ADDENDUM C
PROCESS INFORMATION

This page intentionally left blank.

ADDENDUM C
PROCESS INFORMATION

Addendums

Figures

C. PROCESS INFORMATION

This Addendum discusses the processes that will be used to dispose waste in the IDF and includes a discussion of the design and function of the following:

- Container
- Disposal landfill
- Leak detection system
- Leachate collection and removal system
- Secondary leak detection system

Note that the SLDS is not a design requirement of WAC 173-303-665, however DOE is adding the design feature pursuant to its authority under the Atomic Energy Act of 1954 (AEA) and not for the purposes of compliance with the dangerous waste regulations. Therefore, information regarding the design, construction, and operation of the secondary leak detection system is provided in this application as information only. Pursuant to AEA, DOE has sole and exclusive responsibility and authority to regulate the source, special nuclear and by-product material component of radioactive mixed waste at DOE-owned nuclear facilities. Source, special nuclear and by-product materials, as defined by AEA, are not subject to regulation under RCRA or the Hazardous Waste Management Act, by the State of Washington and are not be subject to State dangerous waste permit, orders, or any other enforceable instrument issued there under. DOE recognizes that radionuclide data may be useful in the development and confirmation of geohydrologic conceptual models. Radionuclide data contained herein is therefore provided as a matter of comity so the information may be used for such purposes.

Waste stream compatibility (i.e., compatibility between individual waste streams and compatibility between waste streams and landfill design and construction parameters) will be assessed on a case-by-case basis. Criteria for assessing and determining compatibility is identified in the Waste Acceptance Criteria, Waste Analysis Plan, or other protocol or procedure as appropriate (Addendum B, for further discussion of waste stream compatibility).

Process Code S01 (container storage) has been included within this permit, in the event that storage is required before final disposal (e.g., to support the confirmation process of the waste or cooling of vitrified waste if required). Waste failing the confirmation process (Addendum B) will be identified as off-specification and may require storage prior to disposal. Only off-specification waste or vitrified waste requiring cooling (due to process heat) may be stored in the lined portion of the IDF pending disposition. To maintain operational flexibility, off-specification containers and vitrified waste requiring cooling could be left on the transport vehicles at the IDF until disposal can occur but may be off-loaded into the lined portion of the IDF pending final disposal provided the temperature administrative control limit is not exceeded. Off-specification waste and vitrified waste requiring cooling will be separated from other waste via tape, ropes, chains, or other cordon mechanism.

C.1 CONTAINERS

All mixed waste accepted for disposal at the IDF will be packaged in standard containers [U.S. Department of Transportation (DOT) and/or DOE], unless alternate packages are dictated by the size, shape, or form of waste (49 CFR 173) (e.g., metal boxes), and self-contained bulk waste.

C.1.1 Description of Containers

Mixed waste disposed at the IDF is limited to vitrified low-activity waste (LAW) from the RPP-WTP and DBVS. Additionally, mixed waste generated by IDF operations will be disposed of in IDF.

The RPP-WTP and DBVS containers are designed specifically for the vitrified low activity waste form. Nominal RPP-WTP container dimensions will be 122 centimeters base outside dimension, 107 centimeters top by 230 centimeters in length, with a wall thickness of 0.357 centimeter with a container volume of 2.55 cubic meters. The DBVS container dimensions are approximately 2.4 meters wide by 3.1 meters tall and 7.3 meters long and a container volume of 54 cubic meters. The vitrified low activity waste will be compatible with the containers, stainless steel for RPP-WTP and carbon steel for DBVS. Before receipt at the IDF, containers will be closed by the generator.

Due to the radioactivity and remote handling of the RPP-WTP immobilized waste containers, conventional labeling of the vitrified immobilized waste containers will not be feasible and an alternative to the standard labeling requirements will be used. This alternative labeling approach will use a unique alphanumeric identifier that will be welded onto each immobilized glass waste container. The welded "identifier" will ensure that the number is always legible, will not be removed or damaged during container decontamination, will not be damaged by heat or radiation, and will not degrade over time.

The identifier will be welded onto the shoulder and sidewall of each immobilized glass container at two locations 180 degrees apart. Characters will be approximately 2 in. high by 1.5 in. wide. The identifier will be formed by welding on stainless steel filler material at the time of container construction. This identifier will be used to track the container from receipt at the RPP-WTP, throughout its subsequent path of shipment and disposal at the IDF.

Each identifier will be composed of unique coded alphanumeric characters. This unique alphanumeric identification will be maintained within the plant information network, and will list data pertaining to the waste container including waste numbers, and the major risk(s) associated with the waste.

Mixed waste generated through waste operations at IDF will be packaged based on the size of the waste, with the most common container being galvanized or aluminized 208-liter containers.

The container packaging and handling for the IDF are designed to maintain containment of the waste, limit storage intrusion, and limit human exposure to mixed waste. Unusual sized containers such as vitrified LAW packages will be handled by using cranes or other appropriate equipment.

Operations personnel will inspect each container to confirm appropriate documentation and compliance with the waste acceptance criteria before the container is placed in the IDF (refer to Addendum B).

If containerized mixed waste must be opened (i.e., for confirmation sampling, repackaging, etc.), the container typically would be removed to an onsite treatment and/or storage unit or other approved location before being opened. The container would be sealed before being returned to the IDF.

C.2 Leachate Collection Tanks

The aboveground leachate collection tank supports the lined IDF landfill. The leachate collection tank will be operated in accordance with the generator provisions of WAC 173-303-200 and WAC 173-303-640 as referenced by WAC 173-303-200.

For informational purposes[1], the following is provided for an understanding of the operation of the Leachate Collection Tank. Procedures will be written to manage the leachate in accordance with WAC 173-303-200. The presence of leachate in the tank will be detected with instrumentation within the two stilling wells. The level instrument within the first stilling well monitors the depth of leachate in the tank. A second stilling well will have instrumentation for high-high and low-low alarm set-point trips. The leachate will be removed from the tank using a transfer pump.

C.3 Landfills

The following addresses the IDF lined landfill.

C.3.1 List of Wastes

- IDF will receive mixed dangerous waste.
- Waste will be accepted in containers (e.g. drums, boxes, larger containers).

[1] Final facility standards do not apply to the leachate collection tank system based upon WAC 173-303-600(3)(d).

- Mixed waste streams acceptable at the IDF facility fall within the range of dangerous waste numbers identified in Addendum A, IDF Part A Form.

C.3.2 Liner System Exemption Requests

This permit documentation does not seek an exemption to liner system requirements.

C.3.3 Liner System, General Items

This section provides a general description of the liner system to be used for the IDF lined landfill.

The liner system was designed to prevent migration of leachate out of the lined landfill during the active life of the landfill. The Active Life will consist of the operational period and the closure/post closure period. The liner system was designed to meet U.S. Environmental Protection Agency (EPA) requirements, as identified in RCRA Subtitle C requirements for hazardous waste disposal facilities (40 CFR 264), technical guidance documents (e.g., EPA 1985), and WAC-173-303-665. In addition, the liner system incorporates the following general functional requirements:

- Range of Operating Conditions: year-round operation, withstand construction, and long-term stresses
- Degree of Reliability: function safely and effectively throughout operating and closure/post closure period with minimum maintenance
- Intended Life: operational phase plus closure/post closure monitoring phase

C.3.3.1 Liner System Description

The landfill liner system will comply with WAC-173-303-665 requirements for dangerous waste landfills. Figure C.2 shows a typical design and includes the following components (from top to bottom).

- Operations layer: minimum 0.9-meter thick of native soil. This layer provides a working surface for equipment, protect the liner from mechanical damage, and prevent freezing of the underlying low hydraulic conductivity soil layer. (Hydraulic conductivity is a measure of how rapidly a material can transmit water and is based on specific ASTM testing requirements.)
- Leachate collection and removal system (LCRS) contains a minimum 0.3-meter-thick drainage gravel layer with a hydraulic conductivity of at least 1×10^{-2} centimeter per second (sometimes including perforated drainage pipes). A nonwoven separation geotextile is located between the operations layer and the drainage gravel layer to minimize sediment (fine-soil) migration into the LCRS. A nonwoven cushion geotextile is located between the drainage gravel and the primary geomembrane to protect the primary geomembrane.

The LCRS liners collect and convey leachate to the LCRS sump for removal and include the following components.

