3.0 PLANT DESCRIPTION

A specific plant design has not been selected for construction at the GGNS ESP Site. Sections 3.1 and 3.2 present general information about a new facility. The remaining sections give basic descriptions of certain aspects of the conceptual plant proposed for the GGNS ESP Site that could have a potential environmental impact. The topics that are discussed include: Plant Water Use (Section 3.3); Cooling System (Section 3.4); Radioactive Waste Management (Section 3.5); Non-radioactive Waste Management (Section 3.6); Power Transmission System (Section 3.7); and Transportation of Radioactive Materials (Section 3.8). The evaluations of the potential environmental effects of the plant are based on bounding information from the Plant Parameters Envelope (PPE) presented in Table 3.0-1 through Table 3.0-8. A description of the development and intended use of the PPE is provided in Section 1.3 of the Site Safety Analysis Report, Part 2 of this Application for an Early Site Permit.

3.1 External Appearance and Plant Layout

3.1.1 Existing Grand Gulf Nuclear Station Description

The Grand Gulf Nuclear Station (GGNS), Unit 1 facility, is located approximately 7300 feet from the east bank of the Mississippi River (approximately river mile 406). The finished station grade is approximately 132.5 feet msl. Radial collector wells, located along the east bank of the Mississippi River and to the south of an existing barge slip, supply the makeup water requirements.

The original site arrangement was designed for two nuclear units and two turbine generator sets. The turbine bays are arranged sidelong. Construction of the second unit was halted prior to its completion; however, the majority of the Unit 2 power block buildings were completed, along with the outer cylindrical concrete wall of the reactor containment, which is only partially complete. Figure 2.1-1 shows the building layout and site property boundary.

A natural draft hyperbolic cooling tower for the completed unit is used for heat dissipation. The tower is approximately 404 feet in diameter at the base and 522 feet above grade elevation. The cooling tower is unpainted reinforced concrete. Subsequent to initial licensing of GGNS Unit 1, an auxiliary mechanical draft cooling tower was added to supplement the original natural draft cooling tower for GGNS Unit 1, located adjacent and to the west of the natural draft cooling tower (Figure 2.1-1).

The Energy Services Center (ESC) building, which accommodates design engineering and the training staff and facilities, is located on the edge of the bluffs to the west of the power block and other facilities.

The switchyard is located east of the power block at an elevation of approximately 161.5 feet msl.

A main access road connects the property with the county road system. A peripheral road serving the power station provides access to the switchyard. A road parallel to the river on the east side of the water supply wells, at existing grade, provides access to the wells. This road joins the heavy haul road that extends across the floodplain from the barge slip on the river to the plant.

Security fences surround the immediate station area. Visitor and employee parking is located outside this fenced area, with access to the plant through a security gate house that is controlled on a 24-hours per day basis.

There are no railroad spurs or active rail lines in the vicinity of the GGNS site. Rail lines and spurs used during construction of the existing plant have since been abandoned and/or removed.

The grounds in the immediate vicinity of the plant buildings are attractively landscaped.

3.1.2 New Facility Arrangement

A specific plant design has not been selected for construction at the GGNS ESP Site, therefore, no specific data is available for this section. Building structures and site arrangement would be designed and constructed in a manner which is aesthetically pleasing, and if possible, consistent with existing architecture at the site.

The proposed location for the power block of a new facility on the GGNS ESP Site is indicated in Figure 2.1-1 and the aerial photograph of Figure 2.1-2. Other potential construction areas for the new facility are also illustrated in these figures.

3.1.3 References

1. Grand Gulf Nuclear Station Updated Final Safety Analysis Report, UFSAR.

3.2 Reactor Power Conversion System

A specific design has not been selected for construction of a new facility at the GGNS ESP Site; therefore, no specific data is available for this section. For the purposes of this application and evaluation of the site for environmental impacts, a target of approximately 2000 MWe for the site was set (refer to Section 1.3 of the Site Safety Analysis Report for additional discussion in this regard).

Specific plant design characteristics would be described in the appropriate design documentation.

Design life for a new facility would be 60 years (Table 3.0-1), and initial operating life would be 40 years based on current regulations.

3.3 Plant Water Use

The detail designs of the water supply systems and the cooling water systems are not finalized at this point in the licensing process for a new facility at the GGNS ESP Site. Based on the location of the site and the available means for providing makeup and cooling water for a new facility, some general conclusions can be made with regards to the types of cooling and makeup water systems that could be used. This section provides some general discussion of these systems and their expected water use requirements. Design parameters given in Table 3.0-1 for cooling systems, and for makeup water needs for a new facility are used in this report to evaluate potential environmental impacts on the site and vicinity.

Raw water will be required to support the needs of a new facility during construction and operation, including the requirements of the normal heat sink main condenser (or gas compressor intercoolers and aftercoolers, depending on reactor design) circulating water system, cooling water systems for plant auxiliary components (e.g., the service water system), and possibly makeup for an Ultimate Heat Sink cooling system. The majority of raw water would be withdrawn from the Mississippi River via an intake structure located at the river shoreline (proposed location is adjacent to the existing barge slip for GGNS Unit 1). Other water sources such as wells may be used to supply water for general site purposes including potable, sanitary, air conditioning and landscape maintenance. Additionally, well water may be used for activities associated with the construction of the plant. Table 3.0-1 and Figure 2.3.29 provide the expected monthly/average and maximum raw water makeup for a new facility.

Section 3.3.1 discusses water consumption by the various cooling and other water use systems for a new facility, and discharges from these systems. Section 3.3.2 discusses possible methods of treatment of water used in the plant and discharged back to the receiving water body (i.e., the Mississippi River).

3.3.1 Water Consumption

3.3.1.1 Normal Plant Heat Sink

The Normal Plant Heat Sink (NHS) is used to remove the waste heat from the main condenser or main plant heat exchangers, depending on the reactor type selected. For those reactor types that use a gas, such as helium, as a reactor coolant and for driving the turbine-generator, the NHS provides cooling for the gas compressor intercooler and aftercooler heat exchangers. Makeup water to the NHS cooling tower(s) replenishes water losses due to evaporation, drift, and blowdown. A more detailed description of the circulating water system (NHS) is presented in Section 3.4, Cooling System. Table 3.0-1 lists the design parameters related to water use (makeup, blowdown, evaporation, etc.) by the NHS for a new facility. For the bounding plant evaluation, the expected average makeup water flow is 47,900 gpm for the NHS, and maximum NHS makeup water flow is 78,000 gpm.

Expected average blowdown from the NHS cooling tower(s) is 12,800 gpm, and maximum blowdown is given as 39,000 gpm in Table 3.0-1. This blowdown would be directed to an outfall that would discharge to the Mississippi River as shown in Figure 2.1-1.

3.3.1.2 Service Water System

For those plant designs that require it, a service water system (SWS) would be used to remove heat from balance of plant (BOP) auxiliary equipment. Service water cooling can be provided either by an open loop type system using once through cooling water from the Mississippi River, or a closed loop type system using heat exchangers, a cooling pond, a cooling tower(s), or a combination of these. A more detailed description of SWS operation is presented in Section 3.4, Cooling System.

For a once through open loop type cooling system, after its use in heat removal from the BOP equipment, the discharged SWS water would be routed to the NHS cooling tower(s) basin to supplement the makeup water requirements for the NHS cooling tower(s); any excess flow would be routed back to the Mississippi River. The maximum flow requirements for makeup water for the NHS cooling tower(s), 78,000 gpm, would bound the maximum flow requirements for a once through open loop type SWS (estimated to be less than half of the NHS requirements); therefore, the once through open loop type SWS would not require additional raw water usage above that required for the NHS.

For a closed loop type cooling system, the SWS cooling pond or tower(s) would require makeup water to replenish water losses due to evaporation, drift (in the case of cooling towers), and blowdown. Blowdown from the pond or cooling tower(s) would be routed to the NHS cooling tower(s) basin or mixed with the NHS cooling tower(s) blowdown. The flow requirements for makeup and blowdown flow for the closed loop type SWS would be negligible compared to the NHS cooling tower(s) makeup and blowdown requirements and are, therefore, considered bounded by the NHS cooling tower quantities discussed previously.

3.3.1.3 Ultimate Heat Sink

The Ultimate Heat Sink (UHS) supplies the cooling water to structures, systems and components important to safety, as necessary to safely shut down and cool down the plant under normal operations, anticipated operational occurrences and accident conditions. UHS cooling can be provided either by a closed loop type system using heat exchangers, a cooling pond, a cooling tower(s), or combination of these, or an open loop type system using once through cooling water flow. For a new facility on the GGNS ESP Site, the UHS is anticipated to be a closed loop type system with water reservoir and mechanical draft cooling tower(s). A more detailed description of the UHS and associated cooling tower operation is presented in Section 3.4, Cooling System. Makeup water to the UHS cooling tower(s) replenishes water losses due to evaporation, drift, and blowdown.

Table 3.0-1 lists the design parameters related to water consumption and discharge by the UHS. Expected average makeup water flow is 1,100 gpm for the UHS, and maximum UHS makeup water flow is 3,400 gpm. Average blowdown from UHS cooling tower(s) is expected to be 288 gpm, and maximum blowdown expected is 1,700 gpm. Blowdown would be directed to an outfall and discharged to the Mississippi River, combining with the NHS cooling tower blowdown before discharging to the river.

3.3.1.4 Potable Water

For the existing GGNS plant, construction activities required approximately 500,000 gpd (gallons per day) or 350 gpm of water for concrete batch plant operation, dust suppression, and sanitary needs. Wells constructed in the terrace deposits were used to supply these needs. Now, these wells are used to supply water for general site purposes including potable water, sanitary water, air conditioning systems makeup, and landscape maintenance. The wells are pumped intermittently to fill various storage tanks on site. The wells supply about 175,000 gallons per day (gpd) depending on seasonal requirements.

The bounding flow for the raw water supply, either from the river intake or from wells, to the potable water/ sanitary waste system for a new facility is expected to be 180 gpm monthly average, and 240 gpm maximum (Table 3.0-1).

The bounding flow for the discharge to the off site water body from potable and sanitary water systems is expected to be 120 gpm monthly average, and 210 gpm maximum (Table 3.0-1).

3.3.1.5 Demineralized Water System

The demineralized water system provides makeup water of reactor coolant quality (for those reactor types that uses light water as a coolant), and/or provides an adequate supply of treated water for other station operating requirements. The bounding flow for raw makeup water to the demineralized water system is expected to be 1,100 gpm monthly average, and 1,440 gpm maximum (Table 3.0-1).

The bounding flow for the treatment system waste discharge water from the demineralized water system to the off site water body is expected to be 220 gpm monthly, and 290 gpm maximum (Table 3.0-1).

3.3.1.6 Fire Protection System

The fire protection system provides water to points throughout the plant where wet system type fire suppression (e.g., sprinkler, deluge, etc.) may be required. For the fire protection system, the bounding flow for makeup from the raw water supply is expected to be 30 gpm monthly average, and 1,890 gpm maximum (Table 3.0-1).

3.3.2 Water Treatment

The actual designs of the water supply systems and the cooling water systems are not finalized at this point in the licensing process. Because of this, exact methods of water treatment and the quantities of chemicals required cannot be specified. The following descriptions are for those methods that may be utilized for a new facility; however, the final methods may differ.

3.3.2.1 Makeup Water System

A makeup water system would supply the required raw water for the circulating water system (Normal Plant Heat Sink - NHS), the SWS, the Ultimate Heat Sink (UHS), the demineralized water system, the fire protection system and other miscellaneous raw water supply needs. The source of raw water for a new facility is an intake on the Mississippi River. Clarifiers, or other filtration equipment, would remove suspended solids from the Mississippi River water. Clarified/filtered effluent would be then used as makeup to the various plant cooling systems. A polyelectrolyte (or similar additive) is expected to be utilized in the clarifiers to enhance flocculation and settling of suspended solids, as required. Waste sludge or solids from the treatment process would be disposed of according to current regulations in effect at the time of operation of the new facility.

3.3.2.2 Circulating Water System

Similar to that for the existing plant, two methods of circulating water system chemistry control are anticipated to be used to prevent biological fouling (e.g., accumulation of algae growth in the cooling tower(s) and the main condenser/heat exchangers). These anticipated methods are the addition of a non-oxidizing biocide and/or a hypochlorite solution. The final choice of methods or combination of methods will be dictated by makeup water conditions and economics.

A non-oxidizing biocide, if used, would be added to achieve a concentration at or below the allowable NPDES (environmental) discharge limits to prevent the interruption of circulating water blowdown flow. The circulating water blowdown flow would be controlled to maintain proper circulating water system conductivity and chemical content.

Hypochlorite solution may be used as another method of circulating water chemistry control. Discharge of free available chlorine to the river would be minimized by controlling the addition of hypochlorite solution so that the free available chlorine concentration in the cooling tower blowdown would not exceed NPDES Permit limits. Chlorine residuals would be monitored to determine the optimum chlorine residual to be maintained and to ensure NPDES Permit limits are not exceeded in the discharge. A surfactant-based bio-dispersant may also be used in conjunction with sodium hypochlorite.

Sulfuric acid (or similar additive) is expected to be used to control pH in the system.

A dispersant and/or a surfactant could be added to the circulating water system, as required, to prevent scaling and deposition of iron oxides and suspended solids in the NHS condenser tubes.

The methods and chemicals required for the control of the NHS water chemistry and prevention of long-term corrosion and biological fouling are not known at this time, but would be in accordance with applicable regulations and permits authorizing such treatment at a new facility on the GGNS ESP Site.

3.3.2.3 Service Water System

The water quality of the SWS would be controlled in order to minimize scaling, corrosion, and biological fouling. Methods similar to those used for the NHS may be utilized for this system, depending on the final design for the system. For a closed loop type cooling system, a portion of the SWS coolant may be blown down to the NHS cooling tower basin(s) or to the river to assist in controlling water chemistry and quality. For a once through type cooling system, the discharge from the SWS would be directed to the NHS cooling tower basin(s) to supplement makeup for the NHS cooling tower(s). Any blowdown will be in strict accordance with NPDES Discharge Permit limits and requirements.

3.3.2.4 Ultimate Heat Sink (UHS)

The UHS cooling tower(s) will be provided with chemical treatment that prevents biological fouling, scaling and system corrosion. A portion of the system coolant may be blown down to the river during normal plant operation (non-emergency), if required to assist in control of water quality.

