Reclamation Plan Sequoyah Facility

SEQUOYAH FUELS
A GENERAL ATOMICS COMPANY
PO Box 610
Gore, Oklahoma

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1.0 INTRODUCTION

1.1 Background

Sequoyah Fuels Corporation (SFC) operated a nuclear fuel-cycle facility licensed by NRC at U.S. Interstate-40 and Oklahoma State Highway 10, Gore Oklahoma 74435. SFC engaged in different operations in different areas of the Facility, pursuant to NRC Source Material License SUB-1010, including (1) the recovery of uranium by concentration and purification processes, (2) the conversion of concentrated and purified uranium ore into UF_6 between the years of 1970 and 1993, and (3) the reduction of UF_6 into UF_4 from February 1987 until 1993.

SFC ceased production in 1993 and submitted a Preliminary Plan for Completion of Decommissioning (PPCD). The PPCD indicated that decommissioning the facility would include construction of an on-site disposal cell using the performance criteria contained in Appendix A to 10 CFR 40 to isolate the decommissioning waste. SFC conducted site characterization and decommissioning planning activities in order to develop a decommissioning plan for the Sequoyah Facility. In addition, SFC submitted information in support of an Environmental Impact Statement (EIS) initiated by the NRC.

In July 1997, the U.S. Nuclear Regulatory Commission (NRC) adopted new regulations that establish radiological criteria for license termination, including restricted release. Under these criteria, SFC submitted a decommissioning plan proposing an onsite disposal cell meeting the performance criteria in Appendix A of 10 CFR 40 with restricted release of the site once decommissioning activities were completed. During the NRC Staff's review of the plan the NRC Staff expressed concern that SFC had not yet identified a third party that would accept responsibility to enforce the proposed institutional controls. Subsequently, the NRC concluded that the front-end waste at the SFC Facility could be classified as byproduct material as defined in section 11e.(2) of the Atomic Energy Act (11e.(2)), and that such waste may be disposed of in accordance with Appendix A to 10 CFR 40. Appendix A provides for long term custody by assigning the

Department of Energy as custodian of reclaimed sites under a general license in 10 CFR 40.

This Reclamation Plan (RP) updates and reformats the previous DP to include changes made to accommodate public input, extensive review by NRC and its contractors, and additional studies and evaluations done by SFC since 1999. As such, it describes the decommissioning and reclamation of the Sequoyah Facility as an 11e.(2) byproduct materials site.

1.2 Purpose, Scope and Objectives of Site Reclamation

The Sequoyah Facility is planned for reclamation as an 11e.(2) byproduct material site under performance standards administered by the NRC. With the exception of raffinate sludge, and sediments from the north ditch, emergency basin, and sanitary lagoon (which may be shipped offsite for permanent disposal), all of the waste materials will be disposed on site. Upon successful demonstration to NRC of meeting these performance standards, the site will be transferred to the U.S. Department of Energy for long-term care and maintenance. SFC's proposed approach would result in the dismantlement of facility equipment and structures, removal of sludges, impoundments, buried wastes and impacted soils, and placement of resulting waste materials in an engineered disposal cell.

The drainages that exit the Institutional Control Boundary (ICB) to the west (001, 005, and 007) contain some residual radioactive materials from historic releases. However, doses from exposure to these materials without restrictions is not distinguishable from background. As a result, SFC plans no further cleanup in these drainages

The strategy for a groundwater protection plan was developed under NRC guidelines. This resulted in the preparation of a Groundwater Corrective Action Plan (CAP) for the site. This CAP was developed independently of this Reclamation Plan and submitted to the NRC by June 15, 2003. As such, the groundwater protection plan is not addressed here.

The reclamation approach consists of the following elements:

- Construction of an above-grade, engineered disposal cell on the SFC site for permanent disposition of the SFC decommissioning and reclamation wastes.
- Removal of sludges and sediments from the ponds and lagoons, excavation of buried low-level wastes, removal of stored soils and debris, and placement of these materials into the disposal cell.
- Dismantlement of process equipment, followed by recovery of gross quantities of contained uranium.
- Size reduction/compaction of process equipment, piping and structural materials (including scrap metal, empty drums, and packaged wastes that will accumulate prior to decommissioning) to satisfy disposal requirements for minimum void volume.
- Dismantlement/demolition of structures excepting the new SFC administrative office building and the storm water impoundment.
- Demolition of concrete floors, foundations and storage pads, and asphalt or concrete paved roadways outside the footprint of the cell. Removal of clay liners and/or contaminated soils from impoundment footprints.
- Excavation of underground utilities, contaminated sand backfill from utility trenches and building foundation areas and more highly contaminated soils under the cell footprint.
- Excavation of contaminated soils lying outside the footprint of the disposal cell that exceed site-specific radiological cleanup criteria.
- Handling and treatment of produced ground water and storm water during cell construction.
- Placement of all SFC decommissioning wastes into the onsite disposal cell, followed by capping and closure of the cell.
- Re-grading the site, backfilling of excavations to the finished grade, and re-vegetation.

- Establishment of a fenced Institutional Control Boundary (ICB) around the cell, installation of additional monitoring wells as necessary, and initiation of a long-term site monitoring plan.
- Transfer title for the restricted property to DOE for long term care and maintenance.
- Termination of SFC's NRC license under the provisions of 10 CFR 40, Appendix A.

1.3 Criteria and Guidelines

The majority of the waste materials to be disposed on site are classified as 11e.(2) by-product materials and, as such, will be reclaimed under the criteria specified in Appendix A of 10 CFR 40. The remaining materials are not classified as 11e.(2) by-product materials, but have similar characteristics which make them candidates for disposal in the cell. This RP proposes to dispose of the non-11e.(2) byproduct materials in the cell. NRC Regulatory Information Summary 2000-23 (November 30, 2000) provides guidance on disposal in tailings impoundments of wastes that are not 11e.(2) byproduct material. Appendix A of this RP addresses each of the eight considerations of RIS-2000-23 and demonstrates that disposal of the SFC non-11e.(2) byproduct material wastes in the disposal cell is consistent with NRC policy. Therefore, no distinction is made between the 11e.(2) materials and the non-11e.(2) materials in the remainder of this RP.

The key design criteria for the disposal cell are to: (1) meet the performance standards for reclamation outlined in Appendix A of 10 CFR 40, (2) provide sufficient capacity for disposal of on-site materials, (3) result in a facility that blends in with the surrounding area (from a visual, hydrologic and vegetative standpoint), (4) have a negligible effect on underlying groundwater, and (5) facilitate site cleanup and reclamation activity. These criteria are outlined below.

1.3.1 Performance standards

The performance standards in Appendix A of 10 CFR 40 include: (1) isolation of the waste materials in a manner that protects human health and the environment,

(2) reduction of radon emanation from the cover to an average of 20 pCi/square meter-second or less, (3) having the reclamation be effective for a long period of time (200 to 1,000 years), and (4) minimizing reliance on active maintenance.

1.3.2 Disposal cell capacity

The disposal cell layout has been sized for a capacity (beneath the cover system) of approximately 9 million cubic feet which accommodates the estimated total volume of 5 million cubic feet. The cell design allows for adjustment of the capacity as needed over a range of 5 to 12 million cubic feet.

1.3.3 Surrounding area impact

The top surface of the cell will be limited to an elevation of approximately 590 feet above mean sea level (AMSL) to minimize the visual impact of the disposal cell from surrounding areas. In addition, the side slopes of the cell will be at 5:1 (horizontal:vertical) or less, with the corners of the cell rounded to create a topographic feature that is visually similar to the surrounding area. The surface of the completed cell will be vegetated with natural species similar to surrounding areas.

1.3.4 Effect on groundwater

The disposal cell cover design strategy includes minimizing infiltration of meteoric water. The cover design incorporates soil layers that promote evapotranspiration from vegetation to minimize infiltration. Synthetic liner materials are included in the cover to restrict short-term infiltration into the underlying waste materials until the vegetation matures and the infiltration is controlled by evapotranspiration.

1.3.5 Facilitation of site cleanup

The siting and layout of the cell has been designed to accommodate stormwater management and construction activity during site cleanup.

1.3.6 Site Selection and Layout

The disposal cell was sited within the major areas of contamination at the facility. The disposal cell was also sited to be close to materials to be placed in the cell to

reduce handling costs. Appendix H, “Disposal Cell Design Siting Study For On-Site Disposal Cell” presents the results of SFC’s siting evaluations.

1.3.7 Institutional Control

The disposal cell design is based on the site being transferred to the U.S. Department of Energy for long-term care and maintenance following completion of decommissioning. As with other 11e.(2) byproduct material sites, the U.S. Department of Energy will exercise institutional control of the site. This means that SFC will fence the site to limit unauthorized access. Activities within the ICB will be only those authorized by the U.S. Department of Energy or its contractors, such as monitoring or maintenance.

