ENVIRONMENTAL REPORT

CHAPTER 3

PLANT DESCRIPTION

3.0 PLANT DESCRIPTION

3.1 EXTERNAL APPEARANCE AND PLANT LAYOUT

The site for the proposed nuclear power plant is the Bell Bend Nuclear Power Plant (BBNPP) property located approximately 5 mi (8 km) northeast of the borough of Berwick, Pennsylvania, and 1.6 mi (2.6 km) to the north and west of the north branch of the Susquehanna River, west of the existing Susquehanna Steam Electric Station (SSES) in Salem Township, Luzerne County, Pennsylvania on properties currently owned either solely by PPL Corporation (100%) or jointly by PPL Susquehanna, LLC (90%) and Allegheny Electric Cooperative (10%). The terrain is a rolling plateau in a rural area of open deciduous woodlands, interspersed with grasslands and orchards as shown in Figure 3.1-1. The plant grade (finished ground surface) is at an approximate elevation of 719 ft (219.2 m) and the finished floor elevation is 720 ft (219.5 m). References to elevation values in this section are based on North American Vertical Datum of 1988 (NAVD 88), unless otherwise stated.

The adjacent SSES features two boiling water reactors (BWRs), designated as Units 1 and 2. Each unit will have an electric generation capacity of 1,300 MWe after the extended power uprate project is completed (PPL, 2006). Existing plant structures occupy a developed area of approximately 487 ac (197 ha), with most of the plant-related structures located west of U.S. Route 11 (PPL, 2006). Additional property is located to the east of SSES on both sides of the Susquehanna River, including the Riverlands Recreation Area, which is located on 401 ac (162 ha) of land between U.S. Route 11 and the Susquehanna River (PPL, 2006). SSES Units 1 and 2 share a common control room, refueling floor, turbine operating deck, radwaste system, and other auxiliary systems (PPL, 2006). The existing SSES Intake and Discharge Structures are located on the west bank of the Susquehanna River. An Independent Spent Fuel Storage Installation is situated west of the SSES natural draft cooling towers. Access to the existing plant is via an onsite road which intersects U.S. Route 11 east of the plant, and a rail spur to the North Shore Railroad (NSRS, 2008).

The proposed plant is a U.S. EPR, referred to as BBNPP. The U.S. EPR is a pressurized water reactor design with a rated core thermal power of 4,590 MWt. The rated and design gross electrical output for the EPR is approximately 1,710 MWe. Electrical power consumption is approximately 110 MWe for auxiliary loads, resulting in a rated and design net electrical output of approximately 1,600 MWe. The plant is proposed to be constructed west of the existing SSES in Salem Township. The area occupied by construction-related and new plant structures is described in Section 4.1.1.1 of the ER. BBNPP will be separated from SSES by a distance of approximately one mile (1.6 km).

Due to the distance and location from SSES Units 1 and 2, the new plant will have a separate protected area from that of the existing plant. A new access road will be built to connect BBNPP to U.S. Route 11. The existing rail spur will be extended from SSES to BBNPP. A Circulating Water System (CWS) Makeup Water Intake and Pump House along with discharge piping will be constructed for BBNPP just to the south of the existing SSES intake on the west bank of the Susquehanna River.

The BBNPP design is a four-loop, pressurized water reactor, with a Reactor Coolant System composed of a reactor pressure vessel that contains the fuel assemblies, a pressurizer including ancillary systems to maintain system pressure, one reactor coolant pump per loop, one steam generator per loop, associated piping, and related control systems and protection systems. The BBNPP Reactor Building and Turbine Building will be oriented side by side, with the Reactor Building oriented towards the west.

The Reactor Building will be surrounded by the Fuel Pool Building, four Safeguard Buildings, two Emergency Diesel Generator Buildings, the Reactor Auxiliary Building, the Radioactive Waste Processing Building and the Access Building. Figure 3.1-1 shows the layout for BBNPP, depicting the following features: exclusion area boundary (EAB), site boundary , liquid and gaseous release points (i.e., discharge piping, and vent stack and CWS Cooling Tower, respectively) and their elevations and distances from the Reactor Building, meteorological towers, the construction zone, land to be cleared, waste disposal areas, and other buildings and structures both temporary (i.e., construction offices/ warehouses) and permanent.

The SSES Units 1 and 2 power block consists of the Reactor, Turbine Generator and Control Buildings. The rectangular complex measures approximately 300 ft (91.4 m) in width by 610 ft (186 m) in length. With the existing plant grade at an elevation of approximately 676 ft (206 m) NGVD 29 and the top of the Reactor Building at an elevation of approximately 201 ft (61.3 m) above grade. Additionally, SSES Units 1 and 2 have two natural draft, hyperbolic cooling towers. Each tower has an approximate height of 540 ft (164.6 m) and a base diameter of 426 ft (129.8 m). Other existing plant buildings are either concrete or steel with exterior metal siding.

The BBNPP Reactor Building is an upright cylinder concrete structure, capped with a spherical dome. The Reactor Building is 186 ft (56.7 m) in diameter with an overall height of 240 ft (73.2 m). The plant grade for BBNPP will be at an elevation of approximately 719 ft (219.2 m). With the bottom of the Reactor Building foundation 35 ft (11 m) below grade, the new Reactor Building will rise approximately 205 ft (62.5 m) above grade. The top of the Reactor Building will be at an elevation of approximately 924 ft (281.6 m).

The vent stack for BBNPP will be the tallest new structure at approximately 212 ft (64.6 m) above grade or about 7 ft (2.1 m) above the Reactor Building. Similar to the existing plant, SSES Units 1 and 2, BBNPP will have a closed-loop cooling system. The BBNPP CWS cooling towers will be round hyperbolic concrete structures with an overall diameter of 350 ft (107 m) and approximate height of 475 ft (145 m). Similar to SSES Units 1 and 2, other BBNPP buildings will be concrete or steel with metal siding. Figure 3.1-2 depicts an aerial view of SSES Units 1 and 2 with the proposed BBNPP superimposed on the photograph.

The ultimate heat sink function for BBNPP will be provided by four Essential Service Water System (ESWS) mechanical forced draft cooling towers situated above storage basin pools. Each of the four pools will have a minimum volume of 337,987 ft^3 (9,572 m^3), occupy a rectangular area approximately 124 ft (37.8 m) by 102 ft (31 m), and be bounded by the tower footprint. The pools will normally be supplied with non-safety-related makeup water from the Raw Water Supply System (RWSS). In the event of a design basis accident, the pools will be supplied with a safety-related makeup water using the onsite ESW Emergency Makeup System (ESWEMS) Retention Pond as detailed in Section 9.2.5 of the FSAR. The ESWS cooling towers will be 96 ft (29 m) tall. The Water Treatment Plant for the RWSS will be approximately 200 ft by 350 ft (61 m by 106.7 m) and situated to the northeast of the BBNPP Switchyard. The Water Treatment Plant will be supplied with river water taken from the RWSS makeup line.

Figure 3.1-3 through Figure 3.1-6 are ground-level photographs of the BBNPP property taken from adjacent properties to the southwest, northeast, east and northwest. Major structures associated with BBNPP have been superimposed on these photographs to depict potential visual impacts as viewed from all four directions. There will be a minor visual impact from the addition of the two new cooling towers and the plume. No mitigation is required as the area already has two cooling towers from SSES which are also higher at 540 ft (165 m).

Forested areas bordering the site, particularly to the south, should provide some screening by trees so that only the tops of the taller new structures may be visible from adjacent properties at ground level. Most new buildings will not be visible since the taller structures will mask the lower rise structures. Topographical features (i.e., hills and valleys) will also help to screen and seclude new plant structures from surrounding properties even when foliage is seasonally absent. In addition, since BBNPP will be located approximately one mile (1.6 km) or more from the more populated concentrations of residential and commercial properties along U.S. Route 11, distance will help to shield BBNPP from view. Nevertheless, some properties immediately to the west of the site will experience direct visual impacts from BBNPP. The BBNPP Intake Structure on the west bank of the Susquehanna River should also have a minimal visual impact, considering its location near the existing SSES Intake Structure and given that it will only be visible from the river itself. The BBNPP discharge pipe for cooling tower blowdown and other plant liquid effluents will be routed underground to a submerged diffuser in the river and will not be visible. No other visual impacts from nearby ground-level vantage points are expected.

Aesthetic principles and concepts used in the design and layout of BBNPP include the following:

- Locating plant facilities outside of existing wetland areas and waterbodies and preserving the site's natural hydrology.
- Placing the BBNPP Intake Structure and discharge piping near the existing, developed section of shoreline.
- Minimizing tree removal by locating plant facilities in either cleared fields or lightly forested areas where feasible.
- Transporting excavated and dredged material to an onsite spoils area outside designated wetlands.
- Adding a new access road to provide a direct route to BBNPP and thereby minimizing the impacts to local roads and the disruption of existing traffic patterns from the construction and operation of the plant.

In addition to the above, exterior finishes for plant buildings will be similar in color and texture to those of the SSES Units 1 and 2 buildings. This provides for a consistent, overall appearance, by architecturally integrating the buildings on the two sites. Areas that are cleared supporting construction activities will be either maintained or restored by reseeding and replanting with native trees and vegetation, so that the BBNPP landscape blends with the SSES Units 1 and 2 landscapes and the remaining undisturbed areas on the BBNPP site. Figure 3.1-7 is an architectural rendering of BBNPP, depicting profiles of major buildings and landscaping features.

3.1.1 References

PPL, 2006. Susquehanna Steam Electric Station Units 1 and 2 License Renewal Application, Appendix E, Applicant's Environmental Report - Operating License Renewal Stage, Susquehanna Steam Electric Station, PPL Susquehanna LLC, September 2006.

NSRS, 2008. North Shore Railroad System, North Shore Railroad System Map, Website: http://www.nshr.com/NSHR/nshr.shtml, Date accessed: June 22, 2008.

Figure 3.1-1— Site Area Topographical Map

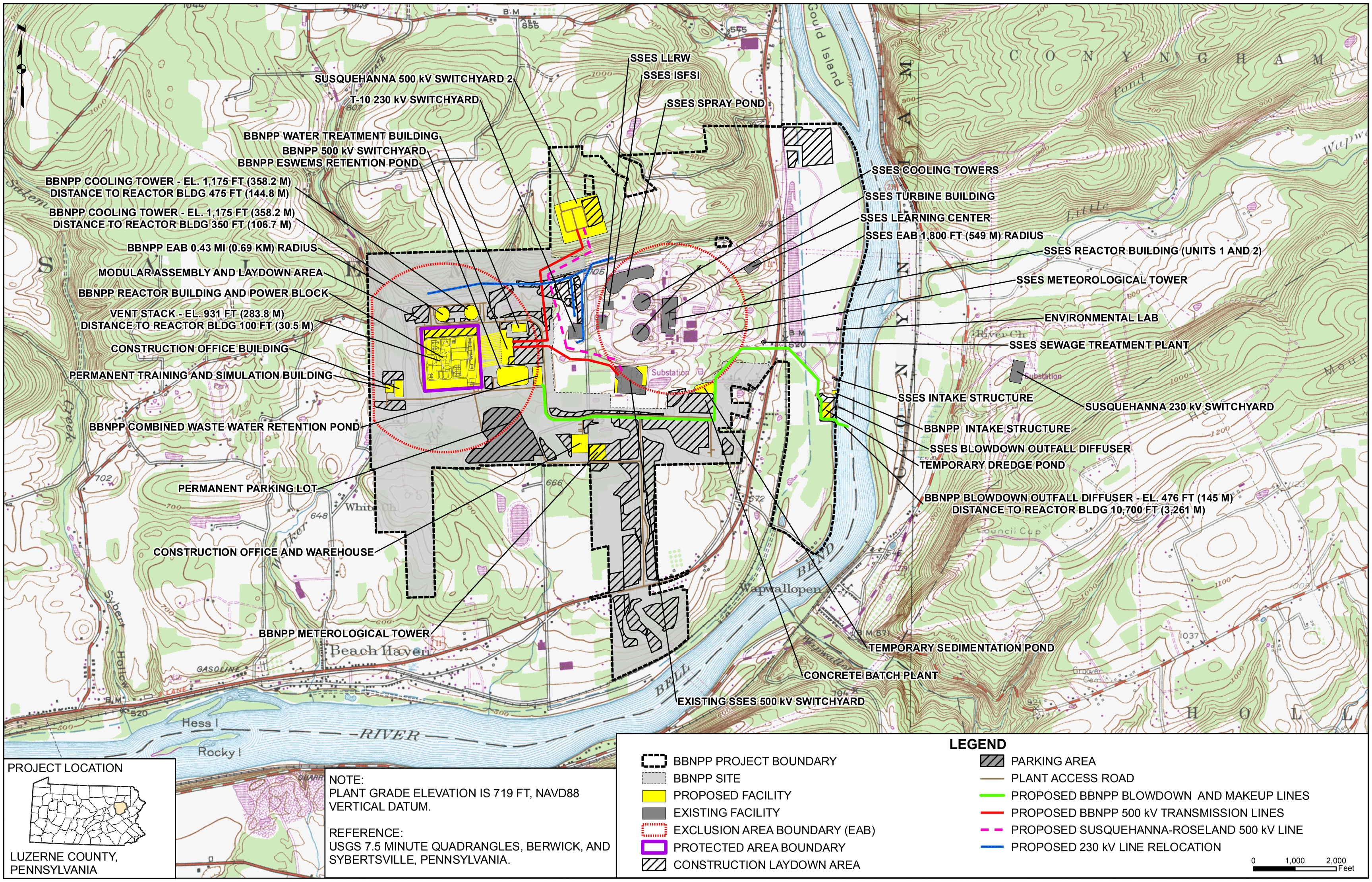


Figure 3.1-2— Aerial View of Susquehanna Steam Electric Station Units 1 and 2 with Bell Bend NPP Superimposed

Figure 3.1-3— Ground Level View Looking Southwest with the Bell Bend Structures Superimposed

Figure 3.1-4— Ground Level View Looking Northeast with the Bell Bend Structures Superimposed

Figure 3.1-5— Ground Level View Looking East with Bell Bend Structures Superimposed

Figure 3.1-6— Ground Level View Looking Northwest with the Bell Bend Structures Superimposed

Figure 3.1-7— Architectural Rendering of Bell Bend NPP Looking Northeast

3.2 REACTOR POWER CONVERSION SYSTEM

3.2.1 General

PPL Bell Bend, LLC proposes construction and operation of a new nuclear power plant to be designated BBNPP to be located on the BBNPP site, near the existing SSES Units 1 and 2 site in Luzerne County, Pennsylvania. PPL Bell Bend, LLC is applying for a combined license for the proposed nuclear power plant.