3.3.3 References

1. Mississippi Power and Light Company, Grand Gulf Nuclear Station Units 1 and 2 Final Environmental Report (FER), as amended through Amendment No. 8.
2. Grand Gulf Nuclear Station Updated Final Safety Analysis Report, UFSAR.

3.4 Cooling System

The detail designs of the cooling water systems are not finalized at this point in the licensing process for a new facility at the GGNS ESP Site. Based on the location of the site and the available means for providing makeup and cooling water for a new facility, some general conclusions[1] can be made with regards to the types of cooling and makeup water systems that could be used. This section provides some general discussion of these systems. Design parameters given in Table 3.0-1 for cooling systems, and for makeup water needs for a new facility are used in this report to evaluate potential environmental impacts on the site and vicinity.

The new facility would have various cooling systems - they may include: a circulating water system (Normal Plant Heat Sink or NHS) for removing heat from the main condenser (or gas compressor intercoolers and aftercoolers, depending on reactor design), a service water system (SWS), for cooling balance of plant auxiliary components, and an Ultimate Heat Sink (UHS) which supplies the cooling water necessary to safely shutdown and cooldown the plant.

Section 3.4.1 gives a description of the various cooling water systems and the operational modes for a new facility, and Section 3.4.2 provides a description of the major components of the systems.

3.4.1 Description and Operational Modes

3.4.1.1 Circulating Water System (Normal Plant Heat Sink)

Heat (thermal energy) is a by-product of the generation of electricity. The primary heat dissipation system or NHS, an integral part of power generation, is designed to dissipate, or transfer, this energy to the environment.

The NHS will be comprised of a closed loop circulating water system, pumps, water basin and cooling tower(s). The cooling water in the circulating water system circulates through the main condenser or heat exchanger and then through the cooling tower(s) where the water is cooled.

The main condenser for each unit of a new facility would reject heat to the atmosphere at a rate of approximately 10.7×10^9 Btu/hr during normal full-power operation (Table 3.0-1). Water from the circulating water system (NHS) is pumped through the condenser and then to the cooling tower(s) where heat, transferred to the cooling water in the condenser, is dissipated to the environment (the atmosphere) by evaporation.

During the heat dissipation process, where some water is evaporated, an increase in the solids level in the NHS cooling tower(s) would result. To control solids levels or concentrations, a portion of the recirculated water must be removed, or blown down. In addition to the blowdown and evaporative losses, an small percentage of water in the form of droplets (drift) is lost from the cooling tower(s). Water pumped from the Mississippi River (Section 3.3) intake structure would be used to replace water lost by evaporation, drift and blowdown from the cooling tower(s). Blowdown water is returned to the Mississippi River via an outfall on the river shoreline (Section 5.3.2). A portion of the waste heat is thus dissipated to the Mississippi River through

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[1] Preliminary reviews of cooling water methods for the NHS eliminated a once-through cooling approach. While, as a matter of completeness, key parameters for the once-through cooling method are listed in the PPE (Table 3.0-1), the once-through cooling method was eliminated due to environmental impact considerations and is not discussed in this section.

the blowdown process. The bounding quantity of NHS cooling tower blowdown for a new facility is 39,000 gpm and blowdown water temperature at the point of discharge is expected to be 100 °F, or less (Table 3.0-1, Figure 2.3.29). The heat rejected to the Mississippi River via blowdown was estimated based on these maximum blowdown flow and temperature conditions (Section 5.3.2).

During other operating modes, heat dissipation to the environment would be less than the bounding values for the full-power operational mode for the NHS.

3.4.1.2 Service Water System

For those plant designs that require it, a SWS would be used to remove heat from balance of plant (BOP) auxiliary equipment. Service water cooling can be provided either by an open loop system using once through cooling water from the Mississippi River, or a closed loop system using heat exchangers, a cooling pond, a cooling tower(s), or a combination of these with only makeup from the Mississippi River. The SWS would reject approximately 83 x 10^6 Btu/hr per unit to the atmosphere during normal plant operation and approximately 296 x 10^6 But/hr per unit during plant cooldown.

A once through open loop type cooling system would be comprised of heat exchangers and a continuous water source, i.e., the Mississippi River water intake structure. Treated river water would be circulated through the BOP loads, where it would remove the dissipated heat, and then be discharged to the NHS cooling tower(s) basin to supplement the makeup water requirements for the NHS cooling tower(s); any excess flow would be routed back to the Mississippi River. The maximum flow requirements for makeup water for the NHS cooling tower(s), 78,000 gpm, would bound the maximum flow requirements for a once through open loop type SWS (estimated to be less than half of the NHS requirements), therefore, the once through open loop type SWS would not require additional raw water usage above that required for the NHS.

A closed loop type cooling system would be comprised of pumps, heat exchangers, a water basin and cooling tower(s) or a pond. The cooling water in a closed loop type SWS would be circulated through the BOP loads and then through the cooling tower(s) or pond. The SWS cooling tower(s) or pond would dissipate the heat from the BOP loads to the atmosphere primarily through evaporation of water. The evaporation would increase the concentration of chemicals and solids in the SWS, and periodic blowdown to the Mississippi River or NHS cooler tower basin(s) would be required to maintain the desired concentrations. The SWS cooling tower(s) or pond would require makeup water to replenish water losses due to evaporation, drift (in the case of cooling towers), and blowdown. The flow requirements for makeup and blowdown flow for a closed loop type SWS would be negligible compared to the NHS cooling tower(s) makeup and blowdown requirements and are, therefore, considered bounded by the NHS cooling tower quantities discussed previously.

3.4.1.3 Ultimate Heat Sink

The UHS supplies the cooling water to structures, systems and components important to safety, as necessary to safely shut down and cool down the plant under normal operations, anticipated operational occurrences and accident conditions. Some reactor designs do not require a dedicated safety related UHS; they may employ unique designs to accomplish this function, or don't require the function at all. The UHS would reject approximately 411.4 But/hr per unit to the atmosphere during plant cool down.

A closed-loop UHS for the new facility would be comprised of pumps, heat exchangers, dedicated water basin and cooling tower(s). Water from the UHS basin would be pumped through the associated equipment or heat exchangers and then to the UHS cooling tower(s) where heat, transferred to the cooling water in the equipment or heat exchangers, is dissipated to the atmosphere by evaporation. In addition, a very small volume of the cooling water is lost as drift from the cooling tower(s). This evaporation and drift increases the concentration of chemicals and solids in the UHS, and blowdown to the river, when the system is in normal (non-emergency) operation, would be used to maintain the concentration at the desired level. Blowdown flow from the UHS would be at a maximum of 1,700 gpm at a temperature of 95 °F (Table 3.0-1). Heat rejection to the river via blowdown from the UHS is based on these maximum blowdown parameters.

3.4.2 Component Descriptions

At this point in the licensing process, a plant type has not been selected for construction on the GGNS ESP Site. Therefore, details of the system and component designs are not final. Bounding design parameters which are evaluated, in this report, for environmental impact and suitability of the site, are given in Table 3.0-1.

3.4.2.1 Intake System

As discussed in Sections 3.3 and 3.4.1, the NHS would be a closed-loop system consisting of a circulating water system and cooling tower(s) and the SWS (for balance of plant loads) would be either a closed loop or open loop system. Makeup water to the cooling tower(s) and supply or makeup water for the SWS will be withdrawn directly from the Mississippi River through an intake structure on the river shore, at or near the existing GGNS barge slip location (Figures 2.2-1 and 5.3-1). Water would be withdrawn from an embayment via piping connected to pumps and equipment housed in an intake pumping station in the vicinity of the embayment (Figure 2.1-1).

The river water intake and makeup water system would be composed of three main parts: river intake screens and makeup water suction pipelines from the embayment, a dry pit pumphouse structure, and piping routed from the pumphouse structure to clarifiers or other filtration equipment at the plant site.

Dredging would be required to form the embayment. The embayment bottom would be at approximately elevation 15 ft msl. A typical embayment configuration and layout are shown in Figures 5.3-1 and 5.3-2; this arrangement is similar to the intake on the Mississippi River at the River Bend Station in St. Francisville, LA. The final embayment design and configuration, however, would be based on actual river conditions and final selected location.

Entrance to a pumphouse structure will be located at or above the Mississippi River Project Design Flood level to protect the equipment housed and allow access in high water conditions. Figure 5.3-2 shows an elevation view of the proposed intake, suction pipelines and intake screens. The embayment slopes would be covered by riprap, or other means, to minimize erosion by river currents and to protect the integrity of the embayment.

Screens would be mounted at the entrance to each suction pipeline to minimize uptake of aquatic biota and river debris. The intake screens would be sized so that the average intake through screen flow velocity would be less than approximately 0.5 fps as required by the Clean Water Act, Section 316(b) (Reference 2). The screens would provide an effective means of minimizing organism mortality from impingement and entrainment.

The embayment would be configured to minimize the amount and rate of sediment deposition and littoral debris carried into the embayment. The base of each intake screen would be at an elevation that would give sufficient separation to the embayment dredged bottom such that dredging due to sedimentation would not be required frequently (e.g., not more frequent than once per year).

A new facility would require a small amount of water withdrawal from the river relative to normal river flow. Based on the flows given in Table 3.4-1, the maximum makeup flow requirement is estimated at approximately 85,000 gpm, which is less than 0.2% of river flow at extreme low flow conditions (approximately 129,000 cfs [57.9 million gpm] per the GGNS FER Table 5.3.2, Reference 1). This maximum withdrawal flow is expected to bound that required for makeup to the NHS cooling tower(s), the SWS, the UHS cooling tower reservoir(s), demineralized water system, and fire protection. Additionally, raw water for the potable water system may be supplied from onsite wells; the flow requirement for potable water is expected to be less than 300 gpm.

3.4.2.2 Discharge System

An effluent (cooling tower(s) blowdown, excess service water return, etc.) discharge would be located downstream from the embayment and inlet screens to avoid recirculation of effluents into the river water intake. An outfall diffuser, located at the termination point of the discharge line, would be used to enhance distribution and cooling of the effluent, and to minimize thermal impacts to the river in the area of the discharge outfall. Dilution and dissipation of the discharge heat as well as other effluent constituents are affected by both the design of the discharge structure and the flow characteristics of the receiving water (river). For this evaluation it was assumed that the effluent discharge outfall would be located approximately 500 to 600 ft downstream of the intake screens, and at approximately 30 ft above the low water reference plane for the Mississippi River (Figure 2.3-21).

Normal plant effluent flow from all sources is estimated at approximately 14,000 gpm as shown on Figure 2.3.29, and maximum effluent flow is approximately 41,700 gpm from all sources. The NHS cooling tower(s) blowdown is the major contributor to the total flow, and its return temperature is estimated at 100 °F.

3.4.2.3 Heat Dissipation System

Heat dissipation from the NHS, SWS and UHS would occur through the use of cooling tower(s) and blowdown and/or discharge to the Mississippi River via an outfall diffuser as discussed above. Wet cooling towers were evaluated for the NHS, SWS, and UHS, as this type would have the highest potential operational impact to the environs, although wet/dry towers would be significantly larger in size. Additionally, once through cooling for the SWS was evaluated as a possible cooling alternative.

3.4.2.4 Normal Heat Sink (NHS)

The NHS cooling tower(s) were evaluated based on a location to the north of the proposed location of the new facility power block (Figure 2.3-1). Two different options for NHS cooling towers were evaluated for the new facility. The first consisted of four natural draft cooling towers (NDCTs) to provide normal heat sink cooling capability. The second utilized four 20-cell linear mechanical draft cooling towers (LMDCTs) for the same function. In both cases, the total heat rejected to the atmosphere is as defined in Table 3.0-1. Since final design is not known at this time, reasonable estimates were made for cooling tower dimensions, layout, and airflow rates for this evaluation. Maximum drift rate for cooling towers of these types, and average Mississippi

River water salt concentration were used to support deposition calculations. Refer to the Section 5.3.3 of this Environmental Report for additional details of the analysis..

The bounding quantity of blowdown for a new facility is provided in Section 3.3, and in Figure 2.3.29. Blowdown water temperature is expected to be 100 °F or less for the new facility, as indicated on Figure 2.3.29. The heat rejected to the Mississippi River via blowdown was estimated based on these maximum blowdown flow and temperature conditions (Section 5.3.2).

The main condenser for each unit of a new facility rejects heat to the atmosphere at a rate of approximately 10.7 x 10^9 Btu/hr during normal full-power operation (Table 3.0-1). Water from the circulating water system (NHS) is pumped through the condenser and then to the cooling tower(s) where heat, transferred to the cooling water in the condenser, is dissipated to the environment (the atmosphere) by evaporation.

3.4.2.5 Service Water System (SWS)

The SWS would reject approximately 83 x 10^6 Btu/hr per unit, or group of modules, to the atmosphere during normal operation, and approximately 296 x 10^6 Btu/hr per unit, or group of modules, during plant cooldown.

3.4.2.6 Ultimate Heat Sink (UHS)

The UHS would reject approximately 411.4 x 10^6 But/hr per unit to the atmosphere during plant cooldown.

Blowdown flow from the UHS would be at a maximum of 1,700 gpm at a temperature of 95 °F (Table 3.0-1). Heat rejection to the river via blowdown from the UHS is based on these maximum blowdown parameters.

3.4.3 References

1. Mississippi Power and Light Company, Grand Gulf Nuclear Station Units 1 and 2, Final Environmental Report (FER), as amended through Amendment No. 8.
2. Federal Register 40 CFR Parts 9, 122, et al. "Regulations Addressing Cooling Water Intake Structures for New Facilities".
3. Grand Gulf Nuclear Station Updated Final Safety Analysis Report, UFSAR.

3.5 Radioactive Waste Management System

3.5.1 Source Terms

Source terms from radiological effluents discharged during normal operations and anticipated operational occurrences are provided in PPE Tables 3.0-1, 3.0-3, 3.0-7 and 3.0-8, and represent bounding values for this GGNS ESP Site environmental impact assessment.

3.5.1.1 Introduction

In normal operation of reactors, fission neutrons may activate some non-radioactive materials normally present in the reactor coolant (for water cooled reactors) and trace metals such as iron, cobalt, and manganese may become activated. The resulting activated materials are called activation products. Small amounts of fission-activated products within the fuel may enter the coolant by diffusing through the fuel containment, or by escaping through fuel cladding leaks, if they occur. Thus, the reactor coolant normally carries materials with varying degrees of radioactivity.