1.3.8 Post-Reclamation Dose

The dose to a member of the public from any activity undertaken on the unrestricted portions of SFC property (outside of the proposed ICB) will not be distinguishable from background.

The dose to a member of the public inside the ICB following completion of reclamation will satisfy not only the requirements of 10 CFR 40, Appendix A (the radium benchmark dose), but also the requirements of 10 CFR 20.1403 (less than 25 mrem/y or less than 100 mrem/y for restricted release with loss of institutional controls).

1.4 Plan Organization

This plan was developed from reports, studies and evaluations developed since 1990. Reliance was placed upon a decommissioning plan which proposed this approach under a different regulatory regime. Although not approved at the time of this writing, the decommissioning plan underwent significant technical and environmental review by the NRC since 1998. The resulting technical exchange between the NRC and SFC has led some refinements of the groundwater model, the dose model and the cell design which have been incorporated here.

This RP relies upon previous studies and reports, many of which have been submitted previously and are on the docket. The decommissioning and

reclamation approach is generally summarized in this plan with much of the details contained in the appendices and attachments. Evaluations, studies, reports, etc. that are relied upon for support of the reclamation plan are included here as Appendices. Program documents, specifications, and project plans, some of which are controlled documents used in field implementation of this RP, are included as Attachments. Information important to the decommissioning, as required by 10 CFR 40.36(f), including documentation of spills, cleanup of contamination, drawings or descriptions of modification of structures in the restricted area, and locations of possible inaccessible contamination, is maintained in the Administration Building at the Sequoyah Facility.

2.0 GENERAL DESCRIPTION OF THE FACILITY

2.1 Facility History

License SUB-1010, Docket No. 40-8027 was originally issued on October 14, 1969 for storage only of uranium ore concentrates. The license was amended on February 20, 1970, authorizing the operation of the Uranium Hexafluoride (UF_6) Conversion Plant. The license was amended on February 25, 1987 to authorize operation of the UF_6 Reduction Plant. The license was last renewed on September 20, 1985, and would have expired on September 30, 1990. The license has remained in effect based on submittal of a renewal application dated August 29, 1990, and provisions in 10 CFR 40.42(a).

By letter dated February 16, 1993, SFC notified NRC of its decision to suspend all production operations permanently, including uranium recovery by concentration and purification processes and subsequent conversion operations, and to decommission the facility. Since July 1993, the concentration and purification processes, the UF_6 conversion processes, and the DUF_4 reduction processes have been closed. By letter dated 11/26/93, NRC advised SFC that authorized activities were limited to those related to decommissioning, and routine environmental and effluent monitoring.

By letter dated January 5, 2001, Sequoyah Fuels Corporation (SFC) requested U.S. Nuclear Regulatory Commission (NRC) to determine if some of the waste material at the Gore, Oklahoma facility could be classified as byproduct material, as defined in Section 11e.(2) of the Atomic Energy Act. After review of the SFC position and the regulations, the Commission concluded that the front-end waste at the SFC Facility could be classified as 11e.(2) byproduct material, and that such waste may be disposed of in accordance with Appendix A to 10 CFR 40. SFC subsequently submitted a license amendment request to possess 11e.(2) byproduct materials which was approved on December 11, 2002.

2.2 Facility Location and Description

The SFC facility (Facility) is a 600-acre parcel of land containing the Industrial Area which occupies roughly 200 acres of the Facility. The Facility is located in Sequoyah County in mid-eastern Oklahoma about 150 miles east of Oklahoma City, Oklahoma, 40 miles west of Fort Smith, Arkansas, 25 miles southeast of Muskogee, Oklahoma, and 2.5 miles southeast of Gore, Oklahoma in Section 21 of Township 12 North, Range 21 East. Figure 2-1 shows the location of the Facility. The Facility is bounded on the north by private property, on the east by State Highway 10, on the south by Interstate 40 (I-40) and on the west by U.S. Government-owned land (managed by the U.S. Army Corps of Engineers [COE]) adjacent to the Illinois and Arkansas River tributaries of the Robert S. Kerr Reservoir. Figure 2-2 shows the topography of the Facility and surrounding area.

Most of the uranium-processing operations were conducted on an 85-acre portion of the Facility that is commonly referred to as the Process Area. SFC uses an additional 115 acres to manage storm water and store by-product materials. The reclamation activities will focus on the Process Area and the additional management areas that are collectively referred to as the Industrial Area. A location map of Facility designations is included in Figure 2-3. Most of the land outside of the Industrial Area is used either for grazing cattle or forage production.

Prior operations at the Facility can generally be summarized as follows. Following receipt of ore concentrates (yellowcake) at the Facility, the ore was subjected to concentration and purification processes to further purify the yellowcake. The purpose of the concentration and purification processes was to control the grade of materials entering the conversion process so as to avoid the contamination of the conversion processing system which if permitted to occur would lead to the production of off-specification material.

Following the concentration and purification processes, the materials were transferred to the conversion facility which produced high purity UF_6 using the purified yellowcake as feed material.

Also located at the Facility was a separate reduction facility which produced UF_4 using depleted UF_6 as feed material.

In addition to the facilities for concentration and purification, conversion, and reduction, the SFC site also includes: (1) a storage area for the yellowcake received from conventional uranium mills; (2) a yellowcake sampling facility; (3) a bulk storage area for chemicals such as ammonia (NH3), tributylphosphate-hexane solvent, and hydrofluoric (HF), nitric (HNO_3), and sulfuric (H_2SO_4) acids; (4) a facility for electrolytic production of fluorine from HF; (5) treatment systems and storage ponds for both radiological and non-radiological liquid effluent streams; and (6) a facility for the recovery and beneficial use of ammonium nitrate solution (which originated from the solvent extraction system) as fertilizer on SFC-owned land.

Additional facilities include the following: a yellowcake drum storage area, an electrical substation, UF_6 cylinder storage area, tank farm for liquid chemicals and fuel oil, cooling tower for waste heat dissipation, sanitary sewage facilities, retention ponds for calcium fluoride sludge, retention ponds for processing raffinate into fertilizer and raffinate sludge, a raffinate sludge concentration and loading facility, retention ponds for fertilizer, and a reservoir for an emergency water supply. A general Facility layout is presented in Figure 2-4.

2.3 Physical Characteristics of the Facility

The SFC site is located above the east bank of the Illinois River at its confluence with the Arkansas River. The site is on the western end of a broad upland area approximately 100 feet above the normal elevation of the Illinois River (as impounded by the Robert S. Kerr Reservoir). The physical characteristics of the site and surrounding areas have been the subject of several studies since 1990. The following sections summarize the findings of these studies. Additional details are available in Appendix B and Appendix D.

2.3.1 Surface Features

The Facility is situated on gently rolling to level land with several steep slopes to the northwest and wooded lands to the north and south. Elevations on or near the Facility range from 460 feet AMSL for the normal pool elevation of the Robert S. Kerr Reservoir to nearly 600 feet amsl (Figure 2-2). Slopes over most of the upland areas of the Facility are less than seven percent. Steeper slopes in creek ravines and on hillsides average roughly 28 percent. Near the Robert S. Kerr Reservoir, slopes are very steep. This area is owned by the federal government and is administrated by the COE.

2.3.2 Surface Water Hydrology

The Facility is located on the east bank of the Illinois River tributary of the Robert S. Kerr Reservoir. Southwest of the Facility the Illinois River joins with the Arkansas River tributary of the Robert S. Kerr Reservoir. Flow in the Illinois River arm of the Robert S. Kerr Reservoir is regulated by releases from the Tenkiller Ferry Reservoir, which is located on the Illinois River approximately seven miles upstream from the Facility. The annual average flow of the Illinois River at the gauging station between the Tenkiller Ferry Reservoir and the Facility is 1,610 cubic feet per second (cfs).

Significant differences occur in water quality between the Illinois and Arkansas Rivers. The Illinois River flows through a rugged, rocky watershed throughout much of its course in northeastern Oklahoma and is fed largely by releases from Lake Tenkiller Ferry Reservoir and from steep, spring-fed streams. This results in relatively clear waters, with an average specific conductance of 170 microsiemen per centimeter (microS/cm). In contrast, the Arkansas River, acquires sediment from farming areas along its course in Colorado, Kansas, and Oklahoma, resulting in relatively turbid waters. Specific conductance values from the Robert S. Kerr Reservoir dam are about 600 microS/cm (SFC, 1998a).