The U.S. EPR design has a rated core thermal power of 4,590 MWt. The rated and design gross electrical output for the U.S. EPR is approximately 1,710 MWe. Net electrical output is approximately 1600 MWe. Although the U.S. EPR is to be licensed for 40 years, the proposed operating life of the U.S. EPR is 60 years.

The U.S. EPR design is a four-loop, pressurized water reactor, with a Reactor Coolant System (RCS) composed of a reactor pressure vessel that contains the fuel assemblies, a pressurizer including ancillary systems to maintain system pressure, one reactor coolant pump per loop, one steam generator per loop, associated piping, and related control systems and protection systems. Referring to Figure 3.2-1, which provides a simplified depiction of the reactor power conversion system for the U.S. EPR, the RCS transfers the heat generated in the reactor core to the steam generators where steam is produced to drive the turbine generator. Water is utilized to remove the heat formed inside the reactor core. The reactor coolant pumps provide forced circulation of water through the RCS and a pressurizer, connected to one of the four loops, maintains the pressure within a specified range. Each of the four reactor coolant loops comprises a hot leg from the reactor pressure vessel to a steam generator, a cross-over leg from the steam generator to a reactor coolant pump, and a cold leg from the reactor coolant pump to the reactor pressure vessel. In each of the four loops, the primary water leaving the reactor pressure vessel through an outlet nozzle goes to a steam generator. The primary water flows inside the steam generator tube bundle and transfers heat to the secondary water. The primary water then goes to a reactor coolant pump before returning to the reactor pressure vessel through an inlet nozzle. The feedwater entering the secondary side of the steam generators absorbs the heat transferred from the primary side and evaporates to produce saturated steam. The steam is dried in the steam generators then routed to the turbine to drive it. The steam is then condensed and returns as feedwater to the steam generators. The alternating current, synchronous type generator, driven by the turbine, generates electricity. The generator rotor will be hydrogen cooled and the generator stator will be cooled with water.

The U.S. EPR reactor core consists of 241 fuel assemblies. The fuel assembly structure supports the fuel rod bundles. Inside the assembly, the fuel rods are vertically arranged according to a square lattice with a 17x17 array. There are 265 fuel rods per assembly with the remaining locations used for control rods or instrumentation. The fuel rods are composed of enriched uranium dioxide sintered pellets contained in a cladding tube made of M5® advanced zirconium alloy. Percentage of uranium enrichment and total quantities of uranium for the U.S. EPR core are as follows:

- Cycle 1 (initial) - average batch enrichment is between 2.23 to 3.14 weight percent U-235 and 2.66 weight percent U-235 for core reload with an enriched uranium weight of 285,483 pounds (129,493 kilograms).
- Cycle 2 (transition) - average batch enrichment is between 4.04 to 4.11 weight percent U-235 and 4.07 weight percent U-235 for core reload with an enriched uranium weight of 141,909 pounds (64,369 kilograms).

- Cycle 3 (transition) - average batch enrichment is between 4.22 to 4.62 weight percent U-235 and 4.34 weight percent U-235 for core reload with an enriched uranium weight of 113,395 pounds (51,435 kilograms).
- Cycle 4 (equilibrium) - average batch enrichment is between 4.05 to 4.58 weight percent U-235 and 4.30 weight percent U-235 for core reload with an enriched uranium weight of 113,417 pounds (51,445 kilograms).

Average batch enrichment is the average enrichment for each fuel assembly comprising a batch of fuel. The enrichment for core reload is the average enrichment for all fuel assemblies loaded in the core which is derived from the mass weighted average for the batches of fuel. The above values are 'beginning of life' enrichment values. Discharged enrichment values will be less at the 'end of life' of the assembly. Assembly enrichment reduction is directly proportional to the assembly burnup.

Discharge burnups for equilibrium cores are approximately between 45,000 MWd/MTU to 59,000 MWd/MTU. The batch average discharge burnups for equilibrium cores is about 52,000 MWd/MTU.

Engineered safety features for the U.S. EPR are designed to directly mitigate the consequences of a design basis accident (DBA) and include the following systems and functions:

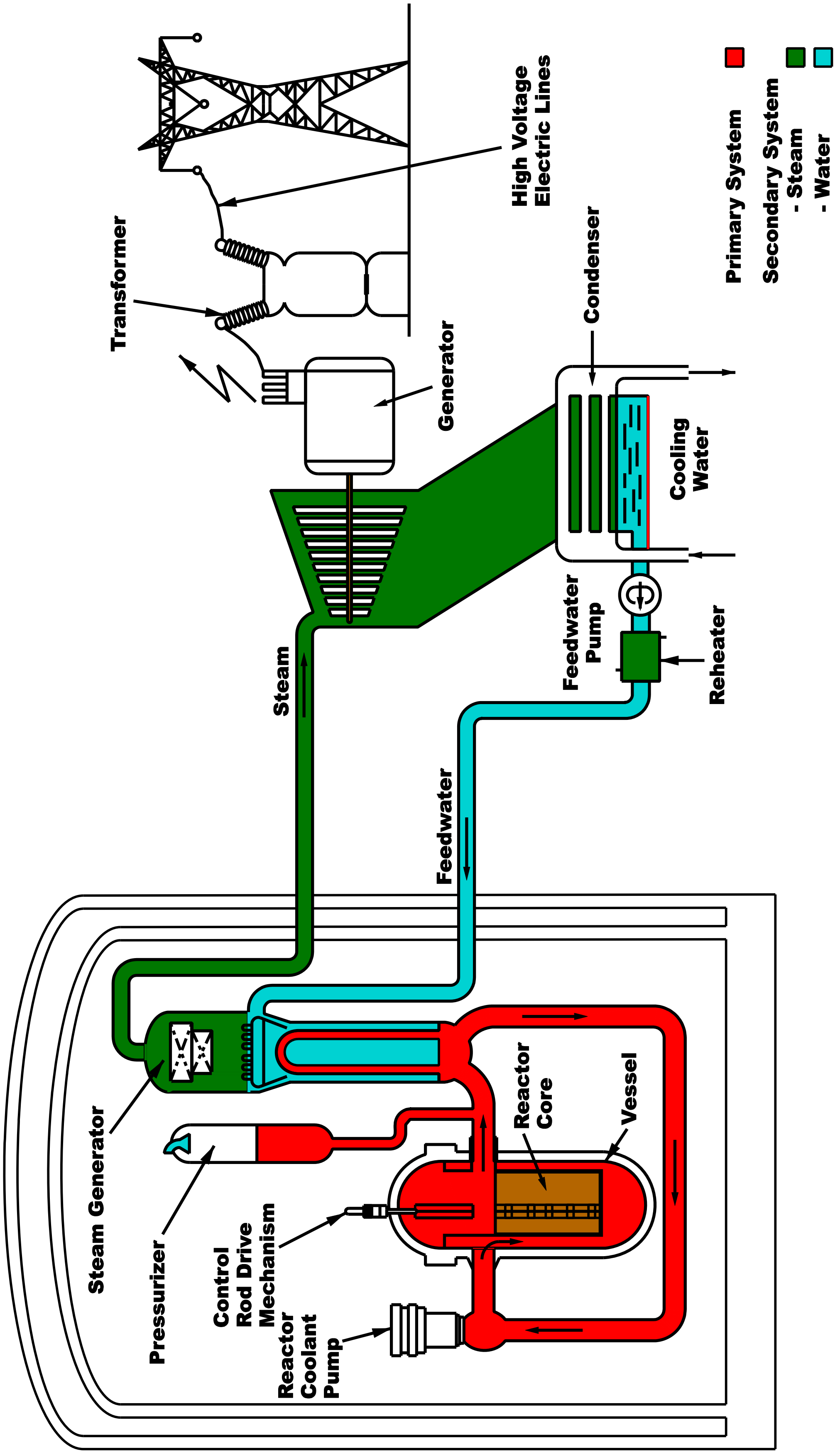
- Containment - provided to contain radioactivity following a loss of coolant accident (LOCA).
- Containment heat removal - associated with the reduction of energy from the containment after a DBA.
- Containment isolation and leakage testing - provided to minimize leakage from the containment.
- Combustible gas control - configured to reduce hydrogen concentrations in order to maintain containment integrity during and immediately following a DBA LOCA.
- Safety injection - designed to provide the emergency core cooling function.
- Control room habitability - designed so that control room occupants can remain in the control room to operate the plant safely under normal and accident conditions.
- Fission product removal and control systems - configured to reduce or limit the release of fission products following a postulated DBA, severe accident or fuel handling accident.
- Emergency heating, ventilation and air conditioning and filtration - provided to reduce radioiodine released as assumed during design basis events.
- Emergency feedwater - designed to supply water to the steam generators following the loss of normal feedwater supplies.
- Control of pH - associated with the control of pH in the containment following a DBA.

The U.S. EPR utilizes a standard nuclear steam turbine arrangement consisting of a tandem compound, six- flow steam turbine, operating at 1,800 revolutions per minute. The generator is an alternating current, synchronous type, with a hydrogen cooled rotor and water cooled stator. The main condenser condenses the steam exhausted from the three low pressure turbine elements, and is a multipressure, three-shell unit with stainless steel tubes and tubesheet overlay. The condenser heat transfer area for all three shells is estimated to be approximately 1.6 million ft^2 (149 thousand m^2).

The operational back pressure range at guaranteed performance (100% load) is based on the condenser operating at 3.20 inches HgA (108.36 mbar), 2.44 inches HgA (82.63 mbar) and 1.85 inches HgA (62.65 mbar) in the high pressure, intermediate pressure and low pressure condenser shells, respectively. For 100% unit load, at the average plant back pressure of 2.5 inches HgA (84.7 mbar), the anticipated turbine heat rate is approximately 9,200 BTU/kW-hr.

Circulating water for the BBNPP is cooled by two closed-loop, natural draft cooling towers.

Figure 3.2-1— Reactor Power Conversion System



3.3 PLANT WATER USE

The Bell Bend Nuclear Power Plant (BBNPP) requires water for cooling and operational uses. Sources for water include the Susquehanna River and municipal water from the Berwick District of Pennsylvania American Water Company (PAW). Water from the Susquehanna River provides makeup water for plant cooling and power plant operations. Municipal water provided by the PAW is used to satisfy the demands of potable, sanitary and miscellaneous plant systems. PAW obtains water from four groundwater wells located in Berwick, PA with a maximum daily capacity of 3,194 gpm (12,090 lpm) (PAW, 2008). Figure 3.3-1 and Table 3.3-1 quantitatively illustrate the average and maximum water flows to and from various plant systems for normal plant operating conditions and normal shutdown/cooldown conditions, respectively. Flow rates for other plant modes are not applicable since there is no change in demand during startup or refueling operating conditions. The average flows represent continuous plant water usage requirements whereas the maximum flows represent intermittent demands. Water use by non-plant facilities includes potable and sanitary needs for administrative buildings and warehouses, and water required for landscaping maintenance. Potable water demand is based on projected staffing during normal plant operation. Other station water users, as noted above, have not been included in the estimated demand. However, the municipal water supply is expected to meet the needs of non-plant facilities, because the potable water main header is designed for peak load provisions.

3.3.1 Water Consumption

Primary water consumption is for turbine condenser cooling. Cooling water for the turbine condenser and closed cooling heat exchanger for normal plant operating conditions is provided by the Circulating Water System (CWS), which is a non-safety-related interface system. Circulating water for condenser heat dissipation is taken from the Susquehanna River and will normally be withdrawn at an average rate of 23,808 gpm (90,113 lpm). A small fraction of the intake water will be used to clean debris from the traveling screens. The CWS discharges the heated water from the condenser to the CWS cooling towers. For the closed-loop CWS cooling towers, approximately two thirds of the water will be lost to the atmosphere as evaporation and to cooling tower drift (i.e., consumptive use). The other third will be released as blowdown. Therefore, the average consumptive use of Susquehanna River water during CWS normal operating conditions will be approximately 6.9 E+08 gallons per month (2.6 E+09 liters per month). Although consumptive rates may fluctuate during droughts, the elevation of pump suction at the BBNPP Intake Structure will be lower than the one day, 100-year low flow water level for the Susquehanna River, allowing for continuous plant operation. Because the pumps and associated electrical equipment are located at an elevation that is above both the 100-year flood level and the flood of record, there will be no high water limit for their operation that would affect water withdrawal during periods of flooding on the Susquehanna River. During normal shutdown/cooldown conditions, the maximum flow of water required by the CWS will be the same as during normal operating conditions.