- Primary geomembrane liner: this liner consists of high-density polyethylene (HDPE) because of its excellent resistance to expected chemicals (Addendum A), nominal 60-mil thickness (54-mil minimum), which is textured (to improve stability against sliding). The geomembrane acts as a moisture barrier. Located immediately above the primary geomembrane the LCRS includes a perforated pipe that helps collect and guide water into the leachate collection sump. The perforated pipe is located along the centerline of the cell and provides high-flow path water to the primary collection sump.
- Primary geosynthetic clay liner (GCL): the GCL consisting of a high-swelling sodium synthetic mat containing bentonite with a hydraulic conductivity of 1×10^{-8} centimeter per second or less. This layer acts as an additional primary moisture barrier directly under the primary geomembrane.

The leak detection system (LDS) is similar to the LCRS except the composite drainage net (CDN) replaces the primary gravel layer, the geosynthetic clay liner (GCL) is placed directly under the secondary geomembrane liner only under the LDS sump and the perforated pipes are not be needed because very high flow capacities are not be required. The purpose of this system is to collect any leachate that leaks through the primary liner system and convey the leachate to the LDS sump for removal. The LDS also serves as a secondary LCRS. The LDS liners will collect and convey leakage to the LDS sump and include the following components:

- Secondary geomembrane liner: same as primary geomembrane liner
- Secondary geosynthetic clay liner: same as primary geosynthetic clay liner
- Admix liner: a minimum 0.9-meter-thick layer of compacted soil/bentonite admixture with a hydraulic conductivity of 1 x 10^{-7} centimeter per second or less. The bentonite is high-swelling sodium bentonite. This layer acts as an additional moisture barrier directly under the secondary geosynthetic clay liner in the LDS sump area and the secondary geomembrane outside the LDS sump area.
- The secondary leak detection system (SLDS) consists of operations layer type fill for a foundation of the LDS admix layer, drainage gravel with a hydraulic conductivity of at least 1 x 10^{-2} centimeter per second adjacent to a perforated pipe, a composite drainage net (CDN) and tertiary geomembrane. A nonwoven separation geotextile is located between the operations layer type material and the drainage gravel to minimize sediment (fine-soil) migration into the SLDS piping. The purpose of this system is to provide access to the area immediately below the LDS sump area. The SLDS collects liquids resulting from construction water and potentially, liquid from other sources. The SLDS liners will convey collected liquids to the SLDS piping for monitoring and/or removal. (Note that the secondary leak detection system is not a design requirement of WAC-173-303-665, however DOE is adding the design feature pursuant to its authority under the Atomic Energy Act of 1954 (AEA) and not for the purposes of compliance with the dangerous waste regulations. Therefore, information regarding the design, construction, and operation of the secondary leak detection system is provided in this application as information only. Pursuant to AEA, DOE has sole and exclusive responsibility and authority to regulate the source, special nuclear and by-product material component of radioactive mixed waste at DOE-owned nuclear facilities. Source, special nuclear and by-product materials, as defined by AEA, are not subject to regulation under RCRA or the Hazardous Waste Management Act, by the State of Washington and are not be subject to State dangerous waste permit, orders, or any other enforceable instrument issued there under. DOE recognizes that radionuclide data may be useful in the development and confirmation of geohydrologic conceptual models. Radionuclide data contained herein is therefore provided as a matter of comity so the information may be used for such purposes).

C.3.3.1.1 Operations Layer

The purpose of the operations layer is to protect the underlying liner components from damage by equipment during lined landfill construction and operation. This layer also protects the admix layer from freezing and desiccation cracking.

Previous research and experience has shown that desiccation cracks can occur under geomembrane liners when either the liner is not in close contact with the compacted admix or when the liner is subjected to wide temperature fluctuations (Corser and Cranston 1991). The operations layer acts as a weight to keep the geomembrane in contact with the admix, thereby reducing the potential for water vapor to form in an underlying airspace. The operations layer also acts as an insulating layer, together with the dead air space trapped in the underlying drainage layers.

The operations layer material typically consists of onsite granular soil that is reasonably well graded. The material has a maximum particle size limit of 5.1 centimeters or less, to facilitate protection of the underlying layers.

C.3.3.1.2 Leachate Collection and Removal System

The LCRS is located below the operations layer and provides a flow path for the leachate flowing into the LCRS sump. Between the operations layer and the underlying drainage gravel, a geotextile layer functions as a filter separation barrier. The geotextile prevents migration of fine soil and clogging of the drainage gravel. On the lined landfill floor the drain gravel is a minimum 0.3-meter-thick layer of washed, rounded to subrounded stone, with a hydraulic conductivity of at least 1×10^{-2} centimeter per second. In addition, a perforated high-density polyethylene drainage pipe placed within the drainage gravel accelerates leachate transport into the LCRS sump during high precipitation events. On the lined landfill floor, the drain gravel layer is underlain by a geotextile cushion resting on the primary high-density polyethylene geomembrane. The geotextile provides additional protection for the primary geomembrane on the floor of the landfill.

On the lined landfill side slopes, the LCRS has a composite drainage net (CDN) layer composed of a geonet (which is a network of HDPE strands, interwoven and bonded to form a panel that provides a drainage pathway for fluids), with a layer of geotextile thermally bonded to each side. This CDN layer has a transmissivity of at least 3×10^{-5} meters squared per second. The CDN is used on the side slopes to avoid problems associated with placement of clean granular material on slopes, thereby minimizing the potential for damaging the underlying liner system.

C.3.3.1.3 Primary Geomembrane Liner

The primary geomembrane liner acts both as an impermeable leachate barrier and as a flow surface, routing leachate to the primary sump. High-density polyethylene was used because of its high resistance to chemical deterioration. Generally, textured (roughened) geomembrane is used to maximize shear strength along adjacent interfaces and to reduce the potential for sliding of the liner system.

C.3.3.1.4 Primary Geosynthetic Clay Liner Layer

A primary geosynthetic clay liner (GCL) consists of a mat of bentonite placed between two geotextiles. The GCL is installed immediately beneath the primary high-density polyethylene liner on the floor of the lined landfill only. The purpose of this liner is to provide extra protection in the case of deterioration (such as stress cracking) of the primary geomembrane where operations will continue for several years.

The in place hydraulic conductivity of the GCL is 1×10^{-8} centimeter per second or less, exceeding the WAC hydraulic conductivity requirement for the secondary soil liners. The upper surface of GCL provides a smooth uniform surface on which to place the overlying geomembrane liner.

C.3.3.1.5 Leak Detection System

The LDS provides the flow path for leachate flowing into the LDS sump. The following is a description of the system to be used in the IDF landfill.

The LDS has a CDN drainage layer on the floor, and a CDN drainage layer on the side slopes. The CDN consist of a layer of geotextile thermally bonded to each side of the geonet. These materials and their configuration is similar to the LCRS described in Section C.3.3.1.2, except for the absence of a drainage gravel layer and a perforated drainage pipe system on the floor of the lined landfill. The LDS will channel leachate that penetrates the primary liner system through the CDN into the leak detection sump.

The LDS serves as a secondary LCRS for the IDF. Leachate collected in the secondary sump will be measured to determine the leakage rate through the primary liner.

C.3.3.1.6 Secondary and Tertiary Geomembrane Liner

The secondary geomembrane liner, located underneath the LDS, is placed directly against the secondary compacted admix liner, except in the LDS sump area which includes a geosynthetic clay liner between the secondary geomembrane liner and the secondary compacted admix liner. For information only, the teriary geomembrane liner for the SLDS is placed directly against subgrade as per Section C.3.3.1.8. The secondary and teriary geomembrane liners are similar to the primary geomembrane described in Section C.3.3.1.3. The secondary geosynthetic clay liner material is similar to the primary geosynthetic clay liner described in Section C.3.3.1.4.

C.3.3.1.7 Secondary Admix Liner

The secondary admix liner has a minimum 0.9-meter-thick compacted soil/bentonite admixture located immediately beneath the secondary high-density polyethylene liner, as required by WAC-173-303-665. The secondary admix liner typically consists of silty sand from local borrow sources mixed with a nominal 12 percent sodium bentonite, by dry weight. The in place hydraulic conductivity of the admix liner is 1 x 10^{-7} centimeter per second or less, consistent with WAC requirements for secondary soil liners. The upper surface of the secondary admix liner is trimmed to the design grades and tolerances. The surface was rolled with a smooth steel drum roller to remove all ridges and irregularities. The result is a smooth uniform surface on which to place the overlying geomembrane liner.

C.3.3.1.8 Subgrade/Liner System Foundation

The lined landfill in the IDF is founded in undisturbed native soils or material compacted to at least 95 %of a standard proctor maximum density (determined by ASTM D698). The liner system foundation is discussed in further detail in Section C.3.4.