The Process Area is located on an upland area approximately 100 feet in elevation higher than the surface elevation of the Robert S. Kerr Reservoir. Relatively steep (28 percent average) surface gradients occur between the

Process Area and the Robert S. Kerr Reservoir and the floodplain area in the southwest portion of the SFC property. Several small ephemeral streams drain the Industrial Area to the Robert S. Kerr Reservoir, including the 001, 004, 005, 007, 008, and 009 streams in Figure 2-5, and the drainage associated with the Storm Water Reservoir. Several other drainages affect the SFC property. One stream, hereafter referred to as Creek A, drains the area south of the Fertilizer Ponds. This stream bends northwestward and follows along the eastern edge of the Agland area, and eventually joins with water from the Storm Water Reservoir drainage. A small, northeast flowing stream occurs east of Highway 10. This stream closely parallels the Carlile School Fault and drains much of the eastern portions of the SFC property (Figure 2-2). This small stream empties into Salt Branch (Figure 2-2), a northwestward flowing drainage that closely parallels the SFC northernmost property boundary.

2.3.3 Climatology and Meteorology

Sequoyah County has a warm, temperate, continental climate. Storms bring ample precipitation when moisture-laden air from the Gulf of Mexico meets cooler, dryer air from the western and northern regions. The most variable weather occurs in the spring, when local storms can be severe and bring large amounts of precipitation. The mean annual temperature is 61.5º F. The monthly average ranges from 40º F in January to 82º F in July. The average daily range in temperature is 24º F. The lowest temperature on record was -19º F in January 1930 and the highest was 115º F in August 1936. The mean annual precipitation ranges from 42.9 inches in the town of Sallisaw, to approximately 44.1 inches in the northeastern part of Sequoyah County. The seasonal distribution of rainfall is fairly even, with 31 percent in spring, 26 percent in summer, 23 percent in fall and 20 percent in winter.

The average amount of snowfall from November through April is about 5.2 inches. Lake evaporation averages about 47.5 inches annually. Of this, 72 percent occurs from May through October. Based on the precipitation and lake

evaporation values, there is a net annual evaporation rate of about 4 inches in the SFC area.

The most severe storms occur in the spring, although thunderstorms are also frequent during the summer months. Strong winds, heavy precipitation, and intense lightning may be associated with these storms.

The nearest Sequoyah County weather station is in the town of Sallisaw, Oklahoma. There is no national weather station in the immediate vicinity. Meteorological data may be obtained from the national weather station at Tulsa, Oklahoma, about 70 miles northwest, and at Fort Smith, Arkansas, about 40 miles east. Fort Smith, Arkansas is the closest data station having topographic and climatological characteristics similar to the Facility.

2.4 Geologic Setting

Based on historic information and data from recent site investigations, the following summarizes the geologic, hydrogeologic and geochemical conditions at the SFC Facility. For a detailed description, see Appendix B, section 6.

As described in Appendix B and Appendix D, the site rests on a ridge or upland area above the headwaters of the Robert S. Kerr Reservoir and the lower Illinois River. The SFC site is underlain by a sequence of approximately 400 feet of sedimentary siltstones and sandstones of the Atoka Formation. The Atoka formation is of the Pennsylvanian geologic period (with these sedimentary rocks formed approximately 280 to 325 million years ago. The bedding of these units is nearly horizontal, with varying depths of weathering and erosion. These units are mantled at varying depths with Pleistocene terrace deposits. The underlying soils and sedimentary rocks at the site have been investigated with regional geologic data and over 500 bore holes.

The site is located on the southwest flank of the Ozark Uplift, a regional structural feature. The site is in an area of low seismic activity with no significant faulting in the area within the last 35 million years. NRC has reviewed the seismic setting

and concluded that no active or capable faults exist around the facility. Appendix E provides the results of the site seismic evaluations.

The Atoka Formation sedimentary rocks beneath the site consist of alternating shale and sandstone layers, extending to depths of several hundred feet. The Atoka Formation sedimentary rocks are mantled or covered with alluvial terrace deposits of the Quaternary geologic period. These terrace deposits were placed during the Pleistocene epoch (approximately 10,000 to 1,000,000 years before present) during high-water stages of flow on the Arkansas and Illinois Rivers. These high-water stages were most likely from melting periods of Pleistocene glaciation. Subsequent downcutting of the Illinois and Arkansas Rivers has left these deposits above the current river elevations. More recent alluvial deposits are found along the banks of the Illinois and Arkansas Rivers.

Groundwater levels and water quality have been evaluated from over 300 wells that have been completed on site. This information is presented in Appendices B and E of this Reclamation Plan. The shale and sandstone units are both of relatively low hydraulic conductivity, so that although groundwater is present in these units, groundwater yield is low. The uppermost groundwater beneath the site is within the uppermost shale layer. A limited, transient amount of groundwater is perched on the uppermost shale within the terrace deposits.

Soils investigated from drilling on site consist of these terrace deposits and weathered zones of the Atoka Formation. These soils range from sandy, clayey gravels to silty clays. The materials are classified (according to the Unified Soil Classification System) as a low to moderate plasticity silt and clay as well as clayey sand and gravel.

2.5 Seismicity and Ground Motion Estimates

The maximum anticipated seismic acceleration at the Site based upon general, published information is less than 0.05 g (Attachment E). Based on a maximum anticipated seismic acceleration of 0.05 g, the corresponding seismic coefficient for use in pseudo-static analyses of the cell and cover system would be 0.03 to 0.04. In the initial stability analyses, SFC used a seismic coefficient of 0.05 to

conservatively represent the conditions at this site, and also to be consistent with the generalized values for the area recommended by the U.S. Army Corps of Engineers (Appendix C).

The site area was evaluated in more detail in terms of (1) historical earthquake events in the region, (2) capable faults in the site area, and (3) probabilistic analyses of seismic events not associated with known faults. From this evaluation, the largest ground acceleration at the site from historical earthquake events was estimated to be 0.06 g. The review of capable faults in the site area showed no capable faults under criteria in 10 CFR 100 Appendix A. The probabilistic analysis of seismic events in the site area resulted in estimated peak ground acceleration values of 0.16 to 0.27 g, and corresponding seismic coefficient values of 0.11 to 0.18 g. The values from the probabilistic analyses were used in the stability analyses for the disposal cell (presented in Attachment E).

2.6 Erosional Stability

The topographic and geologic descriptions above indicate that the site is on an upland area of Pennsylvanian-age sedimentary rocks that have been mantled with Pleistocene epoch terrace deposits and recent alluvial deposits. Erosion during the Quaternary period has been limited to downcutting of the bed of the Arkansas and Illinois Rivers, with no significant erosion of the sedimentary rocks or overlying alluvial deposits at the western end of the upland area.

The SFC site as well as planned reclaimed features of the site are hydraulically separate and erosionally stable from extreme flood events on the Illinois and Arkansas Rivers, as summarized below.

1. The location of planned reclaimed site features are at an elevation approximately 100 feet above the normal and flood-stage elevations of the Illinois and Arkansas Rivers in the site area.

2. The recent geomorphologic history of the site indicates that the most significant periods of erosion and sediment deposition from

rivers in the site area coincided with glacial periods over 10,000 years ago. Estimated extreme flow events (under probable maximum precipitation calculation methods) are significantly lower than the Pleistocene epoch flows that were experienced over sustained periods at the site.

3. The Pennsylvanian-age sedimentary rocks that form the foundation for reclaimed features at the SFC site are not susceptible to rapid or significant erosion that would expose the planned reclaimed features at the site.

4. The current topography of the Arkansas and Illinois River basins in the site area shows a large area of lower elevation to the west of the site. There is not a constriction of flow or a bend in the bed of either river that would indicate significant flow velocities or a potential for riverbed migration toward the upland area where the site is located.

5. The relatively low seismic activity with no significant faulting in the area indicates that seismically-induced features that would be susceptible to erosion are not present.

3.0 FACILITY DECOMMISSIONING AND SURFACE RECLAMATION

3.1 Summary of Radiological Conditions

The Site Characterization Report (SCR) included as Appendix D, and the Facility Environmental Investigation (FEI) (RSA, 1991) provide thorough descriptions of Facility operations, along with the identification of source characteristics associated with various processes. Detailed historical information about the facility is provided in the documents listed in section 2.2.4 of the SCR. This section summarizes the extent and concentration of the contamination found during those studies.

The contamination at the Facility is a result of uranium processing activities that took place during the operation of the plant. Throughout the operating life of the plant, on-going evaluations of the impact of plant operations, including airborne and liquid discharges, and soil and groundwater sampling, occurred.

In the vicinity of the process buildings, process impoundments and uranium handling areas, concentrations of uranium in the soils exceed background and in many areas exceed the proposed soil cleanup criterion (see section 3.2.2). Uranium in soil at concentrations above 27 pCi/g is found to a maximum depth of about 31 feet beneath the Process Area. In addition, a few areas of limited extent are impacted by thorium-230 and/or radium-226. Soils containing thorium or radium in excess of the proposed limits are confined to areas where raffinate sludge was managed.