A secondary source of water consumption is for makeup to the Essential Service Water System and other plant uses. Mechanical draft cooling towers with water storage basins (i.e., one basin for each of the four trains) comprise the Ultimate Heat Sink (UHS) which functions to dissipate heat rejected from the Essential Service Water System (ESWS). The ESWS is vital for all phases of plant operation and is designed to provide cooling water during power operation and shutdown of the plant. Under normal operating and normal shutdown/cooldown conditions, the ESWS cooling tower water storage basins will be supplied with non-safety-related makeup water pumped from the Raw Water Supply System (RWSS) at an average rate of 1,713 gpm (6,484 lpm). The makeup water serves to replenish water losses due to cooling tower evaporation and drift at a rate of 1,142 gpm (4,322 lpm) and 2 gpm (8 lpm), respectively. The remaining water is released to the Susquehanna River as ESWS cooling tower blowdown at an average rate of 569 gpm (2,154 lpm). For normal operation, ESWS water consumption will average approximately 4.9 E+07 gallons per month (1.9 E+08 liters per month). Consumptive rates should not vary during dry periods. During normal plant shutdown/cooldown, when all four trains of the ESWS are operating and assuming a maximum makeup flow rate of 856 gpm (3,242 lpm) for each ESWS cooling tower, the peak water demand will be 3,426 gpm (12,967 lpm). The maximum water flow will be provided by the RWSS and from water stored in the ESWS cooling tower basins. Peak water demand will only be for a short period of time.

The ESWS cooling towers are connected to the remainder of the ESWS through intake and discharge paths. The ESWS takes suction from the ESWS cooling tower basins and cools the Component Cooling Water System (CCWS) heat exchangers. The CCWS is a closed-loop cooling water system that in conjunction with the ESWS provides a means to cool the reactor core, removing heat generated from plant essential and non-essential components connected to the CCWS.

During a design basis accident, the ESWEMS Retention Pond will provide safety-related makeup water for the ESWS cooling tower, for the UHS functions. The ESWEMS Retention Pond is supplied with filtered Susquehanna River water by the RWSS. Because of the nominal surface area of the ESWEMS Retention Pond, evaporation will be minor and vary seasonally. However, since the consumptive rate for accidents is not associated with normal modes of plant operation, this rate is not shown on the water use diagram, Figure 3.3-1.

Sustained RWSS water demand for power plant makeup is 117 gpm (443 lpm) and includes water supplies for the Demineralized Water Distribution System, Floor Wash Drains, and the Fire Water Distribution System. The Demineralized Water Distribution System produces and delivers demineralized water to the power plant for systems that need high quality, non-safety makeup water. Except for containment isolation, the Demineralized Water Distribution System interfaces are non-safety-related. Under normal system operation, water consumption by the Demineralized Water Distribution System is 80 gpm (303 lpm). During normal shutdown/cooldown conditions, water consumption is also anticipated to be approximately 80 gpm (303 lpm). Makeup water to the Demineralized Water Distribution System that is supplied from the RWSS will be pretreated to remove dissolved solids using dual media filters, which will require an additional flow of 27 gpm (102 lpm) to account for filter reject. During normal plant operation, the Potable and Sanitary Water Distribution System supplies consumers with pre-treated water (i.e., Drinking Water Supply) at an average rate of 103 gpm (390 lpm). Due to potential surges in demand, water consumption during normal shutdown/cooldown conditions is anticipated to be 236 gpm (893 lpm). The system provides water for human consumption and sanitary cleaning purposes, and can be used by other systems as a water source. Plant water usage for just non-plant users is estimated to be 10 gpm (38 lpm) during normal plant operation and 20 gpm (76 lpm) during shutdown/cooldown conditions. The Potable and Sanitary Water Distribution System is not connected with any radioactive source or other system which may contain substances harmful to the health of personnel. Failures in the Potable and Sanitary Water Distribution System will have no consequences on plant operation or safety functions. Similarly, the Fire Water Distribution System is classified as a non-safety system. It is required to remain functional following a plant accident, to provide water to hose stations in areas containing safe shutdown equipment. Water consumed by the Fire Water Distribution System during normal conditions is required to maintain system availability. The maximum consumptive rate accounts for system actuation. During normal operation, water consumed by the Fire Water Distribution System is due to system leakage and periodic testing. The maximum consumptive rate is based on meeting the National Fire Protection Association (NFPA)'s requirements for replenishing fire protection water storage. The average and maximum flows for powerplant floor wash drains are anticipated to be the same.

Miscellaneous low volume waste generated by demineralizer makeup reject, other BBNPP plant systems, and treated radiological liquid waste are discharged at a combined average rate of 77 gpm (292 lpm). This equates to an average consumptive rate of 40 gpm (151 lpm) for power plant makeup, or 1.7 E+06 gallons per month (6.5 E+06 liters per month). As previously stated, water consumption may vary during drought conditions. Also, as previously stated, there will be no high water limit due to flooding. Maximum water flow required for power plant makeup during normal shutdown/cooldown conditions is 737 gpm (2,790 lpm).

Prior to discharge into the Susquehanna River, CWS cooling tower and ESWS cooling tower blowdown, and miscellaneous low volume waste are directed to the Combined Waste Water Retention Pond. Wastes resulting from the backwash of the RWSS filtration system and reject from the Demineralized Water Distribution System filtration equipment will also collect in the Combined Waste Water Retention Pond. RWSS Pump Strainer Cleaning Water Discharge and River Intake Screen Cleaning Water are directly discharged to the Susquehanna River. The Combined Waste Water Retention Pond serves as an intermediate discharge reservoir. During plant startup, startup flushes and chemical cleaning wastes will first collect in temporary tanks or bladders, and will then be discharged into the Combined Waste Water Retention Pond. Treated liquid radwastes are discharged downstream of the Combined Waste Water Retention Pond directly to the final plant discharge.

Total water demand for the Susquehanna River during normal operations is 25,729 gpm (97,383 lpm). From this total, 8,654 gpm (32,755 lpm) is returned to the Susquehanna River from the Combined Waste Water Retention Pond and 11 gpm (42 lpm) from treated liquid radwaste. Consumptive water losses are 17,024 gpm (64,311 lpm) from evaporation and drift in the CWS and ESWS cooling towers and 40 gpm (151 lpm) for power plant systems. Therefore, the total average consumptive use of Susquehanna River water during normal operating conditions will be approximately 7.37 E+08 gallons per month (2.8 E+09 liters per month).

Section 2.3.2 provides a discussion of permitted activities associated with plant water consumption. Section 4.2 provides a discussion of limitations and restrictions on water consumption during construction activities.

3.3.2 Water Treatment

Water treatment will be required for both influent and effluent water streams. The source of cooling and plant makeup water for BBNPP will be Susquehanna River water. Table 3.3-2 lists the principal water treatment systems and treatment operating cycles. The types, quantities and points of addition of chemical additives to be used for water treatment are also indicated.

The Circulating Water Treatment System provides treated water for the CWS and consists of three phases: makeup treatment, internal circulating water treatment and blowdown treatment. Makeup treatment will consist of a biocide (i.e., sodium hypochlorite) injected into Susquehanna River water influent at the BBNPP Intake Structure to minimize microbiological growth and control fouling in service water piping. Treatment for internal circulating water components (i.e., piping between the cooling towers and condensers) may utilize existing power industry control techniques consisting of intermittent chlorination for no more than two hours per day, acid addition for alkalinity and pH control, and the addition of scale and corrosion inhibitors. Treatment will improve makeup water quality and allow for increased cycles of concentration in the cooling towers. The use of water treatment chemicals will be regulated under a National Pollutant Discharge Elimination System (NPDES) discharge permit. Blowdown treatment will depend on water chemistry, but is anticipated to include the application of a dechlorination chemical (i.e., sodium bisulfite) at the Combined Waste Water Retention Pond outlet to reduce the effluent concentration of residual chlorine.

The RWSS Water Treatment System provides treated water for the ESWS and power plant makeup, including the Demineralized Water Distribution System and the Fire Water Distribution System. Raw water from the Susquehanna River is pumped from the intake pumphouse, which is shared with the CWS intake pumps, to the Water Treatment Building, and then filtered to remove suspended solids. Dual media filters comprised of silica sand and anthracite will be used to treat the raw Susquehanna River water. Raw water makeup to the RWSS at the intake pumphouse will receive the same treatment as described above for the CWS. Zebra mussels have been observed along the North Branch of the Susquehanna River, therefore chemical treatment may be required for their control.

The ESWS water chemistry will be maintained by the ESWS Water Treatment System, which is a nonsafety-related system designed to treat water received from the RWSS for normal operating and normal shutdown/cooldown conditions. Treatment of internal circulating water, and blowdown will be similar to the Circulating Water Treatment System described above. During design basis accident conditions, the ESWS Water Treatment System is assumed to be non-operational.

Filtered Susquehanna River water from the RWSS will receive additional treatment from the Demineralized Water Treatment System, which provides demineralized water to the Demineralized Water Distribution System. During normal operation, demineralized water is delivered to power plant consumers. In addition to meeting secondary and primary water chemistry specifications for the U.S. EPR, treatment techniques will meet makeup water treatment guidance set by the Electric Power Research Institute, and may include reverse osmosis, ion-exchange demineralization, and the addition of corrosion inhibitors.

The Potable and Sanitary Distribution System will utilize municipal water supplied by PAW. PAW will deliver water that meets the Commonwealth of Pennsylvania's potable (drinking) water program and the standards of the U.S. EPA for drinking water quality under the National Primary Drinking Water Regulation (NPDWA) and National Secondary Drinking Water Regulation (NSDWA). The system will be designed to function during normal operation and outages (i.e., shutdown).

As described below, liquid wastes refers to waste water. Liquid wastes generated by the plant during all modes of operation will be managed by the Liquid Waste Storage System and the Liquid Waste Processing System. The Liquid Waste Storage System collects and segregates incoming waste streams between radioactive and non-radioactive sources, provides initial chemical treatment of those wastes, and delivers them to one or another of the processing systems. The Liquid Waste Processing System separates waste waters from radioactive and chemical contaminants. The treated water is returned to the Liquid Waste Storage System for monitoring and eventual release. Chemicals used to treat waste water for both systems include sulfuric acid for reducing pH, sodium hydroxide for raising pH and an anti-foaming agent, complexing agent and/or precipitant for promoting settling of precipitates.

Sanitary Waste Water from the plant will be discharged to the Berwick Area Joint Sewer Authority via a lift station that will pump sanitary waste to a sewer main on U.S. Route 11.

Effluents from water treatment systems discharged to the Susquehanna River will meet chemical and water quality limits established in the National Pollutant Discharge Elimination System (NPDES) permit for BBNPP. Section 5.2 provides a discussion on effluent limitations and permit conditions.

3.3.3 References

PAW, 2008. 2007 Annual Water Quality Report, Berwick, PWS ID: PA4190013, Pennsylvania American Water, 2008.

Table 3.3-1— Anticipated Water Use

(Page 1 of 2)

Water Streams	**Average Flow [a] gpm (lpm)**	**Maximum Flow [b] gpm (lpm)**
Susquehanna River Water Demand	25,729 (97,384)	28,179 (106,656)
BBNPP Intake Structure Screen Cleaning Water [c]	---	---
Raw Water Supply System (RWSS)	1,921 (7,271)	4,371 (16,544)
RWSS Pump Strainer Cleaning Water [c]	---	---
RWSS Filter Backwash [d]	91(344)	208 (787)
Essential Service Water System(ESWS)/Ultimate Heat Sink (UHS) Makeup [e, f]	1,713 (7,124)	3,426 (12,967)
ESWS Cooling Tower Evaporation [f]	1,142 (4,322)	2,284 (8,645)
ESWS Cooling Tower Drift [f]	2 (8)	4 (15)
ESWS Cooling Tower Blowdown [f]	569 (2,154)	1,138 (4,307)
Power Plant Makeup	117 (443)	737 (2,790)
Demineralized Water Distribution System [g]	107 (405)	107 (405)
Fire Water Distribution System [h]	5 (19)	625 (2,366)
Floor Wash Drains	5 (19)	5 (19)
ESWEMS Retention Pond [c]	---	---
Circulating Water System (CWS) [i]	23,808 (90,113)	23,808 (90,113)
CWS Cooling Tower Evaporation [i]	15,872 (60,076)	15,872 (60,076)
CWS Cooling Tower Drift [i]	8 (30)	8 (30)
CWS Cooling Tower Blowdown [i]	7,928 (30,007)	7,928 (30,007)
Municipal Water Demand (PAW) (Groundwater)	103 (390)	236 (893)
Potable and Sanitary Water Distribution System [j]	103 (390)	236 (893)
Plant Users [k]	93 (352)	216 (818)
Non-Plant Users [l]	10 (38)	20 (76)
Effluent Discharge to Susquehanna River	8,665 (32,797)	9,367 (35,454)
Combined Waste Water Retention Pond Discharge [m]	8,654 (32,755)	9,356 (35,412)
RWSS Filter Backwash Discharge	91 (344)	208 (787)
Miscellaneous Low Volume Waste [n]	39 (148)	55 (208)
Demineralizer Feed Filter Reject [g]	27 (102)	27 (102)
ESWS Cooling Tower Blowdown	569 (2,154)	1,138 (4,307)
CWS Cooling Tower Blowdown	7,928 (30,007)	7,928 (30,007)
Startup Temporary Storage Discharge [o]	---	---
Treated Liquid Radwaste [m]	11 (42)	11 (42)
River Intake Screen Cleaning Water Discharge [c]	---	---
RWSS Pump Strainer Cleaning Water Discharge [c]	---	---
Effluent Discharge to Municipal Sewer (Berwick Area Joint Sewer Authority)		
Sanitary Waste [p]	103 (390)	236 (893)
Consumptive Water Losses (Surface Water and Groundwater)	17,064 (64,587)	18,812 (71,203)
ESWS Cooling Tower Evaporation [f]	1,142 (4,322)	2,284 (8,645)
ESWS Cooling Tower Drift [f]	2 (8)	4 (15)
CWS Cooling Tower Evaporation [i]	15,872 (60,076)	15,872 (60,076)
CWS Cooling Tower Drift [i]	8 (30)	8 (30)
Power Plant Systems [q]	40 (151)	644 (2,438)

