2015	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03	1.3E+04	9.5E+02	2.2E+02	4.3E+04
	2016	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03	1.3E+04	9.5E+02	2.2E+02	4.3E+04
	2017	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03	1.3E+04	9.5E+02	2.2E+02	4.3E+04
	2018	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03	1.3E+04	9.5E+02	2.2E+02	4.3E+04
	2019	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03				2.9E+04
	2020	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03				2.9E+04
	2021	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03				2.9E+04
	2022	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03				2.9E+04
	2023	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03				2.9E+04
	2024	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03				2.9E+04
	2025	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03				2.9E+04
	2026	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03				2.9E+04
	2027	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			4.7E+02		1.4E+02			2.0E+04		9.0E+02		4.2E+02	1.1E+03	1.1E+03				2.9E+04
	2028	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			2.4E+02		8.9E+01			7.9E+03		8.8E+01		3.9E+02	2.9E+02		1.7E+05	2.4E+04	2.7E+02	2.1E+05
	2029	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			2.4E+02		8.9E+01			7.9E+03		8.8E+01		3.9E+02	2.9E+02		1.7E+05	2.4E+04	2.7E+02	2.1E+05
	2030	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			2.4E+02		8.9E+01			7.9E+03		8.8E+01		3.9E+02	2.9E+02		1.7E+05	2.4E+04	2.7E+02	2.1E+05
	2031	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			2.4E+02		8.9E+01			7.9E+03		8.8E+01		3.9E+02	2.9E+02		2.2E+05	2.8E+04	4.8E+02	2.6E+05
	2032	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02			2.4E+02		8.9E+01			7.9E+03		8.8E+01		3.9E+02	2.9E+02		2.2E+05	2.8E+04	4.8E+02	2.6E+05
	2033	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02															2.2E+05	2.8E+04	4.8E+02	2.5E+05
	2034	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02															2.2E+05	2.8E+04	4.8E+02	2.5E+05
	2035	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02															4.6E+04	4.1E+03	2.1E+02	5.5E+04
	2036	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02															4.6E+04	4.1E+03	2.1E+02	5.5E+04
	2037	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02															4.6E+04	4.1E+03	2.1E+02	5.5E+04
	2038	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02															4.6E+04	4.1E+03	2.1E+02	5.5E+04
	2039	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02															4.6E+04	4.1E+03	2.1E+02	5.5E+04
	2040	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02																		5.3E+03
	2041	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02																		5.5E+03
	2042	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02																		5.3E+03
	2043	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02																		5.3E+03
	2044	6.4E+02	2.7E+02	9.6E+02	1.6E+02	1.8E+02	2.5E+03	5.8E+01	3.1E+02	5.9E+01	1.3E+02																		5.3E+03
Totals		2.2E+04	9.5E+03	3.3E+04	5.6E+03	6.2E+03	8.8E+04	2.0E+03	1.1E+04	2.0E+03	4.6E+03	3.7E+04	2.8E+03	5.2E+04	1.3E+03	3.3E+03	2.3E+02	4.6E+02	5.0E+05	2.5E+03	1.9E+04	1.8E+02	1.2E+04	2.5E+04	2.4E+04	1.7E+06	2.1E+05	5.1E+03	2.8E+06

Table 8.2-4. Annual Volumes and Waste Streams for the FWF-CDU and FWF-NCDU

Class		FWF-CDU Cubic Feet		FWF-NCDU Cubic Feet	Forecast Cubic Feet
		CLASS A	CLASS B/C	CLASS A	
OPERATIONAL YEAR	**2010**	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2011	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2012	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2013	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2014	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2015	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2016	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2017	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2018	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2019	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2020	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2021	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2022	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2023	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2024	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2025	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2026	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2027	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2028	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2029	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2030	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2031	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2032	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2033	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2034	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2035	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2036	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2037	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2038	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2039	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2040	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2041	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2042	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2043	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	2044	2.40E+05	4.54E+05	9.31E+05	1.63E+06
	Totals	8.41E+06	1.59E+07	3.26E+07	5.69E+07

Waste Trends and Generation – For the CWF, calculations assume that non-utility generators will provide a minority of the waste volume at a constant yearly rate and radionuclide concentration. Utility waste streams are estimated with respect to expected operational lives and anticipated decommissioning periods of the nuclear reactors in the Texas Compact. Tables 8.2-3 and 8.2-5 illustrate the volume and activity changes as utilities operate and proceed through decommissioning.

During the first five years of CWF operation, the Vermont Yankee reactor is expected to cease operations and begin decommissioning. For the years 2010 through 2012, the reactor will operate and produce waste at a constant rate. Decommissioning of Vermont Yankee was assumed to begin in 2013 and continue for six years. The changes in waste streams, volumes, and activities that result from decommissioning are reflected in Tables 8.2-3 and 8.2-5.

For the two FWF facilities, waste volume and activity estimates assume that the entire volume is received at a constant rate over a 35-year period. This is consistent with current Federal government cleanup strategies to accelerate remediation more aggressively than originally planned so that long-term costs are reduced.

Limitations on Waste Composition – The site geology and planned use does not require limitations, in addition to TCEQ regulations, on waste form, receipt, packaging, isotopic concentration, or other characteristics. The performance assessment demonstrates that there is no need to limit the waste volume, activity, or quantities of particular radionuclides in order to meet the performance objectives. The CWF is assumed to accept any LLRW generated in the Texas Compact that is classified as Class A, B, or C. The two FWF facilities are assumed to accept any of the 69 waste streams identified in Appendix 8.0-2, which are taken from DOE's 70-year waste projections (Department of Energy 2000, and 1998). All of the 69 Federal waste streams are acceptable for disposal at the FWF and meet the performance objectives.

Projected Waste Volume and Activity Summary – The total projected waste volume for the CWF is 2.8 million ft^3. Year-by-year breakdowns of volume and activity are presented in Tables 8.2-3 and 8.2-5, respectively. Total activity over the 35-year operational life is estimated at 4.7 million curies.

The total projected waste volume for the FWF-CDU and FWF-NCDU is about 57 million ft^3. Year-by-year breakdowns of volume and activity are presented in Tables 8.2-4 and 8.2-6, respectively. Total activity over the operational life is estimated at 16.4 million curies for the FWF-CDU and FWF-NCDU combined.

For the FWF, calculations assume that the entire 70-year disposal forecast for DOE is received at a constant rate over a 35-year period. Annual volume receipts are forecast at 19,700 m^3/year for the FWF-CDU and 26,400 m^3/yr for the FWF-NCDU. Annual activity receipts are forecast at 470,000 Ci/year for the FWF-CDU and 214 Ci/year for the FWF-NCDU.

Table 8.2-5. Annual Activity and Waste Streams for the CWF

Class		Non Utility Waste Streams Curies										Utility Waste Streams Curies																	Forecast Curies
		ABSLIQD	BIOWAST	COTRASH	HIGHACT	LOWASTE	NCTRASH	NCTRASH	SOURCES	SOURCES	SOURCES	CONDFSL	CONDFSL	COTRASH	DECONRS	FLDRFSL	FPFILSL	FPFILSL	NCTRASH	NFRCOMP	PROCFIL	RWCUPRS	RWDMRES	RWDMRES	SSYSRES	D&D	D&D	D&D	
		A	A	A	A	A	A	B	A	B	C	A	B	A	A	A	A	C	A	C	C	B	A	B	A	A	B	C	
Operational Year	2010	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02	1.3E+02	5.9E+01	6.3E+01	4.3E+02	1.7E-02	8.7E+00	5.5E+01	2.6E+02	4.5E+05	5.2E+03	2.1E+01	2.5E+02	3.3E+03	4.6E-06				4.6E+05
	2011	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02	1.3E+02	5.9E+01	6.3E+01	4.3E+02	1.7E-02	8.7E+00	5.5E+01	2.6E+02	4.5E+05	5.2E+03	2.1E+01	2.5E+02	3.3E+03	4.6E-06				4.6E+05
	2012	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02	1.3E+02	5.9E+01	6.3E+01	4.3E+02	1.7E-02	8.7E+00	5.5E+01	2.6E+02	4.5E+05	5.2E+03	2.1E+01	2.5E+02	3.3E+03	4.6E-06				4.6E+05
	2013	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.5E-06	1.2E+02	2.4E+03	6.8E+04	7.6E+04
	2014	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06		2.4E+03		7.6E+04
	2015	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06		2.4E+03		7.6E+04
	2016	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06	1.2E+02	2.4E+03	6.8E+04	7.6E+04
	2017	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06	1.2E+02	2.4E+03	6.8E+04	7.6E+04
	2018	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06	1.2E+02	2.4E+03	6.8E+04	7.6E+04
	2019	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06				5.8E+03
	2020	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06				5.8E+03
	2021	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06				5.8E+03
	2022	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06				5.8E+03
	2023	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06				5.8E+03
	2024	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06				5.8E+03
	2025	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06				5.8E+03
	2026	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06				5.8E+03
	2027	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			1.7E+00		8.7E-03			1.0E+02		2.6E+03		1.2E+02	1.7E+03	2.3E-06				5.8E+03
	2028	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			8.6E-01		5.7E-03			4.0E+01		2.6E+02		1.1E+02	4.3E+02		3.4E+03	1.1E+05	1.3E+05	2.5E+05
	2029	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			8.6E-01		5.7E-03			4.0E+01		2.6E+02		1.1E+02	4.3E+02		3.4E+03	1.1E+05	1.3E+05	2.5E+05
	2030	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			8.6E-01		5.7E-03			4.0E+01		2.6E+02		1.1E+02	4.3E+02		3.4E+03	1.1E+05	1.3E+05	2.5E+05
	2031	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			8.6E-01		5.7E-03			4.0E+01		2.6E+02		1.1E+02	4.3E+02		4.4E+03	1.3E+05	2.3E+05	3.7E+05
	2032	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02			8.6E-01		5.7E-03			4.0E+01		2.6E+02		1.1E+02	4.3E+02		4.4E+03	1.3E+05	2.3E+05	3.7E+05
	2033	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02															4.4E+03	1.3E+05	2.3E+05	3.7E+05
	2034	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02															4.4E+03	1.3E+05	2.3E+05	3.7E+05
	2035	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02															9.2E+03	1.9E+04	1.0E+05	1.2E+05
	2036	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02															9.2E+02	1.9E+04	1.0E+05	1.2E+05