Groundwater beneath portions of the SFC site is impacted by uranium from past leaks and spills. The vertical extent of the groundwater impact is limited by an almost impervious sandstone layer, referred to as the Unit 4 Sandstone, that underlies the majority of the site. Monitoring wells in the groundwater zone immediately beneath Unit 4 Sandstone confirm that there is no significant impact below that level.

Groundwater flow on the site is generally to the southwest, conforming to the tilt of the bedrock strata in the area. Some localized areas of groundwater flow to

the south and northwest have been measured, however these flows appear to be influenced by erosional features and mounding of water in the vicinity of facility impoundments.

The groundwater is not currently a threat to human health or the environment. The strategy for a groundwater protection plan will be developed under NRC guidelines as the result of a Corrective Action Plan for the site. The groundwater protection plan was submitted June, 2003.

A characterization of structures and equipment in the restricted area was performed to provide information concerning the degree of radioactive contamination and radiation levels in order to provide a basis for identifying contamination control efforts that will be required during decommissioning. The characterization data was compiled from routine and special surveys performed during 1994, 1995, and 1996.

Areas identified as impacted by operation of the SFC Facility are the Process Area, portions of the 1986 Incident Plume pathway, Fertilizer Storage Pond Area, the historic Combination Stream, a drainage pathway south of the plant entrance, the drainage pathway designated as Outfall 005, and most structures within the restricted area. Figure 2-1, Attachment B, summarizes the impacts.

3.2 Decommissioning and Reclamation Activities

Decommissioning and reclamation plans and specifications are presented in Attachment A - F. This section provides an overview of the activities planned during decommissioning and reclamation for the site.

3.2.1 Description of Activities and Tasks

The scope of decommissioning activities includes the dismantlement and removal of systems and equipment, the deconstruction of structures, the removal and treatment of sludges and sediments, the removal of contaminated soils, and the treatment of wastewater. The placement of these materials in the disposal cell will be in layers by category of radioactivity, as well as in three areas of the cell in phases. The following summarizes these activities.

Structures, Systems and Equipment

A detailed volume estimate of the facility equipment and structural materials was made and the disposal volume was estimated to be 824,660 cf (after dismantlement and size reduction; 50% of the concrete left in place). This estimate was based on a review of drawings and other data for the facility structures, equipment, utilities, and concrete in order to determine the location of contamination, to understand the construction of the facility, and to facilitate planning of dismantlement methods. Appendix F describes the review described above.

The majority of the salvageable or recyclable equipment and materials have been removed and dispositioned. Only limited decontamination of materials for unconditional release is planned. All remaining equipment and structures will be dismantled and size reduced, as necessary. The dismantled equipment and structural components will be placed into the cell. Concrete and asphalt will be broken into manageable pieces and placed in the cell.

Soils, Sediments and Sludges

<u>Raffinate Sludge</u>

The raffinate sludge contains a significant fraction of the radionuclides presently on the SFC site (34% of the uranium or 60,800 kg, 76% of the thorium 230 or 156 Ci, and 38% of the radium 226 or 1.1 Ci.). The sludge has been removed from the Clarifier A Basin and processed to reduce the water content.

The de-watering method removed free water from the sludge resulting in a 50% reduction in the weight, approximately 11,000 tons of de-watered sludge. The de-watered sludge has been placed in bags for off-site disposal or placement into the disposal cell.

Calcium Fluoride (CaF_2) Sludge

Calcium fluoride (CaF_2) sludge will be dewatered to improve its structural strength prior to placement into the disposal cell.

Sediments

Sediments from the Emergency Basin, North Ditch and Sanitary Lagoon will be dewatered or stabilized to improve their structural strength prior to placement into the disposal cell.

Soils

Soils outside the footprint of the disposal cell which contain uranium, radium, or thorium in excess of the proposed site-specific cleanup criteria will be excavated and placed in the disposal cell. This volume is estimated to range from 0.5 to 3.0 million cf depending on the final soil cleanup criteria that is selected. At a minimum, soils under the footprint of the disposal cell that exceed the uranium DCGL (the concentration that would result in an equivalent dose from Ra-226 at 5 pCi/g) will also be excavated, and placed in the cell. The volume of these soils is estimated to be about 345,000 cf. The depth of excavation will be based initially on soil sampling data from characterization studies. Follow-up sampling will be done to determine if additional excavation is required, and to demonstrate that the cleanup criteria have been satisfied.

Additional soil will be excavated, most likely to the soil/bedrock interface, in those areas where the uranium concentration in the perched groundwater is elevated in excess of 150 pCi/l (the SFC license action level, 225 µg/l). This would be done to facilitate the removal and treatment of the impacted perched groundwater. It is likely that some of the soils in the areas of perched groundwater impact contain uranium in the forms of uranyl nitrate and related compounds, which are much more soluble than the oxide forms.

Soils collected from prior cleanup activities that are presently located in the Interim Storage Cell and in the Pond 1 Spoils Pile will also be removed and placed in the disposal cell. These materials have a volume of about 578,000 cf. An additional 952,000 cf of potentially contaminated clay and soil lies beneath the facility ponds, basins and clarifiers. The fraction of this soil exceeding the applicable cleanup criteria is expected to be less than 10% of the total volume, or 95,200 cf.

Soils from excavation areas will be transported to the disposal cell by haul trucks for long distances, or loaders for shorter distances. Existing roads will be used as much as possible; new haul roads will be constructed only if necessary.

Soils will be placed in the cell in lifts and mechanically compacted according to design requirements (Attachment A). Placement of this material will be sequenced with other materials to assure stability of the cell, to minimize voids and settlement, to limit leaching and to further restrict the emanation of radon from the cell. Attachment E, Disposal Cell Construction Plan, discusses the placement sequence.

Wastewater Management

Wastewater includes water from existing ponds and impoundments, storm water runoff from work areas, water used for processing operations, and recovered groundwater.

The Wastewater Treatment System, located south of the Clarifier Basins (Figure 2-4) is designed for batch treatment of wastewater to remove uranium. The system utilizes precipitation, filtration, and ion exchange processes to remove uranium prior to release of the water.

Treated water will be sampled and analyzed for uranium prior to discharge through permitted outfall 001. The cleanup goal for the Wastewater Treatment System is to reduce the uranium concentration to less than 30 µg/l, the drinking water MCL.

Site Restoration

After the removal of systems and equipment, structures, and soils and sediments, the site will be restored by backfilling (if necessary), grading and seeding with vegetation.

3.2.2 Cleanup Levels

The cleanup levels for this reclamation plan were either specified by regulations, or derived using guidance provided by the NRC. 10 CFR 40, Appendix A, Criterion 6 (6) limits the concentration of Ra-226 in soil, and concentrations of other radionuclides in soil based on the equivalent dose from Ra-226. Derived concentration guideline levels (DCGL) have been developed as concentrations of residual radioactivity in soils that are equivalent to the Ra-226 concentration. The detailed dose modeling is presented in Appendix G. The approach used is summarized here. Cleanup levels were subsequently chosen based on the DCGLs, application of the ALARA principle, and the limiting conditions of 10 CFR 40, Appendix A, Criterion 6 (6).

Identification of Constituents of Concern (CoC)

The CoCs were determined to be natural uranium and associated transformation products, thorium-230, and radium-226.

Exposure Methodology

The dose from residual radioactivity was determined by constructing a source term and exposure scenario, and using a computer model to simulate the release and transport of radionuclides and radiation in the environment on a site-specific basis. The assessment reflected the site-specific characteristics of the residual radioactivity (e.g. type, extent, concentration) and of the environment (e.g. soil, surface water, groundwater, and air) at the site. Exposure pathways relevant to the exposure scenario were chosen based on this information. The source term and exposure scenario are described in the following sections.

The dose was determined first for a Ra-226 concentration in surface soil of 5 pCi/g. This Ra-226 dose is hereafter referred to as the radium benchmark dose. The residual concentration in surface soil was subsequently determined for each of natural uranium and thorium-230 that resulted in a dose equal to the radium benchmark dose.

Source Term

The source term was assumed to be an uncovered contaminated surface soil zone of cylindrical shape. The CoCs for the radium benchmark dose are Ra-226 and Pb-210 each at 5 pCi/g. The CoCs are assumed homogeneously distributed within the contaminated zone. The contaminated zone is modeled as a 0.3 meter layer of unconsolidated soil. The contaminated soil is known to be underlain by one uncontaminated unsaturated zone; this zone is modeled as a 1.4 meter thick layer of unconsolidated soil. The next layer is an uncontaminated saturated zone; this zone is modeled as shale. The final layer is sandstone; this layer functions as an aquitard and is not included in the model. The relationship between Facility conditions and the source term parameters, and the physical characteristics (density, porosity, ...) of each layer are described in Appendix G.