3.5.1.2 Sources of Radioactivity in Liquid Effluents

The following sources are typically considered in calculating the release of radioactivity in liquid effluents from normal operations, including anticipated operational occurrences:

a. Processed liquid wastes from the equipment drain subsystems

b. Processed liquid wastes from the floor drain subsystems

c. Processed liquid wastes from the chemical waste subsystems

d. Processed liquid regenerant wastes

e. Detergent wastes

The bounding annual average activity released to the environment in liquid effluents from a new facility is estimated at 0.694 Ci/yr. In addition, there would be a total annual average release of 6,200 Ci/yr of tritium (in the form of tritium oxide) included with the bounding release activity. (Table 3.0-8)

3.5.1.3 Sources of Radioactivity in Gaseous Effluents

The following sources are typically considered in calculating the release of radioactive materials (noble gases, radioactive particulates, tritium, and iodine) in gaseous effluents from normal operations, including anticipated operational occurrences:

a. Main condenser offgas system (BWR plant)

b. Mechanical vacuum pumps (BWR plant)

c. Ventilation exhaust air from the various plant buildings with potentially contaminated ventilation systems

d. Waste gas processing and handling systems.

The bounding annual releases of radioactivity in gaseous effluents from a new facility is 32,699 Ci/yr from all sources (Table 3.0-1). The maximum annual average tritium gas release, included in the above number, is estimated at 7,060 Ci/yr.

3.5.1.4 Sources for the Solid Radwaste Processing System

Radioactivity inputs to the solid radwaste system are predominantly radioactive nuclides accumulated in filters, demineralizer resins, and waste evaporator bottoms. Additional radioactive inputs are from air filters, paper, rags, contaminated clothing, contaminated tools and equipment, and laboratory solid wastes.

Estimated quantities of solid wastes from all sources in terms of volume for a new facility 18,646 ft^3/yr, and total Curie content is 5,400 Ci/yr. The principal constituents in the solid radwaste contributing to the Curie content above are given in Table 3.0-3.

3.5.2 Liquid Radwaste Systems

Liquid radioactive wastes originate from minor leaks or drainage of equipment containing water contaminated with radioactivity. The liquid radwaste system collects, processes, and disposes of liquid radioactive wastes and collects and transfers to the solid radwaste system certain solid wastes that are produced during shutdown, startup, and normal plant operation.

Liquid radwaste system design will be such that water which is discharged to the environment shall result in radioactive releases which conform to the "as low as reasonably achievable" requirements of 10 CFR 50.34a.

3.5.3 Gaseous Radwaste System (Airborne Releases)

Radioactive waste products in the form of gases or airborne particles can be released to the environment by the ventilation systems or by other waste gas processing and handling systems.

Gaseous radwaste system design, including ventilation systems exhaust systems, will be such that radioactive gases which are discharged to the environment from these systems shall result in radioactive releases which conform to the "as low as reasonably achievable" requirements of 10 CFR 50.34a.

3.5.4 Solid Radwaste System

Certain amounts of radioactive materials are generated in solid form. The solid radwaste system collects, processes, packages, and stores these solid radioactive wastes for offsite shipment and permanent disposal.

3.5.5 Process and Effluent Monitoring

Radioactive material can leave the plant in liquid, gaseous and solid forms. Radiation monitoring instrumentation will be provided at radioactive liquid and gaseous effluent release points.

3.6 Non-Radioactive Waste Systems

The specific non-radioactive waste management systems design is not yet known. This section describes typical non-radioactive waste streams that would be expected at a new nuclear power facility, including cooling water and auxiliary boiler blowdown that may contain water-treatment chemicals or biocides, water-treatment wastes, floor and equipment drains, storm water runoff, laboratory waste, trash, hazardous waste, effluents from the sanitary sewer system, and miscellaneous gaseous, liquid, and solid effluents.

Information regarding estimates of the types and volumes of chemicals and biocides likely to be used at a new facility is based on the Plant Parameters Envelope (PPE) (Table 3.0-1), and from the chemical usage identified for the existing GGNS Unit 1 facility. It is expected as plant designs and processes are refined and as design options are narrowed to a specific design, chemical usage and effluent waste streams may change from that described in this section.

3.6.1 Effluents Containing Chemicals or Biocides

Chemicals are typically used to control water quality, scale, corrosion and biological fouling. Because the specific reactor plant design is not known, the exact effluent streams are difficult to anticipate. The chemical concentrations within effluent streams from a new facility would be controlled through engineering and operational/administrative controls in order to meet NPDES requirements at the time of construction and operation.

3.6.1.1 Cooling Tower Blowdown

The evaporation of water within the cooling tower(s) leads to an increase in chemical and solids concentrations in the circulating water, which in turn increases the scaling tendencies of the water. The circulating water system would be operated so that the concentration of solids in the circulating water would typically be approximately four times the concentration in the make-up water (i.e., four cycles of concentration). The concentration ratio would be sustained through the use of blowdown of the circulating water from the cooling system(s) to the Mississippi River. Cooling tower(s) makeup water would replenish water lost through blowdown and evaporation. The addition of an acid (e.g., sulfuric) would maintain the required pH and would control scaling.

The types of chemicals which would increase in concentration due to the recirculation of blowdown water may include, but are not limited to the following: chromium, copper, iron, zinc, phosphate, and sulfates. Estimated blowdown constituents and concentrations are provided in Table 3.0-2.

The makeup water would be withdrawn from the Mississippi River. This water may require pre-treatment prior to use in the plant. The treatment system could include sediment removal, consisting of sedimentation, flocculation, coagulation, and sludge removal. Waste solids from these treatment processes would be either dewatered and transported to an approved onsite or offsite landfill. Any liquid releases would be in compliance with an approved NPDES permit.

3.6.1.2 Cooling Tower Drift

The concentration of chemicals and solids in the cooling tower drift is expected to be the same as is in the circulating water.

3.6.1.3 Treatment of Circulating Water and Service Water Systems Against Biological Fouling

To minimize undesirable slime and algae growths in the circulating water and plant service water systems, a biocide, most likely a sodium hypochlorite solution, would be added intermittently. The dosage of biocide would be adjusted to keep residuals in the blowdown within permissible regulatory limits. The exact chemical formulation and estimated volumes of biocides required cannot be finalized at this time.

3.6.1.4 Demineralized Water Treatment

The demineralized water treatment systems would likely consist of activated carbon filters, layered bed demineralizers (including associated water storage), transfer equipment, and regeneration facilities.

An estimate for the maximum and average discharge flow rates for makeup water demineralizers is provided in Table 3.0-1. The design maximum waste water discharge from the process is anticipated to be 290 gpm, while the average discharge is anticipated to be 220 gpm. During demineralization, it is anticipated that chemicals like sulfuric acid and caustic soda would be utilized for regeneration of resins. The pH value of the wastes associated with this process would typically be adjusted to between 6 and 9 prior to discharge of the effluent.

3.6.2 Sanitary System Effluents

The purpose of this section is to identify anticipated volumes of sanitary effluent during the construction and operation of the proposed project, including the nature of sanitary effluents.

Sanitary systems installed during pre-construction and construction activities would likely include portable toilets supplied and serviced by a contracted vendor.

A permanent sanitary waste system would be provided for the operational phase of the proposed project. The system would be designed solely to treat domestic waste. Industrial materials, such as chemistry laboratory wastes, would be excluded from the sanitary waste system. The chosen sanitary waste system design would incorporate state of the art sewage treatment and disposal technologies and would comply with future NPDES permit requirements.

Effluent discharges are regulated under the provisions of the Clean Water Act and the conditions of discharge for the plant would be specified in the NPDES permit. Estimated discharge flow rate and raw water makeup requirements for the potable water/sanitary waste system are provided in Table 3.0-1.

3.6.3 Other Effluents

This section addresses miscellaneous gaseous, liquid, and solid effluents that are non-radioactive including gaseous releases from operation of auxiliary boilers, standby diesel generators, and gas turbines, the chemical waste treatment system, plant and mechanical drain systems, and storm drainage.

3.6.3.1 Gaseous Effluents

Non-radioactive gaseous effluents result from operating auxiliary boilers, and from testing and operating the standby power system which may be diesel and/or gas turbine generators. These effluents commonly include particulates, sulfur oxides, carbon monoxide, hydrocarbons and nitrogen oxides.

Yearly emissions from the auxiliary boilers are provided in Table 3.0-4. Yearly emissions from standby diesel generators are provided in Table 3.0-5. Yearly emissions from the gas turbines are provided in Table 3.0-6.

Gaseous effluent releases would comply with Federal, State, and local emissions standards.

3.6.3.2 Drainage Systems and Disposal of Miscellaneous Waste

The final design of building structures and drainage systems would accommodate oil and other chemical disposal for potential waste streams. Drainage systems would be routed to the appropriate treatment, collection, or discharge unit, so that quantities and concentrations of discharges and/or disposal of these wastes meets applicable Federal, State, and local regulations. The expected normal and maximum flow rates for miscellaneous drains are provided in the Table 3.0-1.

Non-hazardous trash would be collected and disposed of at offsite approved landfills in accordance with applicable Federal, State, and local regulations. Hazardous Wastes would be treated and disposed of in accordance with all applicable Federal, State, and local regulations.

3.6.3.3 Petroleum Storage, Collection, and Disposal

Standby power systems may include diesel engine and/or gas turbine driven generators. Fuel storage facilities and collection systems and volume estimates for stored fuel and for waste oil will be included in the final design for a new facility that may be constructed on the GGNS ESP Site as required.

3.6.3.4 Chemical Waste System

Chemical wastes from laboratory drains, equipment decontamination, and chemical additives would be collected in chemical waste sumps or approved chemical storage units.

Chemical drainage system wastes would be monitored, treated, and released in accordance with an approved NPDES permit, or otherwise disposed. Discharges from the chemical drainage system would comply with applicable Federal, State, and local standards in place during operation of a new facility.

3.6.3.5 Surface Drainage and Roof Drains

It is expected based on the current Storm Water Pollution Prevention Plan that storm water from structures constructed as part of a new facility would flow into major drainage courses and finally to Hamilton Lake which is linked to the Mississippi River.

The design of the storm water systems for a new facility would comply with relevant federal, state, and local storm water regulations. The Storm Water Pollution Prevention Plan would account for the project design chosen. Major changes to current drainage courses at the GGNS plant are not anticipated; however, any changes in drainage would be reviewed and approved by the Mississippi Department of Environmental Quality Office of Pollution Control, the regulatory agency that enforces storm water regulations at the GGNS site.

Other non-radioactive waste (i.e. paper, metals, garbage, and other non-radioactive waste) would be disposed in accordance with applicable regulations.

Non-radioactive effluents would be treated, controlled, and discharged or disposed as required to meet Federal, State, and local regulations and guidelines.

3.6.4 References

1. Mississippi Power and Light Company, Grand Gulf Nuclear Station Units 1 and 2, Final Environmental Report (FER), as amended through Amendment No. 8.

3.7 Power Transmission System

Currently GGNS Unit 1 is linked to load demand areas by a system of transmission lines in the Entergy Electric System. The Entergy Electric System grid system consists of interconnected hydro-plants, fossil fuel plants, and nuclear plants supplying electric energy over a 500/230/115 kV transmission system. Entergy Mississippi, Inc. owns the 52-acre GGNS Unit 1 plant switchyard area. System Energy Resources, Inc. (SERI), is a member of the Entergy Electric System. Other members are Entergy Mississippi, Inc., Entergy Arkansas, Inc., Entergy Louisiana, Inc., New Orleans Public Services, Inc. (NOPSI), and Entergy Gulf States. (Reference 2)

There are three transmission lines associated with GGNS: (1) the Baxter Wilson line, a 22-mile single-circuit 500 kV transmission line connecting GGNS to the Baxter Wilson EHV Substation near Vicksburg, Mississippi; (2) the Franklin line, a 43.6-mile single-circuit 500 kV transmission line connecting the GGNS switchyard to the Franklin EHV Substation; and, (3) the Port Gibson line, a 5.5-mile single-circuit 115 kV transmission line connecting the GGNS switchyard to the Port Gibson Substation. The electrical power generated by GGNS Unit 1 is transmitted by interconnection with 500 kV transmission facilities that were in existence when Unit 1 was constructed. (References 1 and 2)

The power transmission and distribution (T&D) system existing at the time of the new facility startup and operation will be relied upon to distribute the electricity generated by a new facility at Grand Gulf. In support of site selection evaluation work (Section 9.3), a sensitivity analysis of the T&D system was performed to assess transmission injection capability for the new potential electrical power generation at GGNS. This study concluded that the existing T&D system is adequate for at least an additional 1311 MWe of generating capacity, provided that certain modifications were accomplished. These modifications are expected to be equipment upgrades and changes in the GGNS switchyard, such that no additional environmental impact would result (for example, changes to circuit breakers located within already established switchyards). It is recognized that the potential new facility could have a capacity of 2000 MWe or higher (See SSAR Section 1.3.1.4 and ER Section 3.2.). Additional analysis would, therefore, be necessary to confirm whether, beyond the addition of 1311 MWe, any supporting system upgrades or changes would be required, and what the associated environmental impacts would be. This additional analysis was not pursued at ESP.

Not only are the reactor type, number of units, and generating capacity not established at ESP, but it is also difficult to accurately forecast the changes to the T&D system that may occur over the time period in question; i.e., during which a decision to proceed with construction of greater than 1311 MWe at Grand Gulf may occur, as a result of numerous factors unrelated to the ESP project. In addition, the need for power and location of the primary market(s) are important considerations in such an assessment of the T&D system. It is likely that such information would not be adequately defined until the decision process regarding final plant selection, design, and construction is begun. For these reasons, it was concluded that further assessment of T&D system adequacy (for new capacity beyond 1311 MWe) would involve considerable uncertainty and produce speculative results.

When the specific facility design, the expected electrical output, the need for power, and primary market location(s) are established, the adequacy of the existing (at that time) T&D system to support the new facility will be determined. If, at that time, additional changes to the T&D system were warranted, the associated environmental impacts would be evaluated.

3.7.1 References

1. Mississippi Power and Light Company, Grand Gulf Nuclear Station Units 1 and Final Environmental Report (FER), as amended through Amendment No. 8.