Table 8.2-5. Annual Activity and Waste Streams for the CWF

Class	Non Utility Waste Streams Curies										Utility Waste Streams Curies																	Forecast Curies
	ABSLIQD	BIOWAST	COTRASH	HIGHACT	LOWASTE	NCTRASH	NCTRASH	SOURCES	SOURCES	SOURCES	CONDFSL	CONDFSL	COTRASH	DECONRS	FLDRFSL	FPFILSL	FPFILSL	NCTRASH	NFRCOMP	PROCFIL	RWCUPRS	RWDMRES	RWDMRES	SSYSRES	D&D	D&D	D&D	
	A	A	A	A	A	A	B	A	B	C	A	B	A	A	A	A	C	A	C	C	B	A	B	A	A	B	C	
2037	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02															9.2E+02	1.9E+04	1.0E+05	1.2E+05
2038	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02															9.2E+02	1.9E+04	1.0E+05	1.2E+05
2039	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02															9.2E+02	1.9E+04	1.0E+05	1.2E+05
2040	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02																		1.3E+03
2041	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02																		1.3E+03
2042	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02																		1.3E+03
2043	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02																		1.3E+03
2044	1.6E+02	1.4E+00	1.5E+01	1.1E+01	2.9E-01	2.2E+01	1.5E+01	2.5E+02	6.7E+01	7.3E+02																		1.3E+03
Totals	5.5E+03	4.8E+01	5.2E+02	3.8E+02	1.0E+01	7.7E+02	5.1E+02	8.8E+03	2.3E+03	2.6E+04	3.8E+02	1.8E+02	2.2E+02	1.3E+03	2.1E-01	2.6E+01	1.7E+02	2.5E+03	1.3E+06	5.6E+04	6.3E+01	3.2E+03	3.7E+04	4.8E-05	3.3E+04	9.9E+05	2.2E+06	4.7E+06

Table 8.2-6. Annual Activities and Waste Streams for the FWF-CDU and FWF-NCDU

Class		FWF-CDU Curies		FWF-NCDU Curies	Forecast Curies
		Class A	Class B/C	Class A	
Operational Year					
	2010	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2011	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2012	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2013	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2014	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2015	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2016	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2017	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2018	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2019	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2020	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2021	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2022	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2023	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2024	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2025	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2026	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2027	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2028	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2029	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2030	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2031	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2032	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2033	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2034	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2035	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2036	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2037	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2038	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2039	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2040	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2041	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2042	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2043	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	2044	2.19E+03	4.67E+05	2.14E+02	4.69E+05
	Totals	7.68E+04	1.63E+07	7.50E+03	1.64E+07

8.2.3 Waste During Closure Period

During the closure period of the CWF and FWF, very little, if any, LLRW or mixed LLRW is expected to be generated. Routine operating procedures and decontamination procedures prior to closure will ensure that no residual radioactive or chemical contamination is present above regulatory limits. Any contamination that is discovered during operations will be cleaned up immediately. Routine operating procedures will maintain the Site in a clean condition. At closure, site structures will be demolished and disposed, but no radiological contamination is expected. In the unlikely event that radioactive waste is generated during closure, the volumes and activities are expected to be insignificant compared to the volumes and activities disposed of during the operational period. No closure waste was included in the inventory for the performance assessment.

8.3 Operations Under Normal and Accident Conditions

8.3.1 Protection of Individuals During Operations

Demonstrate that operations at the land disposal facility shall be conducted in compliance with the standards for radiation protection set out in 30 TAC 336 Subchapter D (relating to Standards for Protection Against Radiation), except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by 30 TAC §336.724 (relating to Protection of the General Population from Releases of Radioactivity). Effort shall be made to maintain radiation exposures as low as is reasonably achievable. [30 TAC §336.726]

Provide analyses of the protection of individuals during operations including assessments of expected exposures due to routine operations and likely accidents during handling, processing, storage, and disposal of waste. The analyses shall provide reasonable assurance that exposures will be controlled to meet the requirements of 30 TAC Chapter 336 Subchapter D (relating to Standards for Protection Against Radiation). [30 TAC §336.709(3), 336.726]

Waste disposal operations will be conducted in compliance with TCEQ regulations, as contained in 30 TAC §336, Subchapter D. Operations are discussed in detail in Section 5. Operations will be conducted to maintain radiation exposures to workers as low as reasonably achievable. The WCS Radiation Safety Program provides a framework for controlling and limiting radiation exposures and describes the efforts to maintain radiation exposures as low as is reasonably achievable (ALARA). The ALARA plan is presented in Appendix 5.5.2-2

Protection of individuals during operations encompasses several exposure scenarios, environmental pathways, and receptor groups. A scenario is a set of conditions, environmental transport pathways, and a receptor individual for whom a dose is calculated. The performance assessment is based on the following four exposure scenarios:

- Normal operation
- Institutional control
- Post-institutional control

- Accidents

Normal operation covers the period during which the waste facilities are actively accepting and disposing of waste. Site access is controlled and the facility is assumed to operate as designed. The institutional control scenario covers the period after waste disposal operations have ceased, the facilities have been closed, but workers maintain the Site and restrict access. The Institutional Control Period is assumed to last for 100 years after closure of the facilities. The post-institutional control scenario, described in Section 8.5, evaluates the time period that begins 100 years after closure of the facilities. Access to the Site is no longer actively restricted and members of the public may visit or occupy the former waste disposal sites. Records of past waste disposal activities are assumed to be ineffective at preventing individuals from occupying the Site. Finally, the accident scenario evaluates the potential consequences of waste-handling accidents, unusual conditions, or severe weather conditions at the facilities during waste disposal operations.

Each of the four exposure scenarios may cause radiological doses to different individuals. For each exposure scenario, potential human receptors are identified at various locations. Doses are evaluated for each individual receptor and the results are compared to the performance objectives. The individual receptors include the following individuals:

- Site worker
- Site boundary individual
- Nearest resident
- On-site inadvertent intruder

The site worker is an employee at the facilities involved in waste handling and disposal operations. After closure, the site worker is an employee who periodically inspects and maintains the Site. The site boundary individual is a member of the public who approaches the facility fence, but remains in an uncontrolled area. It is conservatively assumed that this hypothetical individual approaches to within 100 meters of the waste disposal cells. The nearest resident is an individual residing west of the WCS Site at a distance of about 6 km who is potentially exposed to trace quantities of radionuclides released from the facilities as a result of normal operations or accidents. After the Institutional Control Period, the nearest resident is assumed to reside immediately adjacent to the waste disposal units. The on-site intruder is any individual who temporarily or permanently occupies the former disposal site after the 100-year Institutional Control Period. The on-site inadvertent intruder includes the intruder discoverer, intruder constructor, intruder driller, and intruder resident, as described in NRC 1986.

Each of the receptors described above may be exposed to radionuclides through several environmental transport pathways. The pathways to be evaluated are specified in 30 TAC 336.709(1). The required pathways are air, soil, groundwater, surface water, plant uptake, and exhumation by burrowing animals. The pathways are grouped into exposure scenarios as shown in Table 8.3-1. The pathways are described in detail in Appendix 8.0-3 and are summarized in Table 8.3-2.

Each exposure scenario has a dose limit associated with each individual receptor. For normal operations (i.e., no accidents) and post-closure, the dose criterion of 25 mrem/yr for a member of the public comes from the performance objective in 30 TAC 336.724. This dose limit applies to the site boundary individual and the nearest resident. The worker dose limit of 5,000 mrem/yr comes from 30 TAC §336.305(a). The 100-mrem/yr dose criterion selected for members of the public under accident conditions is the value for normal operations stated in 30 TAC 336.313(a)(1). Although this dose criterion does not specifically apply to accident conditions, it serves as a basis to evaluate protection of the public for the accident scenario.

Table 8.3-1. Scenarios for Performance Assessment

Receptor	Pathways		Dose Limit
Normal Operations Scenario			
Worker	A1	Airborne dust from bulk waste cell	5,000 mrem/yr
	A2	Airborne dust from bulk waste handling	
	A3	Airborne radioactive gases from open waste cell	
	A4	Evaporating water from disposal unit sumps	
	S1	Worker inadvertent soil ingestion	
	---	External exposures as calcualted in Appendix 8.0-4 “Worker Doses”	
Site Boundary	A1	Airborne dust from bulk waste cell	25 mrem/yr
	A2	Airborne dust from bulk waste handling	
	A3	Airborne radioactive gases from open waste cell	
	A4	Evaporating water from disposal unit sumps	
	S2	Suspension of off-site soil contamination	
	S3	External radiation from off-site soil contamination	
	G1	Groundwater transport through red beds	
	G2	Groundwater transport through 125-foot sandstone	
	G3	Groundwater transport to 225-foot sandstone	
	W1	Surface water transport of bulk waste	
	W2	Surface water transport of residual soil contamination	
	W3	Surface water run-on and bulk waste transport	
Nearest Resident	A1	Airborne dust from bulk waste cell	25 mrem/yr
	A2	Airborne dust from bulk waste handling	
	A3	Airborne radioactive gases from waste cell	
	A4	Evaporating water from disposal unit sumps	
	S2	Suspension of off-site soil contamination	
	S3	External radiation from off-site soil contamination	
	W1	Surface water transport of bulk waste	
	W2	Surface water transport of residual soil contamination	
	W3	Surface water run-on and bulk waste transport	
Institutional Control Scenario			
Worker	A5	Residual soil contamination suspension	5,000 mrem/yr
	A6	Radioactive gas emanation through cover	
	D2	Direct radiation through finished cover	
Site Boundary	A5	Residual soil contamination suspension	25 mrem/yr
	A6	Radioactive gas emanation through cover	
	G1	Groundwater transport through red beds	
	G2	Groundwater transport through 125-foot sandstone	
	G3	Groundwater transport to 225-foot sandstone	
Nearest Resident	A5	Residual soil contamination suspension	25 mrem/yr
	A6	Radioactive gas emanation through cover	
Post-Institutional Control Scenario			
Intruder Discoverer	A5	Residual soil contamination suspension	25 mrem/yr
	A6	Radioactive gas emanation through cover	
	A7	Exhumed contamination suspension, plants and animals	
	D2	Direct radiation through finished cover	
Intruder Constructor	A5	Residual soil contamination suspension	25 mrem/yr*
	A6	Radioactive gas emanation through cover	
	A7	Exhumed contamination suspension, plants and animals	
	D2	Direct radiation through finished cover	
Intruder Driller	A5	Residual soil contamination suspension	25 mrem/yr*
	A6	Radioactive gas emanation through cover	
	A7	Exhumed contamination suspension, plants and animals	
	D3	Exposure to inadvertent intruder well mud pit	
Intruder Resident	A5	Residual soil contamination suspension	25 mrem/yr*
	A6	Radioactive gas emanation through cover	
	A7	Exhumed contamination suspension, plants and animals	
	G3	Groundwater transport to 225-foot sandstone	
	P1	Root penetration into waste, mesquite fire wood	
	P2	Root penetration into waste, cattle grazing	
	B1	Burrowing animals, waste exhumation	
	D3	Exposure to inadvertent intruder well mud pit	
Site Boundary (former)	A5	Residual soil contamination suspension	25 mrem/yr
	A6	Radioactive gas emanation through cover	
	G1	Groundwater transport through red beds	
	G2	Groundwater transport through 125-foot sandstone	
	G3	Groundwater transport to 225-foot sandstone	
Accident Scenario			
Worker	A8	Air releases from dropped waste canister	5,000 mrem/yr
	A9	Air releases from fire	
	A10	Air releases from tornado	
	D1	Direct radiation from high activity waste package	
Site Boundary	A8	Air releases from dropped waste canister	100 mrem/yr
	A9	Air releases from fire	
	A10	Air releases from tornado	
	D1	Direct radiation from high activity waste package	
Nearest Resident	A8	Air releases from dropped waste canister	100 mrem/yr
	A9	Air releases from fire	
	A10	Air releases from tornado	
	D1	Direct radiation from high activity waste package	