Table 3.3-1— Anticipated Water Use

(Page 2 of 2)

Water Streams	Average Flow [a] gpm (lpm)	Maximum Flow [b] gpm (lpm)
Key: gpm - gallons per minute lpm - liters per minute Notes: a. Average flow represents the expected water consumptive rates and returns for normal plant operating conditions. b. Maximum flow represents water consumptive rates and returns during normal shutdown/cooldown. c. Makeup flows and discharges associated with river intake screen cleaning, RWSS pump strainer cleaning, and the ESWEMS Retention Pond during normal operations and shutdown/cooldown are anticipated to be minimal. d. It is assumed that less than 5% of the RWSS flow will be used as filter backwash e. Two trains will be operating under normal conditions and four trains during shutdown/cooldown. Refer to Section 3.4.1.2. f. The ESWS cooling tower evaporation rate is identified in U.S. EPR FSAR Table 9.2.5-2. Makeup and blowdown flows are calculated based on the assumption that the cooling towers will operate at 3 cycles of concentration. g. It is assumed that makeup water from the RWSS to the Demineralized Water Distribution System will require treatment with filters prior to other treatment steps and that approximately 25% of the makeup flow will be discharged as filter reject water. h. During normal operating conditions, water consumed by the Fire Water Distribution System is attributed to system leakage and periodic testing. The maximum consumptive rate is based on meeting the National Fire Protection Association's requirement for replenishing fire protection water storage. i. Average and maximum evaporation, drift and blowdown flows for the CWS cooling tower are based on the assumption that the tower will operate at 3 cycles of concentration. j. The average and maximum water demand of the Potable and Sanitary Water Distribution System is estimated based on the sum of the continuous flows calculated for the Power Plant and the sum of the continuous flows plus the maximum process-related intermittent flow, respectively. k. The average flow for potable and sanitary water demand is based on projected staffing during normal plant operation. l. Non-plant water users include potable and sanitary needs for administrative buildings and warehouses, and water required for landscaping maintenance. Non-plant water users have not been included in the estimated demand. However, the municipal water supply is expected to accommodate other station water users since the potable water main header is designed for a peak load. m. Treated liquid radwaste will not be discharged to the Combined Waste Water Retention Pond. Rather, it will be piped to a discharge line downstream of the retention pond. n. Average and maximum flows for miscellaneous low volume waste are estimated as the sum of miscellaneous low volume wastes and discharges from Other Plant Systems. o. Startup effluents occur during plant startup; the effluents will be stored within tanks or bladders, which will be removed once startup is complete. Makeup and discharge flows associated with startup are anticipated to be minimal. p. Maximum flow for sanitary waste is taken as the design flow under normal plant operating conditions. q. The consumptive water loss from power plant systems is estimated at 40 gpm (151 lpm).		

Table 3.3-2— Water Treatment Systems

(Page 1 of 2)

System	Operating Cycle(s)	Points of Addition	Chemical Processed	Estimated Total Amount Used per Year
Circulating Water Treatment System[a]	Normal Operating Conditions and Normal Shutdown/ Cooldown	CWS Makeup/Water Intake CWS Piping CWS Blowdown/ Retention Pond Outlet	Oxidizing Biocide (Sodium Hypochlorite)	248,033 gal (938,805 l)
			Deposit Control Agents (organic phosphonate and acrylate copolymer)	172,929 lbs (78,440 kg)
			Biofilm Control Agent	172,929 lbs (78,440 kg)
			Sulfuric Acid	3.43 million lbs (1.56 million kg)
			Dechlorinator (Sodium Bisulfite)	86,464 lbs (39,220 kg)
ESWS Water Treatment System (ESWS System) [c]	Normal Operating Conditions and Normal Shutdown/ Cooldown	ESWS Piping ESWS Blowdown/ Retention Pond Outlet	Oxidizing Biocide (Sodium Hypochlorite)	17,855 gal (67,581 l)
			Deposit Control Agents (organic phosphonate and acrylate copolymer)	12,411 lbs (5,630 kg)
			Biofilm Control Agent	12,411 lbs (5,630 kg)
			Sulfuric Acid	246,740 lbs (112,154 kg)
			Dechlorinator (Sodium Bisulfite)	6,205 lbs (3,373 kg)
RWSS Water Treatment System [d]	Normal Operating Conditions and Normal Shutdown/ Cooldown	RWSS Makeup/Water Intake RWSS Filters	Oxidizing Biocide (Sodium Hypochlorite)	2,190 gal (8,289 l)
Liquid Waste Storage System and Liquid Waste Processing System [e, f]	Normal Operating Conditions and Normal Shutdown/ Cooldown	Influent Waste Water	Sulfuric Acid Sodium Hydroxide	22,900 gal (86,686 l) 2,400 gal (9,085 l)
Demineralized Water Treatment System [g]	Normal Operating Conditions and Normal Shutdown/ Cooldown	Demineralized Water Distribution System Makeup	Sulfuric Acid Sodium Hydroxide	2,650 gal (10,031 l) 2,400 gal (9,085 l)

Key:
gal - gallons
l - liters
lb - pounds
kg - kilogram

Table 3.3-2— Water Treatment Systems

(Page 2 of 2)

Notes:

a. The Circulating Water System has no safe shutdown or accident mitigation functions. Sodium hypochlorite will typically be added to makeup water. Sodium hypochlorite and dispersant may be added to piping. Chlorine may also be added to piping for prevention of legionella. The estimated quantities of chemical additives are totals used throughout the Circulating Water Treatment System.

b. The estimated dosage rates were calculated as described in Section 3.6.

c. During a Design Basis Accident, the ESWS Water Treatment System is assumed to be non-operational. The estimated quantity of chemical additives is a combined total for the chemicals used in the ESWS.

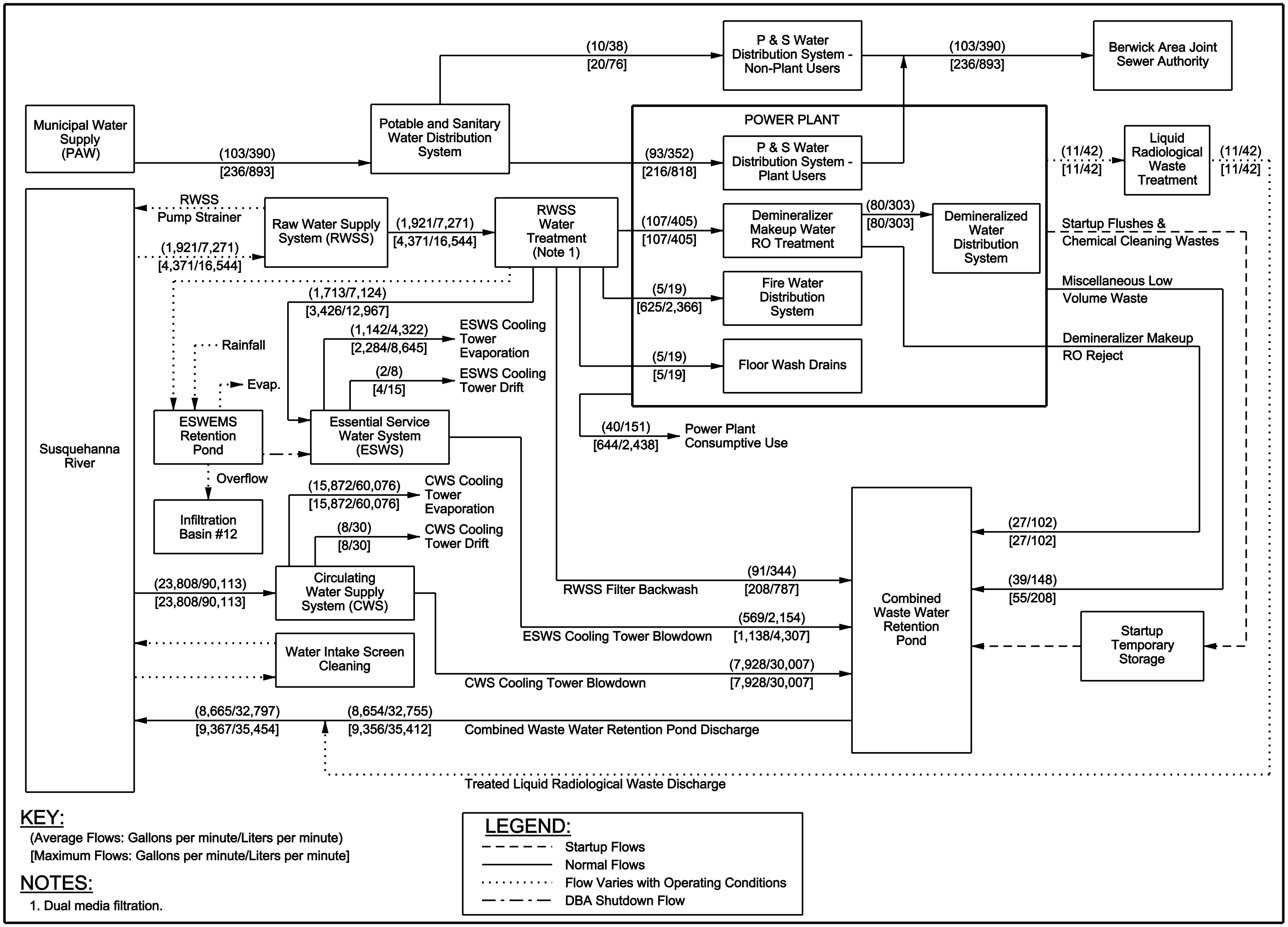
d. RWSS has no safe shutdown of accident mitigation functions. Sodium hypochlorite will typically be added to makeup water. Sodium hypochlorite and dispersant may be added to piping. The estimated quantity of chemical additives is a combined total for the chemicals used in the RWSS.

e. Types and estimated quantities of chemical additives are based on those used at an existing plant.

f. An anti-foaming agent, complexing agent and/or precipitant may also be used to promote settling of precipitates.

g. The estimated quantities of chemical additives are based on the existing CCNPP Units 1 and 2 Demineralized Water Treatment System which uses the indicated chemicals for the regeneration of condensate demineralizers. The actual quantities of chemical additives will depend on how the demineralizer for BBNPP will be used (i.e., full-flow demineralizers use higher quantities).

Figure 3.3-1— Anticipated Water Use Diagram



KEY:
(Average Flows: Gallons per minute/Liters per minute)
[Maximum Flows: Gallons per minute/Liters per minute]

NOTES:
1. Dual media filtration.

3.4 COOLING SYSTEM

The Bell Bend Nuclear Power Plant (BBNPP) cooling system design, operational modes, and component design parameters are determined from the U.S. EPR design documents, site characteristics, and engineering evaluations. The plant cooling systems and the anticipated cooling system operational modes are described in Section 3.4.1. Design data and performance characteristics for the cooling system components are presented in Section 3.4.2. These characteristics and parameters are used to assess and evaluate the impacts on the environment. The environmental interfaces occur at the intake and discharge structures and the cooling towers. There are two cooling systems that have intakes and cooling towers. These systems are the Circulating Water System (CWS) and the Essential Service Water System (ESWS). Figure 3.4-1 is a general flow diagram of the cooling water systems for BBNPP. The BBNPP Intake Structure houses both the CWS makeup water pumps and the Raw Water Supply System (RWSS) pumps which provide makeup water to the ESWS.

3.4.1 Description and Operational Modes

3.4.1.1 Circulating Water System/Auxiliary Cooling Water Systems

The U.S. EPR uses a Circulating Water System (CWS) to dissipate heat. A closed-cycle, wet cooling system is used for BBNPP. The BBNPP system uses two non-plume abated natural draft cooling towers for heat dissipation. The CWS at BBNPP dissipates up to $1.0\text{x}10^{10}$ BTU/hr ($2.52\text{x}10^{9}$ Kcal/hr) of waste heat rejected from the main condenser and the Closed Loop Cooling Water System (CLCWS) during normal plant operation at full station load. The exhausted steam from the low pressure steam turbine is directed to a surface condenser (i.e., main condenser), where the heat of vaporization is rejected to a loop of CWS cooling water. Cooling water from the CWS is also provided to the auxiliary cooling water system. Two 100% capacity auxiliary cooling water system pumps receive cooling water from the CWS and deliver the water to the CLCWS heat exchangers. Heat from the CLCWS is transferred to the auxiliary cooling water system and heated auxiliary cooling water is returned to the CWS. The heated CWS water is sent to the spray headers of the cooling towers, where the heat content of the water is transferred to the ambient air via evaporative cooling and conduction. After passing through the cooling towers, the cooled water is recirculated back to the main condenser and auxiliary cooling water system to complete the closed cycle cooling water loop. The CWS has nominal flow rate of 720,000 gpm (2,725,496 lpm).

