11.2 Liquid Waste Management System

The liquid waste management system is designed to monitor, control, collect, process, handle, store, and dispose of liquid radioactive waste generated as the result of normal plant operations and AOOs. The liquid waste management system collects radioactive liquid effluents, then temporarily stores, and treats radioactive liquid effluents from several systems throughout the plant. Some plant systems also discharge decontaminated wastewater from various processes. The liquid waste management system consists of two subsystems: the liquid waste storage system and the liquid waste processing system. The liquid waste storage system collects radioactive wastewater into five liquid waste storage tanks, then discharges the collected wastewater in batches to the liquid waste processing system for treatment. The wastewater is subsequently treated with either an evaporator, a centrifuge, an evaporator in series with a demineralizer, a centrifuge in series with a demineralizer, or with the demineralizer system alone. Treated wastewater next discharges to the monitoring tanks. In the monitoring tanks, the treated wastewater is chemically adjusted to an optimum pH and checked for activity prior to its discharge from the plant. The wastewater activity is constantly monitored during discharge. If the activity exceeds an allowable limit, the discharge valves automatically close and the content of the monitoring tanks is sent back to the processing system for further treatment.

11.2.1 Design Basis

The liquid waste storage system is designed to store radioactive liquid wastes collected from the various systems and buildings in which they were generated and transfer these liquid wastes to the liquid waste processing system. The treated wastewater is returned to the storage system, where it is monitored to verify compliance with regulatory limits. The U.S. EPR liquid waste management system is designed to meet the individual dose limits and compliance specified in 10 CFR 20.1301 and 20.1302 and the ALARA design objectives of 10 CFR Part 50, Appendix I. In addition, effluent concentrations are well below the annual average concentration limits of 10 CFR Part 20, Appendix B, Table 2. The ALARA design objectives are consistent with the Environmental Radiation Protection Standards for Nuclear Power Operations of 40 CFR Part 190 as implemented under 10 CFR 20.1301(e).

The primary functions of the liquid waste processing system are to separate radionuclides from the stored liquid wastes and to return both the decontaminated liquids and the concentrated radionuclides to the liquid waste storage system in separate process streams. The liquid waste storage and liquid waste processing systems fulfill these primary design functions under modes of normal plant operation. The U.S. EPR liquid waste storage and processing systems have the design capacity to receive, hold, process, and release the maximum expected volume of wastewater arising from plant operations (including startup, shutdown, and outage periods).

RG 1.143 acknowledges that although the impact of the liquid waste storage and processing systems on safety is limited, the design for these systems includes some functions to limit the uncontrolled releases of radioactivity to the environment. The guidance identifies a radwaste classification for differentiation of applicable radwaste system design requirements based on the total design basis unmitigated radiological release (considering the maximum inventory of a given radwaste system) at the boundary of the unprotected area. Based on calculation of the total design basis unmitigated radiological release from either the liquid waste storage or liquid waste processing systems, these systems are assigned to RG 1.143 classification RW-IIa (High Hazard).

Calculations of doses and radioactive releases are performed consistent with the methodologies described in SRP Section 11.2, BTP-11-6 and RGs 1.109, 1.112, and 1.113.

Design features are provided to control and collect radioactive material spills from liquid tanks outside containment. The tanks are housed in rooms with drains to collect any spills and to prevent any uncontrolled release to the environment. In addition, these rooms have no doors leading directly to the outside environment.

Consistent with the requirements of 10 CFR 20.1406, the U.S. EPR, including the liquid waste management system, is designed to minimize, to the extent practicable, contamination of the facility and the environment; facilitate eventual decommissioning; and minimize, to the extent practicable, the generation of radioactive waste. The LWMS design also incorporates features which address NRC concerns identified in IE Bulletin 80-10. Minimization of contamination and radioactive waste generation is described in Section 12.3.6.

11.2.1.1 Design Objectives

In addition to fulfilling their primary design functions, the liquid waste storage and liquid waste processing systems meet the following design objectives:

- Selectively segregate influent liquid wastes according to chemical composition and radioactivity of the source stream.
- Allow analysis of the contents of each liquid waste storage tank.
- Discharge sludge and concentrated wastes to the radioactive concentrates processing system. The radioactive concentrates processing system is an element of solid waste management and is addressed in Section 11.4.
- Prevent unintentional discharge of clean wastewater. Locked discharge valves subject to administrative control prevent discharge of treated wastewater from the monitoring tanks unless the radionuclide concentration of that wastewater has been demonstrated to be within administrative limits.

11.2.1.2 Design Criteria

The liquid waste storage and liquid waste processing systems are subject to the following GDC found in 10 CFR Part 50, Appendix A. The U.S. EPR liquid waste management system is designed to meet the ALARA design objectives of 10 CFR Part 50, Appendix I, and the requirements for limiting dose to individual members of the public as specified in 10 CFR 20.1301 and 20.1302. In addition, effluent concentrations are well below the annual average concentration limits of 10 CFR Part 20, Appendix B, Table 2. The ALARA design objectives are consistent with the Environmental Radiation Protection Standards for Nuclear Power Operations of 40 CFR Part 190.

- GDC 60 requires that the nuclear power unit design include the means to suitably control the release of radioactive materials in liquid effluents produced during normal reactor operation, including AOOs. The design must also provide sufficient holdup capacity for retention of liquid effluents containing radioactive materials.

- GDC 61 requires in part that radioactive waste systems be designed to operate safely under normal and postulated accident conditions. Radioactive waste systems must be designed with a capability to permit appropriate periodic inspection and testing of components important to safety; with suitable shielding for radiation protection; and with appropriate containment, confinement, and filtering systems.

11.2.1.2.1 Capacity

The liquid waste storage system can store a volume of wastewater equivalent to the average quantity of liquid waste produced in one week. Liquid waste is segregated into three groups for storage:

- Group I consists of liquid wastes with high activity levels, low levels of organic substances, and low conductivity.

- Group II consists of liquid wastes with low activity levels, high levels of organic substances, and high conductivity.

- Group III consists of liquid wastes with no activity under normal plant operation conditions, but that may have high levels of organic substances or conductivity.

The liquid waste storage system includes five liquid waste storage tanks (19,600 gallons gross volume each): two each for Groups I and II, and one for Group III. The system also contains three concentrate tanks, which hold liquid wastes concentrated by the evaporator and sludge from the liquid waste storage tank bottoms. Additionally, the system contains two monitoring tanks, which hold treated wastewater prior to discharge.

The liquid waste processing system has the capacity to process the average weekly discharge quantity of the three liquid waste groups in less than half a week. The Group I wastes contain low levels of organics and solids, so they are processed by evaporation. The evaporator is capable of processing 1050 gallons per hour, which is sufficient capacity to process the entire maximum weekly Group I liquid waste volume in slightly more than 25 hours. The Group II and III waste streams are processed by a centrifugal separator because they contain organics and solids but have low or no level of activity. The separator can process 1300 gallons per hour, which is sufficient capacity to process the entire maximum weekly Group II and Group III liquid waste volumes in 63 hours. The demineralizer system can process 2400 gallons of liquid waste per hour, which is sufficient capacity to process the combined maximum weekly volumes of the Group I, II, and III waste streams in about 40 hours.

11.2.1.2.2 Quality Group Classification

Design criteria pertinent to systems classified as RG 1.143 classification RW-IIa (High Hazard) and tabulated in RG 1.143, Table 2 (Natural Phenomena and Internal/External Man-Induced Hazard), Table 3 (Design Load Combinations), and Table 4 (SSC Design Capacity Criteria) are used in design analyses of the liquid waste storage and processing systems. Table 3.2.2-1 provides the seismic design and other design classifications for components in the liquid waste management system.

The liquid waste storage and liquid waste processing systems are classified as Radwaste Seismic (RS). Structures, systems, and components composing the liquid waste storage and processing systems that are classified as RG 1.143 classification RW-IIa (High Hazard) are designed to withstand a seismic loading equivalent to one-half the amplitude of the safe shutdown earthquake (SSE).

11.2.1.2.3 Controlled Releases of Radioactivity

Expected Releases

The U.S. EPR is designed so that liquid waste releases are within ALARA design objectives. This release calculation includes active liquid releases from the plant, since effluents from other systems that handle activated or potentially activated liquid wastes can only be released through the liquid waste storage system. These other systems include the coolant treatment system, the steam generator blowdown demineralizing system, and the Nuclear Island (NI) drain and vent system.

Release Monitoring

The liquid waste storage system uses two monitoring tanks to aid in measuring the activity of processed liquid wastes. If the measured activity is too high for immediate release, the system returns the wastewater in the affected monitoring tank to the five liquid waste storage tanks. This wastewater is subsequently returned to the liquid waste processing system for additional removal of radioactive constituents. If the measured activity of a monitoring tank is within release limits, the water in that tank is discharged to the release line.

A locked, closed valve normally shuts the liquid waste storage system release line. Administrative controls preclude unlocking the valve until activity measurements of the liquid waste held in the monitoring tank are below the concentration limits for release. The release line contains an activity-measurement tank. Radiation sensors (refer to Section 11.5.3.2 and Table 11.5-1, Monitor R-32) are mounted in the activity-measurement tank, and flow sensors are mounted in the liquid waste release piping downstream of the activity-measurement tank; together these sensors continually measure and record the total actual activity and activity release rate during each release of processed liquid waste effluents to the environment. Each radiation sensor can generate control signals that stop the discharge pump and isolate the release path if the sensor detects activity in excess of the anticipated level or release rate. Discrepancies between the two radiation sensors or between the two flow sensors also result in control signals that terminate the discharge and isolate the release line.

Operator Error or Malfunction

The radiation sensors (refer to Section 11.5.3.2 and Table 11.5-1, Monitor R-32) the liquid waste storage system release line generate alarm signals in the main control room and signal interlocks that close the release line isolation valves to prevent further releases if an operator error or equipment malfunction occurs during release. If these isolation valves are closed, the liquid waste management system is designed with enough redundancy and capacity to operate without discharging until the alarm condition is resolved. Although the evaporator, centrifugal separator, and demineralizer are each separate subsystems in the liquid waste processing system, the configuration of that system provides sufficient redundancy that a failure to one subsystem is covered by another subsystem. Also, sufficient storage capacity exists in the five liquid waste storage tanks and two monitoring tanks to collect up to a week's volume of liquid wastes without processing and release. Operator actions are required to align different liquid waste storage tanks to the various liquid waste processing systems, to align the system for recirculation of a given tank, or to return the contents of a monitoring tank or concentrate tank for additional processing. Administrative control of the locked closed release path adds additional confidence that operator error does not cause inadvertent discharges of liquid waste that contains activity in excess of the limits for release.

11.2.1.2.4 Mobile Systems

A COL applicant that references the U.S. EPR design certification and that chooses to install and operate mobile skid-mounted processing systems connected to permanently installed LWMS processing equipment will include plant and site-specific information describing how design features and implementation of operating procedures for the LWMS will address the requirements of 10 CFR Part 20.1406(b) and guidance of SRP Section 11.2, RG 4.21 and 1.143, IE Bulletin 80-10, NEI 08-08 and all quality assurance requirements as stated in Section 4.3 of ANSI/ANS 55.6-1993 (Reference 7).

11.2.2 System Description

The U.S. EPR liquid waste storage and liquid waste processing systems manage liquid wastes generated by the plant during normal modes of operation. The liquid waste storage system collects and segregates incoming waste streams, provides initial chemical treatment of those wastes, and delivers them to one of the processing systems. The liquid waste processing system uses evaporation, centrifugal separation, and demineralization to remove the radioactive and chemical contaminants from the wastewater and to concentrate those contaminants. The treated wastewater is returned to the liquid waste storage system for monitoring and eventual release. The concentrates are returned to the liquid waste storage system concentrate tanks for eventual transfer to the radioactive concentrates processing system.

The liquid waste storage and processing systems operate independently of the operating modes of the plant. The systems provide sufficient storage and treatment capacity to process the daily inputs produced during plant startup, normal operation, plant shutdown, maintenance, and refueling periods. The systems are operated on an as-needed basis throughout the plant operating cycle. Operating experience has shown that the peak volume demand occurs during plant outages, when maintenance activities generate increased volumes of wastewater (particularly the Group II wastewater streams).

The liquid waste storage system, schematically illustrated in Figure 11.2-1—Liquid Waste Storage System includes liquid waste storage tanks, concentrate tanks, and monitoring tanks that temporarily store the liquid wastes at various stages of treatment. The system also includes recirculation pumps, a sludge pump, a concentrate pump, and combination recirculation-discharge pumps to move the liquid waste between the various tanks. Chemical tanks and chemical proportioning pumps precisely mix and inject chemicals to treat the liquid wastes. Piping and control valves route the liquid wastes between the storage system tanks and pumps, and to interfaces with the liquid waste processing system.

The liquid waste processing system consists of three separate unit operations:

- The evaporator, shown in Figure 11.2-2—Liquid Waste Processing System, Evaporator System, employs a vapor-compressor evaporator with a separate evaporator column. The evaporator system also includes evaporator feed, forced recirculation, and distillate pumps to move liquid waste through the evaporation process; several heat exchangers to condition the liquid waste at various stages of the process; and a distillate tank to collect the treated wastewater for further processing by the demineralizer, if required.

- The centrifuge, shown in Figure 11.2-1, employs both a decanter and a centrifugal separator to separate organic and inorganic contaminants from the wastewater. The contaminant sludge is collected in a waste drum for collection and processing as solid waste. The treated wastewater is sent to the demineralizer, if required, for further treatment before it is returned to the liquid waste storage system. Solids collected in the ultrafilter are backwashed off the media and sent to a solids collection tank.