C.3.3.1.9 Access Ramp

The lined landfill has an access ramp outside the lined portion of the landfill, minimizing damage to the liner system from vehicle traffic into the lined landfill. As the landfill expands the access ramp will be reconstructed to the south of each expansion in the landfill. The access ramp design could vary as the landfill expands.

C.3.3.1.10 Landfill Expansion

The initial phase of the IDF liner was complete at the north end of the landfill. As shown in Figure C.1, construction of the initial IDF phase completed the liner system on the north side slope and the excavated portions of the landfill floor, east side slope, and west side slope. The dashed line of Figure C.1 across the south edge of the landfill floor denotes the southern extent of the landfill liner. The liner system will be installed to extend approximately 15 meters beyond the estimated toe of slope of the first phase waste placement. This extension will also allow waste haul vehicles to be staged or unloaded over a lined area. Termination detail for the south edge of the liner system is found in Addendum C.1, Drawing H-2-830840. The south side slope of the first phase of IDF is not lined to allow future expansion of the IDF. At the south end of the cells is a storm water berm/ditch with an infiltration area, which will capture clean runoff from the unlined south side slope before it runs onto the lined landfill. The landfill floor slopes up 1% from north to south to allow adequate leachate collection capacity for a 25-year storm event. Each future liner construction project will connect to the south edge of the previously constructed liner and operations systems and extend the disposal area further to the south. With the expansion of the IDF in subsequent phases, access ramps for the previous phase will be destroyed and new ramps built on the south edge of the landfill.

C.3.3.2 Liner System Location Relative to High Water Table

The water table is located approximately 90 to 100 meters below the ground surface in the IDF. It is anticipated that the deepest point of the liner system is no greater than 20 meters below ground surface. Consequently, the liner systems are at least 69 meters above groundwater. The liner systems will not be affected by the water table because of this large elevational difference.

C.3.3.3 Loads on Liner System

The liner system experiences several types of stresses during construction, operation, and closure/post closure periods. The following sections discuss the types of stress and analytical methods used to design the IDF liners.

C.3.3.3.1 Liner Stress

The geosynthetic liner components experience some stress particularly during installation and before placing waste in the lined landfill but also during the entire lifecycle. The high-density polyethylene liner is temperature sensitive, expanding, and contracting as liner temperatures increase and decrease. Thermally induced stresses could develop in the liner if deployment and anchoring occur just before a significant decrease in the liner temperature. The operations layer is sufficiently thick to ensure liner stress remains below the yield strain and stress. Administrative procedures will prevent loading and backfilling of waste exceeding applicable thermal limits due to recent vitrification processes to avoid potential liner damage.

The drainage gravel has the potential to produce localized stress on the geomembrane liner during gravel placement with construction equipment. The geotextile cushion placed at the base of the drainage gravel protects the underlying geomembrane. A puncture analysis was performed to select a sufficiently thick cushion geotextile. This analysis incorporated expected construction vehicle ground pressures and design drainage gravel gradation listed in the construction specifications. If required, engineering controls such as independent foundations will be installed to minimize liner stress involved with large package disposal.

On the landfill side slopes, tension induced by liner component load transfer is not anticipated, because the liner interface effective shear strength angles are higher than the side slope angles. The liner component interface strengths were determined by laboratory direct shear tests. Both static and dynamic stability analyses were performed, using standard methods, design accelerations, and factors of safety.

Stress on the geomembrane in the anchor trench also was evaluated during detailed design. Wind uplift and thermal expansion and contraction could cause stress in the geomembrane during construction. However, these stresses are not a problem, because the stress is relatively low as compared to the tensile strength of the liner. In addition, these stresses are minimized by using sand bags to control liner position during liner panel placement and welding, as well as keeping the anchor trench open until the liner is stabilized with overlaying fill material. Placement of overlaying fill material is controlled to limit stress buildup in the liner. The stress is not present after construction, because of the weight and insulating properties of the operations layer.

C.3.3.3.2 Stress Resulting From Operating Equipment

Operations equipment provides a design load case on the IDF liner, which was analyzed as part of the IDF design (Addendum C.1). The analyses show that the 0.9-meter-thick operations layer dissipates stress produced by the operating equipment and is sufficient to protect the IDF liner system.

C.3.3.3.3 Stress from Maximum Quantity of Waste, Cover, and Proposed Closure/Post Closure Land Use

When the lined landfill is full and the cover system is in place, the liner system will experience a static load from the overlying waste, backfill, and cover materials. No significant increase in stresses on the liner system is anticipated from closure/post closure land use. The maximum design load of material overlying the liner system includes an allowance for the cover system. Analyses include puncture protection of the geomembrane by the cushion geotextile, and decrease in transmissivity of CDN drainage layers. Materials were specified based on the ability of the materials to perform adequately under closure/post closure loading conditions.

Dynamic stress on the liner system will result primarily from ground accelerations during seismic events. Both static and dynamic analyses were performed on the subgrade and liner components based on the finished configuration of the empty landfill. Under closure/post closure conditions, the waste, backfill, and cover materials will tend to buttress the liner system, resulting in greater stability relative to the operational phase. All of the analyses verified adequate stability for the IDF.

C.3.3.3.4 Stresses Resulting From Settlement, Subsidence, or Uplift

The subgrade settlement produced by waste loading essentially will be elastic because of the coarse-grained, noncohesive, and drained nature of the soil. The subgrade rebounded during the excavation phase of construction and will settle as the landfill is filled. The compacted admix liner will consolidate under waste loads. The total settlement will be a combination of the subgrade elastic and the admix consolidation settlements. These settlements were analyzed with standard methods during detailed design of the lined landfill. In general, differential settlements will be expected to occur primarily across the lined landfill side slopes as the thickness of waste decreases from maximum to zero. The geosynthetic liner components were analyzed, the anticipated strains likely will not produce any appreciable stresses in the liner system.

The potential for subsidence induced stress is believed to be negligible based on the following information:

- The soils underlying the IDF tend to be coarse-grained soils, sands, and gravels, in a relatively dense configuration that will not be subject to piping effects that could transport soil resulting in subsidence.
- The groundwater level is deep, at least 69.6 meters below the base of the lined landfill, and will not affect bearing soils.
- No natural voids, or man-made mining or tunneling has been noted. If the groundwater level was lowered substantially and consolidation occurred in the aquifer, local site-specific subsidence would be negligible because of the depth of the groundwater below the lined landfill.

The potential for stresses resulting from uplift on the liner system also is expected to be negligible. The seasonal groundwater level is very deep, and higher elevation perched groundwater likely will not develop because of the absence of aquitards in the coarse-grained Hanford formation underlying the IDF. The coarse-grained nature of the Hanford formation also promotes rapid, primarily vertical, infiltration, which means it is unlikely that infiltration from outside the lined landfill boundary would be transported laterally underneath the landfill liner. Gas pressures similarly are unlikely to develop because of the absence of any organic material that could generate significant subsurface gas (from organic material decomposition) and the coarse-grained, highly permeable sands and gravels underlying the landfill.

C.3.3.3.5 Internal and External Pressure Gradients

Pressure gradients across the liner caused by liquids or gases will be expected to be negligible. Internal pressures due to liquids will be controlled by the leachate collection and removal system. Because leachate will be removed from the flat 50-foot by 50-foot LCRS sump in a timely manner, there will be minimal liquid head on the liner (less than 30.5 centimeters according to WAC regulations). Gas generated internally is expected to be minimal because waste is inorganic and non-reactive. However, any pre-closure internally generated gas will be vented through either the waste or the leachate collection system. The closure cover design will consider gas venting.

External pressures on the liner system are expected to be minimal. Gas pressures will be negligible because the subgrade soil contains no gas producing materials and is highly permeable, readily venting any potential gas to the atmosphere. External pressure from liquids is not anticipated because of the deep groundwater table and the highly permeable foundation soils.

C.3.3.4 Liner System Coverage

The liner system covers all soils underlying the lined landfill and extends over the crest of the side slopes into the anchor trench (Figure C.2, Detail 3).

C.3.3.5 Liner System Exposure Prevention

No geosynthetic or admix components of the liner system are exposed to the atmosphere. The minimum 0.9-meter-thick operations layer covers the entire lined landfill surface. This layer serves both as a physical protective barrier and as thermal insulation, protecting the admix layer from desiccation and frost damage.

Excessive erosion, such as gullying, will be repaired by replacing the eroded soil. Dust suppression agents will be used to prevent excessive wind erosion on the landfill side slopes. The dust suppression agents will bind the surface of the operations layer and will minimize wind entrainment of soil.

C.3.4 Liner System, Foundation

The following sections discuss the foundations beneath the liner systems.