Evaporation in the cooling towers increases the level of solids in the circulating water. To control solids, a portion of the recirculated water must be removed or blown down and replaced with clean water. In addition to the blowdown and evaporative losses, a small percentage of water in the form of droplets (drift) would also be lost from the cooling towers. Maximum anticipated evaporative losses are approximately 15,872 gpm (60,076 lpm). Maximum blowdown is approximately 7,928 gpm (30,007 lpm). Maximum drift losses are about 8 gpm (30 lpm) based upon 0.001% of the CWS nominal flow rate. Makeup water from the Susquehanna River is required to replace the 23,808 gpm (90,113 lpm) losses from evaporation, blowdown and drift.

CWS makeup water pumps will be installed in the BBNPP Intake Structure located east of the BBNPP power block on the west bank of the Susquehanna River. The makeup water is pumped through a common header directly to the common cooling tower basin. Blowdown from the CWS pumps discharge to the Combined Waste Water Retention Pond to provide time for settling of suspended solids and to permit further chemical treatment of the wastewater, if required, prior to discharge to the Susquehanna River. Figure 3.1-1 shows the location of the

BBNPP Intake Structure, cooling towers, Combined Waste Water Retention Pond and discharge.

The CWS water is treated as required to minimize fouling, inhibit scaling on the heat exchange surfaces, to control growth of bacteria, particularly Legionella bacteria, and to inhibit corrosion of piping materials. Water treatment is discussed in Sections 3.3 and 3.6.

3.4.1.2 Essential Service Water System/Ultimate Heat Sink

The U.S. EPR design has a safety-related ESWS to provide cooling water to the Component Cooling Water System (CCWS) heat exchangers located in the Safeguards Building and to the heat exchangers of the emergency diesel generators located in the Emergency Power Generating Buildings. The ESWS is used for normal operations, refueling, shutdown/cooldown, anticipated operational events, design basis accidents and severe accidents. The ESWS is a closed-loop system with four safety-related trains and one non-safety-related dedicated (severe accident) train to dissipate design heat loads. The non-safety-related train is associated with one safety-related train.

Safety-related two-cell mechanical draft cooling towers with water storage basins comprise the Ultimate Heat Sink (UHS) which functions to dissipate heat rejected from the ESWS. The two cells of a ESWS cooling tower share a single basin. The ESWS cooling tower basins are sized to provide sufficient water to permit the ESWS to perform its safety-related heat removal function for up to 72 hours post-accident under worst anticipated environmental conditions without replenishment. After 72 hours have elapsed post-accident, if required, the safety-related Essential Service Water Emergency Makeup System (ESWEMS) pumps may be operated to provide water from the ESWEMS Retention Pond to the ESWS cooling tower basins to maintain water inventory for the 30 day post-accident period as stipulated in Regulatory Guide 1.27 (NRC, 1976).

Each of the four ESWS cooling towers has a dedicated CCWS heat exchanger to maintain separation of the safety-related trains. Each ESWS safety-related train uses a dedicated mechanical draft cooling tower to dissipate heat during normal conditions, shutdown/cooldown, or design basis accident conditions. The non-safety-related train uses its associated safety-related train ESWS cooling tower to dissipate heat under severe accident conditions.

Heated ESWS water returns through piping to the spray distribution header of the ESWS cooling tower. Water exits the spray distribution header through spray nozzles and falls through the tower fill. Two fans provide upward air flow to remove latent and sensible heat from the water droplets as they fall through the tower fill. The heated air will exit the tower and mix with ambient air, completing the heat rejection process. The cooled water is collected in the tower basin for return to the pump suction for recirculation through the system. Each ESWS cooling tower has a dedicated ESWS pump with an additional pump to supply the severe accident train. Table 3.4-1 provides nominal flow rates and heat loads in different operating modes for the ESWS.

The water loss from the ESWS is expected to be 1,713 gpm (6,484 lpm) based on 1,142 gpm (4,322 lpm) from evaporation, 569 gpm (2,154 lpm) from blowdown, and drift loss of 2 gpm (8 lpm) during normal conditions based on two trains operating. The water loss under shutdown/cooldown conditions will be approximately 3,426 gpm (12,967 lpm) based on 2,284 gpm (8,645 lpm) from evaporation, 1,138 gpm (4,307 lpm), from blowdown and drift loss of 4 gpm (15 lpm) with all four ESWS cooling towers in operation. The blowdown from the four ESWS cooling towers will flow by gravity to the Combined Waste Water Retention Pond. The expected ESWS blowdown and makeup rates are based on maintaining three cycles of concentration as discussed in Section 3.6.1, and an evaporation of 571 gpm (2,161 lpm) per ESWS cooling tower.

Makeup water to the ESWS is normally supplied from the Raw Water Supply System (RWSS). The RWSS pumps are located in BBNPP Intake Structure and obtain water from the Susquehanna River. Under post-accident conditions lasting longer than 72 hours, makeup water to the ESWS will be supplied from the safety-related ESWEMS. The safety-related ESWEMS makeup pumps are housed in the safety-related ESWEMS Pumphouse (Figure 3.4-8 and Figure 3.4-9) near the ESWEMS Retention Pond (Figure 3.4-10).

The ESWEMS makeup water will be provided under DBA conditions at a maximum flow rate of approximately 400 gpm (1,515 lpm) to each operating ESWS cooling tower basin to replenish the ESWS inventory losses due to evaporation, drift, and incidental system leakage starting 72 hours post-accident. The ESWS and ESWEMS are discussed in FSAR Sections 9.2.1 and 9.2.5, respectively.

The ESWS water is treated as required to minimize fouling, inhibit scaling on heat exchanger surfaces, to control growth of bacteria (particularly Legionella bacteria) and to inhibit the corrosion of piping materials. Water treatment is discussed in Section 3.3 and Section 3.6. Pumps, valves and other system component materials will be designed for use in a fresh water application.

Figure 3.4-2 shows the preliminary details for the Combined Waste Water Retention Pond.

3.4.1.3 Common Operational Factors

3.4.1.3.1 Station Load Factor

The U.S. EPR is designed to operate with a capacity factor of 95% (annualized), considering scheduled outages and other plant maintenance. For the site, on a long-term basis, an average heat load of 9.5×10^9 BTU/hr (2.40×10^9 Kcal/hr) (i.e., 95% of the maximum rated heat load of 1.0×10^{10} BTU/hr (2.52×10^9 Kcal/hr)) will be dissipated to the atmosphere.

3.4.1.3.2 Susquehanna River Water Temperature

Water temperatures range between 32°F (0°C) and 86.5°F (30.3°C). At BBNPP, in the event water temperature at the intake structure approaches 32°F (0°C), warm water from the discharge of the Combined Waste Water Retention Pond is used for deicing any ice that might have formed at the intake structure. A water level decrease in the BBNPP Intake Structure due to potential icing conditions will be detected by level instrumentation.

3.4.1.3.3 Susquehanna River Water Level

BBNPP will rely on the Susquehanna River for normal makeup water to the CWS cooling towers, ESWS cooling towers, and the ESWEMS Retention Pond. However, BBNPP will not rely on water from the Susquehanna River for safe shutdown, because the basins for the ESWS cooling towers and the ESWEMS Retention Pond contain sufficient storage volume for shutdown loads. BBNPP is not required to be shutdown based on minimum Susquehanna River water level.

The BBNPP plant grade elevation is 719 ft (219 m) msl, which is about 201.64 ft (61.46 m) higher than the highest recorded water level. Therefore, it is anticipated that the Susquehanna

River flooding does not affect the plant. The plant site is dry with respect to major flooding on the Susquehanna River.

3.4.1.3.4 Anti-Fouling Treatment

Bio-fouling is controlled using chlorination or other treatment methods in the CWS cooling tower basin. The chemical addition to the cooling tower ensures that the fill in the cooling tower remains free of biofilms and other organic deposits. Additional means of treating bio-fouling in the makeup water obtained from the Susquehanna River is provided at the BBNPP Intake Structure. Additional pre-treatment of the cooling tower makeup is provided, if required, based on periodic water chemistry sampling. Corrosion inhibitors may also be introduced at these injection points, as required, based on the system piping materials and water chemistry.

Bio-fouling is controlled using chlorination or other treatment methods in the ESWS cooling tower basins. ESWS cooling tower makeup water is normally supplied by fresh water from the RWSS. Under post accident conditions lasting longer than three days, however, the makeup water will be from the ESWEMS Retention Pond. The RWSS makeup water will be subjected to appropriate filtration and treatment as required, based on periodic water chemistry sampling. Corrosion inhibitors may also be introduced at the injection points, as required, based on the system piping materials and water chemistry. Specific chemicals and concentrations are discussed in detail in Section 3.3 and Section 3.6.

Other cooling systems will also be chemically treated to control deposits,corrosion and biological growth. Specific chemicals and concentrations are discussed in detail in Sections 3.3 and 3.6.

3.4.2 Component Description

The design data of the cooling system components and their performance characteristics during the anticipated system operation modes are described in this section. Site-specific estimates are used as the basis for discussion.

3.4.2.1 BBNPP Intake Structure

The BBNPP Intake Structure is the non-safety-related intake structure on the Susquehanna River that houses the non-safety-related CWS makeup pumps, the non-safety-related RWSS pumps, and the makeup water chemical treatment system. The general site location of the BBNPP Intake Structure is shown in Figure 3.4-3. Figure 3.4-4 and Figure 3.4-5 show the BBNPP Intake Structure in more detail. Section 2.3.1.1.1.7 provides information on bathymetry of the Susquehanna River.

The BBNPP Intake Structure is located east of the BBNPP power block on the west bank of the Susquehanna River. The forebay of the intake structure is on the bank of the Susquehanna River, perpendicular to the river's flow to minimize the potential of fish entering the intake structure as shown on Figure 3.4-3. The flow velocities at the intake structure would be less than 0.5 fps (0.15 mps). The area from the river bed to the forebay is designed to allow for gradual transition without excessive turbulence. Dredging in the area immediately in front of the entrance to the intake structure is discussed in Section 5.3.11.

The BBNPP Intake Structure will be an approximately 124 ft (37.8 m) long, 90 ft (27.4 m) wide structure with individual pump bays. Three 50% capacity, vertical shaft CWS makeup pumps provide up to 23,808 gpm (90,123 lpm) of makeup water. Three 50% capacity, vertical shaft RWSS pumps provide for the maximum 4,371 gpm (16,544 lpm) of raw water.

The BBNPP Intake Structure is divided into three bays. Each bay contains one RWSS pump followed by one CWS makeup pump. Water from the river flows into each bay through fixed bar grating and then a traveling screen prior to reaching the RWSS pump and then the CWS makeup pump. There are cross bay stop log slots to permit isolation of pumps on an individual bay basis. Debris collected by the bar grating and the traveling screens will be collected in a debris basin for cleanout and disposal as solid waste. The through-bar grating and through-screen mesh flow velocities will be less than 0.5 fps (0.15 mps). The dual flow type of traveling screens with a flow pattern of double entry-center exit will be used for each bay. This arrangement prevents debris carry over. The screen panels have a mesh size of 0.08 in (2 mm) square. The screen mesh is mechanically rotated above the water for cleaning via spray water. The screen wash system consists of three screen wash pumps that provide a pressurized spray to remove debris from the water screens. There is no need for a fish return system since the flow velocities through the screens are less than 0.5 fps (0.15 mps) in the worst case scenario (minimum bay level with highest makeup demand flow). Aquatic impingement and entrainment are discussed in Section 5.3.1.2.

In order to perform the excavation and construction of the intake structure in dry conditions, a seepage cutoff and retaining walls will be required. A cofferdam will need to be installed in front of the BBNPP Intake Structure to prevent the river flow from entering the excavation. The cofferdam will be driven to refusal into the underlying bedrock to form a seepage cutoff. Utilizing the cellular type cofferdam, the individual steel sheets would be driven in a near circular formation. The initial cells could be installed using a crane and pile driver from the shore. As the work progresses, the crane could be mounted on the cofferdam if it has a sufficient diameter to support the crane. If the cell is too small, then a crane mounted on a barge could be used to drive the sheet piles. As the cells are completed, special interconnecting pieces are installed between the cells to maintain the water tight effect. The stability of the cells is maintained by the friction of the cell on the bottom of the river in conjunction with the lateral resistance provided by the lateral pressure from their embedment in the soil substrate in the river bottom. The barge could be a commercially available barge pushed into position by a small tug or boat capable of navigating the Susquehanna River. If no commercial barges are available, then the barge can be trucked to the site in sections and assembled nearby before floating it to the site. A small boat or tug would be needed to maneuver the barge into position. Jacks or spuds would be needed at the corners of the barge to stabilize it in the river during sheet pile installation. After the barge is fixed in its location, the boat would not be needed until the barge was to be relocated. Thus the effects of the boat would be equivalent to normal river boat traffic. The barge could be located within the area of the excavation for most of the sheet pile installation, thus minimizing the effects of the jacks on the river bottom. The sheet piles would be straight sections and interlock in a near circular formation with interconnecting pieces. Either a drop hammer, hydraulic hammer, or a vibratory hammer will be used to install the sheet pile sections. The circular cells would be designed to be self-supporting in conjunction with the interconnecting pieces to maintain a continuous seepage cutoff. Thus, no additional support piers would be required.

A standard sheet pile wall will then be constructed around the remainder of the excavation and will be tied into the cofferdam for stability and as a seepage barrier. The installation of the cofferdam will occupy some space in the river but will have minimal impact on the river flow. A similar approach would be utilized for the construction of the discharge pipeline and the diffuser. The barge could be set up on the equivalent interior (downstream) side of the cofferdam and thus would have minimal net effect on the Susquehanna River. The area of disturbance for the removal of the cofferdam would be approximately 800 ft (244 m) long (total length of cofferdam around the excavation) by 16 ft (4.9 m) wide (width of cofferdam) for a disturbed area of 12,800 ft^2 (1189 m^2). This area is included in the total disturbed area of 18,900 ft^2 (1755 m^2) for the discharge pipeline discussion in Section 4.3.2.2. The cofferdams are shown on Figure 3.4-11 and Figure 3.4-12. The cofferdam details are discussed in Section 4.3.2.2.