- The demineralizer, shown in Figure 11.2-3—Liquid Waste Processing, Demineralizer System, includes a demineralizer and an ultrafiltration unit. The demineralizer receives treated wastewater from both the evaporator and the centrifuge waste processing subsystems or directly from the liquid waste storage tanks. Piping and control valves allow liquid wastes to be passed through either unit, or through both units consecutively. Contaminants are retained in the filter media and resin and the treated wastewater is returned to the liquid waste storage system.

Both the liquid waste storage and liquid waste processing systems are located entirely within the Radioactive Waste Processing Building. Interfacing system piping delivers influent liquid wastes from the adjacent Nuclear Auxiliary Building.

Table 11.2-1—Liquid Waste Management System Design Parameters, lists the key design parameters for the liquid waste storage and processing systems. Table 11.2-2—Liquid Waste Management System Component Data, lists specific component data for the major components of the liquid waste storage and processing systems.

Section 11.4 provides additional information on the expected volumes, activity levels, and processing of wet and solid wastes produced throughout the plant.

Refer to Section 12.3.6.5.4 for radioactive waste management system design features which demonstrate compliance with the requirements of 10 CFR 20.1406.

11.2.2.1 Liquid Waste Storage System Operation

11.2.2.1.1 Waste Input Streams

Group I wastes are those wastes expected to contain high levels of radioactivity and boron, but little or no organic substances or solids. Sources of Group I liquid wastes include the following:

- Wastewater from the fuel pool cooling and fuel pool purification systems.

- Wastewater from process drains and sumps collected in the Nuclear Auxiliary Building.

- Wastewater drained from the evaporator column in the liquid waste processing system.
- Wastewater decanted from the concentrate tanks and wastewater returned from the radioactive concentrates processing system.
- Wastewater collected from the floor drains and sumps of the NI and Radioactive Waste Processing Building.
- Treated wastewater returned from the centrifugal separator in the liquid waste processing system (if still radioactive).
- Wastewater from sampling.

Group I wastes are stored in the Group I liquid waste storage tanks.

Group II wastes are those wastes expected to contain low levels of radioactivity, along with organic and inorganic substances and some solids. Sources of Group II liquid wastes include:

- Wastewater from the hot laboratory transferred through the sumps of the Nuclear Auxiliary Building.
- Wastewater from the showers and washrooms in the Nuclear Auxiliary Building.
- Distillate from the reactor coolant treatment system.
- Steam generator blowdown demineralizer system flushing water (if radioactive).
- Wastewater collected from the floor drains and sumps of the NI and Radioactive Waste Processing Building.

Group II wastes are stored in the Group II liquid waste storage tanks.

Group III wastes are those wastes expected to contain no radioactivity, but some organic or inorganic chemicals. Group III waste collection headers are shared with some of the Group II collection headers; the wastes carried in these headers normally are stored in the Group III liquid waste storage tank if there are no indications that the wastewater contains radioactivity. Because they normally have no activity, several of the Group III wastewater streams can be routed directly to the monitoring tanks in the liquid waste storage system. Sources of Group III wastes include:

- Steam generator blowdown demineralizing system flushing water (if non-radioactive).
- Non-radioactive floor drains.

11.2.2.1.2 Storage

The liquid waste storage tanks have sufficient capacity to store the liquid waste generated under normal modes of plant operation. In the event of a design basis accident (DBA), these tanks are not affected directly because they are located in the Radioactive Waste Processing Building and thus isolated from the high hazard sources in the Reactor Building. For both Groups I and II wastes, only one of the two liquid waste storage tanks is configured to receive wastes at a given time. When this tank fills, control valves in the liquid waste storage collection piping automatically place the other tank in that group in service and isolate the full tank. The full tank is sampled for activity, pH, and chemical contents. Chemicals are added to this tank to balance the pH and to precipitate those radionuclides that react to form an insoluble solid; adsorption and mixed crystal formation helps to remove other impurities such as corrosion products.

The full storage tank is then connected to one of the three liquid waste processing system operations, and the pretreated wastewater in the tank is pumped through the selected processing operation. The treated wastewater is subsequently returned to the liquid waste storage system; the concentrates are directed to the concentrate tanks, and treated wastewater is directed to the monitoring tanks. Treated wastewater decanted from the concentrate tanks can be returned for further processing to the Group I liquid waste storage tanks. Treated water in the monitoring tanks that still has radioactivity in excess of release limits can be returned to the Group I or II liquid waste storage tanks. Precipitates, corrosion products, and other solids that settle out on the conical bottoms of the liquid waste storage tanks are periodically pumped to one of the concentrate tanks.

Control valve interlocks prevent simultaneous filling and draining of each liquid waste storage tank, except when a tank is configured for recirculation. During tank recirculation, control valves block other routes connected to the recirculation piping for that subgroup.

11.2.2.1.3 Chemical Addition

The wastewater collected in the storage tanks must be pretreated to prevent the precipitation of solids by pH corrections or other inherent chemical changes that may occur during treatment processes. Chemical addition procedures are a part of the operating procedures that will be developed by the COL applicant (see COL Item 13.5-1). The pH adjustment of wastewater in the Group I liquid waste storage tanks and of the treated wastewater in the monitoring tanks also significantly reduces or eliminates the discharge of boric acid to the environment. The Group II liquid waste storage tanks also include provisions for the introduction of aerobic bacteria to consume the organic compounds that collect in these tanks. The U.S. EPR design considers IE Information Notice 84-72 by continuously venting the liquid waste storage tanks to the radioactive waste processing building ventilation system to remove any gases produced by the bacteria. The ventilation system is equipped with HEPA and activated carbon filters to maintain plant radioactive releases ALARA. After decomposing the organic compounds in these tanks, the bacteria die and settle out as part of the sludge that collects on the bottom of the tanks. These bacteria can only be treated in the centrifuge system.

Three of the four chemical addition tanks are piped to the liquid waste storage tanks via the liquid waste storage recirculation system. The first tank supplies an acidic solution to reduce wastewater pH. The second tank supplies an alkaline solution to raise wastewater pH. The third tank supplies an anti-foaming agent, which promotes the settling of precipitates. The anti-foaming agent prevents foam from entering the evaporator distillate column. Little anti-foaming agent is required because the U.S. EPR does not contain a laundry system. The soapy waste that is expected will typically be considered Group III wastes (i.e., floor and shower drains) and not processed. If soapy water is processed, anti-foam is added to the liquid waste storage tank. The contents of the tank are then sent to the evaporator for processing. If the soapy waste water is processed by the demineralizer, the anti-foam will not be added to the storage tank. There is not a significant amount of residual anti-foam expected in the evaporator distillate. In accordance with Information Notice 88-08, caution will be taken to verify that chemicals used will not have adverse reactions with substances that may be entrained in the waste stream and impact evaporator concentrates or spent demineralizer resins. These three chemical addition tanks are also piped to the concentrate tank recirculation header and to the evaporator column in the liquid waste processing system and can be used to adjust the pH and prevent foaming in the drum drying stations of the radioactive concentrates processing system or the evaporator column. The two pH adjustment tanks are also piped to the monitoring tank recirculation header, and can be used to balance the pH of clean treated wastewater that is otherwise ready to be released. The fourth chemical addition tank delivers a chelating agent to the evaporator column in the liquid waste processing system to aid in column cleaning after a processing cycle. The chelating agent is added to the evaporator column, on an as needed basis, to remove any encrusted solids accumulated on the column walls. Once the cleaning process is complete, the waste is collected in the bottom of the evaporator column where it is drained to the concentrate tanks to be sent to the solid waste processing system. After the waste is sent to the concentrate tanks, the evaporator column is rinsed to verify that any remaining chelating agent and solids have been removed prior to the next processing cycle. The U.S. EPR design considers IE Information Notice 83-14 by not forwarding the removed solids to the demineralizer system. A dedicated chemical proportioning pump is provided for each of the four chemical addition tanks to permit precise metering of chemical additions for wastewater treatment.

The U.S. EPR design also considers IE Information Notice 90-50 by employing tactics to prevent organic substances from interacting with the demineralizer ion-exchange resins. The waste water is drawn from the top of the tank for processing, thus reducing the potential for organic sludge to enter the processing systems. If the waste water is sent to the demineralizer system directly, the pre-filters and ultra-filters trap any solids that are entrained in the waste stream. If the waste water is first sent to the evaporator, any organics are retained in the evaporator column bottom.

11.2.2.1.4 Recirculation

The liquid waste storage system has two recirculation pumps that are used to recirculate the contents of a given liquid waste storage tank, to move wastewater from one liquid waste storage tank to another, or to move wastewater from a liquid waste storage tank to the monitoring tanks. Recirculation is performed as needed to promote mixing the contents of a liquid waste storage tank for sampling and to promote the uniform distribution of chemical additions. Transfer between liquid waste storage tanks allows consolidation of water from the two liquid waste storage tanks of Group I or Group II into a single tank of the respective group.

Each liquid waste storage tank outlet has a branch with a control valve that connects to a common suction header. The suction header is divided by a manually operated valve, with the Group I tanks and recirculation pump on one side of the valve and the Groups II and III tanks together with another recirculation pump on the other side of the valve. Both recirculation pumps discharge to a common header that is divided between Group I and Groups II and III by a manually operated valve. Branches from the discharge header return recirculation flow to the top of the liquid waste storage tanks. An additional branch on the Groups II and III side of the recirculation discharge header connects to the inlets of the two monitoring tanks. Piping from each of three chemical addition tanks (acidic solution, alkaline solution, and antifoaming agent) connects to the recirculation discharge header on both sides of a manually operated valve. The normally closed, manually operated valves that divide the suction and discharge headers segregate the high-activity Group I wastes from the low-activity Groups II and III. The piping configuration provides operational flexibility, allowing either recirculation pump to be configured to take suction from or to pump to the liquid waste storage tanks on the other side of these manually operated valves.

11.2.2.1.5 Concentrates

The liquid waste storage system receives wastewater with concentrated quantities of radionuclides that returns from the liquid waste processing system and concentrated wastewater that contains the precipitates from the bottom of the liquid waste storage tanks. These concentrated wastes are collected and stored in the three concentrate tanks for further processing in the radioactive concentrates processing system. Each liquid waste storage tank has an outlet at the bottom of the conical base of the tank.

This outlet connects to the suction header of the sludge pump. The sludge pump draws wastewater from the liquid waste storage tank, entraining the precipitate sludge that has settled on the bottom of the tank, and pumps this waste to one of the three concentrate tanks. Concentrates from the evaporator column in the liquid waste processing system are routed to the other two concentrate tanks.

After allowing time for sedimentation of the concentrates, the concentrate pump decants wastewater from the concentrate tanks through a series of three taps set at progressively higher elevations in the side of each tank, and returns that water to the Group I liquid waste storage tanks. The concentrate pump can recirculate the wastewater in a given concentrate tank to promote the mixing of tank contents prior to sampling or to promote the mixing of chemical additives (acidic solution, alkaline solution, and anti-foaming agent) injected for treatment. When a concentrate tank has collected a sufficient quantity of radioactive concentrates to warrant further processing, the concentrate pump is configured to recirculate while taking suction from a fourth tap located near the bottom of the concentrate tank. While recirculating in this configuration, the collected concentrates are diverted in batches to the radioactive concentrates processing system through a branch from the concentrate pump discharge header.

11.2.2.1.6 Monitoring and Discharge

The liquid waste storage system collects treated wastewater and Group III wastewater streams with no indications of radioactivity in two monitoring tanks. Distillate discharged from the evaporator system and treated wastewater discharged from the demineralizer system share a common header for distribution to the monitoring tanks, although during normal operations, distillate discharged from the evaporator may be sent to the demineralizer for further processing. Treated wastewater discharged from the centrifugal separator may be distributed to the monitoring tanks through a separate header, although during normal operations, as with the evaporator, the treated wastewater from the centrifuge may be sent to the demineralizer for further processing. Flushing water from the steam generator blowdown demineralizing system and wastewater from the coolant treatment system can be routed to one of the monitoring tanks.

The recirculation and discharge pumps recirculate treated wastewater in the monitoring tanks for sampling and analysis. Monitoring tank samples are analyzed for activity, radionuclides, pH, and other properties. The results of the analysis determine whether or not the treated wastewater is within the limits for release. An acidic or alkaline solution can be injected into the treated wastewater to balance the pH via the monitoring tank recirculation header. However, if other measurements indicate that the treated wastewater exceeds the allowed limits for release, it is returned to the liquid waste storage tanks for further processing via the liquid waste storage recirculation discharge piping.

If the activity and pH of the treated wastewater in a monitoring tank are within limits, then the recirculation and discharge pumps are aligned to pump that tank to the release line. The release line contains an administratively controlled, locked-closed upstream isolation valve. Personnel in the main control room maintain custody of the key to this valve and only issue the key upon receipt of a completed analysis demonstrating that the treated wastewater in a monitoring tank is within limits for release. When this valve is opened, the treated wastewater enters the activity-measurement tank in the release line. Radiation sensors (refer to Section 11.5.3.2 and Table 11.5-1, Monitor R-32) in this tank continuously measure and record the activity as the treated wastewater is released. Flow sensors downstream of the activity-measurement tank continuously measure and record the volume and flow rate as the treated wastewater is released. If the total activity indicated by sensors exceeds predetermined limits, control signals are generated automatically to close two downstream isolation valves, close the upstream isolation valve, and shut down the operating recirculation and discharge pump(s).