* 25 mrem/yr as directed by TCEQ citing the 25 mrem/yr dose limit specified in 30 TAC §336.72

Normal Operation Scenario – Doses to site workers during normal operation are evaluated in Appendix 8.0-4, “Worker Doses,” and Appendix 8.0-6, “Detailed Pathway Analysis.” External radiation exposures are addressed in Appendix 8.0-4, and internal exposures from inhalation of dust and gaseous radionuclides and inadvertent soil ingestion are addressed in Appendix 8.0-6, pathways A1, A3, A4, and S1 (see Table 8.3-2 for pathway descriptions). As shown in Table 8.3-3, the average worker dose from all pathways is 360 mrem/yr, well below the regulatory limit of 5,000 mrem/yr in 30 TAC §336.305.

Dose to a member of the public at the disposal site boundary during normal operations are evaluated in Appendix 8.0-6. The analysis considers air, soil, surface water, and groundwater pathways, as shown in Table 8.3-1. The doses to an individual at the disposal site boundary during normal operations are summarized in Table 8.3-3. The total dose is 2.5E-02 mrem/yr, compared to the performance objective limit of 25 mrem/yr.

The nearest resident may potentially be exposed during operations through air, surface water, and soil pathways. These exposures are evaluated in Appendix 8.0-6. There are no groundwater doses to the nearest resident during operations. The doses to the nearest resident during normal operations are summarized in Table 8.3-3. The nearest resident’s dose is 1.1E-4 mrem/yr, compared to the performance objective limit of 25 mrem/yr.

Institutional Control Scenario – Doses to site workers during the 100-year Institutional Control Period are evaluated in Appendix 8.0-6, “Detailed Pathway Analysis.” The pathways of interest during the Institutional Control Period are gaseous radionuclides, residual soil radionuclides, and external radiation. As shown in Table 8.3-3, the dose to a site maintenance worker is 0.4 mrem/yr, well below the regulatory limit of 5,000 mrem/yr in 30 TAC §336.305.

The site boundary individual may potentially be exposed to groundwater, gaseous radionuclides, and residual soil radionuclides, as shown in Table 8.3-1 for the institutional control scenario. The doses are calculated in Appendix 8.0-6. No groundwater doses are received during the 100-year Institutional Control Period because no radionuclides migrate off site during that time frame. The dose to the site boundary individual is 1.2 mrem/yr from gaseous radionuclide inhalation, which is less than the performance objective of 25 mrem/yr.

The nearest resident may be exposed to gaseous radionuclides. Groundwater pathways do not affect the nearest resident during the Institutional Control Period because no radionuclides travel off site. The doses to the nearest resident for the institutional control scenario are shown in Table 8.3-3. The dose for this scenario is 5.2E-03 mrem/yr, well below the 25 mrem/yr performance objective.

Post-Institutional Control Scenario – Doses are calculated for intruders and for a member of the public who resides immediately adjacent to the former disposal units. Four intruders are evaluated, unsing the same approach as in NRC 1986. As shown in Table 8.3-1, the four intruders are the intruder discoverer, intruder constructor, intruder driller, and intruder resident. The four intruders are described in Appendix 8.0-6, “Detailed Pathway Analysis.” The maximum doses to intruders, as shown in Table 8.3-3, are an acute dose of 6.7 mrem to the intruder driller and a maximum chronic dose of 4.6 mrem/yr to the intruder resident. The intruder driller is exposed to contaminated drill cuttings in the mud pit and radioactive gases emanating from the disposal units. The driller was assumed to drill through the particular waste stream that causes the highest dose, rather than the facility average radionuclide mix. The intruder resident is exposed to the covered mud pit, radioactive gases from the disposal units, and groundwater. Although there are no regulatory dose limits for intruders, the doses are below the 100 mrem/yr limit for doses to the public during normal operations (30 TAC 336.313(a)).

The post-institutional control scenario also includes a member of the public who resides immediately adjacent to the former disposal units. This individual does not intrude on the waste site, but is exposed to radioactive gases that may emanate through the cover system and to potentially contaminated groundwater. The maximum dose to the adjacent resident, shown in Table 8.3-3, is 3.4 mrem/yr, which is below the 25 mrem/yr performance objective for members of the public.

Accident Scenario – Inhalation and external radiation doses to site workers during accidents or unusual conditions are evaluated in Appendix 8.0-5, “Accident Analysis.” The accident scenario analyzes a dropped waste container, a truck fire or explosion, tornado or severe winds, flooding, and a crane malfunction. The highest dose to a worker for an accident is 670 mrem, for a dropped container of depleted uranium oxide at the FWF-CDU. The doses to workers from accidents and unusual conditions are all below the 5,000-mrem/yr dose limit that applies to normal operations (30 TAC §336.305). The doses from accidents are shown in Table 8.3-3.

The highest dose from the accident scenario to an individual at the site boundary is from a fire in the FWF-CDU. The maximum dose is 2.5 mrem. The dose from a similar accident at the CWF is 2.2 mrem. There are no regulatory limits that apply specifically to accident conditions, but the predicted accident dose is below the 100 mrem/yr limit that applies to members of the public during normal operations.

The highest dose to the nearest resident for the accident scenario is 4.5E-03 mrem, from a fire in the FWF-CDU. The dose from a fire in the CWF is slightly lower at 4.0E-03 mrem. The accident dose to the nearest resident is well below the 100 mrem/yr dose limit that applies to normal operations.

Table 8.3-3 shows that all of the potential doses for workers and members of the public for normal operations, accidents, and unusual conditions are within the regulatory limits that apply to normal operations.

8.3.2 Protection of Members of the Public

Demonstrate that concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals shall not result in an annual dose above background exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, or 25 millirems to any other organ of any member of the public. Effort shall be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable. [30 TAC §336.724]

Pathways analyzed in demonstrating protection of the general population from releases of radioactivity including air, soil, groundwater, surface water, plant uptake, and exhumation by animals shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate that there is reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits specified in 30 TAC §336.724 (relating to Protection of the General Population from Releases of Radioactivity). A minimum period of 1,000 years after closure or the period where peak dose occurs, whichever is longer, is required as the period of analysis to capture the peak dose from the more mobile long-lived radionuclides and to demonstrate the relationship of site suitability to the performance objective in 30 TAC §336.709(1) and to the performance objective in 30 TAC §336.724. [THSC §401.113(c)(1)] & [30 TAC §336.709.(1)]

Protection of members of the public is demonstrated by the analyses in Appendix 8.0-6, “Detailed Pathway Analysis.” Under normal operating conditions, the highest dose to a member of the public is 2.5E-02 mrem/yr for the individual at the disposal site boundary, which satisfies the 25-mrem/yr performance objective.

The individual organ dose limits are also satisfied. The dose to the individual at the disposal site boundary is dominated by the dust inhalation pathway (pathway A1 from Table 8.3-2). The most important radionuclides are uranium, thorium, americium, and plutonium. The critical organ for all of these radionuclides is the lung, which has an organ weighting factor of 0.12 (ICRP Publication 26, EPA 1988). Therefore, the lung dose can be no more than 1/0.12, or about 8.3 times the committed effective dose equivalent. The upper bound for the dose to the lung would be 0.21 mrem/yr (2.5E-02 mrem/yr / 0.12). Even using the smallest organ weighting factor of 0.03, which applies to the thyroid or bone surface, the maximum organ dose could be no more than 0.83 mrem/yr (2.5E-02 mrem/yr / 0.03). This bounding analysis serves to demonstrate compliance with all of the organ dose limits. Because the organ doses are so far below the 25/75-mrem/yr limits, the organ doses were not explicitly calculated in the detailed analyses.

Protection of the public is provided by a combination of the natural disposal site characteristics and engineered features. The primary engineered features that contribute to public protection are:

- The depth of the disposal units below the ground surface
- Placement and compaction of bulk waste
- The method of waste placement, containment in concrete canisters, and backfilling of voids, both inside and around concrete canisters

- The engineered cover system, constructed of red bed material that isolates the waste from infiltrating water
- The cobble layer in the cover that prevents erosion and bio-intrusion into the waste by plant roots and burrowing animals

The natural site characteristics provide for the long-term isolation of the waste. The natural site characteristics that contribute to public protection are:

- The low red bed hydraulic conductivity, which minimizes radionuclide migration to the groundwater
- The significant depth to groundwater and low groundwater quality, which reduce the likelihood of drilling at the Site
- The remote location of the Site relative to human populations
- The low precipitation and high potential evapotranspiration that minimize water infiltration
- The lack of groundwater recharge through the waste from the surface

Together, the natural site characteristics and the design features provide protection to members of the public. The potential doses to the public are summarized in Table 8.3-3, for a period of 10,000 years after facility closure. Peak doses in the groundwater pathway all occur after 10,000 years. The approach for performance modeling and compliance demonstration is presented below.