The growth of slime, algae, and other organic materials will be monitored in the intake structure and their components as well as the accumulation of debris on the bar grating and trash rake. Cleaning will be performed, as necessary.

The combined pumping flow rate from Susquehanna River for BBNPP will be a maximum of approximately 31,709 gpm (120,032 lpm) based on a maximum RWSS flow of 7,901gpm (29,909 lpm).

3.4.2.2 Final Plant Discharge

The final discharge consists of cooling tower blowdown from the CWS cooling towers, the ESWS cooling towers, and site wastewater streams. All biocides or chemical additives in the discharge will be among those approved by the U.S. Environmental Protection Agency and the Commonwealth of Pennsylvania as safe for humans and the environment, and the volume and concentration of each constituent discharged to the environment will meet requirements established in the National Pollutant Discharge Elimination System (NPDES) permit. The types and quantities of chemicals used are discussed in Section 3.3 and Section 3.6.

The discharge flow to the Susquehanna River is mainly from the Combined Waste Water Retention Pond. Note that treated liquid radioactive waste will be injected directly into the Combined Waste Water Retention Pond discharge piping. Discharge from the Combined Waste Water Retention Pond occurs through a discharge pipe with a diameter of at least 24 in (61 cm) to the discharge diffuser where there are seventy-two 4 in (10 cm) diameter port holes to distribute the discharge flow into the river. The normal (average) discharge flow will be 8,665 gpm (32,801 lpm) and the maximum discharge flow will be 9,367 gpm (35,458 lpm). This includes the maximum discharge flow from the CWS cooling towers of 7,928 gpm (30,011 lpm) . Figure 3.4-2 shows details for the Combined Waste Water Retention Pond.

The discharge structure will be designed to meet all applicable navigation and maintenance criteria and to provide an acceptable mixing zone for the thermal plume per the Commonwealth of Pennsylvania regulations for thermal discharges. The terminal end of the discharge diffuser is near the southwest bank of the Susquehanna River approximately 825 ft (251 m) south of the BBNPP Intake Structure East-West centerline. The BBNPP discharge pipe and diffuser is aligned parallel to, and approximately 380 ft (116 m) south, of the existing Susquehanna Plant Units 1 and 2 discharge lines. Figure 3.4-3 shows the location of the BBNPP intake structure and discharge lines. The 24 in (61 cm) discharge pipe extends approximately 212 ft (64.6 m), measured perpendicular from the shoreline to the first diffuser port, into the river. Connected to the discharge pipe is a 106.5 ft (32.5 m), as measured from the first to the last port, long diffuser. Figure 3.4-6 shows details of the diffuser pipe. The centerline elevation of the discharge diffuser is Elevation 476 ft (145 m) msl. The diffuser center elevation is approximately 9 ft (3 m) below the probable minimum flow river level as discussed in FSAR Section 2.4.11. The diffuser seventy-two 4 in (10 cm) diameter port holes are spaced center-to-center at 1.5 ft (0.5 m). The height of the port holes above the river bed varies as the river bed elevation varies. The angle of discharge of the port holes is 45 degrees to horizontal. The discharge diffuser will be supported in the river utilizing equally spaced anchors embedded in a 111.5 ft (34 m) long concrete pad as shown on Figure 3.4-6 and Figure 3.4-12. Dredging /excavation along the river bottom will be required for installation of the discharge structure and is discussed in Section 4.3.2.2. Riprap will be placed around the discharge diffuser to resist potential erosion.

The areal extent of the riprap around the diffuser will be approximately 140 feet by 20 feet (2800 square feet), which includes the area comprised of the length of the diffuser plus approximately 10 feet at both ends, approximately 5 feet upstream and 15 feet downstream of the diffuser. The riprap layer extends upstream for a short distance to prevent scour of the material upstream of the concrete pad. The layer extends downstream for a designated distance to prevent scour and undermining from the river flow and the discharge from the diffuser. The riprap is placed so that it does not interfere with the discharge from the diffuser portals.

The riprap consists of durable rock, typically limestone, from nearby sources. The riprap size is selected based on the flow conditions in the river and the size of the bedding material to prevent piping of the smaller sized bedding material. The sizing of the riprap will be performed during final design when the gradation of the existing river bottom material is available. The thickness of the riprap layer will be approximately 1.5 times the largest size of stone used to ensure that there is more than one piece of stone over the bedding material.

Since the excavation for the diffuser is performed within the limits of a cofferdam, the work is performed under dry conditions after the river water is pumped out. After the concrete pad, diffuser, anchors, and soil backfill are installed, the riprap is placed using a backhoe or similar equipment. The riprap is lowered to within a short distance above the bedding and carefully placed on the bedding in one continuous uniform lift. The riprap is not dropped to prevent damage to either the riprap or the diffuser pipe. This careful placement of the riprap results in a fairly uniform thickness for the protection of the pipe and its foundation.

Since the placement of the riprap is performed under dry conditions within the limits of the cofferdam, it will not cause any additional disturbance to the river during construction. The riprap is placed so that it does not interfere with the discharge from the diffuser portals. Thus, the top of the riprap will be lower than the top of the diffuser pipe and will not inhibit the flow of the river after removal of the cofferdam. The riprap will therefore have no additional effect on the river characteristics. Because of the larger size of the material, it will not contribute to any increase in suspended solids in the river flow.

Any potential scouring of the river bed by the flow from the discharge diffuser is discussed in FSAR Section 2.4.11. Fish screens are not required on the diffuser since there will always be flow through the discharge piping, even during outages, to maintain discharge of treated liquid radioactive waste within the concentration limits of the applicable local, Commonwealth, and Federal requirements. The length of the diffuser flow after exiting the nozzle is approximately 54.1 ft (16.5 m). Thermal modeling of the discharge is discussed in Section 5.3.2.

3.4.2.3 Heat Dissipation System

The CWS cooling towers are used as the normal heat sink. The two CWS cooling towers are natural draft cooling towers that each have a concrete shell rising to a height of approximately 475 ft (145 m). Internal construction materials include polyvinyl chloride (PVC) for piping laterals, polypropylene for spray nozzles, and PVC for fill material. Natural draft towers use drawn air conduction across sprayed water to reject latent and sensible heat from the sprayed water to the atmosphere. The CWS cooling towers will dissipate a maximum waste heat load of up to approximately 1.0×10^{10} BTU/hr (2.52×10^{9} Kcal/hr) from the unit, operate with a 17°F

(9.4°C) approach temperature, and maintain a maximum 90°F (32°C) return temperature at design ambient conditions. Table 3.4-2 provides specifications of the CWS cooling towers. The two cooling towers occupy a total area of approximately 8.8 ac (3.6 ha). EPA noise guidelines and local noise standards are discussed in Section 5.3.4.2. The estimated noise generated from the cooling towers operation has been modeled to assess the impact to the nearby community and beyond the site boundary as discussed in Section 5.8.1.3. Figure 3.1-3 shows the location of the CWS cooling tower. Figure 3.1-2 depicts the planned natural draft towers, while Figure 3.4-7 provides an elevation view of a typical natural draft tower for BBNPP.

The ESWS cooling tower is a rectilinear mechanical draft structure. Each of the four ESWS cooling towers are a counterflow, induced draft tower and are divided into two cells. Each cell uses one fan, located in the top portion of the cell, to draw air upward through the fill, counter to the downward flow of water. One operating ESWS pump supplies flow to both cells of an operating ESWS cooling tower during normal plant operation. Table 3.4-1 provides system flow rates and the expected heat duty for various operating modes of the ESWS cooling towers. The ESWS cooling towers are designed to maintain a maximum 92°F (33°C) return temperature to the supplied heat exchangers during normal operation, (95°F (35°C) during both design basis accident and severe accident conditions, and 90°F (32°C) during Shutdown/ Cooldown. Temperature rise through the ESWS heat exchangers will be approximately 15.3° F (8.5° C) during normal operation and 14.3° F (7.9° C) during cooldown operation based on the heat transfer rates defined in Table 3.4-1. Blowdown from the ESWS cooling towers is mixed with CWS blowdown. The ESWS cooling towers are located on either side of the power block (two ESWS cooling towers per side), to provide spatial separation, with each ESWS cooling tower occupying an area of approximately 0.37 acres (0.15 hectares). EPA noise guidelines and local noise standards are discussed in Section 5.3.4.2. The estimated noise generated from the cooling towers operation has been assessed in Section 5.8.1.3. Table 3.4-3 provides specifications of the ESWS cooling towers. Figure 3.1-7 provides a layout for the ESWS cooling towers.

3.4.3 References

NRC, 1976. Ultimate Heat Sink for Nuclear Power Plants, Regulatory Guide 1.27, Revision 2, Nuclear Regulatory Commission, January 1976.

Table 3.4-1— Minimal and Nominal Essential Service Water System Flows and Heat Loads at Different Operation Modes Per Train

	Minimum Flow (gpm / lpm)*	Nominal Flow (gpm / lpm)*	Heat Transferred (BTU/ hr / Kcal/hr)	Anticipated Number of Trains Operating
Normal Operation (Full Load)	17,340 / 65,639	19,075 / 72,206	165 E6 / 416 E5	2
Cooldown	17,340 / 65,639	19,075 / 72,206	182 E6 / 459 E5	4
Design Basis Accident	17,340 / 65,639	19,075 / 72,206	313 E6 / 789 E5	2
Severe Accident	2,420 / 9,160	2,665 / 10,088	55 E6 / 139 E5	1

Note:
*Based on a mass flow (lbm/hr) converted to gpm using water properties at 14.7 psia (101.4 kPa) and 60°F (15.56°C)

Table 3.4-2— Circulating Water System Cooling Tower Design Specifications

Design Conditions	**Natural Draft Cooling Towers**
Number of Towers	2
Heat Load	1.0E+10 BTU/hr (2.52E+9 Kcal/hr)
Circulating Water	720,000 gpm (2,725,497 lpm)
Cycles of Concentration - Normal	3
Approximate Dimensions - Height	475 ft (145 m)
Approximate Dimensions - Diameter	350 ft (107 m) (at the base)
Design Dry Bulb Temperature	81°F (27.2°C) (summer)
Design Wet Bulb Temperature	73°F (22.8°C) (summer)
Design Range	27.6°F (15.3°C)
Design Approach	17°F (9.4°C)
Air Flow Rate (at ambient design point)	54,850,000 cfm (1,553,000 m^3/min)
Drift Rate	<0.001%

Note:
*Based on a mass flow (lbm/hr) converted to gpm using water properties at 14.7 psia (101.4 kPa) and 60°F (15.56°C)

Table 3.4-3— Essential Service Water System Cooling Tower Design Specifications

Number of Towers	**4**
Heat Load	See Table 3.4-1
Essential Service Water	See Table 3.4-1
Cycles of Concentration - Normal	3
ESW Cooling Tower Structure Approximate Dimensions - Height	96 ft (29 m)
ESW Cooling Tower Structure Approximate Dimensions - Length	158 ft (48.2 m)
ESW Cooling Tower Structure Approximate Dimensions - Width	102 ft (31.1 m)
Design Dry Bulb Temperature	98.55°F (37°C) (summer) / 25°F (-3.9°C) (winter)(1)
Design Wet Bulb Temperature	81°F (27.2°C) (summer) / 24.3°F (-4.3°C) (winter)(2)
Design Range	18.4°F (10.2°C)
Design Approach	7°F (3.9°C)
Air Flow Rate (at ambient design point)	1,213,000 cfm (3,438 m^3/min)
Drift Rate	<0.005%

Notes:
(1) Based on tower design at 50% relative humidity
(2) Includes 1°F (0.56°C) for recirculation