Exposure Scenario

The exposure scenario modeled here, representing a residential farmer, is comprised of direct exposure to external radiation and inhalation and ingestion of radioactive material to an individual who lives on the site and ingests food grown on the site. The scenario is based on assumptions that tend to realistically estimate potential doses. The model used to assess the dose to the residential farmer was the RESRAD computer code. A justification and more complete description of the residential farmer scenario are provided in Appendix G.

The residential farmer scenario is unlikely since the DOE will restrict access and land use in the reclaimed area, but considered to be a

possibility if land use controls failed. Three primary exposure pathways were not considered. The rationale for excluding each is summarized as follows:

Drinking Water

The scenario assumes that readily available, nearby surface water is used for drinking and for irrigation. Use of groundwater is not considered because of the limited quantity and generally poor quality encountered near the SFC site.

A corrective action plan addressing groundwater is described elsewhere. By regulation, that plan includes engineering and/or institutional controls protective of human health and the environment. The plan will ensure that concentrations of groundwater at all locations outside the institutional control boundary, where it would be possible for groundwater to be accessed, will be acceptable for all potential future uses including human consumption. The alternatives for the plan include active, passive and institutional control mechanisms.

Cell Intrusion

Development of the DCGLs did not consider failure or intrusion of the cell's engineered cover. The cover is designed such that failure is not a credible event. The scenario assumes that an individual had access to the restricted area but would not disturb the disposal cell. DOE will ultimately take control of the site as long term custodian and will prevent any unauthorized intrusion into the cell.

Radon

The radon pathway was not considered because it is specifically excluded from the scope of the technical criteria.

Selection of Cleanup Levels

The radium benchmark dose resulting from the exposure scenario described above was 57 mrem per year to the resident farmer. The

DCGLs in surface soil for U-natural and Th-230 that result in 57 mrem/y for the same exposure scenario are 570 pCi/g and 66 pCi/g, respectively.

The technical criteria provide limits for Ra-226 in soil. Specifically, the concentration of Ra-226 in soil, averaged over areas of 100 square meters, cannot exceed the background level by more than: (i) 5 pCi/g averaged over the first 15 cm below surface, and (ii) 15 pCi/g averaged over 15 cm thick layers more than 15 cm below the surface. Application of the technical criteria includes consideration of the in-growth of Ra-226 from Th-230 over a 1000-year design period. The Th-230 concentration is limited such that it will not cause any 100m^2 area to exceed the Ra-226 limit at 1000 years (i.e. current concentration of Th-230 is less than 14 pCi/g surface and 43 pCi/g subsurface, if Ra-226 is at approximately background levels).

Cleanup levels have been selected based on the ALARA principle, and regulatory requirement. Cleanup levels for uranium and thorium have been set at concentrations that are much lower than the DCGLs. Cleanup levels for radium have been set at the regulatory limit. Table 3-1 presents the DCGLs and the cleanup levels.

Table 3-1 Derived Concentration Guideline Levels (DCGL) and Cleanup Levels (CL)

Condition	Uranium-Nat pCi/g	Thorium-230 pCi/g*	Radium-226 pCi/g*
DCGL	570	66	5.0 / 15
CL	100	≤ 14 / ≤ 43	≤ 5.0 / ≤ 15

* first 15cm below surface / 15cm layers greater than 15cm below surface

The cleanup levels will be applied without subtracting background.

The subsurface cleanup level will be applied to small areas on site where Th-230 and Ra-226 are present as contaminants. These areas are depicted in Figure 2-1 of Attachment B as the Th-Ra areas. In these

areas, uranium, thorium, and radium will be considered in combination where the sum of ratios for the concentration of each radionuclide present to the respective cleanup level concentration will not exceed one (unity). At least 0.5 foot and likely several feet of clean fill will be placed over these areas following decontamination. The clean fill is expected to remain in place for the foreseeable future after reclamation.

In areas where radium and thorium are not present, the uranium cleanup level will be used.

Dose Assessment

Inside the ICB and using the DCGLs for radium, thorium, and uranium developed in Appendix G, the dose to a person carrying out authorized activities is estimated to be less than 2 mrem/y. For a resident farmer intruder inside the ICB (equivalent to loss of institutional control scenario in 10 CFR 20.1403) the dose will be 57 mrem/y, the SFC site radium benchmark dose. Utilizing the cleanup levels listed in Table 3-1, the dose rate to the industrial worker and the resident farmer would be approximately 20% of the dose from radium benchmark soil concentrations or 0.4 mrem/y and 11 mrem/y, respectively.

As demonstrated in Appendix G, the dose to a member of the public from contamination that is presently in the drainages that exit the ICB and cross U.S. Army Corps of Engineers property (drainages 001, 005, and 007) is less than 0.2 mrem/y.

3.2.3 Final Status Survey

The final status surveys have been designed from the guidance contained in NUREG-1575 "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM) and the requirements of 10 CFR 40, Appendix A, Criterion 6 (6). The surveys will demonstrate that the residual radioactivity in each survey unit satisfies the applicable criteria described in Section 3.2.2.

The survey designs began with the development of data quality objectives (DQOs). The DQOs were developed using guidance provided on the DQO Process in Appendix D of MARSSIM. On the basis of these objectives, applicable requirements of 10 CFR 40 Appendix A, and the known or anticipated radiological conditions at the site, a survey design was developed to determine the numbers and locations of measurement and sampling points to demonstrate compliance with the release criterion. Finally, survey techniques were selected appropriate for development of supporting data.

3.3 Disposal Cell Design

The preliminary disposal cell design is presented in Appendix C, Preliminary Design Report for the Disposal Cell at the Sequoyah Fuels Corporation Facility (December, 2002), based on the design criteria and strategy outlined in Section 1.3. The various calculations and analyses are presented in Appendix C. The 2002 preliminary design has been updated based upon additional characterization work and construction sequencing. The updated design is presented in Attachment E, Cell Construction Plan, and summarized in the following subsections.

3.3.1 Site Selection

SFC evaluated four possible locations within its property boundary for siting the disposal cell. All four locations were found to be acceptable, each having advantages and disadvantages. The Process Area location was chosen as the best option due to proximity to materials destined for disposal, pre-existing contamination of the sub-surface, and reduced material handling costs. Appendix H presents the siting evaluation.

3.3.2 Layout and Capacity

The disposal cell layout consists of a four-sided domed structure to contain the disposed materials beneath a multi-layered cover system. The direction of top surface drainage was chosen to be toward the highest ground elevation and away from the west side of the cell. The top surface of the structure drains to the

southeast at a one-percent slope. The side slopes of the cell are at 5:1 (20 percent), the maximum slope under NRC reclamation criteria.

The disposal cell layout for the estimated 8.3 million cubic feet of disposed materials (Table 3-2) is shown on Figure 3-1. Due to the variability in disposed material density and the amount of soils that may actually be excavated, the disposal cell location and layout has been planned to accommodate a range of disposed material volumes from 5 million to 12 million cubic feet. For this range of disposal volumes, the north, east and west sides remain in the same location and with the same height, while the location of the south side is adjusted. A typical cross section through the disposal cell (for any of these volumes) is shown in Figure 3-2.

3.3.3 Cover System

The disposal cell cover design is a layered system with a moisture retention, (store-and-deplete) zone and a vegetated surface. The cover is designed to promote long-term vegetative growth that optimizes evapotranspiration and subsequently minimizes infiltration. The total cover thickness is ten feet, and is sufficient for root zone development and radon attenuation. The cover system is shown in Figure 3-2.

The upper 18 inches of the cover system consists of an erosion protection and vegetation zone. On the top surface, the upper 18 inches of the cover thickness consists of a topsoil layer. On the side slopes, the upper 18 inches consists of an eight-inch thick topsoil layer above a ten-inch thick rock mulch layer. The cover surface will be vegetated, with the long-term vegetation being a native grass, forb and brush system. The bottom 2.0-foot thick zone of the cover system is a compacted clay overlain by a synthetic liner to provide infiltration control under short-term conditions. The remaining 6.5-foot thickness of the cover system will consist of a 5.0-foot thick zone of on-site soils to provide a root zone and long-term moisture retention zone for infiltrating meteoric water. Beneath this zone is a 1.5-foot thick drainage layer.

The reduction in emanation of radon-222 from disposed materials by the cover system was evaluated using calculation procedures outlined in NUREG 3.64. The evaluation results in Attachment E show that the cover system and sequence of disposed material placement in the cell reduces the average rate of radon-222 emanation to below the limit of 20 pCi/square meter-second (from Appendix A of 10 CFR 40).