2. Grand Gulf Nuclear Station Updated Final Safety Analysis Report, UFSAR.

3.8 Transportation of Radioactive Materials

This section addresses the transportation issues associated with siting and operating a new reactor and is divided into two main sections. The first section addresses the light-water-cooled reactor (LWR) designs presently being considered. The second section addresses the gas-cooled reactor designs also being considered. This split addresses the regulatory distinction made in 10 CFR 51.52 for light-water-cooled reactors.

3.8.1 Light-Water-Cooled Reactors

As required by 10 CFR 51.52, every environmental report prepared for the construction permit stage of a light-water-cooled nuclear power reactor (LWR), and submitted on or after February 4, 1975, is to utilize Table S-4, “Environmental Impact of Transportation of Fuel and Waste To and From One Light-Water-Cooled Nuclear Power Reactor,” and shall contain a statement concerning transportation of fuel and radioactive wastes to and from the reactor.

Table S-4 (as provided in 10 CFR 51.52(c) and repeated herein as Table 3.8-3) is a summary impact statement concerning transportation of fuel and radioactive wastes to and from a reactor. The table is divided into two categories of environmental considerations: (1) normal conditions of transport and (2) accidents in transport. The normal conditions of transport consideration are further divided into environmental impact, exposed population, and range of doses to exposed individuals per reactor reference year. The "accidents in transport" consideration is concerned with environmental risk. Under "normal conditions of transport," the environmental impacts of the heat of the fuel cask in transit, weight, and traffic density are described. Also the number and range of radioactive doses to transportation workers and the general public are described. Under "accidents in transport," the environmental risk from radiological effects and common nonradiological causes such as fatal and nonfatal injuries and property damage are described.

To indicate that Table S-4 adequately describes the environmental effects of the transportation of fuel and waste to and from the reactor, the reactor licensee must state that the reactor and this transportation either meet all of the conditions in paragraph (a) of 10 CFR 51.52 or all of the conditions in paragraph (b) of 10 CFR 51.52. Subparagraphs 10 CFR 51.52(a)(1) through (5) delineate specific conditions the reactor must meet to use Table S-4 as part of its environmental report. Subparagraph 10 CFR 51.52(a)(6) states, "The environmental impacts of transportation of fuel and waste to and from the reactor, with respect to normal conditions of transport and possible accidents in transport, are as set forth in Summary Table S-4 in paragraph (c) of this section; and the values in the table represent the contribution of the transportation to the environmental costs of licensing the reactor." Paragraph 10 CFR 51.52(b) states that reactors not meeting the conditions of 10 CFR 51.52(a) shall make a full description and detailed analysis of the environmental impacts for their reactor.

The light water cooled reactor technologies being considered have characteristics that fall within the conditions of 10 CFR 51.52, for use of Table S-4, with one minor exception for two of the reactor designs, i.e., rated core thermal power level. The effect of this difference will be discussed later.

The light-water-cooled technologies considered include the ABWR (Advanced Boiling Water Reactor), the ESBWR (Economic Simplified Boiling Water Reactor), the AP-1000 (Advanced Passive PWR), the IRIS (International Reactor Innovative and Secure), and the ACR-700 (Advanced CANDU Reactor). The standard configuration for each of these reactor technologies is as follows. The ABWR is a single unit, 4,300 MWt[1], nominal 1,500 MWe reactor. The ESBWR is a similar BWR, single unit, 4,000 MWt, nominal 1,390 MWe. The AP-1000 pressurized-water reactor single unit specifications are, 3,400 MWt, nominal 1,117-1,150 MWe. The IRIS is a three-module pressurized-water reactor configuration for a total of 3,000 MWt and nominal 1,005 MWe. And the ACR-700 is a twin unit, 3,964 MWt, nominal 1,462 MWe, light-water-cooled reactor with a heavy-water moderator.

10 CFR 51.52 lists several conditions that need to be addressed by these reactor technologies. If all the conditions are satisfied by all of the reactor technologies, then the Table S-4 values are appropriate for use in the Early Site Permit. These conditions are reactor core thermal power; fuel form; fuel enrichment; fuel encapsulation; average fuel irradiation; time after discharge of irradiated fuel before shipment; mode of transport for unirradiated fuel; mode of transport for irradiated fuel; and mode of transport for radioactive waste other than irradiated fuel. There are two other conditions in S-4 that require that radioactive waste, with the exception of irradiated fuel, be packaged and in solid form. Table 3.8-1 was prepared to succinctly show the reference conditions along with the bounding values for the new reactor technologies. The information to complete the table was supplied by the reactor vendors.

10 CFR 51.52(a)(1) requires that the reactor have a core thermal power level not exceeding 3,800 megawatts. Of the considered LWR technologies, only the two boiling water reactors, the ABWR and the ESBWR, exceed this value. The ABWR has a core thermal power level of 4,300 megawatts thermal (MWt) while the ESBWR reactor power level is 4,000 MWt. The higher rated core power level would typically indicate the need for more fuel and therefore more fuel shipments. This is not the case in this instance due to the higher unit capacity and higher burnup for the reactors with the increased power level. The annual fuel loading for the reference reactor was 35 MTU while the annual fuel loading for both the ABWR and ESBWR is only 32.8 MTU. In fact, the annual MTU of fuel normalized to equivalent electrical generation is just slightly more than half of the reference LWR, 18.4 versus 35. This reduced annual MTU of fuel will mean fewer shipments and less environmental impact. Also, WASH-1238 states: “The analysis is based on shipments of fresh fuel to and irradiated fuel and solid waste from a boiling water reactor or a pressurized water reactor with design ratings of 3,000 to 5,000 megawatts thermal (MWt) or 1,000 to 1,500 megawatts electric (MWe).” Both the ABWR and the ESBWR fall within these bounds.

10 CFR 51.52(a)(2) requires that the reactor fuel be in the form of sintered uranium dioxide (UO_2) pellets. The LWR technologies being considered have a sintered UO_2 pellet fuel form.

10 CFR 51.52(a)(2) requires that the reactor fuel have a uranium-235 enrichment not exceeding 4% by weight. The NRC has subsequently concluded that enrichment up to 5% is also bounded by the environmental impacts considered in Table S-4. These evaluations are documented in the “NRC Assessment of the Environmental Effects of Transportation Resulting From Extended Fuel Enrichment and Irradiation” as provided in 53FR30555 and 53FR32322, and in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. The LWR technologies being considered meet this subsequent evaluation condition.

[1] This specification of thermal power of 4,300 MWt includes a consideration for approximately 10% power uprate from the design certified thermal power level of 3,926 MWt (and corresponding electrical output of 1,356 MWe).

10 CFR 51.52(a)(2) requires that the reactor fuel pellets be encapsulated in Zircaloy rods. 10 CFR 50.44 also allows use of ZIRLO™. License amendments approving the use of ZIRLO have repeatedly indicated that the use of ZIRLO rather than Zircaloy does not involve a significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. Based on this assessment, the LWR technologies being considered meet this subsequent evaluation condition.

10 CFR 51.52(a)(3) requires that the average burnup is not to exceed 33,000 megawatt-days per metric ton of uranium (MWd/MTU). The NRC has subsequently concluded that average burnup up to 62,000 MWd/MTU for the peak rod is also bounded by the environmental impacts considered in Table S-4. These evaluations are also documented in the “NRC Assessment of the Environmental Effects of Transportation Resulting From Extended Fuel Enrichment and Irradiation” as provided in 53FR30555 and 53FR32322, and in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. The LWR technologies being considered meet this subsequent evaluation condition.

10 CFR 51.52(a)(3) requires that no irradiated fuel assemblies be shipped until at least 90 days after it is discharged from the reactor. Table S-4 assumes 150 days of decay time prior to shipment of any irradiated fuel assemblies. For the LWR technologies being considered, five years is the minimum decay time expected before shipment of irradiated fuel assemblies. The five-year minimum time is supported additionally by two current practices. One is per contract with DOE, who has ultimate responsibility for the spent fuel. Five years is the minimum cooling time specified in 10 CFR 961, Appendix E. The other practice is the NRC specifies five years as the minimum cooling period when they issue certificates of compliance for casks used for shipment of power reactor fuel. (NUREG-1437, Addendum 1, pp 26) In all likelihood, the decay time will be at least ten years and probably even longer. In addition to the minimum fuel storage time, NUREG-1555 Environmental Standard Review Plan, Section 3.8 asks for the capacity of the onsite storage facilities to store irradiated fuel. The LWR technologies being considered are designing for on-site storage of spent fuel for up to 60 years through a combination of pool and dry storage.

10 CFR 51.52(a)(5) requires that unirradiated fuel be shipped to the reactor by truck. The LWR technologies being considered are planning to ship their unirradiated fuel by truck.

10 CFR 51.52(a)(5) allows for truck, rail, or barge transport of irradiated fuel. The LWR technologies being considered comply with the transport mode. Three of the reactor vendors identified rail as the shipment mode, two reactor vendors specified truck as the shipment mode, and the vendor for the ABWR and the ESBWR stated either rail or truck. Of note, the DOE is responsible for transport from reactor sites to the repository and DOE will make the decision on transport mode. NUREG-1555, Environmental Standard Review Plan, Section 3.8, also asks for the estimated transportation distance from the plant to the facility to which irradiated fuel will most likely to be sent. Recognizing the uncertainty in predicting the future destination of spent fuel in the United States, 2500 miles is utilized as a bounding distance at this time. This length bounds the approximate average distance from typical reactor sites to potential repository locations in the US.

10 CFR 51.52(a)(5) requires that the mode of transport of low-level radioactive waste is either truck or rail. The LWR technologies being considered plan to ship their radioactive waste by truck.

Finally, 10 CFR 51.52(a)(4) requires that with the exception of spent fuel, radioactive waste shipped from the reactor is to be packaged and in a solid form. The LWR technologies being considered will solidify and package their radioactive waste. Additionally, existing NRC (10 CFR 71) and DOT (49 CFR 173,178) packaging and transportation regulations specify requirements for the shipment of radioactive material. The LWR technologies being considered are also subject to these regulations.

In conclusion, since the LWR technologies being considered satisfy the basis 10 CFR 51.52(a) conditions for use of Table S-4, the environmental impacts of transportation of fuel and radioactive wastes are represented by the values given in 10 CFR 51.52(c), Table S-4. Thus, the radiological and nonradiological environmental impacts of transportation of fuel to and from, and waste from, an LWR are small.

3.8.2 Gas-Cooled Reactors

3.8.2.1 Introduction and Background

The following assessment of the environmental impacts of the transportation of fresh and spent fuel to and from, and low-level waste from, the reactor for gas-cooled reactor technologies is based on a comparison of the key parameters and conditions that were used to generate the impacts listed in 10 CFR 51.52(c), Table S-4. This comparison can then demonstrate that the environmental impacts of these gas-cooled reactor technologies are no worse than the impacts previously identified in Table S-4 for the light-water-cooled technologies. The premise being that if the values of the major contributors to the health and environmental impacts that were used for the reference LWR are greater than those comparable values for the gas-cooled reactor technologies, then the subsequent impacts would also be greater and therefore bounding. It is important to point out that even though we are looking at the contributors individually, it is the overall cumulative impact that is of concern. That is, for purposes of comparing/evaluating cumulative impacts, there may be increases in select individual contributors if offset by decreases in other contributors.

The parameters that have been chosen for purposes of comparison include not only the major contributors to the health and environmental impacts but also the conditions listed in 10 CFR 51.52. The major contributor to transportation risk is the number of shipments. Basically, the more shipments, the more risk; if there are no shipments, there is no risk. The Table S-4 shipments include fresh fuel for both initial core loading and reloads, irradiated fuel, and low-level waste (LLW) from operations. The second main contributor to the transportation risk would be the mode of shipment. In this case, only trucks and trains are considered. The last important risk factor relates to what kind of material is being shipped. In the category for irradiated fuel, we compared fission product inventory, krypton inventory, actinide inventory, total radioactivity, decay heat, and weight of shipment. For radioactive waste, we used the volume to determine the number of shipments. Radioactivity was also estimated to verify that the assumption about the percentage of LLW that might require shielding was reasonable.

The 10 CFR 51.52 conditions are: reactor core thermal power; fuel form; fuel enrichment; fuel encapsulation; average fuel irradiation; time after discharge of irradiated fuel before shipment; mode of transport for unirradiated fuel; mode of transport for irradiated fuel; and mode of transport for radioactive waste other than irradiated fuel. In addition, there are two other conditions that require that radioactive waste with the exception of irradiated fuel be packaged and in solid form. Since existing packaging and transportation regulations already address those items and these regulations would also apply to these new reactor technologies, no further discussion is needed for these two conditions.

Before proceeding with the evaluation, it is important to note that the NRC has an ongoing review of the safety of spent fuel transportation. One recent evaluation is NUREG/CR-6672, "Reexamination of Spent Fuel Shipment Risk Estimates," published in March 2000. The NRC in their document "An Updated View of Spent Fuel Transportation Risk," concluded that the NUREG/CR-6672 study confirmed that: 1) earlier risk estimates (NUREG-0170, "Final Environmental Statement on the Transport of Radioactive Materials by Air and Other Modes") to the public remain conservative by factors of 2 to 10 or more; 2) existing regulations governing the shipment of spent fuel are adequate; and 3) no unreasonable risk is posed to the public by the continued shipment of spent fuel. The range of conservative risk factors covers differences in mode of transport (rail or truck) and either accident or accident-free scenarios.

These same NRC conclusions support the position that environmental assessments of the transport casks do not have to be done for the Part 71 cask certifications because they meet the categorical exclusion criteria in 10 CFR 51.22(c)(13) that package designs used for the transportation of licensed materials do not require an environmental review. As discussed in 10 CFR 51.22(a), the NRC has determined that certain categories of licensing and regulatory actions have already been determined individually or cumulatively to not have a significant effect on the human environment; thus, a separate environmental assessment is not required. As mentioned in the previous paragraph, a generic assessment of the environmental effects associated with transportation of radioactive material, including spent fuel, has already been done as provided in NUREG-0170, "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes," dated December 1977. This environmental impact statement (EIS) provided the regulatory basis for continued issuance of general licenses for transportation of radioactive material under 10 CFR 71. In addition, the NRC has conducted a reexamination of the risks associated with spent fuel shipments as documented in NUREG/CR-6672. This reexamination concluded that the estimated risks for future shipments are well below those in the 1977 study. Thus, NUREG-0170 remains valid as the baseline report on which National Environmental Policy Act (NEPA) analyses of transportation risk are based.