C.3.4.1 Foundation Description

At the IDF, the Hanford formation consists mainly of sand dominated facies with lesser amounts of silt dominated and gravel dominated facies. Where sands are present, these sands are underlain by the Hanford formation. Here, the Hanford formation has been described as poorly sorted pebble to boulder gravel and fine to course grained sand, with lesser amounts of interstitial and interbedded silt and clay.

The two geologic units pertinent to the IDF lined landfill are summarized as follows.

Recent eolian sand: The sand is light olive gray in color and has a density that is loose at the surface but becomes compact with depth. The sand has a fine to medium grain size and includes little to some nonplastic silt sized fines. The deposit is homogeneous except for a distinguishable layer of volcanic ash in some locations.

Glaciofluvial flood deposit: This deposit has well graded mixtures of sands and gravels with trace to little nonplastic silt sized particles. The gravel content can vary with depth, and the deposit can become predominantly gravel. This coarse-grained deposit is part of the Cold Creek Bar, which was formed during the Pleistocene Epoch by glacial outburst flooding.

C.3.4.2 Subsurface Exploration Data

Geological site investigations were used to support the detailed design of the landfill. The investigations consisted of a review of historical data, including well logs (Addendum D), exploratory borings, and surface pit samples data. Because the foundation soils are relatively consistent over broad areas, the need for additional borings and geophysical investigations will be determined on a case-by-case basis. If boreholes are drilled, penetration test data will be collected to determine the strength of the foundation materials in situ.

C.3.4.3 Laboratory Testing Data

Laboratory testing will be performed on the surface soil samples and borings, both from the lined landfill site and from potential borrow source locations as follows. Testing will be performed to classify soils, provide input parameters to verify engineering analyses, and for preparing material and construction specifications. The following tests will be performed on the soil samples:

- Visual classification (ASTM D2487)--to classify soils
- Natural moisture content (ASTM D2216)--for input to engineering analyses and preparing construction specifications
- Particle size analysis (ASTM D422 or D1140/C136)--for classification and input to engineering analyses
- Moisture density relationships (ASTM D698 or D1557)--for preparing compaction specifications

Laboratory testing will be performed according to the most recent versions of ASTM methods or other recognized standards. Additional tests will be performed as needed.

C.3.4.4 Engineering Analyses

The subgrade will be required to support the liner system and overlying materials (waste, fill, and cover) without excessive settlement, compression, or uplift that could damage the liner system. This section describes the design approach used to satisfy these criteria.

C.3.4.4.1 Settlement Potential

The subgrade settlement produced by waste loading essentially will be elastic because of the coarse-grained, noncohesive, and drained nature of the soil. The subgrade will rebound during the excavation phase of construction and will settle as the landfill is filled. An elastic settlement analysis using standard methods was performed and results indicate the magnitude of the total and differential settlement is within performance limits.

C.3.4.4.2 Bearing Capacity

The bearing capacity of the subgrade soil will need to support structures such as leachate collection tanks. The construction specifications typically will require that the upper portion of the subgrade soil and all structural fill be moisture conditioned and compacted to at least 95 percent of the maximum standard Proctor dry density (ASTM D698). Maximum allowable bearing capacities for foundations have been established using standard geotechnical methods. Bearing capacities for the types of soils expected at the IDF typically are greater than the maximum expected loads from the support structures.

C.3.4.4.3 Stability of Lined Landfill Slopes

The lined landfill was constructed in eolian sand and the underlying coarse-grained Hanford formation. In granular, cohesionless, and drained soils such as these, the stability of the slope will be related primarily to the maximum slope angle. Both veneer and global stability analyses were performed to determine both static and dynamic side slope stability. Results demonstrate adequate stability for the IDF throughout its design life.

C.3.4.4.4 Potential for Excess Hydrostatic or Gas Pressures

Because the seasonal high-water level is at least 69 meters below the base of the deepest lined landfill, no external hydrostatic pressure will be expected from this source. Because of the coarse-grained nature of the foundation soils, any infiltration of surface water around the perimeter of the lined landfill will be expected to travel primarily downward. Therefore, infiltration should not cause substantial pressure on the exterior of the liner system. Internal hydrostatic pressure from leachate will be negligible because the leachate will be removed from the lined landfill to limit head on the liner.

Gas pressure exerted externally on the liner system is expected to be negligible, because no gas generating material (i.e., organic material) is expected in the foundation soils. If any gas were generated below the liner system, little pressure buildup would occur because of the unsaturated coarse-grained nature of the foundation soils, which would vent the gas to the atmosphere. Internal gas pressure buildup will not be anticipated, because wastes are generally inorganic and have low gas generating potential, and the leachate collection system will be vented to the atmosphere and dissipates any gas.

C.3.4.4.5 Seismic Conditions

Potential hazards from seismic events will include faulting, slope failure, and liquefaction. Disruption of the lined landfill by faulting is not considered a significant risk because (1) no major faults have been identified at the IDF (DOE/RW-0164) and (2) only one central fault at Gable Mountain on the Hanford Site shows evidence of movement within the last 13,000 years. The potential for slope failure is considered low, because granular materials typically have high strengths relative to the maximum side slope angles expected for the lined landfill. Liquefaction will occur in loose, poorly graded granular materials that are subjected to shaking from seismic events. Saturated soils will be most susceptible because of high dynamic pore pressures that temporarily lower the effective stress. During this process, the soil particles will be rearranged into a denser configuration, with a resulting decrease in volume. The foundation materials at the IDF is not considered susceptible to liquefaction because the materials are well graded granular soils that are unsaturated and relatively dense.

The IDF support building (not sited within the TSD boundary) will be located in Zone 2B as identified in the Uniform Building Code (ICBO 1997).

C.3.4.4.6 Subsidence Potential

In general, subsidence of undisturbed foundation materials would be the result of dissolution, fluid extraction (water or petroleum), or mining. The potential for subsidence will be negligible at the IDF based on the following.

- The soils underlying the IDF are coarse-grained sands and gravels, in a relatively dense configuration, which are not subject to piping that can cause transport of soil and resulting subsidence.
- The groundwater level is deep, at least 69 meters below the base of the lined landfill, and does not affect bearing soils.
- The soil and rock types below the IDF are not soluble.
- No mining or tunneling has been noted. If the groundwater level was lowered substantially and consolidation occurred in the aquifer, local site-specific subsidence would be negligible because of the depth of the groundwater table below the lined landfill.

C.3.4.4.7 Sinkhole Potential

Borings in and around the IDF have not identified any soluble materials in the foundation soils or underlying sediments. Consequently, the potential for any sinkhole development is negligible.

C.3.5 Liner System, Liners

The following sections discuss the individual components of the IDF liner systems.

C.3.5.1 Synthetic Liners

As described in Section C.3.3, the synthetic liners act as an impermeable barrier for leachate migration (Figure C.2). The synthetic liners consist of high-density polyethylene material that makes the liners resistant to chemical deterioration. Section C.3.3 describes the synthetic liner system in detail.

C.3.5.2 Synthetic Liner Compatibility Data

During detailed design of the lined landfill, the composition of the expected leachate was estimated. Expected leachate composition was based on known waste composition, process information, leachate from other operating lined landfills, and similar sources of data. Leachate constituents were compared to manufacturers' chemical compatibility data for synthetic liner components. In addition, the results of previous chemical compatibility testing and studies were evaluated against leachate composition. Information gained from this evaluation was used to select a liner that will be compatible with the expected leachate.

Compatibility testing for leachate tank liner material is planned for construction. An immersion test program is included in the technical specifications for the tank liner (anticipated to be XR-5 material). The immersion-testing program will require the construction general contractor to submit tank liner samples to the design engineer for immersion testing as part of the submittal and certification process for the tank. Immersion testing will follow EPA 9090A (and ASTM) test protocols.

During landfill operation, the compatibility of waste receipts with the liner will be ensured. The compatibility of the waste constituents with the liner material will be established by laboratory testing if determined to be necessary, based on waste type and concentrations. Such tests will follow EPA Method 9090A or other appropriate methods. Test results will be evaluated using statistical methods and accepted criteria (based on past projects and agency acceptance) for liner/leachate compatibility.

C.3.5.3 Synthetic Liner Strength

As discussed in Section C.3.3.3, the liner system will experience loads from several sources. During the detailed design process for the landfill, the strength of liner system materials was evaluated against these loads. The analysis indicated an adequate factor of safety for liner system materials.

Seams in geomembranes are a critical area; however, correct installation methods make the seams stronger than the surrounding material. Detailed installation and testing requirements will be included in the construction quality assurance plan (Section C.3.7.3) to ensure that the liner is constructed properly. In addition, methods will be established to demonstrate adequate seam strength is achieved during installation.