Pathways Conceptual Model – Within the four scenarios modeled, there are a variety of environmental transport pathways. These transport pathways are described as the LLRW Disposal Exposure Pathways Conceptual Model (Pathways Model), which includes a description of the release mechanisms, environmental transport pathways, and receptors of concern for demonstrating that the radiological performance objectives will be satisfied. The Pathways Model is based on the Facility and Site Conceptual Models and includes all potential releases, transport pathways, and receptors for the sites and activities of interest. The Pathways Model summarizes the basis for focusing the performance assessment on the particular release mechanisms, pathways, and receptors that are potentially significant determinants for site performance.

The surface and subsurface features of the Site are described in the Section 2.5, which presents the site stratigraphy (Section 2.5.8) and shows the location of the disposal units. The waste will arrive at the facility in bulk shipments, drums, boxes, liners, and casks. The disposal units are excavated below ground in the red bed clay. Class C, Class B, Containerized Class A, and unstable Class A waste will be disposed of in reinforced concrete canisters. The Pathways Model describes the approach for demonstrating that the facilities (i.e., the CWF, FWF-CDU, and FWF-NDCU) will satisfy the performance objectives in state and federal regulations.

The Texas regulations in 30 TAC §336.709 require that several environmental pathways be analyzed. The required pathways are air, soil, groundwater, surface water, plant uptake, and exhumation by burrowing animals. More details on transport pathways are given in the Texas and NRC guidance documents (TCEQ 2004, NRC 1991, NUREG-1199, NUREG-1200, and

NRC 2000). Together, these documents contain an extensive list of pathways that serve as the starting point for the Pathways Conceptual Model development. From the initial group of pathways, a site-specific list of pathways for the Site was developed, taking into account the site characteristics.

Of particular importance in the performance assessment is the groundwater pathway. The groundwater pathway at the WCS Site is unusual because of the presence of the very-low-permeability red beds. The groundwater transport pathway assumes that water will make contact with the disposed waste, leach radionuclides from the waste, and that contaminated leachate will move through the red beds and sandstone units. The groundwater pathway conceptual model includes the following features and processes:

- Infiltration of water through the cover system
- Contact of water and waste in the disposal unit
- Release and transport of waterborne radionuclides to the bottom of the disposal unit
- Transport of radionuclides through the red beds and/or sandstone units, both horizontally and vertically
- Discharge of radionuclides into a water-bearing zone
- Dilution/withdrawal of radionuclides from a well

Both horizontal and vertical radionuclide transport are evaluated. For horizontal transport, the potentially contaminated leachate is assumed to travel southward laterally through the red beds to a location where the leachate discharges from the red beds into the alluvial materials of the overlying OAG formation. From there the leachate travels along the top surface of the red beds until reaching a local depression on top of the red beds, where it then accumulates. The viability of the horizontal transport pathway is discussed in Appendix 8.0-6, “Detailed Pathway Analysis.” Horizontal transport through the sandstone of the 125-foot zone is also evaluated. Alternatively, for vertical transport from the disposal unit, the potentially contaminated leachate is assumed to travel downward to a water-bearing zone at depth.

Groundwater transport to the 225-foot water-bearing zone is evaluated quantitatively as the primary groundwater transport pathway because this is the same water-bearing formation where the groundwater monitoring wells will be installed. It is also the shallowest formation that is saturated across the full extent of the disposal facilities. The 225-foot zone has a low conductivity and, therefore, a low yield of water, but it is sufficient to accomplish the monitoring function. The 600-foot water bearing zone was evaluated only qualitatively, because any radionuclide transport to this formation would occur at much later times than transport to the 225-foot zone and the concentrations in the 600-foot zone would be more dilute than those in the overlying 225-foot zone. Likewise, the Santa Rosa formation, at a depth of 1,000 feet or more, is not evaluated quantitatively because its greater depth requires much longer times for radionuclides to reach that aquifer. In addition, radionuclides that might reach the Santa Rosa formation would be more dilute than those in the 225-foot zone or the 600-foot zone. Data suggest that the Santa Rosa Aquifer has no current active source of recharge from surface infiltration, further reducing the importance of this potential pathway.

The full set of site-specific pathways for consideration in the performance assessment is listed below. The pathways, release processes, and receptors are shown in Table 8.3-2. The pathways are described in greater detail in the appendices, particularly in Appendix 8.0-3, “Qualitative Pathway Analysis” and Appendix 8.0-6, “Detailed Pathway Analysis.”

Table 8.3-2. Pathways Model Summary

Pathway	Release Process	Receptor				Period of Concern		
		Worker	Disposal Site Boundary	Nearest Resident	On-site Intruder	Operations	Institutional Control	Post-Institutional Control
Air Pathway								
A1, Airborne dust from open bulk waste cell during operations	Dust resuspension	X	X	X		X		
A2, Airborne dust from loading and transport of bulk waste	Dust resuspension	X	X	X		X		
A3, Airborne gases from waste cell during operations (H-3, C-14, Kr-85, I-129, radon)	Waste decomp. & rad. decay	X	X	X		X		
A4, Evaporating water from disposal unit sumps in bulk waste cell during operations	Evaporation	X	X	X		X		
A5, Suspension of post-closure residual soil contamination	Dust resuspension	X	X	X	X		X	X
A6, Gas emanation through finished cover (H-3, C-14, Kr-85, I-129, radon)	Waste decomp. & rad. decay	X	X	X	X		X	X
A7, Transport of contamination exhumed by burrowing animals and deep-rooted plants	Dust resuspension				X			X
A8, Air releases associated with a dropped, breached canister	Dust resuspension	X	X	X		X		
A9, Air releases associated with a truck fire	Fire	X	X	X		X		
A10, Air releases associated with a tornado	Dust resuspension	X	X	X		X		
Soil Pathway								
S1, Worker inadvertent soil ingestion	Residual contamination	X				X		
S2, Inhalation of off-site resuspended soil contamination (contaminated by dust deposition)	Dust deposition & resuspension		X	X		X		
S3, External radiation from off-site soil contamination (contaminated by dust deposition)	Dust deposition		X	X		X		
Groundwater Pathway								
G1, Leaching and groundwater transport through red beds to a well screened above the red beds	Leaching from disposal cell		X		X	X	X	X
G2, Leaching and groundwater transport through 125-foot zone to a well screened above the red beds	Leaching from disposal cell		X		X	X	X	X
G3, Leaching and groundwater transport of radionuclides to a well screened in the 225-foot water-bearing zone	Leaching from disposal cell		X		X	X	X	X
G4, Leaching and groundwater transport of radionuclides to a well screened in the Trujillo sandstone	Leaching from disposal cell		X		X	X	X	X
G5, Leaching and groundwater transport of radionuclides to a well screened in the Santa Rosa formation	Leaching from disposal cell		X		X	X	X	X
Surface Water Pathway								
W1, Off-site transport of bulk waste as a result of high precipitation or flood conditions	Surface runoff		X	X		X		
W2, Surface water transport of ground-deposited contaminated dust to a low-lying area	Surface runoff		X	X		X		
W3, Surface water run-on and contaminant transport (precluded by design features)	Surface runoff		X	X		X		
Plant Pathway								
P1, Mesquite logs gathered from the Site, post-closure, used locally for firewood	Waste exhumation by roots				X			X
P2, Cattle grazing on deep-rooted grass	Waste exhumation by roots				X			X
Burrowing Animal Pathway								
B1, Waste exhumation by burrowing animals (precluded by depth of burial)	Dust resuspension				X			X
Direct External Pathway								
D1, Exposure to high activity waste packages during operations	Direct radiation	X	X			X		
D2, Exposure through the finished cover to an on-site maintenance worker after closure	Direct radiation	X					X	
D3, Exposure to inadvertent intruder well mud pit	Direct radiation	X			X			X

All of the potential exposure pathways listed in Table 8.3-2 are first evaluated qualitatively. The qualitative analysis involves comparing and grouping similar pathways. Within each group, pathways are selected whose impacts are expected to be the highest. The qualitative analysis provides justification for the selection of the limiting, or bounding, pathways. This approach ensures a greater focus on the pathways of most importance. The qualitative analysis is documented in Appendix 8.0-3, "Qualitative Pathway Analysis."

The result of the qualitative analysis is a list of the most important pathways for determining compliance with the performance objectives. This list of pathways is analyzed in detail using computer models, spreadsheets, and hand calculations to demonstrate compliance. The pathways analyzed in detail are the following:

- Pathway A1, Airborne dust from open bulk waste cell during operations
- Pathway A3, Airborne gases from waste cell during operations (H-3, C-14, and radon)
- Pathway A6, Gas emanation through finished cover (H-3, C-14, and radon)
- Pathway A8, Air releases associated with a dropped, breached canister
- Pathway A9, Air releases associated with a truck fire
- Pathway S1, Worker inadvertent soil ingestion
- Pathway S3, External radiation from off-site soil contaminated by dust deposition
- Pathway G1, Leaching and groundwater transport through the red beds to a well screened above the red beds
- Pathway G2, Leaching and groundwater transport through the 125-foot zone to a well screened above the red beds
- Pathway G3, Leaching and groundwater transport of radionuclides to a well screened in the 225-foot water-bearing zone
- Pathway W2, Surface water transport of ground-deposited contaminated dust to a low-lying area
- Pathway D1, Exposure from high activity waste packages during operations
- Pathway D3, Exposure to inadvertent intruder well mud pit

One of the key parameters in the long-term performance assessment is the water infiltration rate through the disposal units. The water infiltration is controlled by the cover design features and meteorological conditions, such as rainfall, temperature, and solar radiation. The water infiltration rate is estimated using the HELP model. The infiltration calculations are presented in Appendix 8.0-6, "Detailed Pathway analysis."