Table 3.8-2 captures the major features of the reference LWR that were used to develop Table S-4 and compares these same features with the gas-cooled reactor technologies being considered. The reference LWR pertains to the typical 1100 MWe light-water-cooled nuclear reactor as described in WASH-1238. The information to construct the worksheet was taken from the "Normal Conditions of Transport" portion of the 10 CFR 51.52 Summary Table S-4 "Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor," WASH-1238 "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants" and Supplement 1 to WASH-1238 (NUREG-75/038) for the reference LWR. The information for the reactor technologies was provided by the reactor vendors.

3.8.2.2 Analysis

This section provides a detailed description of the comparison of the individual characteristics supporting Table S-4 against the corresponding parameters for the gas-cooled reactor technologies. The value for the reference reactor is given along with the corresponding values or range of values for the gas-cooled reactor technologies. As appropriate, additional information and/or observations are provided. Table 3.8-2 provides additional details regarding the reactor technology specific values.

There are two gas-cooled reactor technologies presently being considered. These gas-cooled reactor technologies are the GT-MHR (Gas Turbine-Modular Helium Reactor), and the PBMR

(Pebble Bed Modular Reactor). The standard configuration for each of these reactor technologies is as follows. The GT-MHR is a four module, 2,400 MWt, nominal 1,140 MWe gas-cooled reactor. The PBMR is an eight module, 3,200 MWt, nominal 1,320 MWe gas-cooled reactor. The unit capacities for these reactors are as follows: 88% for the GT-MHR; 95% for the PBMR. These values are contrasted with the reference LWR, a single unit, 1,100 MWe plant with a unit capacity factor of 80%.

Before beginning direct comparisons, it is important to note that the plants being considered are a different physical size, have a different electrical rating, and have a different capacity factor from the reference LWR. In order to make proper comparisons, we need to evaluate the characteristics based on equivalent criteria. In this case, electrical generation is the metric of choice. Electrical generation is why the plants are being built, and we want to know if these new reactor technologies, for the same electrical output, have a greater or lesser impact on the health and environment. The reference LWR is a nominal 1,100 MWe plant with a capacity factor of 80%. Based on this, the reactor technologies should be normalized to 880 MWe using their plant specific electrical rating and capacity factor. For many of the characteristics being examined, this adjustment is not necessary. But in a few cases, specifically those dealing with the number of shipments of fuel and waste, an adjustment is appropriate. The amount of this adjustment ranges from minus 12% for the GT-MHR to minus 30% for the PBMR.

3.8.2.2.1 Table S-4 Conditions

As discussed previously, Table S-4 lists several conditions that need to be addressed by the new reactor technologies. These conditions are reactor core thermal power; fuel form; fuel enrichment; fuel encapsulation; average fuel irradiation; time after discharge of irradiated fuel before shipment; mode of transport for unirradiated fuel; mode of transport for irradiated fuel; and mode of transport for radioactive waste other than irradiated fuel. Two other conditions in S-4 require that radioactive waste, with the exception of irradiated fuel, be packaged and in solid form.

10 CFR 51.52(a)(2) requires that the reactor have a core thermal power level not exceeding 3800 MWt. The gas-cooled reactors being considered meet this condition. The GT-MHR has a core thermal power level of 600 MWt per module. The PBMR has a core thermal power level of 400 MWt per module.

10 CFR 51.52(a)(2) requires that the reactor fuel be in the form of sintered UO_2 pellets. The fuel forms for the gas-cooled reactors being considered are blocks of TRISO coated uranium oxycarbide fuel kernels for the GT-MHR and spheres of TRISO coated uranium dioxide fuel kernels for the PBMR.

10 CFR 51.52(a)(2) requires that the reactor fuel have a uranium-235 enrichment not exceeding 4% by weight. The NRC has subsequently concluded that enrichment up to 5% is also bounded by the environmental impacts considered in Table S-4. These evaluations are documented in the “NRC Assessment of the Environmental Effects of Transportation Resulting From Extended Fuel Enrichment and Irradiation” as provided in 53FR30555 and 53FR32322, and in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. The PBMR has an equilibrium enrichment of 12.9% while the GT-MHR fissile particle enrichment is 19.8%.

10 CFR 51.52(a)(2) requires that the reactor fuel pellets be encapsulated in Zircaloy rods. 10 CFR 50.44 also allows use of ZIRLO™. License amendments approving the use of ZIRLO have repeatedly indicated that the use of ZIRLO rather than Zircaloy does not involve a significant

increase in the amounts and no significant change in the types of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. However, the gas-cooled reactors being considered have a different configuration. The fuel kernels are coated with layers of pyrolytic carbon and silicone carbide. These coatings are considered the equivalent of the fuel cladding. For the GT-MHR these TRISO fuel particles are blended and bonded together with a carbonaceous binder. These are stacked within a graphite block. For the PBMR, the fuel unit is a 6 cm diameter graphite sphere containing approximately 15000 TRISO fuel particles.

10 CFR 51.52(a)(3) requires that the average burnup is not to exceed 33,000 MWd/MTU. The NRC has subsequently concluded that average burnup up to 62,000 MWd/MTU is also bounded by the environmental impacts considered in Table S-4. These evaluations are documented in the "NRC Assessment of the Environmental Effects of Transportation Resulting From Extended Fuel Enrichment and Irradiation" as provided in 53FR30555 and 53FR32322, and in NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. The gas-cooled reactors have an expected burnup of 133,000 MWd/MTU for the PBMR and 112,742 MWd/MTU for the GT-MHR.

10 CFR 51.52(a)(3) requires that no irradiated fuel assemblies be shipped until at least 90 days after it is discharged from the reactor. Table S-4 assumes 150 days of decay time prior to shipment of any irradiated fuel assemblies with a condition of not less than 90 days. For the gas-cooled reactor technologies being considered, five years is the minimum decay time prior to shipment of irradiated fuel assemblies. This is per contract with DOE, who has ultimate responsibility for the spent fuel. In all likelihood, the decay time will be at least ten years and probably even longer. The gas-cooled reactor technologies being considered are designing for on-site storage of spent fuel for up to 60 years including potential modular storage expansions.

10 CFR 51.52(a)(5) requires that the unirradiated fuel be shipped to the reactor by truck. The gas-cooled reactor technologies being considered are planning to ship their unirradiated fuel by truck.

10 CFR 51.52(a)(5) allows for truck, rail, or barge transport of irradiated fuel. The gas-cooled reactor technologies being considered plan to allow for irradiated fuel shipment by truck. However, the actual mode of shipment will be determined by DOE and may include either rail or truck shipments.

10 CFR 51.52(a)(5) requires that the mode of transport of low-level radioactive waste is either truck or rail. The gas-cooled reactor technologies being considered plan to ship their radioactive waste by truck.

Finally, 10 CFR 51.52(a)(4) requires that that, with the exception of spent fuel, radioactive waste shipped from the reactor is to be packaged and in a solid form. The gas-cooled technologies being considered will solidify and package their radioactive waste. Additionally, existing NRC (10 CFR 71) and DOT (49 CFR 173,178) packaging and transportation regulations specify requirements for the shipment of radioactive material. The gas-cooled technologies being considered are also subject to these regulations.

In summary, the descriptions provided above indicate that the criteria of 10 CFR 51.52(a) are met with the exceptions of fuel form, cladding configuration, enrichment, and burnup. 10 CFR 51.52(b) states that reactors not meeting the conditions of 10 CFR 51.52(a) shall make a full description and detailed analysis of the environmental impacts for their reactor. As previously indicated, the risk to the environment associated with the transportation of fuel is a function of the number of shipments and the contents of the shipments. Thus, a detailed analysis of these risk contributors is provided discussed in the following sections.

3.8.2.2.2 Risk Contributors – Shipments

This section discusses the type and number of shipments for the gas-cooled reactor technologies and the values used for the reference LWR.

The reference LWR assumed an initial core loading of 100 MTU for a PWR and 150 MTU for a BWR. These quantities resulted in 18 truck shipments. For the new gas-cooled reactor technologies, the numbers of shipments were 44 for the PBMR and 51 for the GT-MHR. If normalized to the equivalent electrical output, the number of shipments would be 31 and 45 respectively.

The reference LWR assumed an annual reload of 30 MTU. This quantity resulted in 6 truck shipments. For the new gas-cooled reactor technologies, the numbers of reload shipments ranged from 3 for the PBMR to 20 for the GT-MHR. The number of shipments normalized to the electrical generation changes slightly to 18 for the GT-MHR.

With respect to the number of spent fuel shipments by truck, the reference LWR assumed 60 shipments annually. For the two gas-cooled reactor technologies, the number of shipments is considerably less. The PBMR requires 16 annual shipments while the GT-MHR requires 38 truck shipments annually. Normalizing to the electrical generation lowers these numbers to 12 to 34, respectively.

The reference LWR assumed 10 rail shipments annually of spent fuel. Since the gas-cooled reactor technologies are not planning to ship their spent fuel by rail, no comparison is needed. However, based on the comparison for truck shipments, fewer than 10 rail shipments annually would be expected if DOE decided to use larger and higher capacity rail transport casks for gas-reactor spent fuel.

The reference LWR also considered transporting spent fuel by barge and assumed 5 shipments annually. Since the gas-cooled reactor technologies are not planning to ship their spent fuel by barge, no comparison is needed.

The reference LWR assumes 46 shipments annually of low-level radioactive waste. The gas-cooled reactor technologies will make far fewer shipments. The GT-MHR will need only 6 shipments while the PBMR will require 9 shipments annually. These results assume that 90% of the LLW can be shipped at 1000 ft^3 per truck, and the remaining 10% can be shipped at 200 ft^3 per truck. If the numbers are normalized to electrical generation, the numbers of shipments range from 6 to 7.

The Table S-4 value, traffic density in trucks per day, for the reference LWR is given as less than one per day. Both the gas-cooled reactor technologies would also have less than one per day. In fact, the new gas-cooled reactor technologies would have far fewer shipments per year. The reference LWR bounding annual value for truck shipments is 110 based on a 40 year period, while the normalized number of truck shipments for the gas-cooled reactor technologies would require as few as 18 for the PBMR and only 41 for the GT-MHR.

The rail density in cars per month for the reference LWR is given as less than 3 per month. Since the gas-cooled reactor technologies are not planning to make any shipments by rail, no comparison is needed. However, as noted above, if DOE decided to use rail transport for spent fuel instead of truck, fewer than 3 shipments per month would be expected based on the expected larger capacity of rail spent fuel casks compared to truck casks.

3.8.2.2.3 Risk Contributors - Contents

This section addresses the radioactive contents of the shipments and their thermal loading and compares them to the reference LWR. The radioactive and decay heat values are based on the earliest time of shipment. For the gas-cooled reactor technologies, the five-year time was selected because it is the current minimum allowed time before shipment per DOE contract. These values are compared with the reference LWR that used a 90-day decay time. Ninety days was the minimum allowed time before shipment for Table S-4. Since we are evaluating the transportation impacts, it is the inventory and associated decay heat at the time of shipment that is of interest, not the inventory and decay heat at any other particular time.

The fission product inventory at the time of shipment for the reference LWR was 6.19 x 10^6 Curies (Ci) per MTU. The values for the fission product inventory at the time of shipment for the gas-cooled reactor technologies were both much lower, from 3.5 to 4 times lower.

The actinide inventory at the time of shipment in Ci per MTU for the reference LWR was 1.42 x 10^5. Because of the longer burnup times for the new gas-cooled new reactor technologies, both of these reactor technologies have values that exceed the reference LWR. The GT-MHR and the PBMR, exceed the reference LWR by ~64% and ~59%, respectively. This comparison changes significantly for the GT-MHR if one considers the Ci per shipment, which is really what is of concern. The reference LWR ships 0.5 MTU per truck cask while the GT-MHR ships about a third less 0.16044 MTU per truck cask. Based on this comparison, the actinide inventory per shipment is about half (53%) for the GT-MHR versus the reference LWR. Since the PBMR plans to ship 0.495 MTU per cask, there is essentially no difference from the comparison per MTU.

The total radioactive inventory in Ci per MTU at the time of shipment for the reference LWR was 6.33 x 10^6. The new gas-cooled reactor technologies have much lower total radioactivity at time of shipment. The differences are from 3 to almost 4 times lower.

The krypton-85 inventory in Ci per MTU at the time of shipment for the reference LWR was 1.13 x 10^4. Both the GT-MHR and the PBMR exceed the reference LWR by about a factor of 2.3. As before, if one considers the Ci per shipment, the Kr-85 inventory for the GT-MHR would be about 71% of the Kr-85 reference LWR inventory. The PBMR comparison remains essentially the same.

The kilowatts per MTU at the time of shipment for the reference LWR were 27.1. This value is considerably higher than for the gas-cooled reactor technologies. At the time of shipment, the decay heat for the gas-cooled reactor technologies being considered ranges from 6.36 kilowatts per MTU for the GT-MHR to 3.91 kilowatts per MTU for the PBMR.

The decay heat (per irradiated fuel truck cask in transit) in kilowatts for the reference LWR was 10. Both the gas-cooled reactor truck casks generate much less heat (5 to 10 times lower) per truck cask than the reference LWR.

The decay heat (per irradiated fuel rail cask in transit) in kilowatts for the reference LWR was 70. Since the gas-cooled reactor technologies are not planning to ship their spent fuel by rail, no comparison is needed. However, should DOE elect to transport by rail, the expected decay heat would be less than 70 based on the comparison for truck shipment.

At the time of the reference LWR evaluation, the road limit was 73,000 lbs. This has changed slightly through the years. 23 CFR 658.17 “Weight” states that for the Interstate and Defense Highways the maximum gross vehicle weight shall be 80,000 pounds. In all cases for the gas-cooled reactor technologies, the road limit is governed by state and federal regulations.