Figure 3.4-1— General Cooling System Flow Diagram for BBNPP

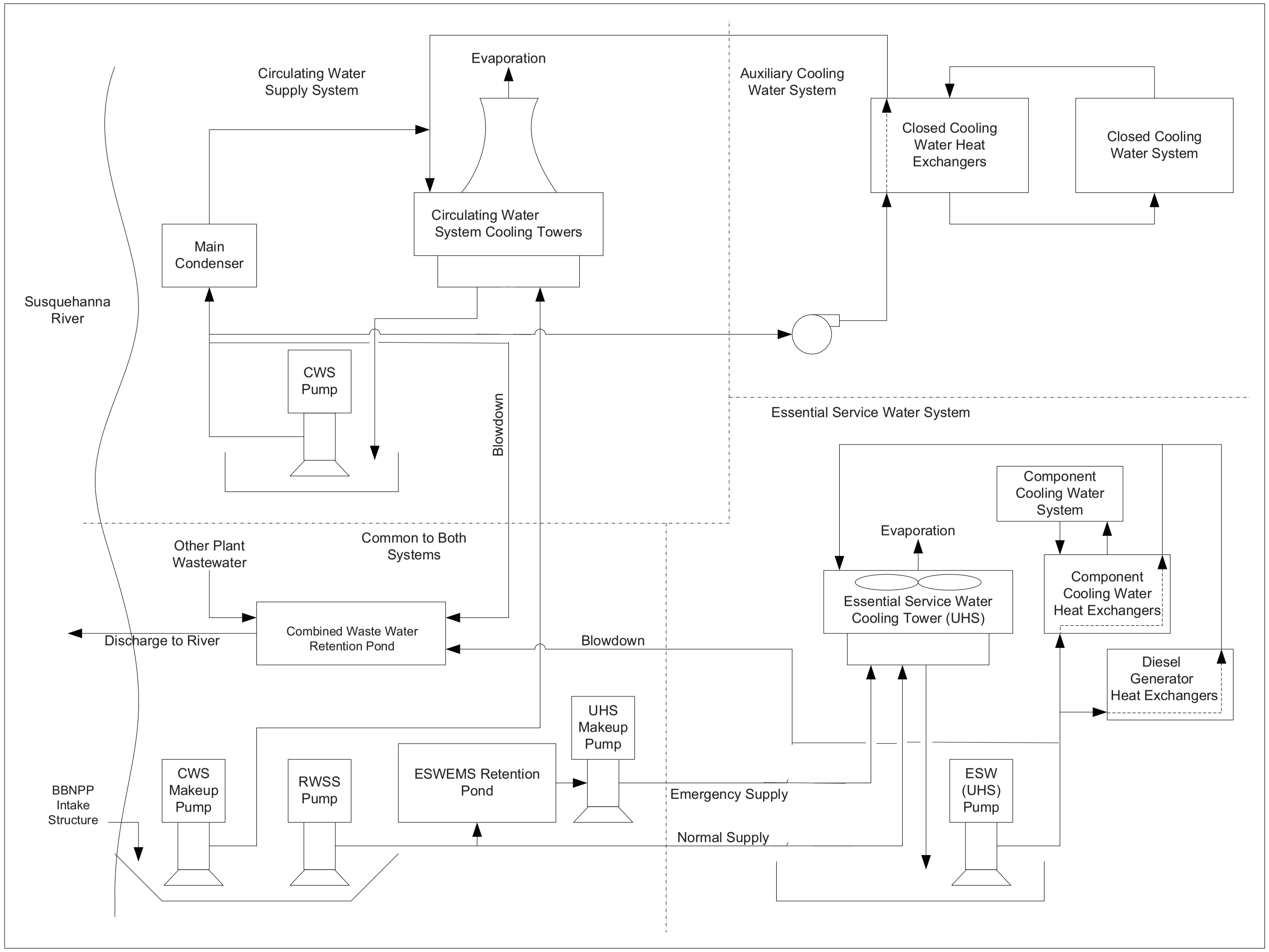


Figure 3.4-2— View of Combined Waste Water Retention Pond for BBNPP

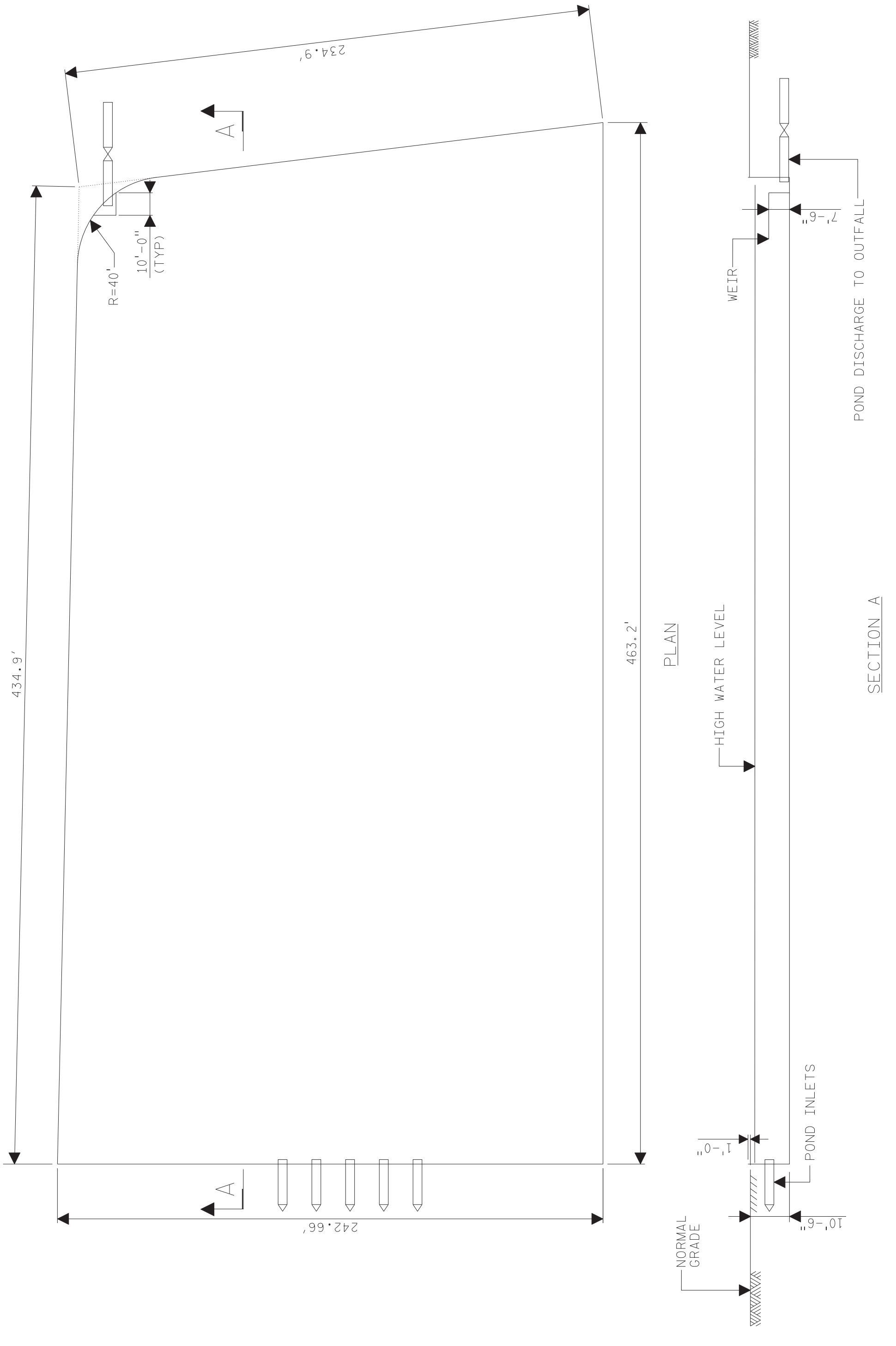


Figure 3.4-3— Circulating Water System Intake/Discharge Structure Location Plan

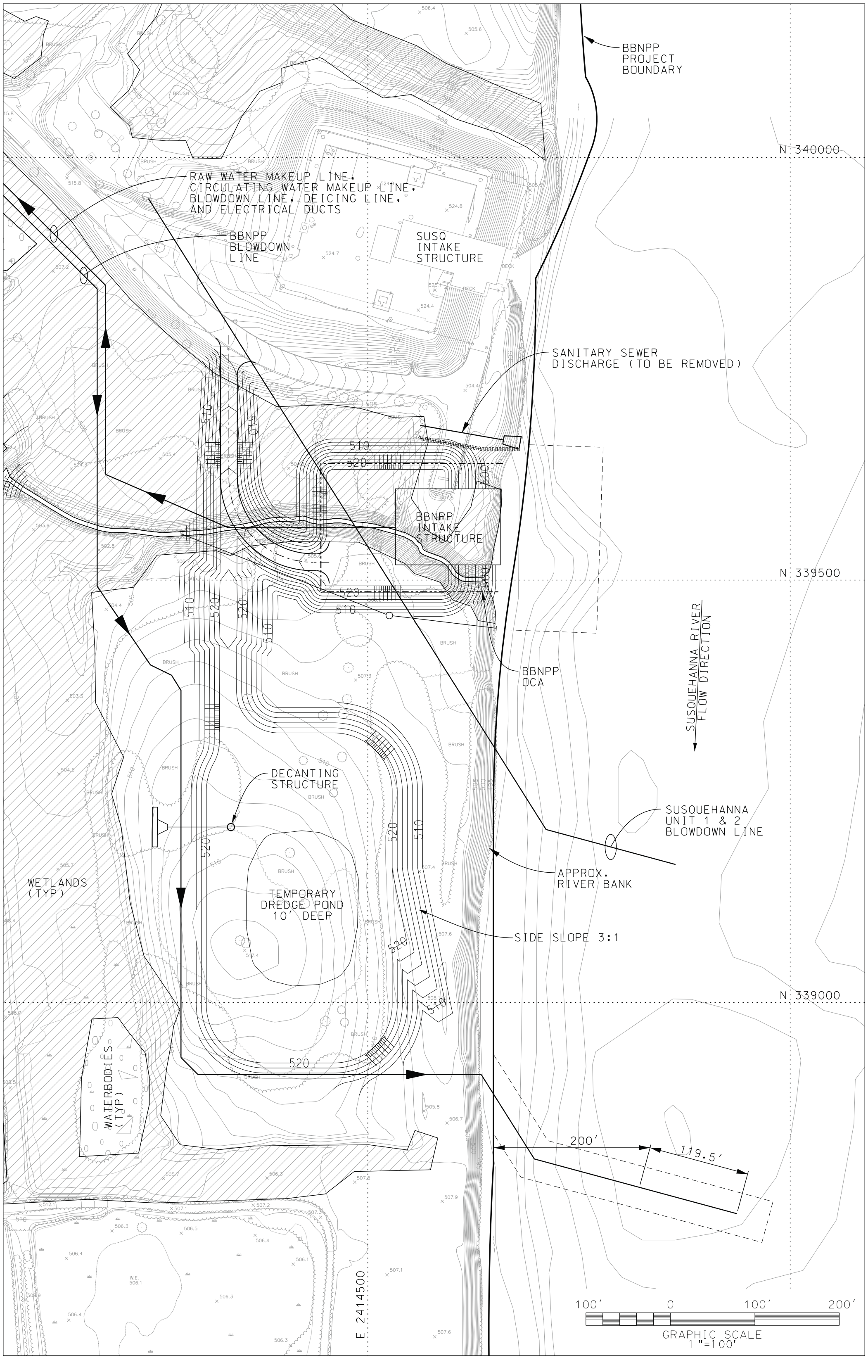


Figure 3.4-4— Plan View of BBNPP Intake Structure

This figure contains security related information and has been withheld under 10 CFR 2.390 (d)(1)