Radionuclide leaching for the groundwater pathway is estimated from a simple K_d exchange model. This leaching method is widely used, simple to apply, and leads to conservative estimates of the radionuclide release rates. All radionuclides are assumed to be immediately available for leaching, regardless of waste containers, concrete canisters, or improved waste forms such as activated metals or solidified waste.

Computer models used in the performance assessment include the RESRAD code for multi-pathway analysis, the MicroShield® model for external radiation exposure, and the HELP model for water infiltration. More detailed information on the model application is contained in Appendix 8.0-6, "Detailed Pathway Analysis."

The RESRAD code, Version 6.3, calculates radiation doses and risks from radionuclides in soil, air, groundwater, plants, and animals. The model calculates the transport of radionuclides through environmental media and exposures to humans. The radionuclide source is specified in terms of the initial concentrations of radionuclides in soil. The model calculates the subsequent releases of radionuclides from soil and their transport to groundwater, air, and into the food chain. The exposure pathways evaluated in the RESRAD model include drinking water, crop irrigation, direct radiation from soil, dust inhalation, radon gas inhalation, production of food crops and livestock (milk and meat) on contaminated soil, soil ingestion, and aquatic foods. The RESRAD model was selected for this analysis because it includes all of the environmental exposure pathways recommended by TCEQ guidance. The RESRAD model uses a level of complexity that is consistent with the available site characterization information for the WCS Site. It is also consistent with the site conceptual model and the pathways conceptual model.

The MicroShield® model, Version 5, calculates radionuclide exposures and doses from external radiation. The model uses analytical expressions and numerical integration to evaluate the radiation exposures from a range of source configurations. The radionuclide source term is specified in terms of the individual radionuclide concentrations and the source configuration. Shielding dimensions and materials are specified, as well as the dose receptor location relative to the source and shields. The output from MicroShield® shows the exposures rate and absorbed dose rate at the receptor location. The MicroShield® model was used to calculate external doses for workers (Appendix 8.0-4, "Worker Doses") and doses for the inadvertent intruder drilling scenarios (Appendix 8.0-6, "Detailed Pathway Analysis"). The model was selected because it is consistent with the Pathways Conceptual Model; the model is widely accepted, easy to use, and well documented.

The HELP model, Version 3, is used to calculate the water infiltration rates through the engineered cover system. Input data for the HELP model include weather, soil, and cover design information. The model considers runoff, infiltration, water storage, evapotranspiration, vegetative growth, and lateral drainage. The solution methods in HELP generally use the saturated hydraulic conductivity of the soil layers, which tends to overestimate water infiltration through the layers. The HELP model was selected for this analysis because it uses simplified solution methods, it is consistent with the pathways conceptual model, and it is widely used and well documented. The HELP model calculations are described in Appendix 8.0-6, "Detailed Pathway Analysis."

A sensitivity and uncertainty analysis was conducted with the RESRAD and HELP models to identify important input parameters and to address the effects of variations in input parameters and the effects of changing site conditions. The sensitivity and uncertainty analysis is provided in Appendix 8.0-7. Computer inputs and outputs are provided in Appendix 8.0-8.

The results of the performance assessment show that the performance objectives and regulatory dose limits are satisfied for workers and members of the public, both during operations and for the long term. The detailed pathway analysis results are summarized in Table 8.3-3 for a 10,000-year simulation period. Pathways eliminated in the qualitative analysis are not included in the table. The performance assessment showed no groundwater doses for at least the first 10,000 years after closure. The simulation extended for 100,000 years to identify any potential groundwater doses from the more mobile long-lived radionuclides. The maximum doses for a 100,000-year period, documented in Appendix 8.0-6, all satisfy the 25-mrem/yr performance objective.

Table 8.3-3. Performance Assessment Dose Summary

	CWF (mrem/yr)	FWF-CDU (mrem/yr)	FWF-NCDU (mrem/yr)	Maximum/ Total (mrem/yr)	Criterion (mrem/yr)
Normal Operations, Worker					
Pathway A1, dust	0	0	1.8E+01		
Pathway A3, gases	0	0	1.1E-03		
Pathway S1, soil ing.	0	0	1.3E-01		
External gamma(a)	2.4E+02	9.5E+01	1.1E+01		
Total	**2.4E+02**	**9.5E+01**	**2.9E+01**	**3.6E+02**	**5,000**
Normal Operations, Site Boundary Individual					
Pathway A1, dust	0	0	2.4E-02		
Pathway A3, gases	0	0	4.6E-06		
Pathway S3, ext rad	0	0	1.4E-05		
Pathway G1, gw red bed	0	0	0		
Pathway G2, 125 zone	0	0	0		
Pathway G3, 225 zone	0	0	0		
Pathway W2, surf water	0	0	4.9E-04		
Total	**0**	**0**	**2.5E-02**	**2.5E-02**	**25**
Normal Operations, Nearest Resident					
Pathway A1, dust	0	0	1.1E-04		
Pathway A3, gases	0	0	2.1E-08		
Pathway S3, ext rad	0	0	6.4E-08		
Pathway W2, surf water	0	0	2.2E-06		
Total	**0**	**0**	**1.1E-04**	**1.1E-04**	**25**
Institutional Control, Worker					
Pathway A6, gases	9.4E-03	3.9E-01	9.8E-05		
Total	**9.4E-03**	**3.9E-01**	**9.8E-05**	**4.0E-01**	**5,000**
Institutional Control, Site Boundary Individual					
Pathway A6, gases	1.2E-02	1.6E-04	1.1E+00		
Pathway G1, gw red bed	0	0	0		
Pathway G2, 125 zone	0	0	0		
Pathway G3, 225 zone	0	0	0		
Total	**1.2E-02**	**1.6E-04**	**1.1E+00**	**1.2E+00**	**25**

Table 8.3-3. Performance Assessment Dose Summary

	CWF (mrem/yr)	FWF-CDU (mrem/yr)	FWF-NCDU (mrem/yr)	Maximum/ Total (mrem/yr)	Criterion (mrem/yr)
Institutional Control, Nearest Resident					
Pathway A6, gases	5.3E-05	5.2E-03	7.4E-07		
Total	**5.3E-05**	**5.2E-03**	**7.4E-07**	**5.2E-03**	**25**
Post-Institutional Control, Intruder Driller					
Pathway A6, gases	3.6E-03	2.9E-03	4.5E-07		
Pathway D3, mud pit	6.7E+00	1.8E+00	1.3E-02		
Total	**6.7E+00**	**1.8E+00**	**1.3E-02**	**6.7E+00(b)**	**100**
Post-Institutional Control, Intruder Resident					
Pathway A6, gases	9.8E-01	8.0E-01	1.2E-04		
Pathway G3, 225 zone, 0-10,000 yrs	0	0	0		
Pathway G3, 225 zone, 0-100,000 years	5.8E-01	1.1E+00	3.4E+00		
Pathway D3, mud pit	3.0E+00	7.9E-01	1.9E-02		
Total	**4.6E+00**	**2.7E+00**	**3.4E+00**	**4.6E+00(c)**	**100**
Post-Institutional Control, Adjacent Resident					
Pathway A6, gases	9.8E-01	8.0E-01	1.2E-04		
Pathway G3, 225 zone, 0-10,000 years	0	0	0		
Pathway G3, 225 zone, 0-100,000 years	5.8E-01	1.1E+00	3.4E+00		
Total	**1.6E+00**	**1.9E+00**	**3.4E+00**	**3.4E+00**	**25**
Accidents, Worker					
Pathway A8, dropped pkg	2.4E+01	6.7E+02	n/a (e)		
Pathway A9, fire	1.6E+02	1.8E+02	n/a (e)		
Pathway D1, ext rad	8.9E-01	8.9E-01	n/a (e)		
Total	**1.6E+02(f)**	**6.7E+02(f)**	**n/a (e)**	**6.7E+02(f)**	**5,000**
Accidents, Site Boundary Individual					
Pathway A8, dropped pkg	2.2E-02	2.5E+00	n/a (e)		
Pathway A9, fire	2.2E+00	2.5E+00	n/a (e)		
Pathway D1, ext rad	7.5E-03	7.5E-03	n/a (e)		
Total	**2.2E+00(f)**	**2.5E+00(f)**	**n/a (e)**	**2.5E+00(f)**	**100**
Accidents, Nearest Resident					
Pathway A8, dropped pkg	3.4E-06	3.8E-04	n/a (e)		
Pathway A9, fire	4.0E-03	4.5E-03	n/a (e)		
Total	**4.0E-03(f)**	**4.5E-03(f)**	**n/a (e)**	**4.5E-03(f)**	**100**

(a) Average over all worker types, from Appendix 8.0-4, Worker Doses.
(b) Driller may drill at any of the three facilities, but only one inadvertent intruder is assumed.
(c) Inadvertent intruder resident may locate over any of the three facilities, but only one intruder is assumed.
(d) Accident severity to workers could be mitigated by requiring respirator while handling DU-oxide packages.
(e) No waste packages in FWF-NCDU. Impacts are bounded by the FWF-CDU accident.

(f) Assumes only one worst-case accident occurs.

8.3.3 Accidents and Unusual Operational Conditions

Provide information regarding the types, significance, and magnitudes of releases of radioactivity associated with accidents or unusual operational conditions. The information should be sufficient to enable analysis of projected radiological impacts to any individual.

The effects of accidents and unusual operating conditions are addressed in Appendix 8.0-5, "Accident Analysis." The accidents include consideration of dropped canisters, a truck fire, a crane malfunction, and unusual weather conditions such as flooding, severe winds, and tornadoes. The detailed calculations and results are given in the appendix and are summarized in Table 8.3-3. The accident analysis evaluates the potential doses to workers, a member of the public at the disposal site boundary, and the nearest resident. The analyses demonstrate that the potential doses to workers from accidents are within the regulatory limit that applies to normal operations (5,000 mrem/yr, 30 TAC §336.305). The analyses also demonstrate that the potential doses to members of the public from accidents are less than the regulatory limit that applies to normal operations (100 mrem/yr, 30 TAC §336.313).

Unusual conditions at the Site are also evaluated in Appendix 8.0-7, "Sensitivity and Uncertainty Analysis." The sensitivity analysis evaluated several unusual conditions that included the following:

- Higher than average rainfall
- Degradation of the performance cover
- Degradation of the lateral drainage layer in the cover system
- Increased radionuclide release rates
- Enhanced radionuclide mobility in the environment
- Increased hydraulic conductivity of the red bed clay
- Effects of chelating agents in waste

In all cases, the performance objectives are met for all times out to 100,000 years after facility closure. The analysis of unusual conditions is documented in Appendix 8.0-7, "Sensitivity and Uncertainty Analysis."