The radon emanation calculations used the RADON model, with conservative parameters for the cover system and disposed materials. Ingrowth from thorium-230 to radium-226 under extreme long-term conditions was included as input for the disposed materials in the calculations.

3.3.4 Perimeter Area

The disposal cell perimeter will transition into the surrounding reclaimed site topography such that drainage from the toe of the side slopes is conveyed away from the cell. Outside the toe of the side slopes will be a 20-foot wide perimeter apron, consisting of riprap designed for energy dissipation.

3.3.5 Erosional Stability

The erosional stability of the disposal cell design was evaluated according to procedures outlined in NRC guidance. The disposal cell surface was evaluated for peak runoff from the Probable Maximum Precipitation (PMP) event. The calculated velocity from the peak runoff was compared with acceptable, non-erosive velocities on the top surface and side slopes of the disposal cell.

On the top surface of the disposal cell, the one-percent slope with vegetated surface conditions provides sufficient resistance to erosion, even under conservative, poor vegetation conditions. On the side slopes of the disposal cell, flow velocities down the 5:1 slopes require rock for erosion protection from PMP runoff. The selected protection is a layer of rock mulch with a median particle size of 3.0 to 3.7 inches (sized for the peak flow from the PMP). In order to promote vegetative growth on the side slopes, the rock mulch layer will be below the topsoil layer. The perimeter apron (to be extended 20 feet from the toe of the

side slopes) will consist of a 20-foot layer of rock mulch with a median particle size of 6.3 inches.

3.3.6 Slope Stability

The slope stability of the disposal cell was evaluated under static and seismic conditions according to standard criteria outlined in NRC guidance. The stability analysis results are presented as calculated factors of safety, which are compared with accepted minimum factors of safety. The analysis results under static conditions show that calculated factors of safety are higher than the minimum long-term criterion of 1.5. The analysis results under seismic conditions (represented by pseudostatic analyses) show that calculated factors of safety are higher than the minimum criterion of 1.1. The stability analyses were conducted using conservative input values for material shear strength and density. A liquefaction analysis of materials in the disposal cell was conducted, with the results showing a negligible potential for liquefaction. The stability analysis results are presented in Attachment E.

3.3.7 Meteoric Water Infiltration

Infiltration of meteoric water and moisture migration through the cover system was evaluated using the TerreSIM model, an MFG model used for land use and ecosystem evaluation. The TerreSIM model uses a detailed method of tracking evapotranspiration and plant canopy evaporation, based on specific plant communities. Modeling was conducted under actual measured climatic conditions for a simulation period of 200 years. The calculated rate of meteoric water migration through the root zone of the cover averaged approximately 6.5 inches/year or 14 percent of average annual precipitation, for the first 50 years of simulation. For the next 150 years of simulation (after plant community development), the calculated rate of meteoric water migration through the root zone averaged 4.6 inches/year, or 10.0 percent of average precipitation. Confirmatory calculations with the EPA HELP model with actual precipitation data show a lower rate of water migration through the root zone (2.7 inches/year or 6.9 percent of average annual precipitation).

The synthetic liner and clay layer beneath the root zone at the base of the cover would significantly reduce moisture migration through the cover under short-term conditions. For long-term conditions, moisture migration through the bottom of the cover would be limited by the clay layer at the base of the cover as well as the vegetation productivity and root zone depth. The actual rate of meteoric water migration through the bottom of the cover would be lower than the long-term average value calculated for the root zone.

3.4 Disposal Cell Construction

The strategy for disposal cell construction (from the base of the disposal cell to the bottom of the cover system) is outlined in the following subsections.

3.4.1 Construction Materials

In the preliminary disposal cell design (Appendix C), materials were grouped by radioactivity content for disposal sequencing to minimize leaching, and optimize shielding and radon attenuation. These groups of materials are summarized in Table 3-2, and are referred to as Types A through D which are described below. Their placement sequencing in the disposal cell is presented in Attachment E and summarized in section 3.4.2 below.

Type A. Type A materials consist of five components: (1) raffinate sludge, (2) Pond 2 residual materials, (3) Emergency Basin sediment, (4) North Ditch sediment, and (5) Sanitary Lagoon sediment. The raffinate sludge has been dewatered, packaged, and stored on-site for either shipment off-site or onsite disposal. Dewatering of the sludge has reduced its volume to approximately one third of the original value.

Due to the relatively high activity concentration of radionuclides in Type A materials, these materials would be the lowest layer in the disposal cell profile. In terms of estimated volume, Pond 2 residual materials comprises most of the Type A materials (65.5 percent), followed by dewatered raffinate sludge (30.5 percent), and the remaining sediments (totaling 4 percent).

Type B. Type B materials consist of soil liner and subsoil materials beneath the clarifier, the calcium fluoride basins, Pond 3E, the Emergency Basin, the North Ditch and the Sanitary Lagoon, as well as Pond 1 spoils pile material. The Type B materials (primarily contaminated soils) would be excavated after removal of Type A materials and placed directly on top of Type A materials in the disposal cell profile. In terms of estimated volume, the Pond 1 spoils pile (35 percent), clarifier liners (26 percent), and Emergency Basin soils (13 percent) comprise approximately 74 percent of the Type B materials.

Type C. Type C materials consist of structural materials, concrete and asphalt, calcium fluoride basin materials, calcium fluoride sediments, and on-site buried materials. These materials would be placed with or above the Type B materials, and covered with contaminated soils (Type D materials). In terms of estimated volume, the calcium fluoride sediments (35 percent), structural materials (32 percent) and concrete and asphalt (14 percent) comprise approximately 81 percent of the Type C materials.

Type D. Type D materials consist of contaminated soils and sedimentary rock that require cleanup. The cleanup level used for the estimated volume of Type D materials is a natural uranium activity concentration of 100 pCi/g outside the cell footprint, and 570 pCi/g under the cell footprint.

The estimated material volumes for each type are presented in Table 3-2 below.

Table 3-2 Disposed Material Summary

Type	Description	Estimated Volume (cu ft)	Fraction of Total Volume (%)	Natural Uranium (pCi/g)	Radium-226 (pCi/g)	Thorium-230 (pCi/g)
A	Sludge and sediment	1,081,890	19	357-12,100	6-332	211-16,300
B	Liner soils and subsoils	1,174,441	21	5-95	0.5-2.1	47-70
C	Calcium fluoride sediments, debris	2,619,390	46	168-520	0.2-0.8	2.1-4.8
D	Contaminated site soils	811,685	14	250	--	--
	Totals	5,687,406	100	--	--	--

3.4.2 Construction Sequence

In conjunction with the overall sequence and water management strategy above, the anticipated construction sequence for the disposal cell is outlined below, and discussed in more detail in Attachment E.

The disposal cell is scheduled to be constructed in three phases to minimize double-handling of materials during cell construction. This phasing allows one area of the cell base to be prepared for receipt of materials excavated from another area of the cell. After all three base areas of the cell have been constructed, materials from outside the disposal cell footprint can be placed throughout the cell.

As shown on the Drawings (Attachment A), the cell base includes a three-foot high perimeter berm on the outside edges of the cell. The perimeter berm is designed with a 3:1 inside slope and 5:1 outside slope to tie into the synthetic liner and outside slope of the cover. The cell base includes a three-foot high internal berm on the inside edges of the cell. The internal berm is designed for the cell base liner system to tie into the adjoining phase of cell base. The perimeter and internal berms are designed to aid in leachate collection within each cell.

Stormwater management is accommodated by water retention with berms or embankments constructed primarily with contaminated site soils, other soils to be disposed in the cell, and minor amounts of broken concrete. The elevation of the retention berms will be maintained at a minimum of five feet above the top surface elevation of the interior materials. The berms will be placed in lifts and compacted to aid with moisture retention. As shown on the Drawings, the berms will be raised in an upstream manner (by constructing additional berm with the centerline toward the inside of the disposal area). Synthetic liner material will be installed on the inside slopes of the retention berms to enhance water retention.

Initial work consists of preparation for construction of the phase I cell base. This includes: (1) dewatering of raffinate sludge, (2) emptying and cleaning of the clarifier ponds (for stormwater storage), (3) moving of UF6 cylinders from the

phase I cell area, and (4) initiation of building demolition in the phase I cell area (incinerator building, solid waste building, and Bechtel building). The DUF4 building is just east of the phase I cell perimeter and can be demolished later.

The northeast corner of the disposal cell footprint is primarily concrete or asphalt that is unaffected by facility operations. The soil sampling and analysis program conducted by SFC in this area has verified that this area has not been contaminated. The northeast portion of the cell would comprise the first phase of the cell construction sequence.