These components are upstream of both the high point in the release line and a drain tank connected to the release line; automatic closure occurs before the treated wastewater that generated the control signal exits the release line. This equipment prevents the release of treated wastewater that exceeds the dose limits to individual members of the public, as specified in 10 CFR 20.1301 and 10 CFR 20.1302, 10 CFR Part 20, Appendix B, Table 2, Column 2 limits, or the 10 CFR Part 50, Appendix I ALARA design objectives in the event that an operator error initiates an inadvertent discharge.

11.2.2.2 Liquid Waste Processing System Operation

The liquid waste processing system consists of three operations that employ different physical processes to separate radioactive material or chemicals from the wastewater generated during plant operation: the evaporator, the centrifuge, and the demineralizer.

11.2.2.2.1 Evaporator System

The evaporator system treats liquid wastes with high activity but low concentrations of organic chemicals or particulate solids. Typically, Group I wastewater, which contains dissolved boric acid, is sent to the evaporator. However, the five liquid waste storage tanks have discharge piping that connects to the supply header for the evaporator. If a batch of Group II wastewater contains activity that is not bound on solids (meaning it is not removable by the centrifugal separation), the wastewater can also be treated by evaporation.

The evaporator unit is a vapor-compressor evaporator with forced recirculation. An evaporator feed pump takes suction from the liquid waste storage tank that contains the wastewater to be treated by evaporation and pumps that wastewater through the pre-heater and into the evaporator column sump. The pre-heater transfers heat from the distillate leaving the evaporator to the wastewater entering it. Additional heat transfer occurs in the evaporator column, as droplets entrained with the vapor are separated by gravity or by the sieve plates and fall into the evaporator column sump where they mix with the influent wastewater. The forced recirculation pump draws the heated wastewater from the evaporator column sump and pumps it into the evaporator. In the evaporator, the circulating wastewater is heated further and changes phase from liquid to vapor before returning to the evaporator column. As the wastewater boils, the nonvolatile constituents (e.g., boron) concentrate in the liquid phase; the vapor phase contains chemically pure water along with volatile fission product gases that are present. The liquid phase concentrates in the evaporator are entrained as droplets in the vapor flow, and carried back into the evaporator column. As the vapor rises through the evaporator column to the outlet, entrained liquid concentrates are stripped away by gravity and by the sieve plates, which retain small droplets of wastewater. The droplets carrying the concentrated wastes collect in the evaporator column sump.

The vapor exits the evaporator column and is compressed by the vapor compressor, which further increases its enthalpy. The compressed vapor is then routed back to the evaporator, where its heat is transferred to boil the next slug of wastewater. This process condenses the chemically pure water vapor to distillate, which may also contain the volatile fission product gases. The distillate drains from the evaporator into the distillate tank. Remaining vapor and fission product gases, vent from the top of the distillate tank to the vent gas cooler. The vent gas cooler condenses the remaining water vapor, which returns to the distillate tank; the noncondensable fission product gases are vented to the radioactive waste processing building ventilation system. The distillate pump draws water from the distillate tank and directs it to the demineralizer for further processing, if required. The design of the evaporator subsystem allows the water from the distillate tank to be routed directly to the monitoring tanks in the liquid waste storage system. A small portion of the distillate is diverted from this path, cooled in the injection water cooler, and injected into the vapor compressor to prevent the vapor compressor from superheating the vapor. Another small portion of distillate is diverted to the evaporator column for use as washing water for the vapor rising through the sieve trays.

During processing, wastes become concentrated in the evaporator column sump. The concentrate eventually contains total solids of approximately 20 to 25 percent by weight. After reaching the required concentration, the concentrate from the evaporator column sump is drained to one of the concentrate tanks in the liquid waste storage system. Wastewater that remains in the evaporator column sump after processing can be directly drained to the Group I liquid waste storage tanks. Alternatively, the evaporator column sump can be aligned to the recirculation pump suction header so that a recirculation pump can draw the wastewater out of the evaporator column and pump it to one of the liquid waste storage tanks.

The evaporator system is not operated continuously, but instead is started and stopped as needed for processing wastewater by evaporation. Since no vapor is available for compression and heat transfer when the evaporator is started, residual distillate in the distillate tank is pumped through an electric heater and then into the evaporator. This provides the heat needed to initiate evaporation of the wastewater stream entering the evaporator. As this process continues, the vapor generated in the evaporator accumulates in the evaporator column, raising the pressure in the evaporator column to the point that sufficient vapor is available to start and operate the vapor compressor. Once the vapor compressor is started, the compressed vapor becomes the source of heat for the evaporator, and the electric heater is secured and isolated from the distillate flow path.

11.2.2.2.2 Centrifuge System

The centrifuge system treats liquid wastes with low radioactivity, but high concentrations of organic chemicals or suspended solids. Typically, the centrifuge treats Group II wastewater. The three liquid waste storage tanks used to collect the Group II and Group III wastewater can each be aligned to the centrifuge system for processing. The centrifuge system employs both a decanter and a centrifuge to concentrate and separate wastes.

The centrifuge feed pump takes suction from the liquid waste storage tank that contains the wastewater to be treated by centrifugal separation and pumps that wastewater into the decanter. The decanter is mounted horizontally and uses a motor-driven screw to inertially separate large particles from the water. The solids collected in the decanter are discharged to the waste drum. The water continues to the separator. The separator is mounted vertically and inertially separates the remaining smaller particles out of the water stream. The small particles separated by the separator are collected in the sludge tank; the treated wastewater is directed to the demineralizer for further processing, if required. The design of the centrifuge subsystem allows the treated wastewater from the centrifuge to be routed directly to the monitoring tanks in the liquid waste storage system.

The sludge tank has a motorized stirrer that promotes the agglomeration of the solids collected from the separator. The decanter feed pump moves batches of this agglomerated sludge from the sludge tank back to the decanter for continued processing. In the decanter, the sludge is further dewatered and is eventually discharged to a waste drum. When the waste drum is full, it is replaced. During drum replacement, solids from the decanter are forwarded to the sludge tank. Once the new drum is in place, the flow from the decanter is again routed to the waste drum. The full drum is transferred to the drum drying stations, an onsite storage location, or offsite disposal facility.

11.2.2.2.3 Demineralizer System

The demineralizer system of the liquid waste processing system is an additional means of processing liquid wastes common in the U.S. nuclear industry. The demineralizer system is capable of processing each of the three liquid waste groups. The supply line to the demineralizer system branches from the evaporation supply line downstream of the evaporator feed pumps, so wastewater from the five liquid waste storage tanks can be pumped to this system. The demineralizer beds include varying combinations of anion resins, cation resins, and mixed anion and cation resins. These resins chemically bind contaminants carried in the waste stream, and an ultrafiltration unit screens out fine particles.

Wastewater routed to the demineralizer is first passed through a prefilter, which removes large particles. The waste stream is then routed through the demineralizer alone, the ultrafilter alone, or through both devices in either sequence. Once the treated wastewater passes through a resin trap, which removes any entrained resin fines, it is returned to the monitoring tanks in the liquid waste storage system via the distillate return piping from the evaporator system.

The contaminants screened out by the prefilter are removed by filter media replacement when the differential pressure across the prefilter reaches its setpoint. The contaminants collected by the ultrafilter are removed by backflushing when the differential pressure across the ultrafilter exceeds predetermined levels. These contaminants are forwarded to the solids collection system where they are stored until ready for disposal. A chemical tank is provided to treat the contaminants as necessary. The resin beds are replaced when the resin in the demineralizer is spent based on plant criteria. The spent resin is pumped to a HIC for dewatering. Spent coolant purification system resins can also be added directly to the demineralizer system HIC. Water removed from the high integrity container (HIC) is sent back through the demineralizer system via a water booster pump for further processing. Dried spent resins may be stored onsite or sent to an offsite disposal facility. Spent demineralizer resins can be sent to the liquid waste storage system for further processing and transfer to the solid waste management system.

The liquid waste processing system may be aligned so that treated distillate from the evaporator and treated wastewater from the centrifuge are routed to the demineralizer system for further processing. This serial processing configuration allows very high decontamination factors to be achieved and minimizes the radioactivity ultimately discharged to the environment. This serial processing configuration is particularly important when high concentrations of radioactivity are present in the liquid waste input stream.

11.2.2.3 Sampling

Samples of the wastewater held in the liquid waste storage system are collected at three sample boxes that are part of the nuclear sampling system-slightly active liquid samples. Samples are drawn from the various tanks in the liquid waste storage system while they are aligned for recirculation. Stirrers are also provided in the liquid waste storage tanks and the concentrate tanks to promote the mixing of tank contents.

The sample piping forms a loop that connects to both the suction and discharge piping of each pump used for recirculating a set of liquid waste storage system tanks. Pump differential pressure drives flow through the sample loop. A tap from each sample loop extends to the respective sample box, which contains an isolation valve and nozzle. Samples of the liquid waste storage tanks are collected at one of the sample boxes; samples from the concentrate tanks and the evaporator column sump are collected at a second sample box; samples from the monitoring tanks are collected at a third sample box. This separation of sample points prevents the acquisition of misleading results either by dilution of contaminated wastes with residual treated wastewater or by the contamination of treated wastewater with residual contaminants in the sample lines. Samples are analyzed, and the results are used to determine the specific quantities and types of chemicals required for treatment of the sample source.

11.2.2.4 Component Description

This section provides detailed descriptions of the individual components that make up the systems described in Section 11.2.2.1 and Section 11.2.2.2.

11.2.2.4.1 Liquid Waste Storage System Components

Liquid Waste Storage Tanks

The five liquid waste storage tanks are vertical, cylindrical tanks with conical bottoms for sludge collection and draining. The tanks are constructed of stainless steel. Each liquid waste storage tank has a motor-operated stirrer mounted in the tank. The stirrer is used (in conjunction with the recirculation pumps) to achieve a homogeneous mixture of the wastewater in the tank and to facilitate the mixing of chemicals (acidic solution, alkaline solution, and anti-foaming agent) injected. This tank configuration allows the use of the liquid waste storage tanks for chemical pretreatment of wastewater to adjust pH and to collect precipitates. The Group II liquid waste storage tanks also have a sparger for the injection of air into the wastewater. Sparging provides another means of agitating the tank contents at the same time that it oxygenates the wastewater to enhance aerobic bacteria respiration.

Chemical Tanks

The liquid waste storage system includes four separate chemical addition tanks; each is independently piped to various systems of the liquid waste storage, liquid waste processing, or radioactive concentrate processing systems. The tanks are designed to mix, store, and supply chemicals required for pretreatment or in-process treatment of wastewater. Each tank is made of stainless steel and has a motor-driven stirrer to promote homogeneous mixing of chemical additives at specific concentrations.

Chemical Proportioning Pumps

The chemical proportioning pumps are piston-type positive displacement pumps that permit precise metering of chemical additions to the liquid waste storage, liquid waste processing and radioactive concentrates processing systems. The chemical proportioning pumps are made of stainless steel to withstand attack by the chemical additives in use.

A pulsation damper is located immediately downstream of each chemical proportioning pump. Each pulsation damper consists of a small stainless steel tank that receives and dissipates the pressure wave pulses generated by the pistons of the chemical proportioning pumps.

Recirculation Pumps

The recirculation pumps are centrifugal pumps that circulate the wastewater within the liquid waste storage tanks to promote homogeneous mixing within the tanks. The recirculation pumps are used to draw samples from the liquid waste storage tanks, to support chemical additions to the liquid waste storage tanks, and to transfer chemically treated wastewater from the liquid waste storage tanks to the monitoring tanks if the activity level permits.

The recirculation pumps share a common suction header and a common discharge header. Each header is divided by a control valve that separates the Group I side from the Groups II and III side. One recirculation pump is on the Group I side, and the other is on the Groups II and III side of the divided recirculation headers. This arrangement promotes operational flexibility in that both a Group I tank and a Group II or III tank may be independently recirculated simultaneously. The piping from the recirculation discharge header to the monitoring tanks connects to the Groups II and III side, so the wastewater from a Group II or III liquid waste storage tank can also be pumped to the monitoring tanks while a Group I tank is recirculated. The Group II and III tanks cannot, however, be recirculated while the wastewater from a Group I tank is pumped to the monitoring tanks.

Sludge Pump

The sludge pump is a centrifugal pump that draws the precipitates and sludge from the bottom of the liquid waste storage tanks and discharges it to the concentrate tanks for further processing.

Concentrate Tanks

The three concentrate tanks are vertical cylindrical tanks with dished heads. The tanks are made of stainless steel. The concentrate tanks collect and hold concentrated wastes that have been separated from wastewater in the liquid waste storage tanks or in one of the liquid waste processing systems for batch processing in the radioactive concentrates processing system.

Each concentrate tank has a motor-operated stirrer mounted in the tank. The concentrate tanks are vented to the radioactive waste processing building ventilation system by piping that connects to the sleeve around the drive shaft for the stirrer. The stirrer is used in conjunction with the concentrate pump to achieve a homogeneous mixture of the wastewater in the tank for sampling, to facilitate the mixing of chemicals (i.e., acidic solution, alkaline solution, and anti-foaming agent) injected for treatment, and to promote the batch transfer of concentrates to the radioactive concentrates processing system. Each concentrate tank also has a sparger mounted in the bottom of the tank, to facilitate agitation by sparging the tank contents with air from the compressed air distribution system.