Seaming requirements for the geotextiles and CDN: These materials were overlapped sufficiently to provide complete area coverage, and relatively light seams were used to hold the panels in position during construction, seam strength requirements for these materials will be negligible.

C.3.5.4 Synthetic Liner Bedding

The primary geomembrane liner is in contact with the GCL and geotextile cushion underlying the drainage gravel.

The secondary geomembrane liner is in direct contact with the compacted admix layer. This type of subgrade is typical for flexible geomembrane liners.

With respect to the drainage gravel and operations layers, the geomembranes are protected by overlying geotextile cushion or CDN layers. These geotextiles were designed to provide adequate protection during construction and operation to withstand the loads discussed in Section C.3.3.3.

C.3.5.5 Soil Liners

The IDF landfill is lined with a minimum (0.9-meter thick) layer of compacted soil/bentonite mixture (admix) under the secondary geomembrane liner. This layer has an in place hydraulic conductivity of less than 1×10^{-7} centimeter per second. The soil component of the admix is silty fine sand or similar material from areas near the IDF. Approximately 12 percent bentonite by dry weight was added to the fine soil to achieve sufficiently low hydraulic conductivity; however, the percent might vary.

C.3.5.5.1 Material Testing Data

Laboratory testing will be performed on soil liner materials to confirm input parameters for engineering analyses and for refining material and construction specifications.

Before constructing the lined landfill, a full-scale test fill of the admix material will be conducted. The primary purpose of the test fill will be to verify that the specified soil density, moisture content, and hydraulic conductivity values will be achieved consistently using proposed compaction equipment and procedures. In place density will be measured using both the nuclear gauge (ASTM D2922) and sand cone (ASTM D1556) methods. In place hydraulic conductivity will be determined from a two-stage infiltration from a borehole (ASTM D6391). Admix hydraulic conductivity will be estimated from thin wall tube samples (ASTM D1587) obtained from the test fill and tested in the laboratory (ASTM D5084). Details of the test fill are presented in the Construction Quality Assurance Plan (Addendum C.2). During construction, field density (e.g., ASTM D2922, D2167, and/or D1556) and moisture content (ASTM D2216) will be measured periodically. Thin wall tube samples (ASTM D1587) will be taken at regular intervals and will be tested for hydraulic conductivity (ASTM D5084). Additional details of field-testing during construction will be presented in the Construction Quality Assurance Plan.

Dispersion and piping in the admix are not considered likely because the hydraulic conductivity, and thus the flow velocity, will be very low, making it difficult to move the soil particles or otherwise disrupt the soil fabric. In addition, the admix will be well graded, so the component particles will tend to hold each other in place. Therefore, testing for these characteristics will not be necessary.

C.3.5.5.2 Soil Liner Compatibility Data

As discussed in Section C.3.5.2, expected leachate composition was determined as part of detailed landfill design. The results of previous chemical compatibility testing and studies were evaluated against leachate composition to determine the effect of leachate on soil liner composition or hydraulic conductivity. The tests followed the procedures of ASTM D5084 (flexible wall parameter) and considered the effects of radiation on the soil liner materials.

C.3.5.5.3 Soil Liner Thickness

The IDF was designed to operate to minimize the leachate head over the liner systems. Design of the primary liner system included an additional clay layer (the primary GCL layer, which was previously described in Section C.3.3.1) underlying the primary HDPE geomembrane to further minimize liner leakage from the primary liner. Note that only a single geomembrane is required under WAC 173-303 for the primary liner.

Calculations evaluated the effectiveness of the primary soil liner as a barrier to leachate. Leakage analyses were performed for the primary liner system using EPA's Hydrologic Evaluation of Landfill Performance (HELP) Model (Schroeder et al. 1997). Estimated leakage rates were compared to the Action Leakage Rate (ALR, which is defined in WAC-173-303-665(8) as the maximum design flow rate that the leak detection system can remove without the fluid head on the bottom liner exceeding 1 foot), and were determined to be much lower than the ALR. This demonstrates the benefit of the GCL included in the primary bottom-lining system, which provides a composite lining system and minimizes actual leakage through the bottom primary lining system.

Overall, the IDF is designed to actively convey and collect leachate from the liner areas of the facility to minimize leachate buildup over the liners. Leachate is conveyed to the LCRS and LDS sumps for active removal from the facility. In addition, the LCRS sump area has been designed with a 6-inch-deep sump trough where the LCRS pumps are positioned to minimize the area of the sump that has a permanent liquid level (below the pump intake/shutoff elevation). Both the LCRS and LDS sump pumps will be operated throughout the Active Life of the facility and into the post-closure period until leachate generation has essentially ceased. By actively removing leachate from the IDF, head buildup is minimized, which in turn minimizes leakage through both the primary and secondary liner systems.

C.3.5.5.4 Soil Liner Strength

The expected loads on the liner system are discussed in Section C.3.3.3. Significant stresses in the soil liner that were considered include (1) stresses from the weight of the liner system, (2) stresses on the interface with the overlying materials, and (3) stresses during construction.

Stresses will be present on the side slopes from the weight of the operations layer and soil liner itself. Using material properties determined from laboratory testing, the stability of the soil liner was evaluated under both static and dynamic loading conditions. Standard methods of slope stability analysis were used. Interface strengths were found to provide adequate veneer stability for the liner system. Interface strength is the shear strength that occurs between layers of liner materials at their interface boundary, as established by ASTM test methods.

The primary concern during construction will be bearing failure caused by the weight of overlying soil components of the liner system (e.g., drainage gravel on the floor) and the construction equipment used to spread these materials. Strength parameters developed from laboratory testing and standard analytical methods were again used to determine that adequate stability and bearing capacity exist for the IDF liner system.

C.3.5.5.5 Engineering Report

An engineering report was prepared for the lined landfill as part of the definitive design document package. The report describes the design of the liner system and includes supporting calculations. The critical systems IDF Design Report is provided in Addendum C.1. The final IDF design report was prepared under the supervision of a professional engineer registered in Washington State.

C.3.6 Liner System, Leachate Collection and Removal System

The purpose of the leachate collection and removal system is to provide sufficient hydraulic conductivity and storage volume to collect, retain, and dispose of, in a timely manner, fluids falling on or moving through the waste. The primary leachate collection and removal system provides the preferential path along which the leachate flows into the primary sump. The secondary leachate collection and removal system (also called the leak detection system) is located between the primary and secondary geomembranes. The secondary leachate collection and removal system provides the preferential path along which any fluids leaking through the primary liner system flow to the secondary sump.

The collected leachate will be pumped to a leachate collection tank, screened and/or sampled, and transferred to a permitted treatment and disposal unit.

C.3.6.1 System Operation and Design

The lined landfill operates in a way that ensures the bottom liner is maintained as dry as possible, and the head on the top liner does not exceed 30.5 centimeters measured above the flat 50-foot-by-50-foot LCRS sump HDPE liner. In extreme conditions (i.e., in excess of a 25-year storm event), the head on the top liner could exceed 30.5 centimeters for short durations. The operating methodology, described in the following paragraphs, ensures that liquids on the bottom liner are removed continuously before liquids could accumulate and exceed 30.5 centimeters for the design storm event.

Both leachate collection systems operate either manually or automatically. When operated automatically, liquid level sensors will cycle the pumps on and off, in response to rising and falling leachate levels. The leakage rate through the top liner will be calculated to demonstrate that the leakage rate is less than the 'action leakage rate'. Data to support the leakage rate calculations will be obtained either from the flow totalizer in the secondary leachate collection pump discharge line or from the liquid level gauges. Collected leachate from the secondary leachate collection system is pumped to the leachate collection tank.

The design of the primary and secondary leachate collection systems is described in Section C.3.3.1. System geometry was completed and material specifications were developed during the detailed design process. The leachate collection and removal system design will comply with WAC 173-303 requirements and applicable guidance.

Each sump has a thick layer of gravel designed to provide high hydraulic conductivity and storage capacity. Leachate is removed from the sumps by a pump installed in side slope riser pipes. Pressure transducers monitor leachate level in the sumps and provide appropriate signals to the pump control system. All pumps and transducers are removable for maintenance, calibration, and related activities.

C.3.6.1.1 Primary System

The base of the leachate collection and removal system is defined by the primary geomembrane. On the floor of the lined landfill, the primary geomembrane is overlain by geotextile cushion, and the granular drainage layer. The granular drainage layer drains to the primary sump and a perforated pipe is located along the centerline of the cell to increase flow capacity to the primary sump. Geotextile layers at the top of the leachate collection and removal system prevent migration of fine soil particles into the gravel or geonet, thus prevent clogging. On the side slopes, a CDN layer is over the geomembrane. The CDN includes bonded geotextiles on both sides of a geonet that increase the interface shear strength. Because of construction difficulties in placing a 30.5-cm thick gravel layer on 3:1 side slopes, no drainage gravel was placed on the side slopes.