3.8.2.3 Discussion

Of the close to 30 characteristics/conditions that were examined, there are only 8 that were exceeded by the gas-cooled reactor technologies being considered. Three of these characteristics have no direct transportation impact on the health and the environment: fuel form, U_{235} enrichment, and fuel rod cladding. There are operational issues and fuel cycle impact issues associated with these characteristics that are addressed as part of the operating license and as part of the evaluation of Table S-3 "Uranium Fuel Cycle Data," respectively. Two of these characteristics (number of shipments for initial core loading and number of reload shipments) are really a part of the overall truck transportation picture. When one considers the total number of truck shipments (fresh fuel, spent fuel, and radioactive waste), the new reactor technologies have many fewer total shipments. For example, on an average annual basis, the new reactor technologies require 69 to 105 fewer truck shipments. Comparing the total number of shipments is appropriate since the radiological impacts from fresh fuel are negligible. One characteristic, burnup, manifests its impact through other characteristics, fuel inventory and decay heat at time of shipment, which are addressed separately. In the case of decay heat, both of the gas-cooled reactor technologies will generate fewer watts per MTU at time of shipment, and fewer kW per truck cask at time of shipment. The fuel inventory will be discussed as part of the remaining two characteristics that were exceeded: actinide inventory and krypton-85 inventory.

That the actinide inventory per metric ton of spent fuel is greater for the majority of the new gas-cooled reactor technologies is not surprising, since actinide activity tends to increase with increasing burnup and both of the gas-cooled reactor technologies plan a higher burnup than the reference LWR. The increase in the actinide activity for the new reactor technologies ranges from 59% to 65%. And as discussed in the previous section, if one considers the actinide inventory per shipment, only the PBMR exceeds the reference LWR by 59%. From NUREG/CR-6703 "Environmental Effects of Extending Fuel Burnup Above 60 GWd/MTU," we learn that "none of the actinides contributes more than one percent of the external dose from an iron transportation cask, and as a group, the actinides do not contribute significantly to the dose from transportation accidents. In fact, increasing the activities of Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-242 and Cm-244 by more than a factor of 1000 only increased the cumulative dose for a transportation accident during shipment of 43 GWd/MTU spent fuel from the northeast to Clark County, NV from 0.0358 to 0.0359 person-mSv/shipment (3.58×10^{-3} to 3.59×10^{-3} person-rem/shipment)." There is one other area where the increased actinide activity needs to be considered and that is the corresponding increase in neutron source term. NUREG/CR-6703 states "because neutrons are effectively attenuated by low-density materials such as plastics and water, it is believed that minor modifications can be made to shipping casks to allow them to transport the higher burnup fuel at full load."

Based on the analysis performed and the conclusions drawn in NUREG/CR-6703 which show that actinides are not major contributors to the transportation risk, either incident free or accident, and with the actinide activity only 59% greater, the environmental impacts would still be bounded even for these higher burnups.

This leaves the Kr-85 inventory as the final characteristic to be addressed. The increase of Kr-85, a long-lived noble gas, would suggest an increase of the consequences associated with an accident that resulted in a breach of the fuel cask and fuel rods. The range of increase for the gas-cooled technologies being considered is from 121% to 133%. And as discussed in the previous section, if one considers the Kr-85 inventory per shipment, only the PBMR exceeds the reference LWR. These amounts are based on a 5-year cooling time. If this decay time were increased by about 11 years, slightly greater than the half-life of Kr-85 (10.6 years), not an unlikely scenario by the way, this increase would for the most part decay away. Another factor to consider is that transportation risk is a function of both consequences and likelihood. Because the new reactor technologies require fewer truck shipments, the likelihood would decrease approximately 37% for the reactor with the greatest Kr-85 inventory. Another factor to consider is that the accident rate for large trucks has steadily declined for more than the past 25 years and is less than half the rate in 1975. Thus, the likelihood has decreased to about 37% (0.63 x 0.5) of the 1975 likelihood. A final and major factor to consider is that the cask regulations are based on allowable releases independent of the inventory. Thus, regardless of the initial source term, if the cask releases more than a specific acceptable amount, it would not be licensed. Based on these considerations, the 5-year Kr-85 quantities would still be bounded by the overall transportation risk profile provided by Table S-4.

3.8.3 Conclusion

The assessment of environmental impacts indicates that the impacts of transportation associated with fuel and waste for a gas-cooled reactor are considered low. The impacts would be similar to those of a light-water reactor, comparable to the values in 10 C.F.R. §51.52, Table S-4. The 30 characteristics examined are bounded by the similar characteristics of the LWR used to generate the Table S4 values, or are mitigated so their impacts are still within the values in Table S4 in the two instances discussed above. In addition, the gas-cooled reactor technologies will use the same transportation modes and will be subject to the same NRC and DOT regulations for packaging and transportation as that used in the original analysis for Table S4 for light-water reactors.

3.8.4 Methodology Assessment

As indicated in Section 3.0, the selection of a reactor design to be used for the GGNS ESP Site is still under consideration. Selection of a reactor to be used at the GGNS ESP Site may not be limited to those considered above. However, the methodology utilized above is appropriate to evaluate the final selected reactor. Further, should the selected design be shown to be bounded by the above evaluation, then the selected design would be considered to be within the acceptable transportation environmental impacts considered for this ESP.

3.8.5 References

1. 10CFR50.44, Standards for Combustible Gas Control System in Light-Water-Cooled Power Reactors.
2. 10CFR51.22, Criterion for Categorical Exclusion; Identification of Licensing and Regulatory Actions Eligible for Categorical Exclusion or Otherwise not Requiring Environmental Review.
3. 10CFR51.52, Table S-4 Environmental Impact of Transportation of Fuel and Waste.
4. 10 CFR 71, Packaging and Transportation of Radioactive Material.
5. 49 CFR 173, Shippers – General Requirements for Shipments and Packagings.
6. 49 CFR 178, Specifications for Packagings.
7. Docket No. 50-400, 53 FR 30355, NRC Assessment of the Environmental Effects of Transportation Resulting From Extended Fuel Enrichment and Irradiation, August 11, 1988, and 53 FR 32322, August 24, 1988.

8. NUREG-0170, Final Environmental Impact Statement on the Transportation of Radioactive Material by Air and Other Modes, Vols. 1 and 2, December 1977.
9. NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Volumes 1 & 2, May 1996.
10. NUREG-1555, Standard Review Plans for Environmental Reviews for Nuclear Power Plants, October 1999.
11. NUREG/CR-6672, Reexamination of Spent Fuel Shipment Risk Estimates, March 2000.
12. NUREG/CR-6703, Environmental Effects of Extending Fuel Burnup Above 60 GWd/MTU, January 2001.
13. WASH-1238, Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants, December 1972.
14. Supplement 1 to WASH-1238 (NUREG-75/038), Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants, April 1975.

TABLE 3.0-1

PLANT PARAMETERS ENVELOPE (PPE)

PPE Section / Parameter [6]		Composite Value [1]	Comments	Value [2]
1.	Structures			
1.1	Building Characteristics			
1.1.2	Foundation Embedment	140 ft.		US
2.	Normal Plant Heat Sink			
2.3	Condenser			
2.3.2	Condenser / Heat Exchanger Duty	10.7 E9 Btu/hr		US
2.4	NHS Cooling Towers - Mechanical Draft (or Natural Draft) (See Note 3)			
2.4.3 (2.5.3)	Blowdown Constituents and Concentrations	See TABLE 3.0-2		US
2.4.4 (2.5.4)	Blowdown Flow Rate	12,800 gpm expected (39,000 gpm max)		TP
2.4.5 (2.5.5)	Blowdown Temperature	100°F		US
2.4.6 (2.5.6)	Cycles of Concentration	4		US
2.4.7 (2.5.7)	Evaporation Rate	35,100 gpm expected (39,000 gpm max)		TP
2.4.8 (2.5.8)	Height	60 ft (475 ft / 550 ft)	See Note 5	US
2.4.9 (2.5.9)	Makeup Flow Rate	47,900 gpm expected (78,000 gpm max)		TP
2.4.10 (2.5.10)	Noise	55 dba @ 1000 ft		US
2.4.12 (2.5.12)	Cooling Water Flow Rate	865,000 gpm		US
3.	Ultimate Heat Sink			
3.3	Mech Draft Cooling Towers			
3.3.4	Blowdown Flow Rate	288 gpm expected (1700 gpm max)		TP
3.3.5	Blowdown Temperature	95°F		US
3.3.7	Evaporation Rate	822 gpm expected (1700 gpm max)		TP
3.3.9	Makeup Flow Rate	1110 gpm expected (3,400 gpm max)		TP

TABLE 3.0-1 (Continued)

PPE Section / Parameter [6]		Composite Value [1]	Comments	Value [2]
3.3.12	Cooling Water Flow Rate	26,125 gpm (normal) 52,250 gpm (shutdown / accident)		US
5.	Potable Water/Sanitary Waste System			
5.1	Discharge to Site Water Bodies			
5.1.1	Flow Rate	120 gpm expected (210 gpm max)		TP
5.2	Raw Water Requirements			
5.2.1	Maximum Use	240 gpm		TP
5.2.2	Monthly Average Use	180 gpm		TP
6.	Demineralized Water System			
6.1	Discharge to Site Water Bodies			
6.1.1	Flow Rate	220 gpm expected (290 gpm max)		TP
6.2	Raw Water Requirements			
6.2.1	Maximum Use	1440 gpm		TP
6.2.2	Monthly Average Use	1100 gpm		TP
7.	Fire Protection System			
7.1	Raw Water Requirements			
7.1.1	Maximum Use	1890 gpm		TP
7.1.2	Monthly Average Use	(30 gpm)		TP
8.	Miscellaneous Drain			
8.1	Discharge to Site Water Bodies			
8.1.1	Flow Rate	200 gpm expected (300 gpm max)		TP
9.	Unit Vent/Airborne Effluent Release Point			
9.4	Release Point			
9.4.2	Elevation (Normal)	Ground level		US
9.4.3	Elevation (Post Accident)	Ground level		US
9.4.4	Minimum Distance to Site Boundary	0.52 mi (841 m) exclusion area		US
9.5	Source Term			
9.5.1	Airborne Effluents (Normal)	32,699 Ci/yr	See TABLE 3.0-7	US

TABLE 3.0-1 (Continued)

PPE Section / Parameter [6]		Composite Value [1]	Comments	Value [2]
9.5.2	Airborne Effluents (Post-Accident)	Based on limiting DBAs.	See Note 4	US
9.5.3	Tritium Airborne Effluent Normal)	7060 Ci/yr		TP
10.	Liquid Radwaste System			
10.2	Release Point			
10.2.1	Flow Rate	35 gpm		US
10.3	Source Term			
10.3.1	Liquid	0.694 Ci/yr	See TABLE 3.0-8	US
10.3.2	Tritium	6,200 Ci/yr	See TABLE 3.0-8	US
11.	Solid Radwaste System			
11.2.1	Activity	5400 Ci/yr		TP
11.2.2	Principal Radionuclides	See TABLE 3.0-3		US
11.2.3	Volume	18,646 ft^3/yr		TP
13.	Auxiliary Boiler System			
13.2	Flue Gas Effluents	See TABLE 3.0-4		US
16.	Standby Power System			
16.1	Diesels			
16.1.3	Diesel Flue Gas Effluents	See TABLE 3.0-5		US
16.2	Gas Turbines			
16.2.3	Gas-Turbine Flue Gas Effluents	See TABLE 3.0-6		US
17.	Plant Characteristics			
17.3	Megawatts Thermal	4300 MWt	Includes allowance for ~10% uprate from design core power of 3,926 MWt.	US
17.4	Plant Design Life	60 years		US
17.5	Plant Population			
17.5.1	Operation	1160		TP
18.	Construction			
18.3.1	Noise	76-101 db @ 50 ft		US
18.4	Plant Population			
18.4.1	Construction	3150 people max		US

TABLE 3.0-1 (Continued)

NOTES:

1. The “Composite Value” provides an envelope (bounding values) for design parameters for the various plant designs considered for the site. See Site Safety Analysis Report Section 1.3 for a discussion of the basis for parameter values.
2. “Value” pertains to the “Composite Value” for each parameter listed. In this table, a value designated “US” represents a “unit specific” value, meaning that it is applied per unit, or group of units or modules. A designation of “TP” is given to a value that represents total facility requirements. See Site Safety Analysis Report Section 1.3 for a discussion of the basis for parameter values.
3. Several main condenser cooling system alternatives were considered (i.e., mechanical and natural draft cooling towers, cooling ponds, and once-through cooling). The most restrictive value for each cooling system PPE section has been used in this table (e.g., 550 ft cooling tower height selected since both mechanical and natural draft towers were considered).
   - The once through cooling option was eliminated due to significant environmental impact.
   - The cooling pond option was eliminated due to insufficient GGNS site acreage to accommodate pond.
4. In general, source terms for any given accident are those used by the Vendors in their safety analyses. The methodologies used by the Vendors for establishing source terms include those established in TID-14844 and Regulatory Guide 1.183. See SSAR Sections 3.3.2 and 3.3.3 for additional detail on accident selection and source term methods.
5. For the purposes of environmental (aesthetic) impact, a natural draft cooling tower with a height of 550 ft is considered. The cooling tower plume model discussed in Section 5.3.3.1 of the ER was done assuming a natural draft cooling tower height of 475 ft., and a mechanical draft cooling tower height of 60 ft.
6. A definition for each parameter is provided in Table 3.0-9.

TABLE 3.0-2

BLOWDOWN CONSTITUENTS AND CONCENTRATIONS[1]

Constituent	Concentration (ppm)[2, 3]		
	River Source	Well / Treated Water	Envelope
Chlorine demand	10.1	--	10.1
Free available chlorine	0.5	--	0.5
Chromium	--	--	--
Copper	--	6	6
Iron	0.9	3.5	3.5
Zinc	--	0.6	0.6
Phosphate	--	7.2	7.2
Sulfate	600	3,500	3,500
Oil and grease	--	--	--
Total dissolved solids	--	17,000	17,000
Total suspended solids	50	150	150
BOD, 5-day	--	--	--

NOTES:
1. See PPE Table 3.0-1 Sections 2.4.3 and 2.5.3.
2. Assumed cycles of concentration equals 4.
3. Concentrations are per unit/group of units, as applicable.