Phase I of the disposal cell would be constructed on top of the concrete or asphalt pads, with the liner system and perimeter berms forming the cell base. Following base construction, excavation of materials from the phase II area of the disposal cell would be placed in the phase I area. The stormwater retention berm would be raised as soils are available and as needed for freeboard requirements.

After the phase II area foundation is cleaned up and the cell base is constructed, excavation of materials and building demolition debris from the phase III area would be placed in the phase II area of the cell. The stormwater retention berm would be raised as soils are available and as needed for freeboard requirements. Phase I and II areas may be joined into one working area.

After the phase III area foundation is cleaned up and the cell base is constructed, excavation of materials and building demolition debris from outside the cell footprint would be placed in the phase III area of the cell. The stormwater retention berm would be raised as soils are available and as needed for freeboard requirements. Phase I through III areas may be joined into one working area.

Work following phase III and prior to cover construction includes: (1) ensuring that materials to be disposed in the cell have been identified and placed in the cell; (2) ensuring that all contaminated site soils outside of the cell footprint have been identified, excavated, and placed in the cell; (3) grading the top surface of

the disposed materials to required bottom-of-cover slopes and grades; and (4) smoothing the final bottom-of-cover surface for clay layer installation.

3.5 Disposal Cell Base Construction

A multilayered liner system will be constructed to form the top zone of the entire disposal cell base. The base of the disposal cell will be sloped to drain to the outside of the cell from each phase to facilitate leachate collection and liner leak detection.

The excavated surface within the disposal cell footprint will be backfilled with random fill, placed in lifts and compacted to form the desired elevations and slopes for the disposal cell base and liner system. The liner system materials are described below (from bottom to top layers).

The lowest layer of the liner system is a 36-inch thick clay layer consisting of on-site silty clay placed in lifts and compacted. Above the clay layer is a 6-inch thick layer of sand (from off-site commercial sources) to provide a bedding layer for a synthetic liner (60-mil thickness high-density polyethylene). The sand bedding layer also serves as a zone for collection of leakage through the synthetic liner should leakage occur. Above the synthetic liner is the uppermost layer of the liner system, an 18-inch thick layer of sand from off-site commercial sources to provide a protective zone between the synthetic liner and subsequent disposed materials. This sand zone also serves as a leachate collection zone for liquids from the disposed materials and meteoric water within the perimeter of the disposal cell.

3.6 Disposal Cell Cover Construction

The cover system over the disposal cell consists of a 10-foot thick soil cover on both the top surface and side slopes of the cell. The elements of the cover system are described in Section 3.3.3. This cover system is summarized in Figure 3-2, Typical Cross-Section on East Side of Disposal Cell.

3.6.1 Construction Materials

The disposal cell cover construction materials are discussed in Attachment A. The material quantities are outlined below.

Cover system materials. The cover material volume (for the 10-foot thick cover) totals approximately 258,700 cubic yards. Significantly more material is available on site than is required for the cover material.

Topsoil. Approximately 30,000 cubic yards of topsoil would be required for the upper layer of the cover on the top and side slopes, and 4,000 cubic yards for the perimeter apron. Sufficient topsoil is available for this volume (and additional volume) from the agland area.

Rock mulch. The rock mulch volume totals 13,000 cubic yards for the cell cover and 8,000 cubic yards for the perimeter apron. Rock mulch material would be obtained from off-site sources.

Cover subsoil materials. The remaining cover material volume (subtracting the topsoil and rock mulch) is approximately 150,000 cubic yards, for the layout shown on the drawings. The likely sources of this material would be the tornado berm and settling pond berm materials, as well as the south borrow area.

Synthetic liner materials. Synthetic liner, most likely 60-mil thickness high density polyethylene, will be installed on top of the clay layer at the base of the cover (approximately 13 acres).

Clay Layer. The clay layer forms the base of the cover system and consists of a 24-inch thick layer of compacted silty clay. The clay layer material would be obtained from the borrow area at the south end of the site. The clay layer material volume would be approximately 42,000 cubic yards for the cover layer and 70,000 cubic yards for the disposal cell base.

3.6.2 Construction Sequence

The anticipated construction sequence for the disposal cell cover is outlined below.

1. Construction of the layers of cover on the side slopes of the disposal cell. The cover material could be placed in horizontal lifts or in lifts parallel to the outside 5:1 slopes. The rock mulch and topsoil would be placed as cover areas are completed to final slopes and grades.

2. Construction of the cover over the top surface of the cell, after the volume of contaminated soils has been established. The elevation of the top surface of the cell will be reduced if the final volume of material is less than 8 million cubic feet (due to higher compacted densities of disposed materials or lower actual volumes of materials).

3. Transition of the perimeter apron of the disposal cell with surrounding reclaimed topography to promote runoff away from the disposal cell.

4. Establishment of vegetation on the disposal cell surface, consistent with the overall plan for mature vegetation development.

5. Establishment and marking of settlement monuments and other monitoring features on the cell surface and perimeter.

3.7 Institutional Control

Following successful completion of performance monitoring, the custody of the site will be transferred to the U.S. Department of Energy pursuant to the provisions of 10 CFR 40.28.

SFC will establish and fence the institutional control boundary (ICB) to limit unauthorized access. Activities within the institutional control boundary are only those authorized by the DOE or its contractors, such as monitoring or

maintenance. The proposed institutional control boundary for the SFC facility after reclamation is shown on Figure 3-1.

4.0 QUALITY ASSURANCE

The quality assurance program for the decommissioning and reclamation is presented in Attachment C.

5.0 RADIATION PROTECTION

5.1 Cover Radon, Gamma Attenuation and Radioactivity Content

5.1.1 Radon Emanation

The disposal cell cover has been designed to limit the rate of emanation of radon-222 to the NRC technical criterion limit of 20 pCi/square meter-second, averaged over the entire cover as outlined in 10 CFR 40, Appendix A, Criterion 6. The disposal cell cover and underlying disposed materials were evaluated according to NRC guidelines, using the RADON model. The evaluation results (outlined in Appendix C of the Attachment E) show calculated radon emanation rates below the 20 pCi/square meter-second limit, under conservative input conditions.

As a confirmation of the cover evaluation for radon emanation, the actual rate of radon emanation will be measured after disposal cell cover construction is completed. Measurement of radon emanation will be conducted according to EPA procedures outlined in 40 CFR 61, Subpart T, Method 115. This consists of measuring radon emanation at a minimum of 100 locations on the cover surface, using canisters containing activated charcoal. The canisters are set on the cover surface for 24 hours, with the charcoal subsequently analyzed for adsorbed radon with gamma spectroscopy. The individual measured values are converted to an emanation rate at each canister location, and these rates are used to calculate an average for the entire cover surface.

5.1.2 Gamma Attenuation

The gamma radiation exposure was estimated at the surface of the disposal cell cover. The effect of a soil cover in reducing exposure from a gamma radiation source is calculated as the ratio of the shielded exposure rate to the unshielded exposure rate. Using coefficients for soil, the shielded exposure rate is approximately $1/10^9$ of the unshielded rate at a soil cover of ten feet which is essentially background. The calculations show that gamma radiation exposure is significantly reduced by a small thickness of soil cover.

5.1.3 Cover Radioactivity

The on-site borrow areas planned for disposal cell cover material have been chosen to provide the physical properties desired for the cover, including a moisture retention zone for evapotranspiration and material to attenuate emanating radon. These borrow areas have been selected to provide soils that are of similar radiological characteristics to native soils in the site area.

5.2 Radiation Safety Controls and Monitoring

A Radiation Safety Program describing measures to protect workers, the public, and the environment will be maintained and followed during decommissioning and reclamation. In recognition that the amount of radioactivity and therefore associated hazards will be reduced as the project progresses, the Radiation Safety Program may be modified commensurate with the activities being performed. SFC will review and approve the Radiation Safety Program, and any revisions that are made during the project. Any such adjustment to the requirements of the Radiation Safety Program shall be made in accordance with document control procedures. Attachment D presents the Radiation Safety Program.

6.0 CELL PERFORMANCE MONITORING AND VERIFICATION

The performance monitoring and verification tasks for the disposal cell are consistent with plans for overall site reclamation and review guidelines in NRC (2002). Key tasks are outlined in the following subsections, and address the period of time from site reclamation until property transfer to the U.S. Department of Energy.

6.1 Settlement

Since the disposal materials will be placed in lifts with compaction to minimize void spaces, cover settlement will not be as critical an issue as for uranium tailings impoundments. However, settlement will be monitored with survey monuments installed on a grid system on the cover surface. The monuments will be surveyed on a quarterly basis until four quarters of stable conditions (less than 0.1 foot of settlement per quarter) are measured.