Concentrate Pump

The concentrate pump is a centrifugal pump that draws batches of sludge and concentrates from the concentrate tanks and discharges it to the radioactive concentrates processing system. The concentrate pump is also used to recirculate wastewater in the concentrate tanks for sampling and chemical additions. The concentrate pump can be used to draw clean wastewater from the upper portions of the concentrate tanks and return that water to the Group I liquid waste storage tanks for additional processing. The concentrate pump is fabricated from stainless steel with high resistance to corrosion and abrasion

Monitoring tanks

The two monitoring tanks are vertical cylindrical tanks with conical bottoms. The tanks are made of stainless steel. The monitoring tanks collect and hold treated wastewater from the liquid waste processing system. One tank can also receive Group III wastes directly from the steam generator blowdown demineralizing system. The monitoring tanks are sampled via the piping that connects them to the recirculation and discharge pumps to determine whether the activity and chemistry of treated wastewater is within limits for release. If it is not, the treated wastewater can be returned to the liquid waste storage tanks for treatment. If the wastewater in the monitoring tanks meets activity limits, but not chemistry (pH) criteria for release, chemical additions of either acidic or alkaline solutions can be injected as needed to balance the pH of the wastewater for release.

Recirculation and Discharge Pumps

The recirculation and discharge pumps are centrifugal pumps configured in parallel for redundancy. The recirculation and discharge pumps are used to recirculate treated wastewater in the monitoring tanks for sampling and to facilitate the injection and mixing of chemicals. These pumps also return treated wastewater back to the liquid waste storage tanks (via the recirculation pumps discharge header) if sample analysis results indicate that further processing is required.

Activity-Measurement Tank

The activity-measurement tank is a small stainless steel tank located upstream of the release line isolation valves. Two radiation sensors (refer to Section 11.5.3.2 and Table 11.5-1, Monitor R-32) are mounted in the release line to continuously measure and record activity discharged during wastewater releases to the environment. Flow sensors are located in the release line downstream of the activity-measurement tank.

Control Valves

The liquid waste storage system employs motor-operated control valves in the influent lines to and effluent lines from the liquid waste storage tanks, the concentrate tanks, the monitoring tanks, and the release line. These valves allow operation of the liquid waste storage system in automatic mode, group or subgroup control mode, interlocked manual mode, and manual mode.

11.2.2.4.2 Liquid Waste Processing System Components

11.2.2.4.2.1 Evaporator System Components

Evaporator Feed Pumps

The evaporator feed pumps are centrifugal pumps that draw wastewater from the liquid waste storage tanks and discharge to the pre-heater. One evaporator feed pump is normally aligned to take suction from the Group I liquid waste storage tanks while the other is normally aligned to take suction from the Groups II and III liquid waste storage tanks; however, either pump can be aligned to draw suction from any of the liquid waste storage tanks.

Pre-Heater

The pre-heater is a tube-and-shell heat exchanger, which transfers heat from the treated distillate that is leaving the evaporator system to the wastewater that is entering. The pre-heater is stainless steel. The incoming wastewater is routed through the tube side, while the departing distillate is routed through the shell side.

Evaporator Column

The lower part of the evaporator column is made from stainless steel with high corrosion resistance; the upper part is stainless steel. Sensors for pressure, temperature, sump level, and differential pressure are mounted on the evaporator column. The evaporator column has connections for the injection of chemicals in both the sump and sieve plate areas. The demineralized water distribution system connects to the evaporator column in both the sump and sieve plate areas.

Forced Recirculation Pump

The forced recirculation pump is mounted horizontally and draws suction on the evaporator column sump and discharges to the evaporator. The forced recirculation pump is made of stainless steel with high corrosion resistance.

Evaporator

The evaporator is a tube-and-shell heat exchanger in which the wastewater is heated to change phase from liquid to vapor. The tube side of the evaporator is fabricated from stainless steel that is highly resistant to corrosion, while the shell side is fabricated from a standard grade of stainless steel.

Vapor Compressor

The vapor compressor is a horizontal rotary type that compresses the cleaned vapor from the evaporator column so that it may be routed to either the evaporator or the distillate tank. The vapor compressor is fabricated of stainless steel.

Distillate Tank

The distillate tank collects the water that condenses from the compressed vapor due to the transfer of heat in the evaporator. The nonvolatile radioactive and chemical contaminants are concentrated by boiling in the evaporator and separated from the vapor in the evaporator column, so the distillate that collects in the distillate tank is treated wastewater with little or no non-volatile radioactive and chemical contamination. Concentration of tritium is unchanged since it is part of the water molecule. The distillate tank is stainless steel.

Distillate Pump

The distillate pump is a horizontally configured centrifugal pump that draws distillate from the distillate tank and pumps it through the pre-heater and distillate cooler, and to the demineralizer subsystem for further processing, if required. The distillate may be sent directly to the monitoring tanks. A small portion of the distillate is diverted from this path and divided for use as wash water on the sieve plates of the evaporator column or as cooling water injected into the vapor stream entering the vapor compressor to prevent superheating. During evaporator system startup, the distillate pump discharges to the electric heater to provide a heat source for the evaporator. The distillate pump is made of stainless steel.

Distillate Cooler

The distillate cooler is a tube-and-shell heat exchanger located downstream of the pre-heater in the distillate return path to the monitoring tanks. The distillate leaving the evaporator system passes through the tube side of the cooler and cools to approximately 100°F before it is sent for further processing to the demineralizer subsystem or to the monitoring tanks. This cooling shortens the hold time in the monitoring tanks required for the treated wastewater to cool to a temperature within thermal limits for release to the environment. Heat is rejected to the process-related component cooling water system. The distillate cooler is made of stainless steel.

Compressor Injection Cooler

The compressor injection cooler is a tube-and-shell heat exchanger. Distillate is cooled as it passes through the tube side. The cooled distillate is then injected into the vapor flow upstream of the vapor compressor, where it acts as a heat sink to prevent the compressor from superheating the vapor. The compressor injection cooler is stainless steel. Heat is rejected to the process-related component cooling water system, which flows through the shell side.

Electric Heater

The electric heater provides a source of heat during startup of the evaporator system. The electric heater is a pressure vessel with heating element installed; distillate is pumped through the electric heater and into the shell side of the evaporator. Heat transfer across the evaporator cools the distillate, which drains to the distillate tank and the cycle repeats until sufficient vapor accumulates in the evaporator column to start the vapor compressor.

Vent Gas Cooler

The vent gas cooler is a stainless steel tube-and-shell heat exchanger that connects to the distillate tank. Vapor released from the hot distillate in the tank is directed to the shell side of the vent gas cooler, where it cools, condenses, and then drains back to the distillate tank. Noncondensable gases carried through the evaporation process to the distillate tank vent from the vent gas cooler to the radioactive waste processing building ventilation system. Heat is rejected to the process-related component cooling water system on the tube side of the vent gas cooler.

Control Valves

The evaporator is designed for automatic operation; it has relatively few motor-operated control valves. A motor-operated valve upstream of the preheater controls the amount of wastewater admitted to the system based on the level in the evaporator column sump. A second motor-operated valve controls the return of evaporator column sump contents to the Group I liquid waste storage tanks, and a third controls the filling and flushing water flow from the demineralized water distribution system to the evaporator column sump. One motor-operated valve controls vapor recirculation flow from the vapor compressor discharge back to the suction side while another controls the injection of cooled distillate to suppress superheating the vapor in the compressor. A motor-operated control valve is provided to bleed excessive vapor compressor discharge pressure to the vent gas cooler. One motor-operated valve controls the flow of distillate to the electric heater based on water level in the heater, while a second balances flow to the electric heater with reflux flow to the evaporator column. One motor-operated valve controls distillate reflux flow to the evaporator column, while another motor-operated valve controls distillate return flow to the demineralizer subsystem or the monitoring tanks based on distillate tank level.

Sealing Liquids

The vapor compressor has a sealing liquid subsystem that prevents the loss of vapor by leakage along the driveshaft from the motor. This subsystem includes a seal water tank, a seal water pump, seal water filter, and a seal water cooler. The sealing liquid is demineralized water from the demineralized water distribution system. The seal water pump takes suction on the seal water tank, and sends the sealing liquid through the seal water filter to the four shaft seals. The seal water filter removes solids from the seal water to prevent damage to or obstruction of the shaft seals. Seal water discharged from the shaft seals may be recycled through the seal water cooler or may be discharged to the distillate tank.

The seal water cooler is a tube-and-shell heat exchanger. The sealing liquid is cooled by the process-related component cooling water system on the shell-side and then returns to the seal water tank for reuse. The seal water pump, seal filter, and seal water cooler are made of stainless steel.

11.2.2.4.2.2 Centrifuge System Components

Centrifuge Feed Pump

The centrifuge feed pump is an eccentric screw pump that takes suction from the Group II and III liquid waste storage tanks and discharges to the decanter. The eccentric screw pump is less susceptible than other types of pumps to be damaged from the solid contaminants likely to be present in the Group II and III wastewater. During waste drum replacement, the centrifuge feed pump is shut down. The centrifuge feed pump is stainless steel.

Decanter

The decanter consists of a horizontal bowl with a motor-driven screw conveyor mounted axially inside that separates large suspended particles from the wastewater. As the screw conveyor turns, it drives the large particles towards one end of the bowl, separating them from the wastewater. The rotational speed of the screw is low enough that gravitational effects cause the wastewater to backflow against the screw motion in order to maintain the equilibrium level of the free surface. The separated large particles are withdrawn from portals in one end of the decanter while the treated wastewater is withdrawn from the opposite end. The parts of the decanter that are in direct contact with the medium are made of stainless steel.

The particles removed using the decanter are sent to the waste drum. The water is sent to the separator for further processing. Particles from the decanter are sent to the sludge tank only when the waste drum is being replaced or is down for maintenance.

Separator

The separator is a disk centrifuge with a vertical axis of rotation. This unit removes small particles from the wastewater. The disk spins at high speed; the resulting centripetal acceleration causes the materials in the centrifuge to separate on the basis of density, with the most dense materials (the small suspended particulates) farthest from the axis of rotation and successively less dense materials (the wastewater) closer to the axis of rotation. The treated wastewater is drawn out of the separator and directed to the demineralizer subsystem for further processing, if required. Alternatively, the treated wastewater may be returned to the monitoring tanks in the liquid waste storage system. The solids are discharged to the sludge tank. The parts of the centrifugal separator that are in direct contact with the medium are made of stainless steel.

Sludge Tank

The sludge tank collects the small suspended particles removed by the centrifugal separator. The sludge tank, which is made of stainless steel, has a motor-driven stirrer that stirs the sludge to facilitate agglomeration of the solids. When the waste drum is being replaced, the large suspended particles removed by the decanter are forwarded to the sludge tank. When a new drum is in place, solids from the decanter are again sent to the waste drum.

Decanter Feed Pump

The decanter feed pump is an eccentric screw pump that moves the agglomerated sludge from the sludge tank back to the decanter. In the decanter, the agglomerated sludge is decanted again to reduce its moisture content, and then discharged to the waste drum. The solids removed from the wastewater in the centrifuge system are collected in waste drums, which can be sealed and sent to the drum-drying stations of the radioactive concentrates processing system, stored onsite, or transported to offsite storage.

Control Valves

The centrifuge system of the liquid waste processing system has two motor-operated control valves, which direct the sludge separated by the decanter to either the sludge tank for further agglomeration or to the waste collection drum at the filling station.

11.2.2.4.2.3 Demineralizer System Components

The components listed below are typical of those found in vendor supplied demineralizer systems.

Prefilter

The prefilter removes suspended solids from the wastewater stream to minimize the potential for flow obstructions in the demineralizer and the ultrafilter. The filter media can be accessed easily for replacement or cleaning.

Demineralizer

The demineralizer beds include varying combinations of anion resins, cation resins, and mixed anion and cation resins. As wastewater passes through the stainless steel demineralizer, ionic contaminants react with the anionic or cationic resins, become chemically bonded to them, and remain fixed on the resin. Treated wastewater discharged from the demineralizer is either returned to the monitoring tanks in the liquid waste storage system or routed to the ultrafilter for further processing.

Ultrafilter

The ultrafilter provides ultra-high-efficiency filtration of wastewater. The ultrafilter retains most contaminants small enough to pass through the prefilter. Treated wastewater discharged from the ultrafilter may be returned to the monitoring tanks in the liquid waste storage system or routed to the demineralizer for further processing.

Spent Resin Drying

The spent resin drying subsystem is provided for receiving, drying, and packaging spent resin from the demineralizer and the Coolant Purification System. This equipment consists of a concrete cask into which a HIC for radioactive waste is placed. Spent resins are pumped into the container and dewatered. The water removed from the HIC is sent back through the demineralizer for further processing. When the HIC is full of dried spent resin wastes, the HIC is sealed and either stored onsite or shipped to an offsite facility.

Resin Trap

The Resin Trap removes resin fines from the demineralizer outlet stream. These resin fines would have the potential to contaminate the cleaned waste water. The filter media can be accessed easily for replacement or cleaning.

Solids Collection System

The solids collection system serves to collect contaminates from the ultrafilter. These contaminates are forwarded to the solids collection system via backwashing of the filters. The collected solids will be chemically treated as necessary and sent to an off-site disposal facility.

Demineralizer Booster Pump

The demineralizer booster pump serves to provide the vendor supplied demineralizer system with enough flow to ensure proper waste treatment.

11.2.2.5 Inspection and Testing Requirements

11.2.2.5.1 Preoperational Testing

The U.S. EPR liquid waste storage and processing systems incorporate features that are subject to performance validation by preoperational testing. Preoperational testing examines proper detection of setpoints by the relevant sensors and proper response by system components. Specifically, the following components and functions receive preoperational testing:

- Automatic control functions of control valves on the liquid waste storage tank influent and effluent lines.
- Chemical proportioning pumps delivery of precisely metered quantities of chemical additives.