The leachate collection and removal system is covered by the operations layer. The layer is a minimum 0.9-meter thick, and provides protection for the underlying liner and drainage materials. The operations layer covers both the landfill floor and the side slopes.

The leachate collection and removal system was designed to accommodate the 25-year, 24-hour storm, as required by WAC regulations. However, the EPA recognizes the need to store temporarily leachate from such rare events (EPA 1985). Should a storm event that exceeds the 25-year, 24-hour storm event occur, the leachate collection and removal system sump was designed to store temporarily leachate at a depth greater than 30.5 centimeters, as opposed to the alternative of constructing an excessively large leachate collection tank.

The leachate collection and removal system sump is equipped with two sump pumps. One pump is a high capacity pump capable of rapid removal of large volumes of leachate, and is suitable for the transfer of batch quantities of leachate, and can handle the larger volumes of leachate anticipated from the 25-year, 24-hour storm event. The other pump is a low capacity submersible pump located in the base of the sump. The sump pumps are located in a sump trough. The sump trough was designed to contain the leachate below the intake of these pumps, within the smallest possible area, to minimize the residual leachate volume after each pumping cycle. The pumps are fabricated from stainless steel or other corrosion resistant material.

C.3.6.1.2 Leak Detection System

The base of the LDS is formed by the secondary geomembrane. The leak detection system is similar to the LCRS, except that the perforated collection pipe is not included. The perforated pipe is not needed because high flow capacity is not required for the low leachate volumes.

The LDS drains to the LDS sump, which is located immediately below the LCRS sump. Because of the low volumes, the LDS is equipped with only one low capacity submersible pump to meet WAC-173-303-665(8)(a).

C.3.6.1.3 Response Action Plan

In compliance with regulatory requirements, a response action plan (Addendum C.3) was prepared for the lined landfill. In accordance with EPA guidance, the action leakage rate was calculated as "the maximum design flow rate that the leak detection system can remove without the fluid head on the bottom liner exceeding 30.5 centimeters" (EPA 1992). If the action leakage rate were exceeded, DOE will do the following:

- Notify the appropriate regulatory authority in writing of the exceedance within 7 days of the determination
- Submit a preliminary written assessment to the appropriate regulatory authority within 14 days of the determination, on the amount of liquids, likely sources of liquids, possible location, size, cause of any leaks, and short-term actions taken and planned
- Determine to the extent practicable the location, size, and cause of any leak
- Determine whether waste receipt should cease or be curtailed, whether any waste should be removed from the unit for inspection, repairs, or controls, and whether the unit should be closed
- Determine any other short-term and/or long-term actions to be taken to mitigate or stop any leaks
- Within 30 days after the notification that the action leakage rate has been exceeded, submit to the appropriate regulatory authority the results of the analyses specified in the following paragraphs, the results of actions taken, and actions planned. Monthly thereafter, as long as the flow rate in the leak detection system exceeds the action leakage rate, DOE will submit to the appropriate regulatory authority, a report summarizing the results of any remedial actions taken and actions planned.

The leachate will be analyzed for RCRA constituents as appropriate. A procedure will be in place to address details of analysis (i.e., analyses, constituents, test methods, etc.). If the analytical results on leakage fluids indicate that these constituents are present, and if the constituents can be traced to a particular type of waste placed in a known area of the lined landfill, it might be possible to estimate the location of the leak. In addition, waste packages might not undergo enough deterioration during the active life of the landfill to permit escape of the contents; the leachate might be clean or the composition too general to show a specific source location.

If the source location cannot be identified, large-scale removal of the waste and operations layer to find and repair the leaking area of the liner would be one option for remediation. However, this risks damaging the liner. In addition, waste would have to be handled, stored, and replaced in the landfill. Backfill would need to be removed from around any waste packages to accomplish this. If the waste packages were damaged during this process, the risk of accidental release might be high. For these reasons, large-scale removal of waste and liner system materials will not be a desirable option and will not be implemented except as a last resort.

The preferred alternative will depend on factors such as the amount of waste already in the landfill, the rate of waste receipt, the chemistry of the leachate (i.e., is it clean?), the availability of other disposal units, and similar considerations. Therefore, no single approach will be selected at this time. If necessary, an interim solution could be implemented while the evaluation and permanent remediation were performed. Examples of potential approaches include the following.

- The surface of the waste could be graded to direct run-off into a shallow pond. The surface would be covered with the low hydraulic conductivity layer (geomembrane). Precipitation would be pumped or evaporated from the pond and would not infiltrate the waste already in the lined landfill. Waste would be placed only during periods of dry weather, and stored at other onsite TSD units at other times. This type of approach also could be used to reduce leakage immediately after the action leakage rate was exceeded, while other remediation options were evaluated.
- Partial construction of the final closure cover could begin earlier than planned. This would reduce infiltration into the lined landfill, and possibly reduce the leakage rate if the cover were constructed over the failed area.
- A layer of low hydraulic conductivity soil could be placed over the existing waste, perhaps in conjunction with a geomembrane, to create a second 'primary' liner higher in the lined landfill. This new liner would intercept precipitation and allow its removal.
- A rigid frame or air supported structure could be constructed over the landfill to ensure that no infiltration occurs. Although costly, this approach could be less expensive than constructing a new landfill.

In general, the selected remediation efforts will be progressive. Those remediation methods that are judged the least difficult and the most cost effective will be used first. If these efforts are not effective, more difficult or expensive options would be used.

C.3.6.2 Equivalent Capacity

The CDN drainage layers used will be available commercially and will have equivalent flow capacity to a 30.5-centimeters layer of granular drainage material with a hydraulic conductivity of 1×10^{-2} centimeter per second.

C.3.6.3 Grading and Drainage

In accordance with EPA guidance, all areas of the lined landfill floor (except the sump bottoms) are graded at a slope of at least 2 percent towards the centerline of each cell. The centerline of each cell has a 1 percent slope lengthwise towards the sump, to facilitate drainage and avoid ponding on the liners. Grading tolerances have been established to ensure proper slope is maintained.

C.3.6.4 Maximum Leachate Head

The maximum head on the primary liner is less than 30.5 centimeters, except for rare storm events as discussed in Section C.3.6.1 and the LCRS sump trough. The sump was sized and designed to provide adequate surge storage to prevent leachate build up on the primary liner.

C.3.6.5 System Compatibility

The primary and secondary leachate collection and removal systems are composed of inert geologic materials (sand and gravel), high-density polyethylene, and other geosynthetic materials such as polypropylene. As described in Section C.3.5.2, the geosynthetics were evaluated for compatibility with the expected leachate. To ensure that the geosynthetics used in the lined landfill are similar chemically to those evaluated, manufacturers will be required to submit quality control certificates and other manufacturing information on all materials.

Before a new waste constituent, not previously analyzed (based on a dangerous waste number), is allowed in the lined landfill, the waste constituent will be evaluated for compatibility with the liner (e.g., identified in 9090A test results or other appropriate testing methods, etc.). Other materials could contact the leachate, for example:

- HDPE and Polyvinyl chloride (PVC) piping will be used
- Polyvinyl chloride and other plastics in miscellaneous uses
- Leachate tank will use a chemically resistant flexible geomembrane liner system.

Compatibility of these materials with the expected leachate was considered in the landfill liner system design. Compatibility of these materials will be of lesser concern, because items that consist of these materials will be located entirely within the containment area. Failure of these items would not result in a dangerous waste release, and the materials would be replaced or repaired.

C.3.6.6 System Strength

Stability of drainage layer, strength of piping, and prevention of clogging are discussed in the following sections.

C.3.6.6.1 Stability of Drainage Layers

As described in Sections C.3.3.3 and C.3.5.3, the stability of the liners and leachate collection and removal systems on the side slopes was evaluated as part of detailed design (Addendum C.1). To provide sufficiently high shear strengths at the interfaces between geosynthetic components, textured geomembranes and thermally bonded CDNs are used.

Bearing capacity of the drainage and sump gravels is expected to be adequate, based on typical strength values for granular materials.

The transmissivity of the drainage layers under the combined load of the waste and cover was addressed in the design and will be adequate to support leachate removal.