6.2 Vegetative Cover

A vegetation plan for the disposal cell surface outlining the initial and mature species desired for the cell and the schedule and methods planned for achieving the mature vegetation (such as transplanting of seedlings and institution of weed control) is included in Attachment A. After establishment of the initial vegetation on the cover surface, the condition of the initial vegetation will be monitored for comparison with the schedule in the vegetation plan. The vegetation performance will be monitored until that responsibility is changed with property transfer to the U.S. Department of Energy.

6.3 Erosional Stability

The erosional stability of the cover surface will be monitored on a semi-annual basis, most likely at the same time as vegetation monitoring. Elements of the erosional stability monitoring are degree of vegetation cover (in terms of surface coverage), identification of settled or ponded areas (such as on the top surface), and identification of rills, gullies, or other areas of runoff concentration. Problem areas that are identified will be monitored to determine if corrective action is

necessary. Corrective action would include fill placement with topsoil or placement of erosion-resistant materials on the surface, such as rock mulch.

6.4 Groundwater Protection

Groundwater will be monitored in a two-step manner. First, the cell liner system has a leak detection component which will provide a more timely indication of leakage from the cell than a monitoring well system in the downgradient aquifer. Second, one upgradient and five downgradient point-of-compliance (POC) wells, will be installed once the cell construction is complete. The combination of the liner leak detection system and the POC wells will provide the earliest practical warning that the impoundment is releasing hazardous constituents to the groundwater.

The POC wells will be monitored on a quarterly basis for the complete list of hazardous constituents, and unique and conservative parameters that will be used for prompt detection of leakage from the disposal cell. The leak detection system will be visually monitored, with a water quality sample collected and analyzed, if leakage is present. Details are provided in Attachment E, Disposal Cell Construction Plan, including the parameters to be analyzed.

7.0 DECOMMISSIONING AND RECLAMATION COST

The costs associated with SFC's proposed decommissioning approach, as presented in Table 7-1, only reflect the direct costs for performing the various decommissioning activities. Costs that are included as direct costs include those associated with engineering, design and construction; excavation and handling of material; backfilling excavated areas; demolition of buildings, structures and equipment; sludge an sediment treatment; cell filling; cell closure; wastewater handling and treatment; monitoring during remediation; and post-remediation monitoring, maintenance and security. As of June, 2008, the direct costs are estimated to total $ 29.1 million. Please note that contractor mobilization/demobilization and engineering/construction management costs have been removed as "Activities" and have been added to the costs of the other "Activities" as appropriate.

General and Administrative costs such as SFC overhead, license and permit fees, taxes, routine environmental monitoring costs, etc., are not included in Table 7-1. As of June, 2008 the General and Administrative Costs for the period required to complete decommissioning of the Sequoyah Facility are estimated to be $9.6 million.

The funding plan and assurance for the funds for decommissioning has been addressed by the Settlement Agreement between the NRC and SFC that was approved by the Commission on October 8, 1997 (CLI 97-13).

Table 7-1 Estimated Remaining Direct Costs for Proposed Decommissioning Approach

Activity	Cost ($,000)	Notes
1. Complete Reclamation Plan and Supporting Documents	400	Includes Responses to RAIs and Revisions to the Reclamation Plan, Groundwater Corrective Action Plan and Preparation of an Alternate Concentration Limit Application
2. NRC Fees	750	Fees charged by the NRC for review of SFC's Reclamation documents, preparation of an EIS, final approval of the various plans and termination survey review.
3. Monitoring Well Removal	62	Abandon and plug 25 wells
4. Disposal Cell Construction and Closure		
4.1 Disposal Cell Detailed Engineering	60	Estimated Cost to complete construction level drawings for disposal cell
4.2 Disposal Cell Cost	3685	Cost to construct and close the Disposal Cell
5. Off-Site Disposal of Raffinate and Miscellaneous U-Bearing Sludges	3029	Includes transportation to the White Mesa Mill (shipping cost for 11,578tons @ $212/ton) plus $140k loading costs and $400k for dewatering remaining raff sludge heel and misc sludges
6. Other Residual Materials, Removal, Treatment and On-Site Disposal	3344	Excavation, treatment and placement of other residual materials in the cell (1,280,000 cu-ft @$2.09/cu-ft)
7. Soil Cleanup		Appendix I, Table 10-1, Item 200 Total adjusted for remediation of 434.000 cf of soil (>100 pCiU/g) (includes cost of cell placement). Unit costs are in 2007 $ from Table 10-1 of M-K Report in Appendix I.
7.1	1,015	Soils > 100/570 pCiU/gm 811,685 cf @ $ 1.25 = $1,014,625
7.2	56	CaF_2 Basin Clay Liners 30,000 cf @ $ 1.88 = $ 56,400
7.3	94	Solid Waste Burials 51,100 cf @ $ 1.83 = $ 93,513
7.4	363	Pond 1 Spoils Pile 437,000 cf @ $ 0.83 = $362,710
7.5	129	Interim Soils Storage Cell 154,887 cf @ $ 0.83 = $128,556
7.6	188	Clarifier Clay Liners 100,000 cf @ $ 1.88 = $188,000
7.7	75	Drummed LLW 5,000 cf @ 15.06 = $ 75,300
7.8	38	Sanitary Lagoon Soil 20,000 cf @ $ 1.88 = $ 37,600
7.9	94	Emergency Basin Soil 50,000 cf @ $1.88 = $94,000
7.10	56	North Ditch Soil 30,000 cf @ $ 1.88 = $ 56,400
7.11	2	Crushed Drums 2,000 cf @ $ 0.83 = $ 1,660
Total Soil Excavation, Remediation and Disposal	2,110	
8. Building and Equip. Demolition	4,310	Estimate based on Old Cotter Mill demolition experience

9. Asbestos Abatement	507	Estimate to remove remaining abestos materials from plant
10. Termination Survey	469	2,000 soil samples @ $100 each plus gamma walkover survey – 500 hours @ $50/hr plus $150k assessment/NRC confirmation
12. Site Restoration	686	Cost to grade, place topsoil and re-vegetate excavations and other affected areas. Based on dozing approximately 1,455,000 cf of dike material into impoundments at $0.101 per cf, grading 83 acres @ $500/acre, applying 6 inches of topsoil to 124 acres (2,701,000 cf at $0.11/cf) and seeding 124 acres at $512/acre.
12. Fertilizer Pond Closure	750	Cost to close fertilizer storage ponds 3E, 3W and 5 based on 2003-2005 cost to close Ponds 4 and 6
13. Groundwater Remediation	1150	$100,000 per year for 7 years plus $100,000 for recovery systems installation plus $350,000 for intercept trench expansion. Includes treatment of stormwater and waste water as necessary.
14. Post-Closure Monitoring Program	81	Post-closure monitoring includes the cost of purging, sampling and analysis for 25 wells for an additional sampling event for the first three to five years after cell closure, cell settlement monitoring, radon emission measurement and cell cover inspection and repair.
15. SFC Staff	6400	Personnel costs associated with supervision and monitoring to assure compliance with SFC's NRC license, including the approved Reclamation Plan
16. Long-Term Site Control Fund	1,349	Assumes an escrow fund at 2% interest to generate funds for the annual long-term maintenance costs of $26,974. Costs include annual sampling of 25 monitoring wells and analysis for uranium, nitrate and arsenic, preparation of an annual report, NRC inspection fees, mowing 6 times per year, and $500 annually for general maintenance. <u>Sampling Costs</u> Well Purging 80 hours @ $35 = $2,800.00 Well Sampling 80 hours @ $35 = $2,800.00 $5600.00 <u>Analytical Costs</u> Uranium $20.00 Arsenic $25.00 Nitrate $15.00 Prep Fee $20.00 Total $80.00 per well x 25 Wells = $2,000.00 <u>Annual Report</u> 80 hours @ $90 = $7,200.00 Copying Costs $ 200.00 = $7,400.00 <u>NRC Inspection Fees</u> Travel Time 8 hours Inspection Time 4 hours Report Preparation 40 hours Total 52 hours @ $156.00 = $8,112.00 <u>Mowing</u> 16 hours per mowing x 6 mowings per year = $3,360.00 <u>General Maintenance</u> $500.00 per year = <u>$500.00</u> Total = $26,974.00
Total Cost	$29,142	

8.0 SCHEDULE

The preliminary schedule for reclamation of the SFC Facility is shown in figure 8-1. The schedule incorporates the major elements of this proposed reclamation plan, and shows the estimated time required to complete these activities. Changes to the schedule will be made to accommodate the contractor(s) selected, seasonal weather impacts and SFC cash flow. The start date is set as the NRC approval date for the reclamation plan.