TABLE 3.0-3

PRINCIPAL RADIONUCLIDES IN SOLID RADWASTE [1]

Radionuclide [3]	Quantity (Ci/yr)
Fe-55	1761.37
Fe-59	1.35
Co-60	395.92
Mn-54	347.22
Cr-51	97.138
C0-58	93.6
NI-63	279
H-3	1.5
C-14	0.3
Nb-95	162
Ag-110m	9
Zr-95	76.45
Ba-140	0.528
Pu-241	0.09
La-140	0.607
Other	72.858
Cs-134	605
Cs-137	507
Sr-90	1.24
I-131	81.91
Ba-137m	507
Na-24	0.44
Ru-103	2.18
Ru-106	1.37
Sb-124	11.29
I-133	4.55
Ce-141	0.14
Ce-144	0.11
Gd-153	3.09
CS-136	0.0287
Zn-65	25.7
Sr-89	0.886
Y-90	1.24
Y-91	4.43 E-4
Rh-103m	1.22 E-3
Rh-106	0.0592
Te-129m	2.31 E-5
Te-129	1.51 E-5
Total (rounded to nearest hundred) [2]	5400

TABLE 3.0-3 (Continued)

NOTES:

1. See PPE Table 3.0-1 Section 11.2.2.
2. This is the bounding total for twice the single unit or group of units, not the total of the bounding quantities above.
3. Individual Radionuclide quantities must be doubled since they represent data for a single unit or group of units.

TABLE 3.0-4

YEARLY EMISSIONS AUXILIARY BOILERS[1]

Pollutant Discharged[2, 3]	Quantity (lbs)
Particulates	17,250
Sulfur oxides	51,750
Carbon monoxide	1749
Hydrocarbons	50,100
Nitrogen oxides	19,022

NOTES:

1. See PPE Table 3.0-1 Section 13.2.
2. Emissions are based on 30 days/yr operation.
3. Individual quantities must be doubled since they represent data for a single unit or group of units.

TABLE 3.0-5

YEARLY EMISSIONS FROM STANDBY DIESEL GENERATORS [1]

Pollutant Discharged [2]	Quantity (lbs)
	Total All DGs [3]
Particulates	1230
Sulfur oxides	4,608
Carbon monoxide	4,600
Hydro-carbons	3,070
Nitrogen oxides	28,968

NOTES:

1. See PPE Table 3.0-1 Section 16.1.3.
2. Emissions are based on 4 hrs/month operation for each of the diesel generators.
3. Individual quantities must be doubled since they represent data for a single unit or group of units.

TABLE 3.0-6

YEARLY STANDBY POWER SYSTEM GAS TURBINE FLUE GAS EFFLUENTS[1]

Gas Turbine Capacity (MWe)	20 MWe
Distillate 20°F Ambient BTU/KWH (LHV)[3]	9,890
BTU/KWH (HHV)	10,480
Fuel Consumption Rate (lbs/hr)[3]	121,200
Effluent	Quantity[2, 3] (lbs or PPMVD)
NOX (PPMVD @ 15% O2	42
NOX as NO2 (lbs)	2016
CO (PPMVD)	31
CO (lbs)	912
UHC (PPMVD)	3
UHC (lbs)	48
VOC (PPMVD)	N/A
VOC (lbs)	10
SO2 (PPMVD)	N/A
SO2 (lbs)	1882
SO3 (PPMVD)	N/A
SO3 (lbs)	30
SULFUR MIST (lbs)	50
PARTICULATES (lbs)	22
Exhaust Analysis (% Vol)	(% Vol)
ARGON	0.87
NITROGEN	72.56
OXYGEN	12.52
CARBON DIOXIDE	5.19
WATER	9.87

NOTES:

1. See PPE Table 3.0-1 Section 16.2.3.
2. Emissions are based on 4 hrs/month operation for each of the gas turbines.
3. Individual quantities must be doubled since they represent data for a single unit or group of units.

TABLE 3.0-7

NORMAL OPERATIONS GASEOUS RELEASE SOURCE TERM[1]

Radionuclide	Composite Normal Release[2] (Ci/yr)	Radionuclide	Composite Normal Release[2] (Ci/yr)
Kr-83m	1.68E-03	Rb-89	8.65E-05
Kr-85m	7.20E+01	Sr-89	1.14E-02
Kr-85	8.20E+03	Sr-90	3.60E-03
Kr-87	5.03E+01	Y-90	9.19E-05
Kr-88	9.20E+01	Sr-91	2.00E-03
Kr-89	4.81E+02	Sr-92	1.57E-03
Kr-90	6.49E-04	Y-91	4.81E-04
Xe-131m	3.60E+03	Y-92	1.24E-03
Xe-133m	1.74E+02	Y-93	2.22E-03
Xe-133	9.20E+03	Zr-95	3.19E-03
Xe-135m	8.11E+02	Nb-95	1.68E-02
Xe-135	9.19E+02	Mo-99	1.19E-01
Xe-137	1.03E+03	Tc-99m	5.95E-04
Xe-138	8.65E+02	Ru-103	7.03E-03
Xe-139	8.11E-04	Rh-103m	2.22E-04
I-131	5.19E-01	Ru-106	2.34E-04
I-132	4.38E+00	Rh-106	3.78E-05
I-133	3.41E+00	Ag-110m	4.00E-06
I-134	7.57E+00	Sb-124	3.62E-04
I-135	4.81E+00	Sb-125	1.83E-04
C-14	2.19E+01	Te-129m	4.38E-04
Na-24	8.11E-03	Te-131m	1.51E-04
P-32	1.84E-03	Te-132	3.78E-05
Ar-41	1.02E+02	Cs-134	1.24E-02
Cr-51	7.03E-02	Cs-136	1.19E-03
Mn-54	1.08E-02	Cs-137	1.89E-02
Mn-56	7.03E-03	Cs-138	3.41E-04
Fe-55	1.30E-02	Ba-140	5.41E-02
Co-57	2.46E-05	La-140	3.62E-03
Co-58	6.90E-02	Ce-141	1.84E-02
Fe-59	1.62E-03	Ce-144	3.78E-05
Co-60	2.61E-02	Pr-144	3.78E-05
Ni-63	1.30E-05	W-187	3.78E-04
Cu-64	2.00E-02	Np-239	2.38E-02
Zn-65	2.22E-02		
		Total without Tritium	25,639
		Tritium (H-3)	7.06E+03
		Total with Tritium	32,699

NOTES:

1. See PPE Table 3.0-1, Section 9.5.1 and 9.5.3.
2. Composite source term based on highest Radionuclide release for all plant types considered.

TABLE 3.0-8

NORMAL OPERATIONS LIQUID RELEASE SOURCE TERM [1]

Radionuclide	Composite Normal Release [2] (Ci/yr)	Radionuclide	Composite Normal Release [2] (Ci/yr)
I-131	2.826E-02	Zr-95	2.080E-03
I-132	5.200E-03	Nb-95	3.820E-03
I-133	2.000E-02	Mo-99	1.659E-03
I-134	3.400E-03	Tc-99m	1.600E-03
I-135	1.503E-02	Ru-103	9.860E-03
H-3	6.200E+03	Rh-103m	9.860E-03
C-14	8.800E-04	Ru-106	1.470E-01
Na-24	5.622E-03	Rh-106	1.470E-01
P-32	3.600E-04	Ag-110	2.800E-04
Cr-51	1.541E-02	Ag-110m	2.100E-03
Mn-54	5.200E-03		
Mn-56	7.622E-03	Sb-124	1.358E-03
Co-57	1.438E-04	Te-129	3.000E-04
Co-58	6.720E-03	Te-129m	2.400E-04
Co-60	1.822E-02	Te-131	6.000E-05
Fe-55	1.162E-02	Te-131m	1.800E-04
Fe-59	4.000E-04	Te-132	4.800E-04
Ni-63	2.800E-04	Cs-134	1.986E-02
Cu-64	1.503E-02	Cs-136	1.260E-03
Zn-65	8.200E-04	Cs-137	2.664E-02
Br-84	4.000E-05	Ba-137m	2.490E-02
Rb-88	5.400E-04	Cs-138	3.800E-04
Rb-89	8.811E-05	Ba-140	1.104E-02
Sr-89	2.200E-04	La-140	1.486E-02
Sr-90	7.027E-05	Ce-141	2.400E-04
Y-90	6.216E-06	Ce-143	3.800E-04
Sr-91	1.800E-03	Ce-144	6.320E-03
Y-91	2.200E-04	Pr-143	2.600E-04
Y-91m	2.000E-05	Pr-144	6.320E-03
Sr-92	1.600E-03	W-187	2.600E-04
Y-92	1.200E-03	Np-239	6.216E-03
Y-93	1.800E-03	All Others	4.000E-05
		Total All w/o Tritium	6.941E-01
		Total Tritium	6.200E+03

NOTES:

1. See PPE Table 3.0-1, Section 10.3.
2. Composite source term based on highest Radionuclide release for all plant types considered.

TABLE 3.0-9

PLANT PARAMETERS DEFINITIONS

Parameter	Units	Definition	Bounding Value (Footnotes)
1.1 Building Characteristics			
1.1.2 Foundation Embedment	Feet	The depth from finished grade to the bottom of the basemat for the most deeply embedded power block structure.	1
2. Normal Plant Heat Sink			
2.3 Condenser			
2.3.2 Condenser / Heat Exchanger Duty	BTU per hour	Design value for the waste heat rejected to the circulating water system across the normal heat sink condensers.	2
2.4 (2.5) NHS Cooling Towers (Mechanical Draft or Natural Draft)			
2.4.3 (2.5.3) Blowdown Constituents and Concentrations	Ppm	The maximum expected concentrations for anticipated constituents in the cooling water systems blowdown to the receiving water body.	2
2.4.4 (2.5.4) Blowdown Flow Rate	Gallons per minute	The normal (and maximum) flow rate of the blowdown stream from the cooling water systems to the receiving water body for closed system designs.	2
2.4.5 (2.5.5) Blowdown Temperature	°F	The maximum expected blowdown temperature at the point of discharge to the receiving water body.	1
2.4.6 (2.5.6) Cycles of Concentration	Number of cycles	The ratio of total dissolved solids in the cooling water blowdown streams to the total dissolved solids in the makeup water streams.	1
2.4.7 (2.5.7) Evaporation Rate	Gallons per minute	The expected (and maximum) rate at which water is lost by evaporation from the cooling water systems.	2
2.4.8 (2.5.8) Height	Feet	The vertical height above finished grade of either natural draft or mechanical draft cooling towers associated with the cooling water systems.	1
2.4.9 (2.5.9) Makeup Flow Rate	Gallons per minute	The expected (and maximum) rate of removal of water from a natural source to replace water losses from closed cooling water systems.	2
2.4.10 (2.5.10) Noise	Decibels	The maximum expected sound level produced by operation of a cooling tower, measured at 1000 feet from the noise source.	1
2.4.12 (2.5.12) Cooling Water Flow Rate	Gallons per minute	The total cooling water flow rate through the normal heat sink condensers/heat exchangers.	1
3. Ultimate Heat Sink			
3.3 Mechanical Draft Cooling Towers			
3.3.4 Blowdown Flow Rate	Gallons per minute	The normal (and maximum) flow rate of the blowdown stream from the UHS system to receiving water body for closed system designs.	2
3.3.5 Blowdown Temperature	°F	The maximum expected UHS blowdown temperature at the point of discharge to the receiving water body.	1

TABLE 3.0-9 (Continued)

Parameter	Units	Definition	Bounding Value (Footnotes)
3.3.7 Evaporation Rate	Gallons per minute	The expected (and maximum) rate at which water is lost by evaporation from the UHS system.	2
3.3.9 Makeup Flow Rate	Gallons per minute	The expected (and maximum) rate of removal of water from a natural source to replace water losses from the UHS system.	2
3.3.12 Cooling Water Flow Rate	Gallons per minute	The total cooling water flow rate through the UHS system.	1
5. Potable Water/Sanitary Waste System			
5.1 Discharge to Site Water Bodies			
5.1.1 Flow Rate	Gallons per minute	The expected (and maximum) effluent flow rate from the potable and sanitary waste water systems to the receiving water body.	3
5.2 Raw Water Requirements			
5.2.1 Maximum Use	Gallons per minute	The maximum short-term rate of withdrawal from the water source for the potable and sanitary waste water systems.	2
5.2.2 Monthly Average Use	Gallons per minute	The average rate of withdrawal from the water source for the potable and sanitary waste water systems.	2
6. Demineralized Water System			
6.1 Discharge to Site Water Bodies			
6.1.1 Flow Rate	Gallons per minute	The expected (and maximum) effluent flow rate from the demineralized water processing system to the receiving water body.	3
6.2 Raw Water Requirements			
6.2.1 Maximum Use	Gallons per minute	The maximum short-term rate of withdrawal from the water source for the demineralized water system.	2
6.2.2 Monthly Average Use	Gallons per minute	The average rate of withdrawal from the water source for the demineralized water system.	2
7. Fire Protection System			
7.1 Raw Water Requirements			
7.1.1 Maximum Use	Gallons per minute	The maximum short-term rate of withdrawal from the water source for the fire protection water system.	2
7.1.2 Monthly Average Use	Gallons per minute	The average rate of withdrawal from the water source for the fire protection water system.	2
8. Miscellaneous Drain			
8.1 Discharge to Site Water Bodies			
8.1.1 Flow Rate	Gallons per minute	The expected (and maximum) effluent flow rate from miscellaneous drains to the receiving water body.	2

TABLE 3.0-9 (Continued)

Parameter	**Units**	**Definition**	**Bounding Value (Footnotes)**
9. Unit Vent/Airborne Effluent Release Point			
9.4 Release Point			
9.4.2 Elevation (Normal Operation)	Feet	The elevation above finished grade of the release point for routine operational releases.	3
9.4.3 Elevation (Post Accident)	Feet	The elevation above finished grade of the release point for accident sequence releases.	3
9.4.4 Minimum Distance to Site Boundary	Feet	The minimum lateral distance from the release point to the site boundary.	3
9.5 Source Term			
9.5.1 Airborne Effluents (Normal)	Curies per year	The annual activity, by isotope, contained in routine (normal) plant airborne effluent streams.	2
9.5.2 Airborne Effluents (Post-Accident)	Curies	The activity, by isotope, activity contained in post-accident airborne effluents.	1
9.5.3 Tritium Airborne Effluents (Normal)	Curies per year	The annual activity of tritium contained in routine (normal) plant airborne effluent streams.	2
10. Liquid Radwaste System			
10.2 Release Point			
10.2.1 Flow Rate	Gallons per minute	The flow rate of liquid potentially radioactive effluent streams from plant systems to the receiving water body.	2
10.3 Source Term			
10.3.1 Liquid	Curies per year	The annual activity, by isotope, contained in routine plant liquid effluent streams.	2
10.3.2 Tritium	Curies per year	The annual activity of tritium contained in routine plant airborne effluent streams.	2
11. Solid Radwaste System			
11.2.1 Activity	Curies per year	The annual activity, by isotope, contained in solid radioactive wastes generated during routine plant operations.	2
11.2.2 Principal Radionuclides	Curies per year	The principal radionuclides contained in solid radioactive wastes generated during routine plant operations.	2
11.2.3 Volume	Cubic feet per year	The expected volume of solid radioactive wastes generated during routine plant operations.	2
13. Auxiliary Boiler System			
13.2 Flue Gas Effluents	Pounds per year	The expected combustion products and anticipated quantities released to the environment due to operation of auxiliary boilers.	2
16. Standby Power System			
16.1 Diesel			
16.1.3 Diesel Flue Gas Effluents	Pounds per year	The expected combustion products and anticipated quantities released to the environment due to operation of the emergency standby diesel generators.	1