- Automatic termination and isolation of the release path from the monitor.
- Automatic control functions that govern evaporator system operation.
- Vapor compressor compression ratios.
- Pressure integrity of liquid waste processing system piping and components for pressure transients expected during system operation.

11.2.2.5.2 Preoperational Inspection

The U.S. EPR liquid waste storage and processing systems incorporate several features subject to performance validation by preoperational inspection. Performance validation includes the inspection and testing of the following system installations and components:

- Pump installation and rotation.
- Heat exchanger installation and connection.
- Piping and system pressure integrity testing to confirm that leak tightness and leak rates comply with out-leakage specification.
- Demineralizer resin bed load capacity.
- Proper types and amounts of adsorption and filtration media have been loaded into each demineralizer resin bed.
- Proper filter media, for the pre-filters, ultra-filters, and main filters, have been loaded into the filter housings.

11.2.2.6 Instrumentation Design

Instrumentation readout is available in the main control room (MCR) and on a local control panel for major components. Instrumentation display for other components is available on a local control panel.

Releases to the environment are monitored using radiation sensors (refer to Section 11.5.3.2 and Table 11.5-1, Monitor R-32) and flow sensors to limit and control offsite releases. See Section 11.2.1.2.3 for a description of this instrumentation.

In accordance with the guidelines of RG 1.143, each tank has level instrumentation that actuates an alarm on detection of high liquid level, allowing action to be taken to divert the flow to a backup tank to avoid a tank overflow. A summary of the tank level indication and associated alarms is provided in Table 11.2-12.

11.2.3 Radioactive Effluent Releases

For the U.S. EPR, releases of radioactive effluent via the liquid pathway only occurs by discharges from the monitoring tanks in the liquid waste storage system. Most of the activity carried into the liquid waste storage and processing systems is removed from the waste stream by a combination of chemical treatments, evaporation, inertial separation, and demineralization and filtration. These treatments may be performed repeatedly, with continuing concentration and chemical treatment cycles, until the wastewater meets release limits. Contaminants removed from the wastewater are transferred to the solid waste management system (see Section 11.4).

Treated wastewater held in the monitoring tanks must be sampled and analyzed in the laboratory before its release can be authorized. The laboratory analysis confirms that the activity of the wastewater in the monitoring tanks is within release limits. Once the laboratory results have been reviewed and confirmed to be within release limits, release is authorized. During the release, two radiation sensors (refer to Section 11.5.3.2 and Table 11.5-1, Monitor R-32) in the activity- measurement tank and two flow sensors downstream of the tank continually monitor and record the discharge. If the sensors detect activity or an activity release rate in excess of release limits, or if a significant discrepancy exists between the two activity measurements or the two flow measurements, the sensors signal automatic valve closure, which terminates the release. After the isolation valves of the liquid waste storage system, the treated wastewater travels through a double-walled pipe to the discharge canal. The treated waste water is diluted with water from the lined retention pond. The treated wastewater environmental interface occurs at the discharge structure. The discharges from the liquid waste storage system do not interact with the Circulating Water System (CWS).

The physical release location and discharge configuration for treated effluent are site-specific and plant-specific. Refer to Section 11.2.3.3 for the related COL item.

11.2.3.1 Discharge Requirements

Discharge requirements consist of liquid radioactive waste activity, flow monitor alarm settings, and automatic isolation settings. These requirements are established for each batch of monitoring tank treated wastewater to meet the ALARA design objectives.

11.2.3.2 Estimated Annual Releases

The GALE Code (Reference 1) was used to provide an estimate of annual releases from the U.S. EPR. Input parameters used in the GALE code model for the U.S. EPR are presented in Table 11.2-3—Liquid and Gaseous Effluent Input Parameters for the GALE Computer Code. Liquid releases (for a single plant unit) in units of Curies/year at the liquid effluent discharge point are presented in Table 11.2-4—Releases to Liquid

Effluent Discharge Point (Ci/yr) Calculated by GALE Code.

11.2.3.3 Release Points and Dilution Factors

The liquid waste storage system has a single release point. The release is further diluted to meet the ALARA design objectives of 10 CFR Part 50, Appendix I. This regulation specifies maximum annual values for dose and dose commitment for individuals in an unrestricted area from the pathways of exposure. The U.S. EPR complies with these values with a dilution flow of 100 cubic feet per second (cfs) without additional downstream dilution. Since dilution is site dependent, discharge flow rates vary for each release.

The activity in the liquid effluent is diluted by two potential means prior to reaching a given dose receptor. The first is the mixing that occurs in the discharge canal, prior to the effluent reaching the plant outfall. The flowrate for this discharge dilution is site-specific, and may be provided by cooling tower blowdown, dilution pumps, and/or other plant discharges. The second dilution source is the mixing with, and subsequent dilution by, the receiving water body prior to reaching the dose receptor (e.g., fish, drinking water supply intake). The value of this dilution is also site-specific and varies with factors such as distance between the outfall and the dose receptor, hydrological mixing characteristics of the receiving body, and design and location of the outfall structure.

The combination of pre-outfall dilution from the discharge flowrate and the post-outfall mixing after the liquid effluent reaches the receiving water body determines the effective dilution of the radioactive effluents. For the generic design calculation of doses from liquid effluents, it is assumed that the discharge flow rate is 100 cfs and that no further mixing or dilution occurs beyond the plant outfall. However, equivalent effective dilution may be achieved by various combinations of pre-outfall dilution from the discharge flowrate and post-outfall mixing, where a reduction in discharge flowrate is offset by a proportional increase in post-outfall dilution.

The physical release location and dilution factors for treated effluent are site-specific. A COL applicant that references the U.S. EPR design certification will provide site-specific information on the release pathway including a detailed description of the discharge path and plant sources of dilution, the need for backflow prevention to the retention pond, the discharge flow rate and dilution factors at or beyond the point of discharge.

11.2.3.4 Estimated Doses

11.2.3.4.1 Liquid Pathways

The LADTAP II computer program (Reference 2) was used to calculate doses to the maximally exposed individual (MEI) from liquid effluents. LADTAP II implements the exposure methodology described in RG 1.109. The program considers the following exposure pathways:

- Ingestion of aquatic foods.
- External exposure to shoreline.
- External exposure to water through boating and swimming.
- Ingestion of drinking water.
- Ingestion of irrigated terrestrial food crops.

Inputs and assumptions are conservatively selected to represent a bounding condition for all pathways. Input parameters used by the LADTAP II code (Reference 2) are presented in Table 11.2-5—Input Parameters for LADTAP II Computer Code.

Note that the default LADTAP II usage factor values for swimming and boating of 0 hours/year are used in the analysis. Therefore, there are no doses associated with the swimming and boating pathways. However, if a specific site has these dose pathways, the pathways would be identified as part of COL Item 11.2-3 and included in the liquid effluent dose analysis.

11.2.3.4.2 Liquid Pathway Doses

The doses calculated by the LADTAP II code meet the 10 CFR Part 50, Appendix I, ALARA design objectives. The dose calculation is based on a dilution flow rate of 100 cfs. The detailed dose commitment results by age group and organs due to liquid effluent releases are provided in Table 11.2-13—Detailed Dose Commitment Results by Age Group and Organ due to Liquid Effluent Releases. Table 11.2-6—Dose Commitment Due to Liquid Effluent Releases summarizes the dose commitment calculation and regulatory requirements.

A COL applicant that references the U.S. EPR design certification will confirm that the site-specific parameters are bounded by those provided in Table 11.2-5 and the dose pathways provided in Section 11.2.3.4.1. For site-specific parameters that are not bounded by the values provided in Table 11.2-5 and dose pathways other than those provided in Section 11.2.3.4.1, a COL applicant that references the U.S. EPR design certification will perform a site-specific liquid pathway dose analysis following the guidance provided in RG 1.109 and RG 1.113, and compare the doses to the numerical design objectives of 10 CFR Part 50, Appendix I and demonstrate compliance with requirements of 10 CFR Part 20.1302 and 40 CFR Part 190.

11.2.3.5 Maximum Release Concentrations

Using annual release data generated by the GALE code and presented in Table 11.2-4, annual average concentrations of radioactive materials released in liquid effluents to the discharge point have been determined by dividing the release rates (Ci/yr) by the annual average dilution flow. Annual average concentrations were determined in the immediate vicinity of the discharge point. No further mixing, dilution, or transport was assumed to occur.

A dilution flow of 9000 gallons per minute (gpm) was used in performing the maximum release concentration analysis. This flowrate is based on the dilution flow being provided by cooling tower blowdown, which operates continuously during plant operation. A capacity factor of 80 percent is used to determine the annual duration of cooling tower blowdown operation, and therefore annual dilution flow.

For each radionuclide released, the average concentration has been compared to the limiting value for that radionuclide specified in 10 CFR Part 20, Appendix B, Table 2. Table 11.2-7—Comparison of Annual Average Liquid Release Concentrations with 10 CFR Part 20 Concentration Limits, presents the results of this comparison. For the annual average radionuclide release concentrations for expected releases, the overall fraction of the effluent concentration limit is 0.12, which is well below the allowable value of 1.0.

Average liquid effluent concentrations for each radionuclide based on design basis conditions (one percent failed fuel fraction) have also been determined and compared to the limiting value for that radionuclide specified in 10 CFR Part 20, Appendix B, Table 2. The expected release concentrations were upwardly adjusted by a multiplication factor[1] that represents the ratio of design basis fuel failure primary coolant activity to expected fuel failure primary coolant activity. Table 11.2-7 presents the results of this comparison. For the annual average radionuclide release concentrations for design basis releases, the overall fraction of the effluent concentration limit is 0.62, which is below the allowable value of 1.0.

A COL applicant that references the U.S. EPR design certification will confirm that the site-specific annual average liquid effluent concentrations are bounded by those specified in Table 11.2-7. For site-specific annual average liquid effluent concentrations that exceed the values provided in Table 11.2-7, a COL applicant that references the U.S. EPR design certification will demonstrate that the annual average liquid effluent concentrations for expected and design basis conditions meet the limits of 10 CFR Part 20, Appendix B, Table 2 in unrestricted areas.

1. For any calculated multiplication factors less than one, a value of 1 was conservatively used. For primary coolant activities reported by GALE that were less than 1.0E-05 µCi/ml (and therefore displayed by GALE as zero), a conservative value of 1,000 was used for the multiplication factor.

11.2.3.6 Radioactive Liquid Waste System Leak or Failure

The U.S. EPR liquid waste management system receives degasified liquids in the storage tanks. These tanks are continuously vented to the radioactive waste processing building ventilation system (refer to Section 9.4.8) so that any generation of gaseous activity is continually removed. Thus, no significant levels of gaseous activity from a liquid waste system leak or failure is expected. An evaluation later in this section addresses the radiological consequences of the leak or failure of a tank containing radioactive liquids from the liquid waste management system.

11.2.3.7 Postulated Radioactive Releases due to Liquid-Containing Tank Failures

A postulated liquid storage tank failure resulting in the release of radioactive materials into the unrestricted area was evaluated using the guidance provided in SRP Section 11.2, Branch Technical Position (BTP) 11-6. BTP 11-6 applies the effluent concentration limits of 10 CFR Part 20, Appendix B, Table 2 as acceptance criteria in assessing the radiological impacts of a tank failure. The results shown in Table 11.2-8 indicate that a release of radioactive materials due to a postulated failure of liquid-containing tanks outside of containment during normal operations or anticipated operational occurrences would not result in release concentrations exceeding the effluent concentration limits specified in 10 CFR Part 20, Appendix B, Table 2 using the unity rule and sum-of-the-fractions.

The U.S. EPR general arrangement drawings were reviewed to determine which component in each of the main areas of the Nuclear Island outside the Reactor Building could contain the maximum radionuclide concentration/volume. This review also determined that the proposed design includes no buildings, facilities, or tanks containing radionuclides outside of the Nuclear Island. Components were evaluated based on their respective volumes and whether they could contain reactor coolant activity. Except for the Reactor Building, there is no secondary containment in the Nuclear Island compartments/buildings. The tanks and components that are designed to contain or process radioactive liquids are located within the Nuclear Island. These components include:

- Reactor coolant storage tanks (total of six, each 4061 ft^3) in the Nuclear Auxiliary Building.
- Liquid waste storage tanks (total of five, each approximately 2473 ft^3) in the Radioactive Waste Processing Building.
- Volume control tank (320 ft^3) in the Fuel Building.
- LHSI heat exchanger (total of four, each 36 ft^3) in the Safeguards Building.

As defined by NUREG-0800, Section 2.4.13, the source term is determined from a postulated release from a single tank or pipe rupture outside of the containment. The postulated source of the liquid effluent is a tank rupture in a reactor coolant storage tank in the Nuclear Auxiliary Building, because these tanks contain the largest volume of reactor coolant water. An instantaneous release from a tank would discharge the contents faster than from a pipe rupture that is connected to the tank and based on the piping configuration discharge more contents to the environment. The piping configuration may cause more contents to be held up in the tank by the nozzle locations and pipe routing than a tank failure. Therefore, modeling a tank failure will result in a more conservative analysis.

The scenario evaluated involves the instantaneous unmitigated release and mixing into groundwater of the entire contents of the reactor coolant storage tank, which is located in the Nuclear Auxiliary Building. The radionuclides chosen for the radioactive source term were selected based on the guidance provided in draft Interim Staff Guidance (ISG) DC/COL-ISG-013 (Reference 5) and include those radionuclides having the highest potential exposure consequences to potential users, including long-lived fission and activation products and environmentally mobile radionuclides. The radionuclide concentrations for the fission products are conservatively based on a 0.25 percent failed fuel fraction, exceeding the 0.12 percent fraction prescribed in BTP 11-6. The radioiodine concentrations are based on the technical specification dose equivalent I-131 limit of 1.0 μCi/g.