Basis for Protection of the Public – Concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals will not result in an annual dose above background exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, or 25 millirems to any other organ of any member of the public. Effort will be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.

This requirement is designed to ensure that members of the general population are protected from releases of radioactivity. The requirement ensures protection of members of the public during operations, closure, institutional control, and after institutional controls have ended. Protection is provided by limiting the dose to a member of the public to no more than

25 mrem/yr from exposure to effluents released from the disposal site in groundwater, surface water, air, soil, plants, and animals. Protection is also ensured by the efforts to maintain the releases to levels that are as low as reasonably achievable.

Four scenarios were evaluated to determine the potential range of exposures through various environmental transport pathways. The scenarios evaluated include the following:

- Normal operations scenario – Exposures through dust inhalation, gas generation, external radiation, groundwater, and surface water to a site boundary individual and a nearest resident.
- Institutional control scenario – Exposures through gas generation, groundwater, and external radiation to a site maintenance worker, a site boundary individual, and a nearest resident.
- Post-institutional control scenario – Exposures through gas generation and groundwater to an adjacent resident.
- Accident scenario – Exposures through inhalation and external radiation from a dropped container, a truck fire, and a crane malfunction.

Within each of these scenarios, potential receptors were identified and doses were calculated for each potential receptor. Exposures were considered through groundwater, surface water, air, soil, plants, and animals. All reasonably applicable environmental transport pathways were included in the dose analysis. The scenarios, receptors, and applicable pathways are summarized in Table 8.3-1.

Bounding Scenarios – Considering the four scenarios listed above, the first three scenarios provide conservative estimates for offsite doses from releases to the general environment from routine operations. The fourth scenario addresses releases and doses from unusual conditions during operations. Together, these four scenarios evaluate and bound the potential releases and doses that could potentially affect members the general population.

Three of the four scenarios are described in detail in Appendix 8.0-6. These include the normal operations, institutional control, and post-institutional control scenarios. The fourth scenario (accidents) is described in detail in Appendix 8.0-5. The four scenarios provide conservative estimates of the releases and doses to the public for the following reasons:

- Each scenario uses conservatively high estimates of radionuclide releases.
- Radionuclide releases from waste do not take credit for waste containers, grout, concrete, or improved waste forms.
- All radionuclides are assumed to be immediately available for release to the groundwater pathway. Radionuclide release rates are based on a simple Kd leaching model with 100 percent of the radionuclide inventory available for leaching.
- Gaseous releases assume 100 percent of the inventories of H-3, C-14, Kr-85, and I-129 are available for decomposition and release in gaseous form.
- All reasonable environmental transport pathways are considered in the analysis, including groundwater, surface water, air, soil, plants, and animals.

- Exposures to individuals consider ingestion, inhalation, and external exposure pathways.
- Environmental dilution of radionuclides is conservatively estimated.

Modeling of all scenarios initially considered the complete set of environmental transport pathways required by 30 TAC 336.724 (i.e., groundwater, surface water, air, soil, plants, and animals). Some of these pathways were not considered to be important enough to be evaluated in detail in every scenario, as discussed below.

- Groundwater Pathway – Doses through the groundwater pathway are based on leaching of radionuclides from the waste, transport through the red clay to the 225-ft zone, and withdrawal from a well at the edge of the disposal trench. Water is used for drinking and livestock watering. Groundwater transport to the 125-ft zone was also modeled, as was direct horizontal flow from the waste trench through the red clay to a shallow well. Site data show there is insufficient water in the 225-ft zone to support irrigation. The groundwater pathways were evaluated for a sufficiently long time to identify peak doses.
- Surface Water Pathway – Surface water transport of radionuclides from the disposal facility is not possible because of design features that prevent overland flow of contaminated surface water. Doses from offsite surface water transport of radionuclides deposited from airborne dust are included in the performance assessment. Following facility closure and decontamination, the surface water transport pathway is not considered viable.
- Air Pathway – Air pathway doses are evaluated during operations from handling of bulk waste during disposal and from accidents, including dropped containers and a truck fire involving waste packages. Airborne radionuclide concentrations are conservatively estimated using simple release and Gaussian transport models. Stable air conditions and low wind speed during the hypothetical accidents ensure conservative dose estimates.
- Soil Pathway – The soil pathway is included by considering external radiation from the ground surface. Doses are calculated from offsite soil that becomes contaminated from airborne dust deposition. Direct radiation from a suspended waste package was also evaluated in the accident scenario.
- Plant and Animal Pathways – Exposures through the plant and animal pathways are included in the assessment, although their impacts to the general public are not significant compared to the other pathways. Plant and animal pathways include deep rooted plants and burrowing animals.

Dose Assessment **–** Table 8.3-3 summarizes the calculated doses for the exposure scenarios for release to the general population. The predicted doses are all below the regulatory limits stated in 30 TAC 336.724. The set of scenarios includes normal and accident conditions and conservatively ensures the protection of the general population.

ALARA Compliance **–** The performance objective in 30 TAC 336.724 requires that releases to the general environment be kept as low as reasonably achievable (ALARA). Natural conditions at the site and facility design features are expected to ensure compliance with this requirement. The operation, closure, and monitoring of the facility also contribute to this requirement.

The Site is located away from population centers, which serves to limit contact of the general population with the facility. The Site is beyond the boundary of the High Plains aquifer, which limits the availability of water at the Site and thereby reduces the likelihood that the area could support a local population. The Site has insufficient water (both in quantity and quality, to allow significant crop irrigation. The semi-arid climate and low water infiltration rate minimize the potential for water to contact the waste after facility closure. This minimizes the potential for groundwater and surface water transport and radionuclides.

Facility design features promote control of radionuclide releases during normal operations and accidents. The depth of the trenches reduces the possibility of offsite releases because disposal operations are conducted at depths of at least 40 feet below the natural grade. Releases from the bulk waste cell are minimized by the placement of temporary cover and stabilizing agents to reduce windblown dust. Canister placement facilitates efficient grouting inside canisters and placement of backfill between canisters. Sloped trench bottoms are designed to keep water from contacting waste and waste canisters while the trench is open. Storm water is directed away from the trenches and water falling directly into the trench is pumped out to minimize contact with waste. After the trench is closed, the low permeability performance cover minimizes infiltration into the waste disposal units. The thick earthen cover system and cobble biobarrier eliminate intrusion by plant roots and burrowing animals. The monitoring system will verify the proper performance of the disposal system.

Waste packages are placed in canisters and grouted in a manner that preserves package integrity, thereby minimizing radionuclide releases from the disposal trenches. Fire protection systems in the waste receiving and handling buildings mitigate releases in the unlikely event of a fire.

A buffer zone is maintained around the entire facility during operations, closure, and institutional control. The monitoring system provides early warning in the event of unexpected radionuclide releases to groundwater or other environmental media. The buffer zone is of sufficient size to allow mitigation of any such releases to the general environment before regulatory dose limits are exceeded. Together, the facility location, design, operation, closure, and monitoring all combine to satisfy the ALARA requirement of 30 TAC 336.724.

8.4 Post-Closure and Institutional Control Period

Provide information on how the disposal facility will be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required. [30 TAC §336.727]

Analyses of the long-term stability of the disposal site and the need for ongoing active maintenance after closure shall be based upon analyses of active natural processes such as erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal units and adjacent soils, and surface drainage of the disposal site. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure. [30 TAC §336.709(4)]

Long-term stability of the Site is ensured by its siting, design, use, operation, and closure. The siting criteria in 30 TAC §336.728(i) and (j) recommend avoiding areas that exhibit severe or frequent faulting, folding, earthquakes, volcanism, slumping, landsliding, erosion, or weathering. The WCS Site satisfies these criteria. The Site is nearly flat, so there is little possibility of landsliding. Settling or slumping is unlikely because the geologic strata are well consolidated and surface soils have low moisture content. The semi-arid climate helps maintain low moisture content of the soils. Surface water is absent except during infrequent rainstorms. In addition, there is minimal seismic and no volcanic activity near the Site. There is no evidence of tectonic or volcanic activity near the Site in the recent past. Groundwater at the Site is of relatively low quality and is located in greatest quantities at depths of 1,000 feet or more. The shallow groundwater is non-potable and unlikely to be used for irrigation because of limited yields, so site stability is not likely to be affected by groundwater withdrawal.

Evidence suggests that over the long term, the Site is aggrading. However, wind and water erosion of the Site have been evaluated using conservative assumptions. Even under the conservative assumption that erosion occurs continuously over the long term, the calculated erosion rates are very low and the Site remains stable.

Water and Wind Erosion – The SWAT model was used to evaluate water erosion at the Site. Current conditions were evaluated using an annual precipitation of 16 inches. Future conditions, characterized by a wetter climate and a higher average precipitation of 29 inches per year, were also evaluated. Under current climatic conditions, the SWAT analysis showed a water erosion rate of 4.1 inches over 50,000 years, or about 8.1E-05 inches per year. For wetter climatic conditions and 29 inches per year of precipitation, the SWAT analysis showed a total water erosion of about 24 inches over 50,000 years, or about 4.8E-04 inches per year. The wetter climate analysis did not take credit for a thicker vegetative cover that would likely be present given the higher precipitation. The SWAT erosion analysis is documented in Attachment 3.0-3.29.

The wind erosion analysis is based on data used for the WIPP site in New Mexico, which has similar weather conditions and vegetative cover. The total amount of wind erosion is estimated at 18.6 inches over 50,000 years. The supporting information for wind erosion is given in Attachment 3.0-18.

The Universal Soil Loss Equation (USLE) is used in Attachment 3.0-3.18 for determination of annual soil loss by sheet and rill erosion. The USLE is generally applicable to agricultural land and incorporates several assumptions that render the calculation conservative when applied to non-agricultural land. However, the input data on soil types were adapted to better represent the site-specific soil conditions. The results from the USLE were combined with the wind erosion rate from the WIPP site to arrive at a total erosion rate, documented in Attachment 3.0-3.18. The total erosion rate shows an estimated time of 63,000 years to erode the top four feet of the cover, down to the cobble biobarrier.