TABLE 3.0-9 (Continued)

Parameter	Units	Definition	Bounding Value (Footnotes)
16.2 Gas-Turbine			
16.2.3 Gas-Turbine Flue Gas Effluents	Pounds per year	The expected combustion products and anticipated quantities released to the environment due to operation of the emergency standby gas-turbine generators.	1
17. Plant Characteristics			
17.3 Megawatts Thermal	Mega-watts	The maximum thermal power generated by a single unit or group of units/modules of a specific reactor plant type.	2
17.4 Plant Design Life	Years	The life for which the plant is designed to operate.	1
17.5 Plant Population			
17.5.1 Operation	Persons	The number of people required to operate and maintain the plant.	2
17.6 Station Capacity Factor	Percent	The percentage of time that a plant is capable of providing power to the grid.	1
18. Construction			
18.4 Plant Population			
18.4.1 Construction	Persons	The number of people required to construct the plant.	2

NOTES:

1. The Bounding Value is the maximum value for any of the plant designs being considered for the site.
2. The Bounding Value is the maximum value for any of the plant design/number of unit combinations being considered for the site.
3. The Bounding Value is the minimum value for any of the plant designs being considered for the site.

TABLE 3.4-1

ESTIMATED PLANT WATER USAGE
(Note 2)

Item		Maximum (gpm)	Average (gpm)
1.	Raw Water from Makeup Water System		
a.	Normal Plant Heat Sink (NHS) makeup	78,000	47,900
b.	Service Water System (SWS) makeup	See Note 1	See Note 1
c.	Ultimate Heat Sink (UHS) makeup	3,400	1,110
d.	Demineralized Water System makeup	1,440	1,100
e.	Fire Protection System makeup	1,890	30
f.	Total	84,730	50,140
2.	Raw Water from Wells		
a.	Potable Water / Sanitary Waste System	240	180
b.	Total	240	180

NOTES:

1. Service Water System (SWS) makeup is included in Normal Plant Heat Sink (NHS) makeup.
2. Plant water usage is collected and presented here as a convenience. The data is presented in (or derived from) Table 3.0-1.

TABLE 3.8-1

LIGHT-WATER-COOLED REACTOR TRANSPORTATION WORKSHEET

Reactor Technology	Table S-4 Condition	ESBWR (Single unit) (4000 MWt) (1390 MWe)	ABWR (Single unit) (4300 MWt) (1500 MWe)	AP-1000 (Single Unit) (3400 MWt) (1117-1150 MWe)	IRIS (3 Reactors) (3000 MWt total) (1005 MWe total)	ACR-700 (Twin Unit) (3964 MWt total) (1462 MWe total)
Characteristic						
Reactor Power Level MWt	Not exceeding 3800 MWt per reactor	4000 MWt	4300 MWt	3400	3000 (1000 MWt per reactor, 3 reactors per plant)	3964 (1982 MWt per reactor, 2 reactors per plant)
Fuel Form	Sintered UO_2 pellets	Sintered UO_2 pellets	Sintered UO_2 pellets	Sintered UO_2 pellets	Sintered UO_2 pellets	Sintered UO_2 pellets
U235 Enrichment	Not exceeding 4%; NUREG 1437 concludes that 5% is bounded	Initial Core < 3.5%; Reload average < 4.5%	Initial Core < 3.5%; Reload average < 4.5%	Initial Core Load Region 1 2.35% Region 2 3.40% Region 3 4.45% Reload Average 4.51%	Fuel cycle average ~4.85%; maximum assembly 4.95%; reload 4.75 - 4.95%	2%
Fuel Rod Cladding	Zircaloy rods; 10 CFR 50.44 allows use of ZIRLO	Zircaloy	Zircaloy	Zircaloy or ZIRLO™	ZIRLO™	Zircaloy-4
Average Burnup MWd/MTU	Not exceeding 33,000; NUREG 1437 concludes 62,000 MWd/MTU for peak rod is bounded	46,000	46,000	48,700	55,200	20,500
Unirradiated Fuel						
Transport Mode	Truck	Truck	Truck	Truck	Truck	Truck

TABLE 3.8-1 (Continued)

Reactor Technology	Table S-4 Condition	ESBWR (Single unit) (4000 MWt) (1390 MWe)	ABWR (Single unit) (4300 MWt) (1500 MWe)	AP-1000 (Single Unit) (3400 MWt) (1117-1150 MWe)	IRIS (3 Reactors) (3000 MWt total) (1005 MWe total)	ACR-700 (Twin Unit) (3964 MWt total) (1462 MWe total)
Irradiated Fuel						
Transport Mode	Truck, rail or barge	Truck, rail	Truck, rail	Rail	Rail	Rail
Decay Time Prior To Shipment	Not less than 90 days is a condition for use of Table S-4; 5 years is per contract with DOE	Five years	Five years	Ten years	Five years	Ten years
Radioactive Waste						
Transport Mode	Truck or Rail	Truck	Truck	Truck	Truck	Truck
Waste Form	Solid	Solid	Solid	Solid	Solid	Solid
Packaged	Yes	Yes	Yes	Yes	Yes	Yes

NOTES:

1. Highlight indicates a value larger than or different from the reference LWR.
2. The "Reference LWR" refers to a typical 1100 MWe light-water-cooled nuclear reactor as described in WASH-1238.

TABLE 3.8-2

GAS-COOLED REACTOR TRANSPORTATION WORKSHEET

Reactor Technology / Characteristic	Reference LWR[3] (Single unit) (1100 MWe)	GT-MHR (4 Modules) (2400 MWt total) (1140 MWe total)	PBMR (8 Modules) (3200 MWt total) (1320 MWe total)	Comments
Capacity	80%	88%	95%	
Normalization factor	1	0.88	0.7	
Reactor Power Level MWt	~ 3400	2400 (600 MWt per module, 4 modules per plant)	3200 (400 MWt per module, 8 modules per plant)	Not exceeding 3800 MWt per reactor is a condition for use of Table S-4
Fuel Form	Sintered UO_2 pellets	TRISO coated particle fuel with uranium oxycarbide (UCO) kernel	Sphere of TRISO Coated UO_2 fuel kernels	Sintered UO_2 pellets is a condition for use of Table S-4
U235 Enrichment	1% - 4%	Fissile particle 19.8%; fertile particle natural uranium	Initial 4.9%; equilibrium 12.9%	Not exceeding 4% is a condition for use of Table S-4; NUREG 1437 concludes that 5% is bounded
Fuel Rod Cladding	Zircaloy	Graphite	Graphite	Zircaloy rods are a condition for use of Table S-4; 10 CFR 50.44 allows use of ZIRLO)
Average burnup MWd/MTU	33,000	112,742	133,000	Not exceeding 33,000 is a condition for use of Table S-4; NUREG 1437 concludes 62,000 MWd/MTU for peak rod is bounded

TABLE 3.8-2 (Continued)

Reactor Technology / Characteristic	Reference LWR[3] (Single unit) (1100 MWe)	GT-MHR (4 Modules) (2400 MWt total) (1140 MWe total)	PBMR (8 Modules) (3200 MWt total) (1320 MWe total)	Comments
Unirradiated fuel				
Unirradiated fuel transport mode	Truck	Truck	Truck	Shipment by truck is a condition for use of Table S-4
# of shipments for initial core loading	18	51 shipments (1020 fuel elements per module x 4 modules; 80 elements per truck)	44 shipments (260,000 fuel spheres per module x 8 modules, 48,000 spheres per truck)	100 MTU for PWR; 150 MTU for BWR
# of reload shipments/year	6	20 shipments (520 elements per reload per 1.32 years x 4 modules; 80 elements per truck)	3 shipments (18,000 fuel spheres per module x 8 modules, 48,000 spheres per truck)	30 MTU annual reload
Irradiated fuel				
Irradiated fuel transport mode	Truck, rail or barge	Truck	Truck	Shipment by truck, rail or barge is a condition for use of Table S-4
Decay time prior to shipment	150 days	Five years	Five years	Not less than 90 days is a condition for use of Table S-4; 5 years is per contract with DOE
Fission product inventory in Ci per MTU after 5 year decay	$6.19x10^6$	$1.55x10^6$	$1.78x10^6$	The value for the LWR is for a 90 day decay time.
Actinide inventory in Ci per MTU after 5 year decay	$1.42x10^5$	$2.33x10^5$	$2.26x10^5$	The value for the LWR is for a 90 day decay time.

TABLE 3.8-2 (Continued)

Reactor Technology / Characteristic	Reference LWR[3] (Single unit) (1100 MWe)	GT-MHR (4 Modules) (2400 MWt total) (1140 MWe total)	PBMR (8 Modules) (3200 MWt total) (1320 MWe total)	Comments
Total radioactivity inventory in Ci per MTU after 5 year decay	6.33×10^6	1.78×10^6	2.01×10^6	The value for the LWR is for a 90 day decay time.
Krypton-85 inventory in Ci per MTU after 5 year decay	1.13×10^4	2.50×10^4	2.63×10^4	The value for the LWR is for a 90 day decay time.
Watts per MTU after 5 year decay	2.71×10^4	6.36×10^3	3.91×10^3	The value for the LWR is for a 90 day decay time.
# of spent fuel shipments by truck	60	38 shipments (520 elements per module x 4 modules per 1.32 years, 42 elements per truck)	16 shipments (12 shipments for 1000 MWe)	0.5 MT of irradiated fuel per cask
Heat (per irradiated fuel truck cask in transit) kW	10	1.02 (6.356 kW/MTU x 0.16044 MTU/shipment)	1.9 (3.9 KW/MTU x 0.495 MTU/shipment)	
# of spent fuel shipments by rail	10	0	0	Appendix B, Table 1 says 3.2 MT of irradiated fuel per cask, Appendix B, Table 3 says 3.5
Heat(per irradiated fuel rail cask in transit) kW	70	NA	NA	
# of spent fuel shipments by barge	5	0	0	
Radioactive waste				
Radioactive waste transport mode	Truck or rail	Truck	Truck	Shipment by truck or rail is a condition for use of Table S-4

TABLE 3.8-2 (Continued)

Reactor Technology / Characteristic	Reference LWR[3] (Single unit) (1100 MWe)	GT-MHR (4 Modules) (2400 MWt total) (1140 MWe total)	PBMR (8 Modules) (3200 MWt total) (1320 MWe total)	Comments
# of rad waste shipments by truck	46	6 (1100 Ci/yr; 98 m^3/yr)	9 (800 drums)	Assumed 90% of the waste shipped at 1000 ft^3 per truck, 10% at 200 ft^3 per truck
Weight per truck lbs.	73,000	Governed by state and federal regulations	Governed by state and federal regulations	Current interstate gross vehicle limit is 80,000 lbs.(23 CFR 658.17)
# of rad waste shipments by rail	11	0	0	
Weight per cask per rail car tons	100	100	100	
Transport totals				
Traffic density, trucks per day	Less than 1	Less than 1	Less than 1	
Rail density, cars per month	Less than 3	0	0	

NOTES:

1. The results for the reactor technologies have not been adjusted for their larger electrical generation or increased capacity factor.
2. Highlight indicates a value larger than or different from the reference LWR.
3. The "Reference LWR" refers to a typical 1100 MWe light-water-cooled nuclear reactor as described in WASH-1238.

SOURCE:

10CFR51.52, Table S-4 Environmental Impact of Transportation of Fuel and Waste

TABLE 3.8-3

SUMMARY TABLE S-4 –
ENVIRONMENTAL IMPACT OF TRANSPORTATION OF FUEL AND WASTE TO AND FROM ONE LIGHT-WATER-COOLED NUCLEAR POWER REACTOR [1]

Normal Conditions of Transport

Condition	Value
Heat (per irradiated fuel cask in transit)	250,000 Btu/hr.
Weight (governed by Federal or State restrictions)	73,000 lbs. Per truck; 100 tons per cask per rail car.
Traffic density:	
Truck	Less than 1 per day.
Rail	Less than 3 per month.

Exposed Population	Estimated Number of Persons Exposed	Range of Doses to Exposed Individuals [2] (per reactor year)	Cumulative Dose to Exposed Population (per reactor year) [3]
Transportation workers	200	0.01 to 300 millirem	4 man-rem.
General public:			
Onlookers	1,100	0.003 to 1.3 millirem	3 man-rem.
Along Route	600,000	0.0001 to 0.06 millirem	

Accidents in Transport

Types of Effects	Environmental Risk
Radiological effects	Small [4]
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year.

SOURCE:
49 FR 9381, Mar. 12, 1984; 49 FR 10922, Mar. 23, 1984, as amended at 53 FR 43420, Oct. 27, 1988.

TABLE 3.8-3 (Continued)

NOTES:

1. Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," WASH-1238, December 1972, and Supp. 1 NUREG-75/038 April 1975. Both documents are available for inspection and copying at the Commission's Public Document Room, 2120 L Street NW., Washington, DC and may be obtained from the National Technical Information Service, Springfield, VA 22161. WASH-1238 is available form NTIS at a cost of $5.45 (microfiche, $2.25) and NUREG-75-038 is available at a cost of $3.25 (microfiche $2.25).
2. The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5,000 millirem per year for individuals as a result of occupational exposure and should be limited to 500 millirem per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirem per year.
3. Man-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1,000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirem) each, the total man-rem dose in each case would be 1 man-rem.
4. Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multireactor site.