The release scenario assumes no credit for building or system design features in mitigating the impact of the spill. The groundwater pathway includes the processes of advection, decay and retardation during transport and dilution within the receiving body of water, prior to reaching a hypothetical user of potable water assumed to be located at about 1200 feet. The radionuclide concentrations, half-lives and partition coefficients are provided in Table 11.2-14. A travel period of 200 days is assumed along with a soil density of 1.75 g/cm^3, an effective soil porosity of 0.37 and a dilution factor of 5.0E-04 to account for mixing within the receiving body of water. Without the benefit of site-specific conditions, the applied parameters are assumed to be conservatively bounding for various site conditions.

Table 11.2-8 shows the resulting radionuclide concentrations at the potable water supply in comparison to the effluent concentration limits of 10 CFR Part 20, Appendix B, Table 2 for a postulated rupture and unmitigated release of the entire contents of the reactor coolant storage tank. The resulting sum-of-the-ratios is 0.6, which is below the allowable value of 1.0 in accordance with the acceptance criteria of BTP 11-6.

A COL applicant that references the U.S. EPR design certification will confirm that the site-specific data (such as distance from release location to unrestricted area, contaminant migration time, and dispersion and dilution in surface or ground water) are bounded by those specified in Section 11.2.3.7. For site-specific parameters that exceed the values provided in Section 11.2.3.7, a COL applicant that references the U.S. EPR design certification will provide a site-specific analysis to demonstrate that the resulting water concentrations in the unrestricted area would meet the concentration limits of 10 CFR Part 20, Appendix B, Table 2 using the guidance provided in SRP Sections 2.4.12, 2.4.13, 11.2 and BTP 11-6. In addition, as addressed in Section 11.5.2, the COL applicant will fully describe the elements of the radioactive effluent monitoring program (REMP) as part of the Offsite Dose Calculation Manual (ODCM). The REMP will reflect current nuclear industry ground water initiatives and NRC assessments of existing nuclear reactors related to groundwater contamination and monitoring and compliance with NRC regulations.

11.2.3.8 Quality Assurance

The quality assurance program governing the design of the liquid waste storage and processing systems conforms to ANSI/ANS 55.6-1993 Section 4.3, as described in Regulatory Guide 1.143 Section 7 and indicated in Table 3.2.2-1. Implementation of the quality assurance as it relates to design is described in Chapter 17. The COL applicant is responsible for quality assurance requirements related to the system procurer and the system constructor.

11.2.4 Liquid Waste Management System Cost-Benefit Analysis

10 CFR Part 50, Appendix I requires that plant designs consider additional items based on a cost-benefit analysis. Specifically, the design must include all items of reasonably demonstrated cleanup technology that, when added to the liquid waste processing system sequentially and in order of diminishing cost-benefit return, can, at a favorable cost-benefit ratio, reduce the dose to the population reasonably expected to be within 50 miles of the reactor. A COL applicant that references the U.S. EPR design certification will perform a site-specific liquid waste management system cost-benefit analysis.

11.2.5 References

1. NUREG-0017, “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors PWR-GALE Code,” Revision 1, U.S. Nuclear Regulatory Commission, April 1985.

2. NUREG/CR-4013, “LADTAP II – Technical Reference and User Guide,” U.S. Nuclear Regulatory Commission, April 1986.

3. NUREG-0800, BTP 11-6, “Postulated Radioactive Releases Due To Liquid-Containing Tank Failures,” Revision 3, U.S. Nuclear Regulatory Commission, March 2007.

4. Deleted.

5. DC/COL-ISG-013, Interim Staff Guidance on NUREG-0800 Standard Review Plan Section 11.2 and Branch Technical Position 11-6, "Assessing the Consequences of an Accidental Release of Radioactive Materials from Liquid Waste Tanks for Combined License Applications Submitted Under 10 CFR Part 52," Draft Issued for Comments, U.S. Nuclear Regulatory Commission, Federal Register, Volume 75, No. 36, February 2010.

6. Health Physics Journal, Vol. 59, No. 4, "Default Soil Solid/Liquid Partition Coefficients, Kds, for Four Major Soil Types: A Compendium," October 1990, p. 471-482.

7. ANSI/ANS 55.6-1993, R2007 (R=Reaffirmed): "Liquid Radioactive Waste Processing System for Light Water Reactor Plants," American National Standards Institute/American Nuclear Society, 2007.

Table 11.2-1—Liquid Waste Management System Design Parameters

Parameter	Design Value
Design capacity—Group I liquid waste storage tanks	39,200 gal (gross) 37,000 gal (net)
Design capacity—Group II liquid waste storage tanks	39,200 gal (gross) 37,000 gal (net)
Design capacity—Group III liquid waste storage tanks	19,600 gal (gross) 18,500 gal (net)
Design storage capacity—monitoring tanks	39,200 gal (gross) 37,000 gal (net)
Design storage capacity—concentrate tanks	28,500 gal (gross) 27,000 gal (net)
Design process capacity (nominal)—evaporation system	≈1050 gal/hr
Design process capacity (nominal)—centrifuge system	≈1300 gal/hr
Design process capacity (nominal)—demineralizer and filtration system	≈2400 gal/hr
Expected Group I waste influent stream	≈13,000 gal/wk
Expected Group II waste influent stream	≈19,000 gal/wk
Expected Group III waste influent stream	≈17,000 gal/wk

Table 11.2-2—Liquid Waste Management System Component Data
Sheet 1 of 9

Components / Parameters[1]	Nominal Value[2]
Liquid Waste Storage System	
Tanks	
Liquid Waste Storage Tanks	
Number	5
Type	Vertical with conical bottom
Design pressure	Full vacuum/0.0 psig
Design temperature	194°F
Design volume	19,600 gal (gross) / 18,500 gal (net)
Material	Stainless steel
Concentrate Tanks	
Number	3
Type	Vertical with conical bottom
Design pressure	Full vacuum/0.0 psig
Design temperature	212°F
Design volume	9,500 gal
Material	Stainless steel
Monitoring tanks	
Number	2
Type	Vertical with conical bottom
Design pressure	Full vacuum/0.0 psig
Design temperature	194°F
Design volume	19,600 gal (gross)/18,500 gal (net)
Material	Stainless steel
Chemical Tanks	
Number	4
Type	Vertical
Design pressure	Full vacuum/0.0 psig
Design temperature	194°F
Design volume	160 gal
Material	Stainless steel
Activity Measurement Tank	
Number	1
Type	Horizontal

Table 11.2-2—Liquid Waste Management System Component Data
Sheet 2 of 9

Components / Parameters[1]	Nominal Value[2]
Design pressure	Full vacuum/175 psig
Design temperature	212°F
Design volume	3.5 gal
Material	Stainless steel
Pumps	
Recirculation Pumps	
Number	2
Type	Centrifugal
Pressure	175 psig
Temperature	212°F
Design flow rate,	350 gpm
Material	Stainless steel
Concentrate Pump	
Number	1
Type	Centrifugal
Design pressure	175 psig
Design temperature	212°F
Design flow rate	45 gpm
Material	Stainless steel
Sludge Pump	
Number	1
Type	Centrifugal
Design pressure	175 psig
Design temperature	212°F
Design flow rate	45 gpm
Material	Stainless steel
Chemical Proportioning Pumps	
Number	4
Type	Piston
Design pressure	175 psig
Temperature	212°F
Design flow rate	2.5 gpm
Material	Stainless steel

Table 11.2-2—Liquid Waste Management System Component Data
Sheet 3 of 9

Components / Parameters[1]	Nominal Value[2]
Recirculation and Discharge Pumps	
Number	2
Type	Centrifugal
Design pressure	175 psig
Design temperature	212°F
Design flow rate	175 gpm
Material	Stainless steel
Liquid Waste Processing System	
Tanks	
Distillate Tank	
Number	1
Type	Vertical
Design pressure	Full vacuum/88 psig
Design temperature	338°F
Design volume	172 gal
Material	Stainless steel
Seal Water Tank	
Number	1
Type	Vertical
Design pressure	0.0 psig
Design temperature	212°F
Design volume	32 gal
Material	Stainless steel
Sludge Tank	
Number	1
Type	Vertical
Design pressure	Full vacuum/88 psig
Design temperature	212°F
Design volume	132 gal
Material	Stainless steel
Pumps	
Evaporator Feed Pumps	
Number	2

Table 11.2-2—Liquid Waste Management System Component Data
Sheet 4 of 9

Components / Parameters[1]	Nominal Value[2]
Type	Centrifugal
Design pressure	175 psig
Design temperature	212°F
Design flow rate	27 gpm
Material	Stainless steel
Centrifuge Feed Pump	
Number	1
Type	Centrifugal
Design pressure	175 psig
Design temperature	212°F
Design flow rate	22 gpm
Material	Stainless steel
Decanter Feed Pump	
Number	1
Type	Centrifugal
Design pressure	175 psig
Design temperature	212°F
Design flow rate	2.2 gpm
Material	Stainless steel
Forced Recirculation Pump	
Number	1
Type	Centrifugal
Design pressure	88 psig
Design temperature	338°F
Design flow rate	3170 gpm
Material	Stainless steel
Distillate Pump	
Number	1
Type	Centrifugal
Design pressure	88 psig
Design temperature	338°F
Design flow rate	34 gpm
Material	Stainless steel

Table 11.2-2—Liquid Waste Management System Component Data
Sheet 5 of 9

Components / Parameters[1]	Nominal Value[2]
Seal Water Pump	
Number	1
Type	Centrifugal
Design pressure	88 psig
Design temperature	212°F
Design flow rate	3.2 gpm
Material	Stainless steel
Heat Exchangers	
Pre-Heater	
Number	1
Type	Tube bundle
Design pressure (shell/tube)	88/88 psig
Design temperature (shell/tube)	338/338°F
Design flow rate (shell/tube)	2.45/2.45 lb_m/s
Temperature inlet (shell/tube)	239/68°F
Temperature outlet (shell/tube)	122/ 185°F
Material	Stainless steel
Evaporator	
Number	1
Type	Tube bundle
Design pressure (shell/tube)	88/88 psig
Design temperature (shell/tube)	338/338°F
Design flow rate (shell/tube)	3.15/441 lb_m/s
Temperature inlet (shell/tube)	243/(77-225)°F
Temperature outlet (shell/tube)	239/(77-225)°F
Material	Stainless steel
Distillate Cooler	
Number	1
Type	Tube bundle
Design pressure (shell/tube)	175/88 psig
Design temperature (shell/tube)	338/338°F
Design flow rate (shell/tube)	4.63/2.45 lb_m/s
Temperature inlet (shell/tube)	100.4/122°F

Table 11.2-2—Liquid Waste Management System Component Data
Sheet 6 of 9

Components / Parameters[1]	Nominal Value[2]
Temperature outlet (shell/tube)	120/110°F
Material	Stainless steel
Cooler for Injection Water	
Number	1
Type	Tube bundle
Design pressure (shell/tube)	175/88 psig
Design temperature (shell/tube)	338/338°F
Design flow rate (shell/tube)	0.661/0.214 lb_m/s
Temperature inlet (shell/tube)	100.4/239°F
Temperature outlet (shell/tube)	120/176°F
Material	Stainless steel
Vent Gas Cooler`	
Number	1
Type	Tube bundle
Design pressure (shell/tube)	88/175 psig
Design temperature (shell/tube)	338/338°F
Design flow rate (shell/tube)	0.154/11.02 lb_m/s
Temperature inlet (shell/tube)	212/100.4°F
Temperature outlet (shell/tube)	208/120°F
Material	Stainless steel
Seal Water Cooler	
Number	1
Type	Tube bundle
Design pressure (shell/tube)	175/88 psig
Design temperature (shell/tube)	212/212°F
Design flow rate (shell/tube)	1.98/1.98 lb_m/s
Temperature inlet (shell/tube)	100.4/140°F
Temperature outlet (shell/tube)	120/122°F
Material	Stainless steel
Special Equipment	
Electric Heater	
Number	1
Design pressure	88 psig

Table 11.2-2—Liquid Waste Management System Component Data
Sheet 7 of 9

Components / Parameters[1]	Nominal Value[2]
Design temperature	338°F
Design flow rate	0.595 lb_m/s
Temperature (inlet/outlet)	212/243°F
Number of Heating Elements	3
Material	Stainless steel
Evaporator Column	
Number	1
Design pressure	Full vacuum–88 psig
Design temperature	338°F
Design volume	4000 gal
Design sump volume	1300 gal
Material	Stainless steel
Vapor Compressor	
Number	1
Type	Horizontal rotary
Design pressure	88 psig
Design temperature	338°F
Material	Stainless steel
Decanter	
Number	1
Type	Horizontal bowl
Design pressure	5 psig
Design temperature	212°F
Design flow rate	3.08 lb_m/s
Material	Stainless steel
Separator	
Number	1
Type	Disk centrifuge with vertical rotation axis
Design pressure	5 psig
Design temperature	212°F
Design flow rate	3.08 lb_m/s
Material	Stainless steel

Table 11.2-2—Liquid Waste Management System Component Data
Sheet 8 of 9

Components / Parameters[1]	Nominal Value[2]
Vendor Supplied Demineralizer System[3,4]	
Demineralizer Booster Pump	
Number	1
Type	Centrifugal
Design Pressure	175 psig
Design Temperature	212°F
Design Flow Rate	40 gpm
Material	Stainless Steel
Pre-Filter	
Number	1
Type	Activated Carbon
Design Pressure	175 psig
Design Temperature	212°F
Design Flow Rate	40 gpm
Particle Size (micron)	500
Filter Housing Material	Stainless Steel
Ultra-Filter	
Number	1
Type	Poly
Design Pressure	175 psig
Design Temperature	212°F
Design Flow Rate	40 gpm
Particle Size (micron)	0.04 micron
Filter Housing Material	Stainless Steel
Demineralizer Resin Beds (Ion Exchange Columns)	
Number	5
Design Pressure	175 psig
Design Temperature	212°F
Design Flow Rate	40 gpm
Nominal Resin Volume (ft^3)	30
Resin Type	Anion and Cation
Vessel Material	Carbon Steel

Table 11.2-2—Liquid Waste Management System Component Data
Sheet 9 of 9

Components / Parameters[1]	Nominal Value[2]
Resin Trap	
Number	1
Design Pressure	175 psig
Design Temperature	212°F
Particle Size (inches)	0.007
Material	Stainless Steel
Solids Collection System	
Number	1
Design Pressure	175 psig
Design Temperature	212°F
Material	Stainless Steel
Spent Resin Dewatering System (HICs)	
Number	1
Type	8-120
Design Pressure	175 psig
Design Temperature	212°F
Nominal Volume (ft^3)	120
Chemical Addition System	
Number	1
Design Pressure	175 psig
Design Temperature	212°F
Material	Stainless Steel

Notes:

1. LWMS processing components are designed to meet or exceed the decontamination factors listed in Table 11.2-3.

2. Processing flow is a nominal value. Actual processing capacity will meet or exceed the listed operating parameters.

3. Typical components are shown for the vendor supplied demineralizer system.

4. The demineralizer subsystem will be designed to meet or exceed the descriptive parameters and decontamination factors listed in Table 11.2-3 in demonstrating compliance with 10 CFR Part 20, Appendix B effluent concentration limits and 10 CFR Part 50, Appendix I design objectives.