C.3.6.6.2 Strength of Piping

The drainpipes in the primary drainage and sump gravel and side slope riser pipes are high-density polyethylene pipe. During detailed design, the required wall thickness of the pipe was determined according to the manufacturer's recommendations and standard analytical methods used by the piping industry (Addendum C.1). In these analyses, the ultimate load (derived from the estimated weight of the waste and cover) was used, the allowable deflections were limited to 5 percent, and conservative values for soil modulus and lateral confinement were assumed.

C.3.6.7 Prevention of Clogging

The geotextiles that separate the drainage layers from adjacent soil layers was selected based on the ability of the geotextiles to retain the soil and to prevent the soil from entering the leachate collection and removal systems. In addition, the amount of fine material in the drainage and sump gravels was limited by specification to less than a few percent, and is not expected to cause clogging problems (Addendum C.1). Because the waste disposed in the lined landfill will be required to satisfy LDR (RCW 70.105.050(2), WAC 173-303-140, and 40 CFR 268), the amount of organic material is minimal, and consequently biologic clogging will not be a problem.

C.3.7 Liner System, Construction and Maintenance

Details relating to the liner system construction and maintenance are discussed in the following sections.

C.3.7.1 Material Specifications

Material specifications are provided in the following sections for each of the materials used in the liner system.

C.3.7.1.1 Synthetic Liners

As described in Section C.3.3.1, both the primary and secondary geomembrane liners consist of high-density polyethylene. As described in Section C.3.3.1.4, the primary barrier also contains a geosynthetic clay liner placed on the floor area only. Detailed specifications were prepared for the lined landfill as part of the design process.

C.3.7.1.2 Soil Liners

As described in Section C.3.3.1, the soil liner consists of imported bentonite (expansive clay) blended with fine soil deposits on or next to the IDF. The fine soil was free of roots, woody vegetation, rocks greater than 2.54 centimeter in diameter, and other deleterious material. The bentonite content is dependent on the characteristics of the fine soil. Mixing was performed under carefully controlled conditions in a pug mill or other approved alternatives. The admix was placed and compacted to achieve an in place hydraulic conductivity of 1×10^{-7} centimeter per second or less. The final surface of the soil liner was rolled smooth before placing the overlying geomembrane. Additional specifications were prepared for the lined landfill as part of the design process.

C.3.7.1.3 Leachate Collection and Removal System

Drainage and sump gravel consisted of hard, durable, rounded to subrounded material. The gravel was washed and the amount of fine material (i.e., passing the number 200 sieve) was limited to a few percent. The hydraulic conductivity of the gravel is 1×10^{-2} centimeter per second or greater. Additional specifications were prepared as part of the design process.

For geotextiles and geonets, the composition, thickness, transmissivity, unit weight, apparent opening size, strength, and other properties were determined during detailed design based on results of engineering analyses, experience, and industry standard approaches.

C.3.7.2 Construction Specifications

Construction requirements for major components of the lined landfill are summarized in the following sections.

C.3.7.2.1 Liner System Foundation

The excavated subgrade surfaces was moisture conditioned and compacted as required to achieve the specified compaction before placing the admix layer.

C.3.7.2.2 Soil Liners

The soil and bentonite was blended thoroughly and moisture conditioned so that the admix is uniform and homogeneous throughout. The admix layer was placed in loose lifts and compacted so that the compacted lift meets the requirements of the Construction Quality Assurance Plan. Each new lift of admix was kneaded into the previously placed lift. The methods for admix preparation, type of compaction equipment, number of passes, and other details of the placement process was determined by constructing a test fill section before placing admix in the lined landfill.

C.3.7.2.3 Synthetic Liners

To protect the overlying geomembranes, the admix surface is smooth and free of deleterious material. In all cases, the high-density polyethylene liner was deployed with the length of the roll parallel to the slope. Adjacent panels were overlapped and thermally seamed using fusion or extrusion methods. Seams were inspected continuously using air pressure tests. A vacuum box was used in areas where air pressure tests cannot be used (e.g., extrusion weld areas). Destructive seam tests (ASTM D4437) (peel and adhesion) were performed on samples taken at regular intervals. Placing the overlying geosynthetic layers when practicable will protect the geomembranes.

C.3.7.2.4 Leachate Collection and Removal Systems

Drainage and sump gravel was placed and spread carefully over the underlying geosynthetics using suitable equipment to prevent damage. Hauling and placing equipment will operate on a minimum thickness of soil above any geosynthetic layer to avoid damage. Geosynthetic layers in the leachate collection and removal system were deployed, overlapped, and joined (e.g., tying for geonets, sewing for geotextiles) according to standard industry practice and the manufacturers' recommendations. Drainage and riser pipes were installed in the landfill. Pipes were bedded carefully and the landfill was backfilled to provide adequate lateral support. Pumps and other mechanical components are installed according to manufacturers' recommendations.

C.3.7.3 Construction Quality Control Program

A construction quality assurance plan (Addendum C.2) will be used during lined landfill construction and establishes in detail the following in accordance with WAC 173-303-335:

Program must include observations, test, and measurements to ensure:

- Proper construction of all components of the liners, leachate collection and removal system,
- Conformity of all materials used in the design.

C.3.7.4 Maintenance Procedures for Leachate Collection and Removal Systems

The accessible components of the leachate collection and removal system will be maintained according to preventive maintenance methods. These methods will require periodic testing to prove that the equipment, controls, and instrumentation are functional and are calibrated properly. Testing intervals will be derived from applicable regulations and manufacturer's recommendations. All pumps and motors will be started or bumped monthly or at intervals suggested by the manufacturer, first, to demonstrate that the pumps and motors are functional and second, to move the bearing(s) so that the bearing surfaces do not seize or become distorted. Instruments will be calibrated annually or at intervals suggested by the manufacturer. When applicable, the preventive maintenance methods will include calibration instructions. The following instruments will require annual calibration:

- LCRS sump level indicator
- LDS sump level indicator

Other instrumentation inside the leachate handling and storage facilities will also require routine maintenance.

C.3.7.5 Liner Repairs during Operations

Because of the 0.9-meter-thick operations layer, damage to the liner system is not expected. If damage did occur, the operations layer could be removed laterally as far as required. Underlying geosynthetic and gravel layers will be removed until an undamaged layer is encountered. The damaged layers will be repaired and replaced from the lowest layer upwards using similar methods to those employed during construction. Most repairs to the geomembranes will be performed using a patch, which will be placed, welded, and tested by construction quality assurance personnel.

C.3.8 Run-on and Runoff Control Systems

Because of the sandy soils, small drainage area, and arid climate at the IDF, storm water run-on and run-off will not be expected to require major engineered structures. Interceptor and drainage ditches will be adequate for run-on and run-off control. The 25-year, 24-hour precipitation event was the design storm used to size the lined landfill systems. Beyond this, surface water evaluation is highly site-specific, and appropriate analyses were performed as part of detailed design for the lined landfill.

C.3.8.1 Run-on Control System

Run-on will be controlled by drainage ditches or berms around the perimeter of the lined landfill. Any overland flow approaching the landfill will be intercepted by the ditches or berms and will be conveyed to existing drainage systems or suitable discharge points. All the drainage ditches or berms were designed to handle the peak 25-year flow from the potential drainage area. By using low channel slopes, design flow velocities in the ditches will be maintained below established limits for sand channels.

Between the landfill crest and the perimeter road, the area will be graded to provide drainage toward the perimeter road. The perimeter road will be sloped outward, at a grade of approximately 2 percent, to provide drainage away from the landfill. On the outside of the perimeter road, drainage ditches will be excavated to provide drainage away from the landfill.

C.3.8.1.1 Design and Performance

Design and performance details were determined for the landfill as part of the detailed design process.

C.3.8.1.2 Calculation of Peak Flow

Computation of design discharge for the drainage ditches or berms was performed using standard analytical methods, such as the Rational Method or the computer program HEC-1 (USACE 1981). The 25-year, 24-hour precipitation depth is 4.0 centimeters, based on precipitation data recorded from 1947 to 1969 (PNL-4622). The tributary area for each section of ditch or berm was based on local topography.

C.3.8.2 Runoff Control System

There will be no run-off from the lined landfill because the landfill will be constructed below grade. Any precipitation falling on the landfill will be removed by either evapotranspiration or the leachate collection and removal systems. Therefore, a run-off control system will not be needed.

C.3.8.3 Construction

The drainage ditches or berms around the lined landfill were constructed with conventional earthmoving equipment such as graders and small dozers.

C.3.8.4 Maintenance

The drainage ditches or berms require periodic maintenance to ensure proper performance. The most frequent maintenance activity, beyond periodic inspection, will be cleaning the ditches or berms to remove obstructions caused by windblown soil and vegetation (e.g., tumbleweeds). After rare storm events, regrading of the ditch bottom or repair of the berm might be required to repair erosion damage. This is expected to occur infrequently; however, inspections will be conducted after 25-year storm events or at least annually.