Headward Erosion of Monument Draw – Monument Draw, New Mexico and Monument Draw, Texas are typical of the draws that cross the Southern High Plains surface. The most recent episode of incision and widening of these valleys began 20,000 years ago, and ended 12,000 years ago when sediment began aggrading in the valleys (Holliday 1995). Filling of the valleys culminated about 3,000 years ago and little aggradation or downcutting has occurred in the past 3,000 years. Estimated rates of recent incision (downcutting) in the modern draws range from 0.06 in/yr to 0.08 in/yr (Gustavson et al. 1980; Finley and Gustavson 1980; Finley 1981). The valleys average about 1,542 feet in width, and the average maximum width is about 3,073 feet (Holliday 1995). If the valleys were initially incised and widened over a time span of 8,000 years (20,000 to 12,000 years ago), then the flanks of the valleys retreated at an average rate of 1.18 in/yr to a maximum of 2.95 in/yr over that time span (assuming parallel slope retreat on either side of the valley axis). The WCS facility is about three miles east of Monument Draw, New Mexico. If, in the future, this draw were to begin a renewed episode of incision and widening, it would take more than 160,000 years (at the average rate of 1.18 in/yr) for eastward retreat of the flank of Monument Draw, New Mexico to approach the WCS facility. These drainages have not widened their valleys for the past 12,000 years; hence, retreat of the valley flanks would require renewed downcutting in the lower reaches of Monument Draw, New Mexico, and would also likely require a return to climatic conditions that prevailed during the Late Pleistocene when the draws were incised (Lehman, Appendix 6.4-1).

Recent site data collection efforts have included the analysis of soil samples from drainage areas on the Site. The soil samples were analyzed by optical luminescence to determine their ages. Ages ranged from approximately 6,000 years to slightly over 50,000 years. The results show that the drainages have been aggrading for at least the last 50,000 years. This includes the last pluvial period at the end of the last glaciation, approximately 10,000 to 15,000 years ago. Although the age dating indicates there were episodes of erosion in the past, those episodes were relatively short-lived and did not reverse the long-term trend of aggradation. Future climate studies anticipate that during the next 50,000 years, there will be periods where the average precipitation exceeds current levels but will be lower than during the last pluvial period. Therefore, it is likely that the Site will continue to aggrade with windblown sediment.

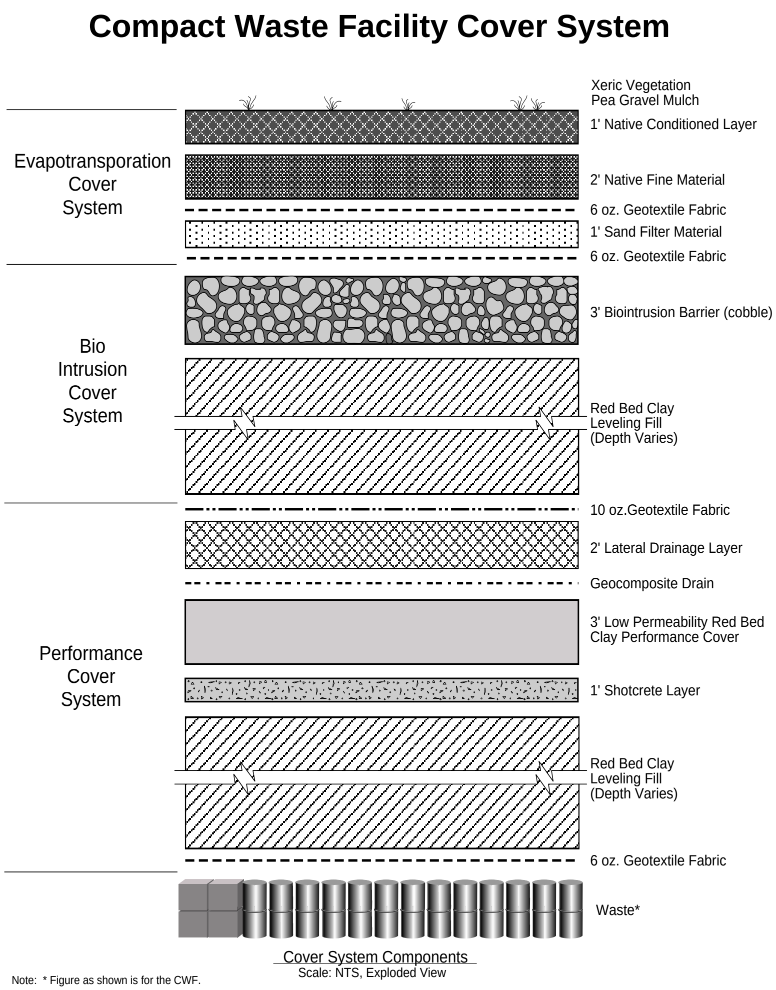
Aerial photographs of the Site over the last 69 years were analyzed to identify trends related to soil erosion. The photographs, and the age dating of soil, are consistent with the conceptual model, which is that the Site is aggrading and that the erosion and drainage features are vwery localized. There is no evidence that the base level of Monument Draw New Mexico has any effect on the Site.

Design, Use, and Operation – The design, use, and operation of the facility will help minimize the need for long-term active maintenance. Section 3.0 presents the complete discussion of waste cell configuration. The disposal units will isolate waste under a thick earthen cover. During waste disposal operations, the waste packages and bulk wastes will be placed using compaction and backfilling procedures to minimize void spaces. All Class C, Class B, containerized Class A, and unstable Class A waste will be placed in reinforced concrete canisters. In addition, bulk waste will be placed and compacted in a manner that ensures long-term stability. Voids inside concrete canisters will be filled with grout and voids between canisters will be backfilled with sand. Waste acceptance criteria will require waste generators to fill voids inside waste packages to the extent practicable. Filling all void spaces in the disposal units to the extent practicable will minimize the potential for long-term settlement and subsidence of the disposal units.

Closure – Facility closure will enhance its long-term stability. The ground surface at the disposal site will be contoured to approximate the original stable ground surface. The contours will divert surface water from the disposal units, promote runoff, and help prevent water and wind erosion. A natural vegetative cover, as shown in Figure 8.4, will be established that will help stabilize and maintain the soil surface and minimize erosion. The water diversion features and the vegetated cover also serve to minimize water infiltration into the disposal units, which further promotes site stability.

Following closure of the disposal units and placement of the final cover system, the facility will be monitored for subsidence. Custodial care and minor repairs to the cover system will be made, if necessary.

Appendix 3.0-3 shows the calculations used for siting, design, and long-term stability.



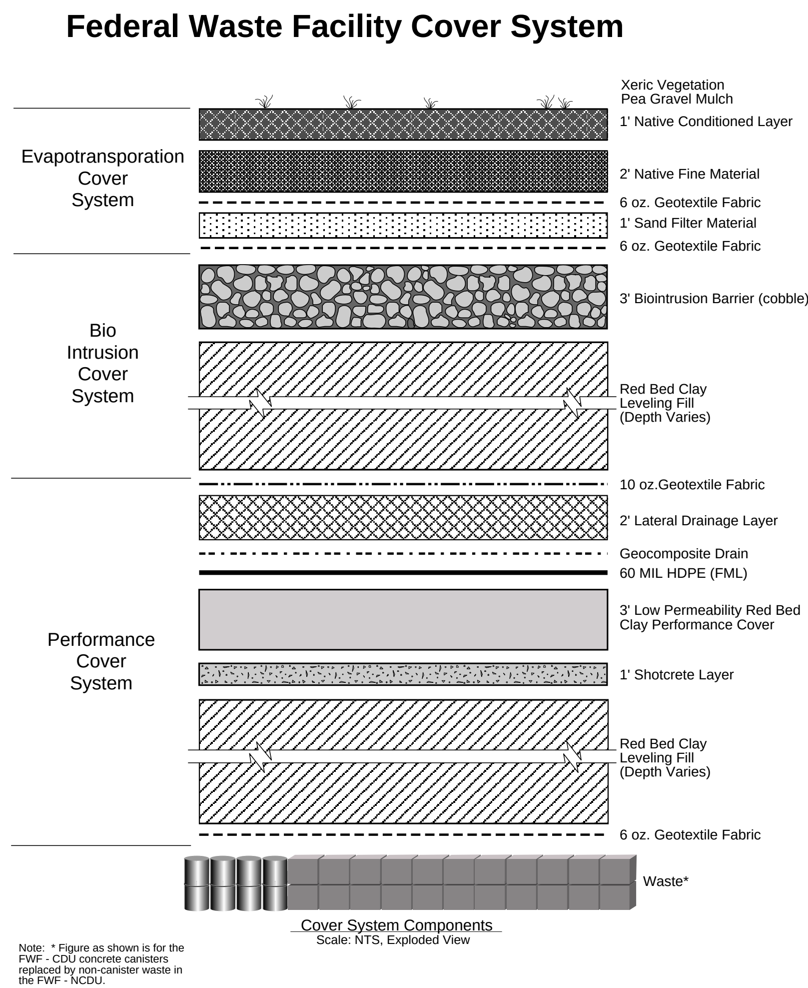


Figure 8.4. Cover System

8.5 Post-Institutional Control Period

Demonstrate how design, operation, and closure of the land disposal facility shall ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed. [30 TAC §336.725]

Provide analyses of the protection of individuals from inadvertent intrusion including demonstration that there is reasonable assurance that the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided. [30 TAC §§336.725, 336.709(2)]

Design, Operation, and Closure – Several features of the facility design, operation, and closure ensure the protection of inadvertent intruders. The design features that help ensure protection of inadvertent intruders include the depth of the disposal units below ground (all waste will be more than five meters below ground) and the siting of the facility in an area where shallow groundwater is largely absent. A 12-inch concrete layer will be placed over the top of the waste at the base of the cover system. During operation of the facility several features will be emplaced or constructed that help ensure protection of inadvertent intruders. These operational features include the placement of Class C, Class B, and containerized Class A wastes in concrete canisters, grouting the voids inside the canisters to make the waste less accessible, and the prohibition of all wastes that are above the Class C concentration limits. Closure of the facility will ensure additional intruder protection by providing a concrete layer over the top of the waste, a thick earthen cover system, a bio-barrier layer of coarse gravel, and surface markers to alert intruders to the buried waste.