Table 11.2-3—Liquid and Gaseous Effluent Input Parameters for the GALE Computer Code
Sheet 1 of 3

GALE Input Parameter	Value
Thermal power level[2]	4612 MW_t
Mass of coolant in primary system (excluding the pressurizer)	5.937E+05 lb_m
Primary system letdown rate	226.7 gpm
Letdown cation demineralizer flow rate	0 gpm
Number of steam generators	4
Total steam flow[3]	2.171E+07 lb_m/hr
Mass of liquid in each steam generator	1.6977E+05 lb_m
SG blowdown rate[4]	2.184E+05 lb_m/hr
Blowdown treatment method (Full blowdown flow processed by blowdown system and recycled to condensate system.)	0
Condensate demineralizer regeneration time (regeneration not used)	0 days
Condensate demineralizer flow fraction	0.33
Shim bleed flow rate[5]	110 gpd
Shim bleed DF for iodine (Evaporator and demineralizer in series)	1.0E+04
Shim bleed DF for cesium and rubidium[8] (Evaporator and demineralizer in series)	1.0E+07
Shim bleed DF for other nuclides[8] (Evaporator and demineralizer in series)	1.0E+07
Shim bleed collection time	8.1 days
Shim bleed processing and discharge times	0.589 days
Shim bleed average fraction of waste to be discharged	1.0
Equipment drains input[6]	1728 gpd
Equipment drains PCA	1.0
Equipment drains DF for iodine (Evaporator and demineralizer in series)	1.0E+04
Equipment drains DF for cesium and rubidium (Evaporator and demineralizer in series)	1.0E+07
Equipment drains DF for other nuclides (Evaporator and demineralizer in series)	1.0E+07
Equipment drains collection time	8.1 days
Equipment drains processing and discharge times	0.589 days

Table 11.2-3—Liquid and Gaseous Effluent Input Parameters for the GALE Computer Code
Sheet 2 of 3

GALE Input Parameter	Value
Equipment drains average fraction of waste to be discharged	1.0
Clean waste input[7] (Clean waste input are included as Group II)	9428 gpd
Clean waste PCA	0.001
Clean waste DF for iodine	1.0E+02
Clean waste DF for cesium and rubidium	1.0E+02
Clean waste DF for other nuclides	1.0E+02
Clean waste collection time	1.6 days
Clean waste processing and discharge times	0.463 days
Clean waste average fraction of waste to be discharged	1.0
Dirty waste input	0 gpd
Dirty waste PCA	0.1
Dirty waste DF for iodine[1]	1.0E+02
Dirty waste DF for cesium and rubidium[1]	1.0E+03
Dirty waste DF for other nuclides[1]	1.0E+03
Dirty waste collection time	0 days
Dirty waste processing and discharge times	0 days
Dirty waste average fraction of waste to be discharged	1.0
Blowdown fraction processed	1.0
Blowdown DF for iodine	1.0E+02
Blowdown DF for cesium and rubidium	1.0E+02
Blowdown DF for other nuclides	1.0E+03
Blowdown collection time	0 days
Blowdown processing and discharge times	0 days
Blowdown average fraction of waste to be discharged	0.0
Regenerant flow rate	0.0 gpd
Regenerant DF for iodine	1.0
Regenerant DF for cesium and rubidium	1.0
Regenerant DF for other nuclides	1.0
Regenerant collection time	0.0 days
Regenerant processing and discharge times	0.0 days
Regenerant average fraction of waste to be discharged	0.0

Table 11.2-3—Liquid and Gaseous Effluent Input Parameters for the GALE Computer Code
Sheet 3 of 3

GALE Input Parameter	Value
Is there continuous stripping of full letdown flow?	No
Holdup time for xenon	27.7 days
Holdup time for krypton	1.67 days
Fill time of decay tanks for the gas stripper	0 days
Waste gas system particulate releases HEPA efficiency	99%
Fuel Handling Building releases: charcoal efficiency	90%
Fuel Handling Building releases: HEPA efficiency	99%
Auxiliary Building releases: charcoal efficiency	90%
Auxiliary Building releases: HEPA efficiency	99%
Containment free volume	2.8E+06 ft^3
Containment internal cleanup system: charcoal efficiency	90%
Containment internal cleanup system: HEPA efficiency	99%
Containment internal cleanup system: flow rate[9]	4.1E+03 cfm
Containment high volume purge: charcoal efficiency	90%
Containment high volume purge: HEPA efficiency	99%
Containment high volume purges at operation: purges per year (GALE code accounts for 2 purges at cold shutdown)	0
Containment low volume purge: charcoal efficiency	90%
Containment low volume purge: HEPA efficiency	99%
Containment low volume purge: Flow rate	3210 cfm
Percent of iodine released from blowdown tank vent	0.0%
Percent of iodine removed from air ejector release	0.0%
Detergent waste PF	0.0
SG blowdown flash tank gases vented via main condenser air ejector?	No
Condenser air ejector offgas released without treatment?	Yes
Condenser air ejector offgas processed via charcoal adsorbers prior to release?	No

Notes:

1. Dirty waste decontamination factor (DF) has no impact on results because dirty waste input is 0 gpd.

2. The GALE code built-in capacity factor of 80 percent is used in the calculation along with operating plant primary coolant concentration data that are over 30 years old when fuel failures were routinely experienced. The minimum capacity

factor for the U.S. EPR is assumed to be 92 percent consistent with current U.S. capacity factors indicative of significant reduction in the severity of fuel defects, resulting in lower fission product concentrations in the primary coolant. The GALE calculation scales the power level and further scaling the capacity factor results in artificially high release estimates.

3. Nominal value of steam flow was increased by 5 percent to bound potential increases in process flow.

4. Nominal value of steam generator blowdown flow was increased by 5 percent to bound potential increase in steam flow rate.

5. Shim bleed nominal flow is first increased by 5 percent for bounding a higher power level. The amount of treated primary coolant discharged as liquid waste is conservatively assumed to be 5 percent to account for recycling the effluent from the boron treatment system.

6. Equipment drain is based on the maximum technical specification leakage rate from the primary system of 1 gpm with 20 percent conservatism added.

7. Clean waste is based on maximum Group II waste water expected, only three or four times per year, which is 66,000 gallons per week.

8. DF values for Cs/Rb and for other nuclides are based on vendor data and represent the evaporator (DF = 1.0E+04) and demineralizer (DF = 1.0E+03) in series.

9. Containment internal clean-up nominal flow rate of 4120 cfm was decreased to 4100 cfm for conservatism.

Table 11.2-4—Releases to Liquid Effluent Discharge Point (Ci/yr) Calculated by GALE Code
Sheet 1 of 2

Nuclide	Shim Bleed	Misc. Wastes	Turbine Building	Total Unadjusted	Total as Adjusted[1]
Na-24	0.00E+00[2]	1.04E-03	1.00E-05	1.05E-03	6.10E-03
Cr-51	0.00E+00	1.80E-04	0.00E+00	1.80E-04	1.00E-03
Mn-54	0.00E+00	9.00E-05	0.00E+00	9.00E-05	5.40E-04
Fe-55	0.00E+00	7.00E-05	0.00E+00	7.00E-05	4.10E-04
Fe-59	0.00E+00	2.00E-05	0.00E+00	2.00E-05	1.00E-04
Co-58	0.00E+00	2.60E-04	0.00E+00	2.70E-04	1.50E-03
Co-60	0.00E+00	3.00E-05	0.00E+00	3.00E-05	1.80E-04
Zn-65	0.00E+00	3.00E-05	0.00E+00	3.00E-05	1.70E-04
Sr-89	0.00E+00	1.00E-05	0.00E+00	1.00E-05	5.00E-05
Sr-91	0.00E+00	1.00E-05	0.00E+00	1.00E-05	8.00E-05
Y-91m	0.00E+00	1.00E-05	0.00E+00	1.00E-05	5.00E-05
Y-93	0.00E+00	6.00E-05	0.00E+00	6.00E-05	3.60E-04
Zr-95	0.00E+00	2.00E-05	0.00E+00	2.00E-05	1.30E-04
Nb-95	0.00E+00	2.00E-05	0.00E+00	2.00E-05	1.00E-04
Mo-99	0.00E+00	3.00E-04	0.00E+00	3.00E-04	1.80E-03
Tc-99m	0.00E+00	2.90E-04	0.00E+00	2.90E-04	1.70E-03
Ru-103	0.00E+00	4.30E-04	0.00E+00	4.30E-04	2.50E-03
Rh-103m	0.00E+00	4.30E-04	0.00E+00	4.30E-04	2.50E-03
Ru-106	1.00E-05	5.18E-03	3.00E-05	5.22E-03	3.10E-02
Rh-106	1.00E-05	5.18E-03	3.00E-05	5.22E-03	3.10E-02
Ag-110m	0.00E+00	7.00E-05	0.00E+00	8.00E-05	4.40E-04
Ag-110	0.00E+00	1.00E-05	0.00E+00	1.00E-05	6.00E-05
Te-129m	0.00E+00	1.00E-05	0.00E+00	1.00E-05	6.00E-05
Te-129	0.00E+00	1.00E-05	0.00E+00	1.00E-05	4.00E-05
Te-131m	0.00E+00	5.00E-05	0.00E+00	5.00E-05	3.10E-04
Te-131	0.00E+00	1.00E-05	0.00E+00	1.00E-05	6.00E-05
Te-132	0.00E+00	8.00E-05	0.00E+00	8.00E-05	4.80E-04
I-131	3.41E-03	2.43E-03	2.00E-05	5.86E-03	3.40E-02
I-132	1.00E-05	1.60E-04	2.00E-05	2.00E-04	1.20E-03
I-133	1.85E-03	4.05E-03	7.00E-05	5.97E-03	3.50E-02
I-135	5.20E-04	1.94E-03	1.00E-04	2.56E-03	1.50E-02

Table 11.2-4—Releases to Liquid Effluent Discharge Point (Ci/yr) Calculated by GALE Code Sheet 2 of 2

Nuclide	Shim Bleed	Misc. Wastes	Turbine Building	Total Unadjusted	Total as Adjusted[1]
Cs-134	0.00E+00	4.50E-04	0.00E+00	4.50E-04	2.60E-03
Cs-136	0.00E+00	5.00E-05	0.00E+00	5.00E-05	3.10E-04
Cs-137	0.00E+00	6.00E-04	0.00E+00	6.00E-04	3.50E-03
Ba-137m	0.00E+00	5.60E-04	0.00E+00	5.60E-04	3.30E-03
Ba-140	0.00E+00	7.20E-04	0.00E+00	7.20E-04	4.20E-03
La-140	0.00E+00	1.30E-03	1.00E-05	1.31E-03	7.60E-03
Ce-141	0.00E+00	1.00E-05	0.00E+00	1.00E-05	5.00E-05
Ce-143	0.00E+00	1.00E-04	0.00E+00	1.00E-04	6.10E-04
Pr-143	0.00E+00	1.00E-05	0.00E+00	1.00E-05	5.00E-05
Ce-144	0.00E+00	2.20E-04	0.00E+00	2.30E-04	1.30E-03
Pr-144	0.00E+00	2.20E-04	0.00E+00	2.30E-04	1.30E-03
W-187	0.00E+00	8.00E-05	0.00E+00	8.00E-05	4.60E-04
Np-239	0.00E+00	1.00E-04	0.00E+00	1.00E-04	5.80E-04
Others	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-05
Total (except H-3)	5.82E-03	2.69E-02	3.30E-04	3.30E-02	1.90E-01
H-3					1.66E+03

Notes:

1. Total liquid releases adjusted by 0.16 Ci/year for AOOs per NUREG-0017 (Reference 1) and reported to the same number of significant figures as the GALE output corresponding to “Total.”

2. 0.00E+00 indicates that the value is less than 1.0E-05.