C.3.9 Control of Wind Dispersal

The IDF will use varied methods to prevent wind dispersal of mixed waste and backfill materials, depending on the waste form. Methods to prevent wind dispersal include containerizing, stabilizing, grouting, spray fixitants, and backfill. In other instances, the operating contractor implements a wind speed restriction during handling, and immediately backfills the waste to prevent wind dispersal.

C.3.10 Liquids in Landfills

Free liquids will not be accepted except as allowed by Addendum B. Waste received at the IDF must comply with waste acceptance requirements.

C.3.11 Containerized Waste

Containerized waste received in the IDF lined landfill will be limited to a maximum of 10 percent void space. Several inert materials (diatomaceous earth, sand, lava rock) will be used as acceptable void space fillers for waste that does not fill the container.

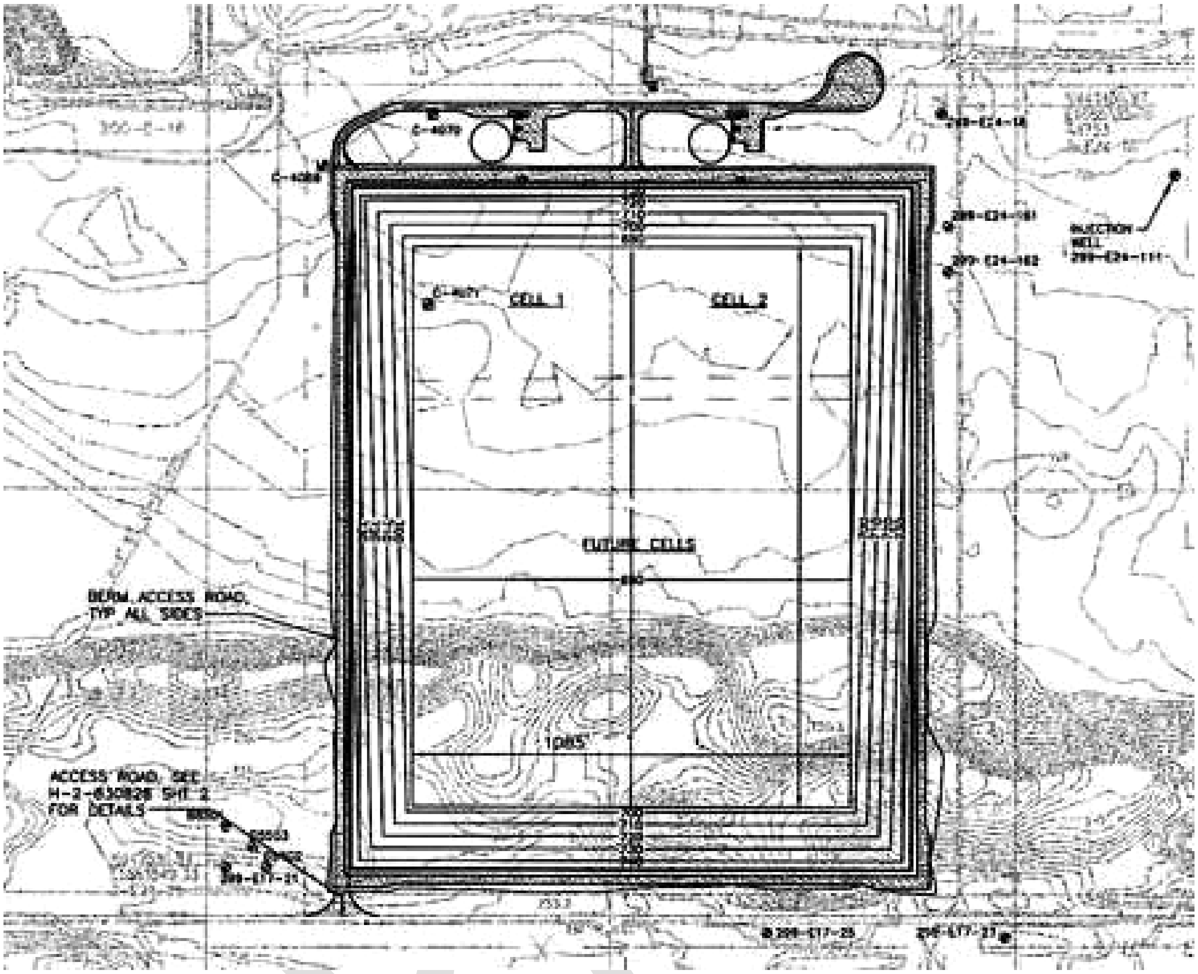

Figure C.1. Integrated Disposal Facility Lined Landfill

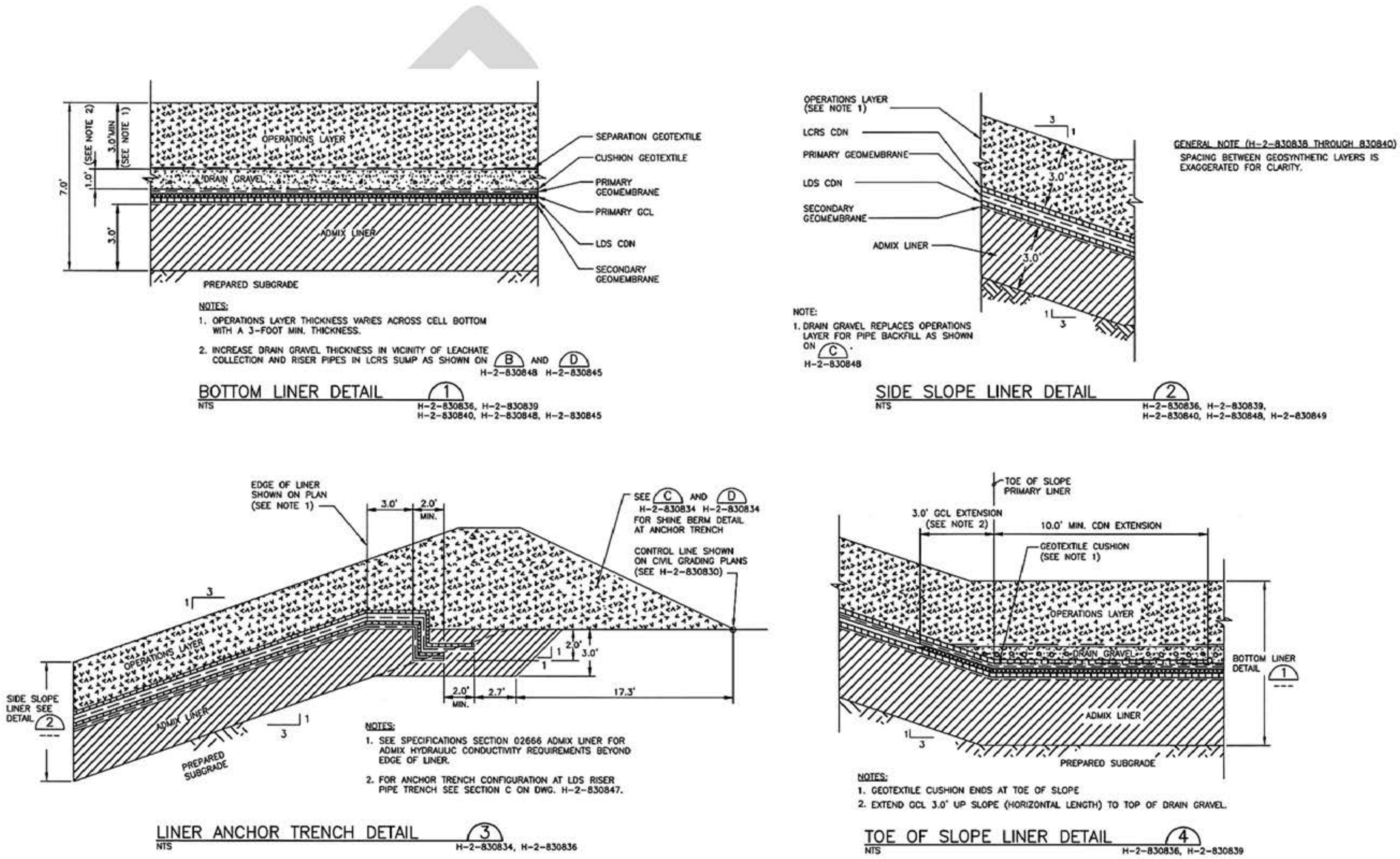

Figure C.2. Example of a Typical Liner

This page intentionally left blank.