Intrusion Analyses – An intrusion analysis was conducted to estimate the potential doses to an inadvertent intruder. The analysis is described in Appendix 8.0-6 and uses the same methodology as the NRC's analysis in NUREG/CR-4370 (NRC 1986). The four inadvertent intruders considered are the intruder discoverer, intruder constructor, intruder driller, and intruder resident. Although other intrusion scenarios are conceivable, the drilling scenario is recommended in the TCEQ guidance document, with specific guidance to model the scenario as described in NRC's analysis. Therefore, the intruder drilling scenario used the same approach as the "Update of Part 61 Impacts Analysis Methodology" (1986).

The inadvertent intruder analysis showed that the maximum dose was less than 7 mrem/yr, which is below the 100 mrem/yr public dose limit contained in 30 TAC §336.313. The doses for the post-institutional control scenario are shown in Table 8.3-3.

The CWF will accept only LLRW while the FWF may accept both LLRW and mixed LLRW. All waste must be appropriately classified before disposal. Wastes will not be segregated by waste class because all wastes will meet the appropriate stability requirements. Low activity waste consisting of inherently stable soil, rubble, or debris will be disposed in a separate disposal unit (FWF-NCDU) from the canister waste, as described in Section 3. Surface markers at the Site may serve as a deterrent and warn intruders of the presence of buried waste. The concrete canisters will provide some degree of inadvertent intruder protection for a period of time. The concrete layer over the top of the waste disposal units may also deter intruders from drilling through the disposal units. The cobble biobarrier layer may also serve as a deterrent to intrusion.

The depth of waste burial is the primary means of intruder protection. The cover system is from 25 to 45 feet thick over both the CWF and the FWF disposal units. With this depth of burial, it is unlikely that the wastes would be disturbed in the future by any means other than drilling. The layered cover system may also serve to alert a driller that the materials are not those that would normally be expected at the Site. For example, the cobble bio-barrier and the red bed fill material may be noticed as components of a designed cover system, rather than natural deposits.

Although the facility is designed, operated, and closed with several intruder protection features, the intruder dose analysis only takes credit for the depth of burial. The intruder analysis assumes that a driller develops a water well that penetrates through a waste disposal unit. Subsequently, a resident permanently occupies the Site. Waste materials are brought to the surface by the driller and discharged to a mud pit. The drilling crew is exposed to direct external radiation from the mud pit. The mud pit is filled with soil after the well is completed and is a source of long-term radiation exposure to the intruder resident.

The calculated maximum doses for the intruder driller and the intruder resident are 6.7 mrem and 4.6 mrem/yr, respectively. The doses are shown in Table 8.3-3. Although there are no regulatory limits specifically for intruders, the doses are below the 100 mrem/yr limit that applies to members of the public during normal facility operations.

Basis for Inadvertent Intruder Protection – The design, operation, and closure of the land disposal facility will ensure protection of any individual inadvertently intruding into the disposal site and occupying the Site or contacting the waste at any time after active institutional controls over the disposal site are removed.

The intruder protection requirement is designed to provide reasonable assurance that an individual who may inadvertently intrude into the disposal site will be protected from radiological hazards. The intruder protection system for the disposal site includes the waste classification system, waste placement procedures, disposal facility design, and materials used in construction and closure of the facility, and institutional controls.

Intruder analyses were developed to assess the potential doses to inadvertent intruders. The analyses included an intruder discoverer, intruder constructor, intruder driller, and an intruder resident. Pathways included groundwater use, external radiation from drill cuttings, and radioactive gases emanating from buried waste. Doses were calculated for hypothetical intruders who occupy the Site, either temporarily or permanently, and who inadvertently disturb the disposed waste after institutional control of the Site has ended.

Four types of intruder were evaluated using the same methodology as the NRC used in its "Update of Part 61 Impacts Analysis Methodology" (NUREG/CR-4370, January 1986). The intruder scenarios used for this analysis are described below.

- Intruder discoverer – An individual discovers and investigates the Site, but does not immediately recognize its former use as a disposal site. The individual spends time at the Site and after realizing that the Site contains buried waste, the individual leaves. The only potential exposure to this individual is from direct radiation through the cover system. Doses are negligible because of the thickness of the cover. Doses for the intruder discoverer are not evaluated quantitatively.

- Intruder constructor – An individual builds a house over the former disposal site. The construction involves digging a basement in the cover system. The thickness of the cover prevents any waste from being disturbed or exposed by the basement excavation. Because of the thick cover system, doses to the intruder constructor are negligible and are not evaluated quantitatively.
- Intruder driller – A drilling crew enters the Site at the end of the Institutional Control Period, unaware of the buried waste, and drills a water well to the 225-foot zone. In drilling the well, the drill penetrates through the disposed waste. The drill crew is exposed to external radiation from the contaminated drill cuttings in the mud pit. After completing the well, the drill crew covers the mud pit and leaves the Site.
- Intruder resident – Following the drilling scenario, a permanent resident is assumed to occupy the Site. The resident uses well water for drinking and stock watering. In addition to well water exposures, the resident is exposed to external radiation from the former mud pit, whose contents have been left in place and covered with soil. Additional exposure also occurs from inhalation of radioactive gases that emanate through the cover from undisturbed buried waste.

The NRC analysis also considered conditions in which the cover eroded completely away, leaving exposed waste at the ground surface. The NRC's analysis did not calculate exposures to an intruder in this case because the waste would be recognizable as such and the intruder would leave the area. In addition, the extremely thick soil cover on the waste greatly reduces the likelihood of complete cover erosion.

The intruder dose assessment contains many conservative assumptions that cause it to overestimate the dose to a driller and subsequent onsite resident. The following conservatisms are contained in the dose analysis. In the unlikely event that an intrusion occurred, the analysis shows that the dose to an intruder would be well within accepted limits, thereby satisfying the performance objective of 30 TAC 336.725.

The conservative assumptions in the intruder dose assessment include the following:

- The intruder driller only goes to the 225-foot zone, which minimizes the volume of drill cuttings (compared to drilling a deeper well) and, therefore, results in the highest radionuclide concentrations in the drill cuttings.
- The drilling event penetrates a stack of canisters that all contain the single waste stream that yields the highest dose to the driller. The chance of having a stack of canisters all containing the same waste stream is very small, since the wastes will be placed in the canisters randomly according to when they arrive at the facility.
- Gases from waste decomposition assume that the full inventory of potentially gaseous radionuclides is available for release to the atmosphere. Gaseous radionuclides include H-3, C-14, Kr-85, I-129, and Rn-222. Simultaneously, the full inventory of all radionuclides was assumed to be available for transport in the groundwater pathway.

In addition to the inadvertent intruder dose assessment, there are several environmental, design, operating, and closure features that serve to minimize or prevent intrusion and protect individuals from inadvertent intrusion.

Environmental features – The primary environmental features that contribute to intruder protection are the site location and the lack of abundant potable water sources. There are no residents in the immediate vicinity of the Site. Present uses of the area do not indicate that it is considered a desirable location for a resident. Well water is not readily available at the Site, except in very low quantities (from the 225-foot zone) or at greater depth.

Design features – The cover system will be from 25 to 45 feet thick over all waste. The cover provides protection from external radiation and makes it very unlikely that an individual would come in direct contact with waste. Granite markers will be placed at the corners of the disposal trenches to warn potential intruders of the hazard. A cobble biobarrier is included in the cover system about four feet below grade. Anyone digging at the Site would recognize that the cobble layer is an engineered feature and not a natural deposit. Deeper excavation by an intruder would reveal the materials of the performance cover. The multilayer design would alert the intruder that the Site contains manmade features. Concrete canisters at the CWF and FWF-CDU will remain recognizable for hundreds of years. Even after significant canister degradation, the materials would remain recognizable as an engineered component.

Waste operations – Waste operations will ensure that each waste package is properly classified as Class A, B, or C low-level waste. No waste above the Class C limit will be accepted for disposal. Generator certification and waste testing and sampling during operations will ensure that all waste is properly classified.

Closure – Institutional control of the Site after closure will extend for at least 100 years. Beyond 100 years, control of the Site may continue, but no credit has been taken for this in the intruder analysis. During the Institutional Control Period, environmental sampling will be conducted to verify facility performance. Minor maintenance activities will be conducted, if necessary, including maintaining proper vegetation and repairing areas of unanticipated settlement. During the Institutional Control Period, radioactive decay will reduce the radiological hazard of the waste. Following the Institutional Control Period the State and local government agencies will likely maintain records of the waste disposed at the Site, as well as deed restrictions to reduce the chance of inadvertent intrusion.

In summary, the intruder scenario assessments, along with the site environment, design, operation, and closure demonstrate that individuals will be protected from inadvertent intrusion into the Site and that the performance objective of 30 TAC 336.725 is satisfied.

REFERENCES

National Enrichment Facility, *Environmental Report, Revision 2,* July 2004.

Rogers and Associates Engineering, *Texas Compact Low-Level Radioactive Waste Generation Trends and Management Alternatives Study*. Rogers and Associates Engineering Branch of URS. August 2000.

Texas Commission on Environmental Quality. *Performance Assessment: A Method to Quantitatively Demonstrate Compliance with Performance Objectives for LLRW Facilities*. Draft Document Version 2, February 6, 2004.

U.S. Department of Energy. *The Current and Planned Low-Level Waste Disposal Capacity Report*. Revision 1, September 18, 1998.

———. *Commercial Disposal Policy Analysis for Low-Level and Mixed Low-Level Wastes*. March 9, 1999.

U.S. Environmental Protection Agency. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*. Federal Guidance Report No. 11, EPA-520/1-88-020, September 1988.

U.S. Nuclear Regulatory Commission. *Update of Part 61 Impacts Analysis Methodology*. NUREG/CR-4370, January 1986.

———. *Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility*. NUREG-1200, Rev. 3. Washington, DC, September 1998.

———. *A Self-Teaching Curriculum for the NRC/SNL Low-Level Waste Performance Assessment Methodology*. NUREG/CR-5539, January 1991.

———. *Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility*. NUREG-1199, Revision 2. Washington, DC, January 1991.

———. *A Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities*. NUREG-1573. Washington, DC, October 2000.