Table 11.2-5—Input Parameters for LADTAP II Computer Code

Parameter[1]	Value
Source Term	GALE (Table 11.2-4)
	(Total as Adjusted)
Shore-width factor	1.0
Discharge flow rate	100 cfs
Impoundment reconcentration model	None
Irrigation rate	50 liters/m^2-month
Dilution factor for aquatic food, boating, shoreline, swimming and drinking water	1
Dilution factor for irrigation water usage location	2
Site type	Freshwater
Exposure Pathway:	
• Transit time - aquatic food	24 hrs
• Transit time – boating	0
• Transit time – swimming	0
• Transit time – shoreline	0
• Transit time – drinking water	12 hrs
• Transit time – irrigated crops	0
• Transit time – milk/meat animal water usage	0
Fraction of crops irrigated using non-contaminated water	0
Fraction of milk/meat animal feed irrigated using non-contaminated water	0
Fraction of milk/meat animal drinking water from non-contaminated water	0

Notes:

1. All other values are LADTAP II default values. This includes the LADTAP II code parameter for the mid-point of reactor operation lifetime, which used the default value of 20 years even though the U.S. EPR is designed to operate for 60 years.

Table 11.2-6—Dose Commitment Due to Liquid Effluent Releases

Type of Dose	Calculated (mrem/yr)	10 CFR Part 50, Appendix I ALARA Design Objective (mrem/yr)
Total Body Dose	2.18 (child)	3
Organ Dose	4.83 (infant thyroid)	10

Table 11.2-7—Comparison of Annual Average Liquid Release Concentrations with 10 CFR Part 20 Concentration Limits
Sheet 1 of 2

Nuclide	Discharge Concentration (µCi/ml)		10 CFR Part 20, Appendix B Concentration Limit (µCi/ml)
	Normal Operation	Maximum Fuel Defect	
H-3	1.2E-04	4.6E-04	1.0E-03
Na-24	4.3E-10	5.5E-10	5.0E-05
Cr-51	7.0E-11	1.0E-10	5.0E-04
Mn-54	3.8E-11	5.3E-11	3.0E-05
Fe-55	2.9E-11	4.1E-11	1.0E-04
Fe-59	7.0E-12	9.9E-12	1.0E-05
Co-58	1.0E-10	1.5E-10	2.0E-05
Co-60	1.3E-11	1.8E-11	3.0E-06
Zn-65	1.2E-11	1.7E-11	5.0E-06
Sr-89	3.5E-12	1.4E-10	8.0E-06
Sr-91	5.6E-12	3.6E-11	2.0E-05
Y-91m	3.5E-12	1.4E-11	2.0E-03
Y-93	2.5E-11	2.5E-11	2.0E-05
Zr-95	9.1E-12	1.9E-11	2.0E-05
Nb-95	7.0E-12	2.1E-11	3.0E-05
Mo-99	1.3E-10	1.7E-08	2.0E-05
Tc-99m	1.2E-10	6.4E-09	1.0E-03
Ru-103	1.7E-10	1.7E-10	3.0E-05
Rh-103m	1.7E-10	1.7E-07	6.0E-03
Ru-106	2.2E-09	2.2E-09	3.0E-06
Ag-110m	3.1E-11	3.1E-11	6.0E-06
Te-129m	4.2E-12	2.9E-10	7.0E-06
Te-129	2.8E-12	2.8E-12	4.0E-04
Te-131m	2.2E-11	4.1E-10	8.0E-06
Te-131	4.2E-12	4.6E-12	8.0E-05
Te-132	3.3E-11	6.6E-09	9.0E-06
I-131	2.4E-09	8.5E-08	1.0E-06
I-132	8.4E-11	1.6E-10	1.0E-04

Table 11.2-7—Comparison of Annual Average Liquid Release Concentrations with 10 CFR Part 20 Concentration Limits
Sheet 2 of 2

Nuclide	Discharge Concentration (µCi/ml)		10 CFR Part 20, Appendix B Concentration Limit (µCi/ml)
	Normal Operation	Maximum Fuel Defect	
I-133	2.4E-09	4.0E-08	7.0E-06
I-135	1.0E-09	4.4E-09	3.0E-05
Cs-134	1.8E-10	3.6E-08	9.0E-07
Cs-136	2.2E-11	1.0E-08	6.0E-06
Cs-137	2.4E-10	2.3E-08	1.0E-06
Ba-140	2.9E-10	2.9E-10	8.0E-06
La-140	5.3E-10	5.3E-10	9.0E-06
Ce-141	3.5E-12	1.8E-11	3.0E-05
Ce-143	4.3E-11	4.3E-11	2.0E-05
Pr-143	3.5E-12	3.5E-09	2.0E-05
Ce-144	9.1E-11	9.1E-11	3.0E-06
Pr-144	9.1E-11	9.1E-08	6.0E-04
W-187	3.2E-11	4.2E-11	3.0E-05
Np-239	4.0E-11	1.3E-10	2.0E-05

Table 11.2-8—Unrestricted Area Water Concentration from Unmitigated Liquid Release

Nuclide[1]	Critical Receptor Concentration (μCi/ml)	10 CFR Part 20 Appendix B, Table 2 Effluent Concentration Limit (μCi/ml)	Fraction of Concentration Limit
H-3	4.8E-04	1.E-03	4.8E-01
Cs-134	5.6E-08	9.E-07	6.2E-02
Cs-137	4.2E-08	1.E-06	4.2E-02
		Total	**0.6**

Notes:

1. Nuclides less than 1.0E-03 in fraction of concentration limit are excluded.

Table 11.2-9—Deleted

Table 11.2-10—Deleted

Table 11.2-11—Deleted

Table 11.2-12—Liquid Waste Storage System Tank Level Indication, Alarms, and Overflows

Tank	Level Indication Location	Alarm Location	Alarm	Overflow To
Liquid Waste Storage Tank	MCR Local Control Panel	MCR Local Control Panel	High	(1) Primary – Redundant storage tank in series (2) Secondary – Room drains, which are pumped to waste storage tanks.
Monitoring Tank	MCR Local Control Panel	MCR Local Control Panel	High	(1) Primary – Redundant monitoring tank in series. (2) Secondary – Room drains, which are pumped to waste storage tanks.
Concentrate Tank	MCR Local Control Panel	MCR Local Control Panel	High	(1) Primary – Redundant concentrate tank in series. (2) Secondary – Room drains, which are pumped to waste storage tanks.

Table 11.2-13—Detailed Dose Commitment Results by Age Group and Organ due to Liquid Effluent Releases
Sheet 1 of 2

Pathway	Skin (mrem/yr)	Bone (mrem/yr)	Liver (mrem/yr)	Total Body (mrem/yr)	Thyroid (mrem/yr)	Kidney (mrem/yr)	Lung (mrem/yr)	GI-LLI (mrem/yr)
Fish								
Adult		2.10E-01	3.87E-01	2.90E-01	2.56E-01	1.46E-01	6.10E-02	6.74E-02
Teen		2.21E-01	3.92E-01	1.70E-01	2.37E-01	1.44E-01	6.35E-02	5.13E-02
Child		2.74E-01	3.42E-01	7.41E-02	2.45E-01	1.21E-01	5.07E-02	2.71E-02
Drinking								
Adult		6.61E-03	8.21E-01	8.18E-01	1.40E+00	8.20E-01	8.13E-01	8.68E-01
Teen		6.44E-03	5.80E-01	5.76E-01	1.08E+00	5.79E-01	5.73E-01	6.14E-01
Child		1.87E-02	1.12E+00	1.10E+00	2.35E+00	1.11E+00	1.10E+00	1.14E+00
Infant		2.20E-02	1.10E+00	1.08E+00	3.05E+00	1.09E+00	1.08E+00	1.10E+00
Shoreline								
Adult	1.75E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03
Teen	9.79E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03
Child	2.05E-03	1.75E-03	1.75E-03	1.75E-03	1.75E-03	1.75E-03	1.75E-03	1.75E-03
Irrigated Foods								
Vegetables								
Adult		6.99E-03	2.98E-01	2.96E-01	3.77E-01	2.94E-01	2.90E-01	3.56E-01
Teen		1.18E-02	3.69E-01	3.59E-01	4.84E-01	3.62E-01	3.55E-01	4.39E-01
Child		2.82E-02	5.86E-01	5.65E-01	8.19E-01	5.74E-01	5.62E-01	6.28E-01
Leafy Vegetables								
Adult		9.50E-04	3.69E-02	3.65E-02	6.96E-02	3.64E-02	3.57E-02	4.43E-02
Teen		8.69E-04	2.47E-02	2.40E-02	5.09E-02	2.43E-02	2.37E-02	2.96E-02
Child		1.56E-03	2.94E-02	2.84E-02	6.86E-02	2.89E-02	2.82E-02	3.16E-02

Table 11.2-13—Detailed Dose Commitment Results by Age Group and Organ due to Liquid Effluent Releases
Sheet 2 of 2

Pathway	Skin (mrem/yr)	Bone (mrem/yr)	Liver (mrem/yr)	Total Body (mrem/yr)	Thyroid (mrem/yr)	Kidney (mrem/yr)	Lung (mrem/yr)	GI-LLI (mrem/yr)
Milk								
Adult		5.36E-03	1.82E-01	1.79E-01	3.35E-01	1.76E-01	1.73E-01	1.74E-01
Teen		9.57E-03	2.40E-01	2.31E-01	4.82E-01	2.31E-01	2.26E-01	2.26E-01
Child		2.27E-02	3.82E-01	3.61E-01	8.65E-01	3.66E-01	3.58E-01	3.57E-01
Infant				5.45E-01	1.78E+00			
Meat								
Adult		1.11E-02	6.22E-02	6.33E-02	6.68E-02	8.18E-02	6.13E-02	7.39E-01
Teen		9.30E-03	3.73E-02	3.79E-02	4.05E-02	5.38E-02	3.66E-02	4.59E-01
Child		1.75E-02	4.52E-02	4.65E-02	5.03E-02	6.70E-02	4.43E-02	3.02E-01
Total								
Adult	1.75E-03	2.43E-01	1.79E+00	1.68E+00	2.51E+00	1.56E+00	1.44E+00	2.25E+00
Teen	9.79E-03	2.67E-01	1.65E+00	1.41E+00	2.38E+00	1.40E+00	1.29E+00	1.83E+00
Child	2.05E-03	3.64E-01	2.51E+00	2.18E+00	4.40E+00	2.27E+00	2.14E+00	2.49E+00
Infant				1.63E+00	4.83E+00			

Table 11.2-14—Parameters used in Liquid Tank Failure Evaluation
Sheet 1 of 2

Radionuclide	Half-life (days)	Partition Coefficient[1] (L/kg)	Activity Concentration in Reactor Coolant Storage Tank ($\mu Ci/cm^3$)
H-3	4510	N/A[2]	1
Cr-51	27.7	30	2.0E-03
Mn-54	313	50	1.0E-03
Mn-56	0.107	50	N/A
Fe-55	986	165	7.6E-04
Fe-59	44.5	165	1.9E-04
Co-58	70.8	60	2.9E-03
Co-60	1.93E+03	60	3.4E-04
Zn-65	244	200	3.2E-04
Br-84	2.21E-02	15	1.7E-02
Rb-88	1.24E-02	55	1.0E+00
Sr-89	5.05E+01	15	6.4E-04
Sr-90	1.06E+04	15	3.3E-05
Sr-91	3.96E-01	15	1.0E-03
Y-91	5.85E+01	170	8.1E-05
Y-92	1.48E-01	170	1.4E-04
Y-93	4.21E-01	170	6.5E-05
Y-91m	3.45E-02	170	5.2E-04
Zr-95	6.40E+01	600	9.3E-05
Nb-95	3.52E+01	160	9.4E-05
Mo-99	2.75E+00	10	1.1E-01
Tc-99m	2.51E-01	0.1	4.6E-02
Tc-99	7.78E+07	0.1	1.1E-09
Ru-103	3.93E+01	55	7.8E-05
Ru-106	3.68E+02	55	2.7E-05
Ag-110m	2.50E+02	90	2.0E-07
Te-129m	3.36E+01	125	1.5E-03
Te-129	4.83E-02	125	2.4E-03
Te-131	1.74E-02	125	2.6E-03

Table 11.2-14—Parameters used in Liquid Tank Failure Evaluation
Sheet 2 of 2

Radionuclide	Half-life (days)	Partition Coefficient[1] (L/kg)	Activity Concentration in Reactor Coolant Storage Tank (µCi/cm^3)
Te-131m	1.25E+00	125	3.7E-03
Te-132	3.26E+00	125	4.1E-02
I-129	5.73E+09	1	4.6E-08
I-131	8.04E+00	1	7.4E-01
I-132	9.58E-02	1	3.7E-01
I-133	8.67E-01	1	1.3E+00
I-134	3.65E-02	1	2.4E-01
I-135	2.75E-01	1	7.9E-01
Cs-134	7.53E+02	270	1.7E-01
Cs-136	1.31E+01	270	5.3E-02
Cs-137	1.10E+04	270	1.1E-01
Ba-140	1.27E+01	N/A[2]	6.2E-04
La-140	1.68E+00	N/A[2]	1.6E-04
Ce-141	3.25E+01	500	8.9E-05
Ce-143	1.38E+00	500	7.6E-05
Ce-144	2.84E+02	500	6.9E-05
W-187	9.96E-01	N/A[2]	1.8E-03
Np-239	2.36E+00	5	8.7E-04

Notes:

1. Partition coefficients taken from Reference 6
2. Partition coefficient not available for this radionuclide in Reference 6. A retardation factor of 1.0 was conservatively applied.

Next File