See Part 9 of the COLA Application

Figure 3.4-5— Section View of BBNPP Intake Structure

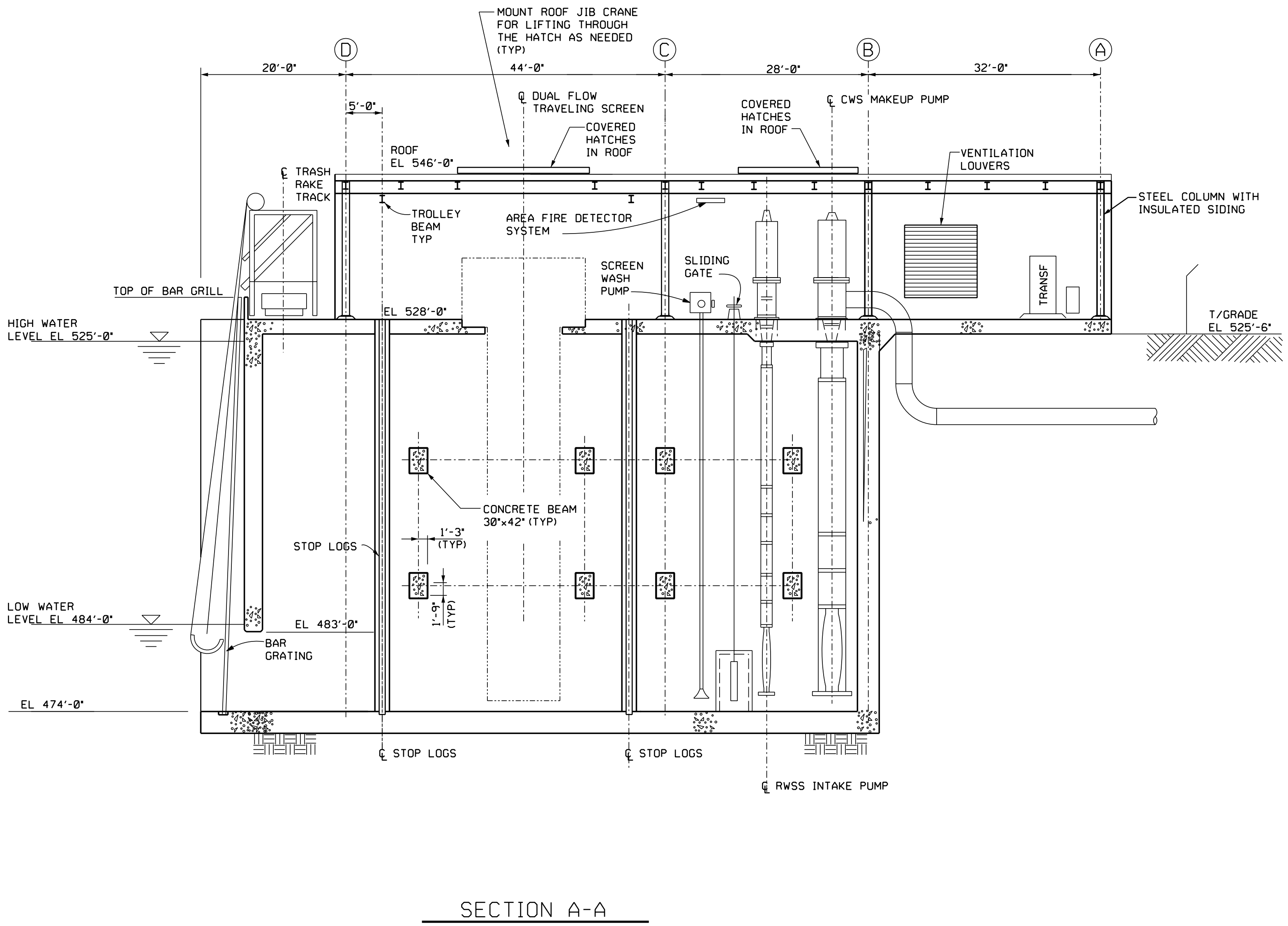


Figure 3.4-6— View of Discharge Outfall for Discharge System for BBNPP

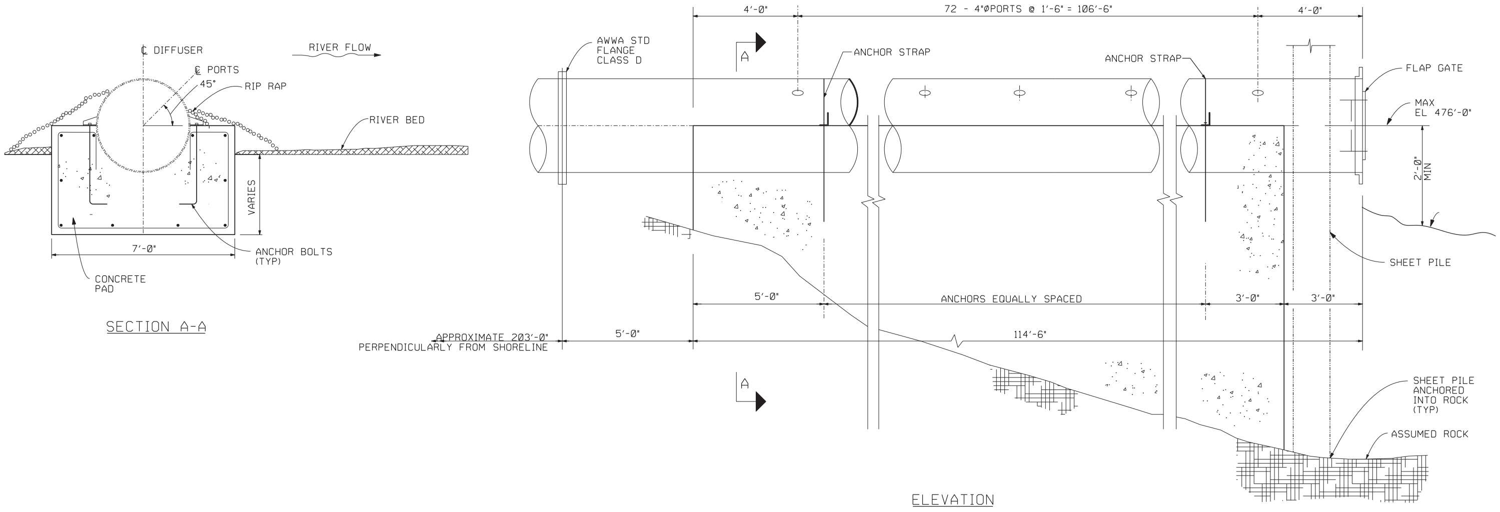


Figure 3.4-7— CWS Cooling Tower Elevation View

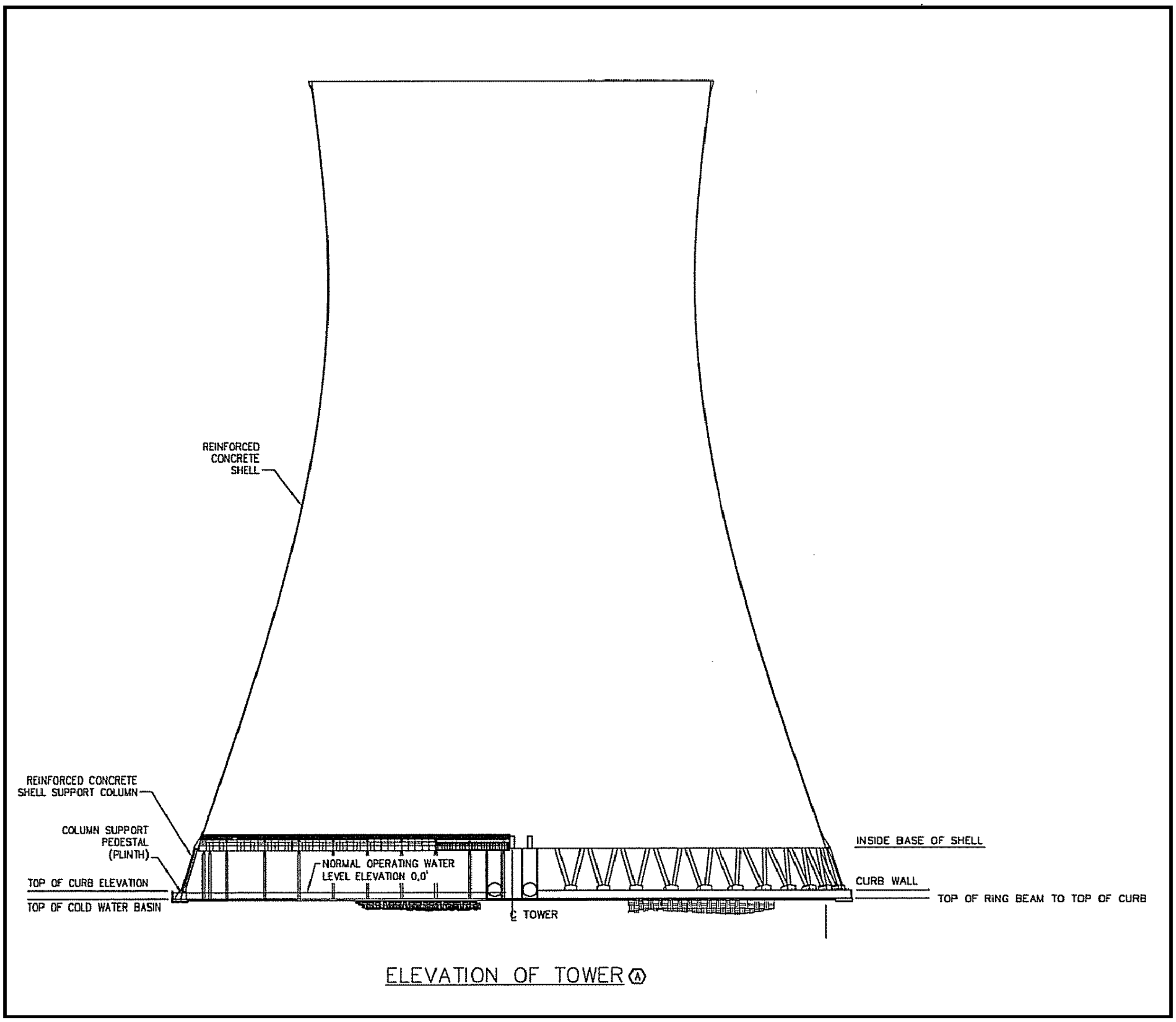


Figure 3.4-8— Plan View of ESWEMS Pumphouse

This figure contains security related information and has been withheld under 10 CFR 2.390 (d)(1)

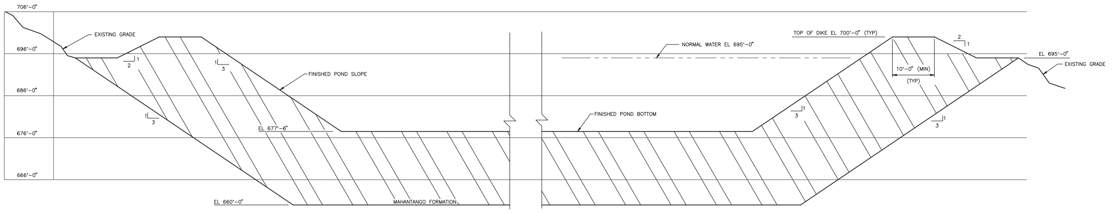
See Part 9 of the COLA Application

Figure 3.4-9— Section View of ESWEMS Pumphouse

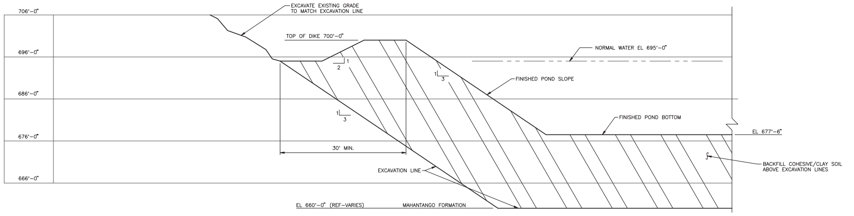
This figure contains security related information and has been withheld under 10 CFR 2.390 (d)(1)

See Part 9 of the COLA Application

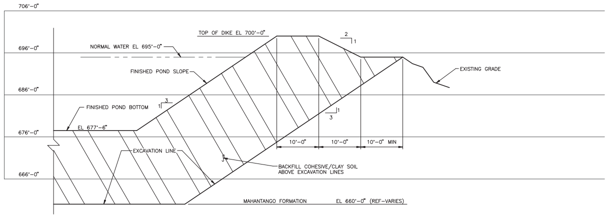
Figure 3.4-10— ESWEMS Retention Pond



SECTION 1 (SIMILAR)
SECTION AT EMBANKMENT OR WITHOUT EMBANKMENT
SEE DWG S1101



SECTION 2 (CASE 1)
TYPICAL CROSS–SECTION NO EMBANKMENT
SEE DWG S1101

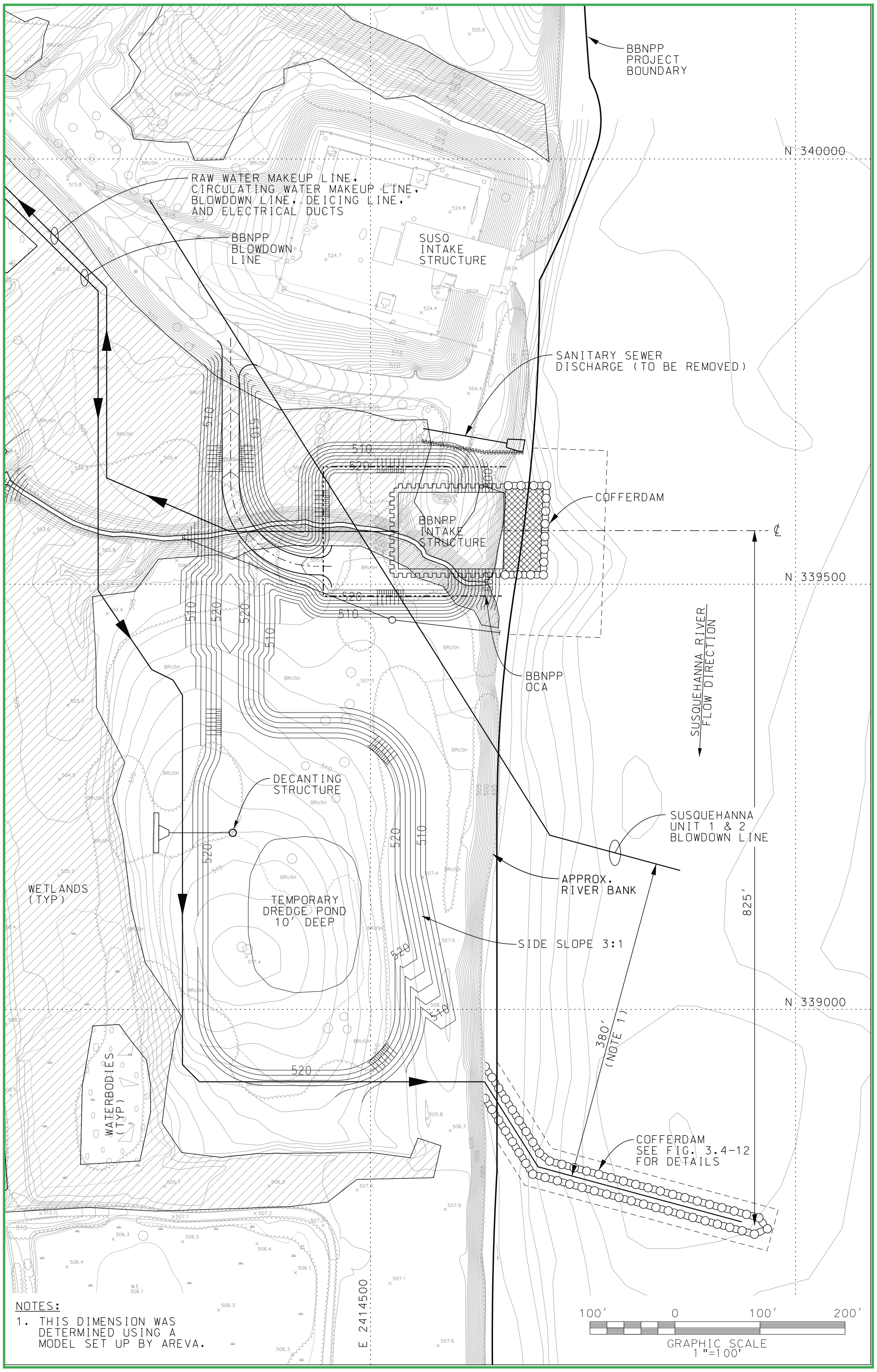


SECTION 2 (CASE 2)
TYPICAL SECTION EMBANKMENT ABOVE GRADE
SEE DWG S1101

NOTES

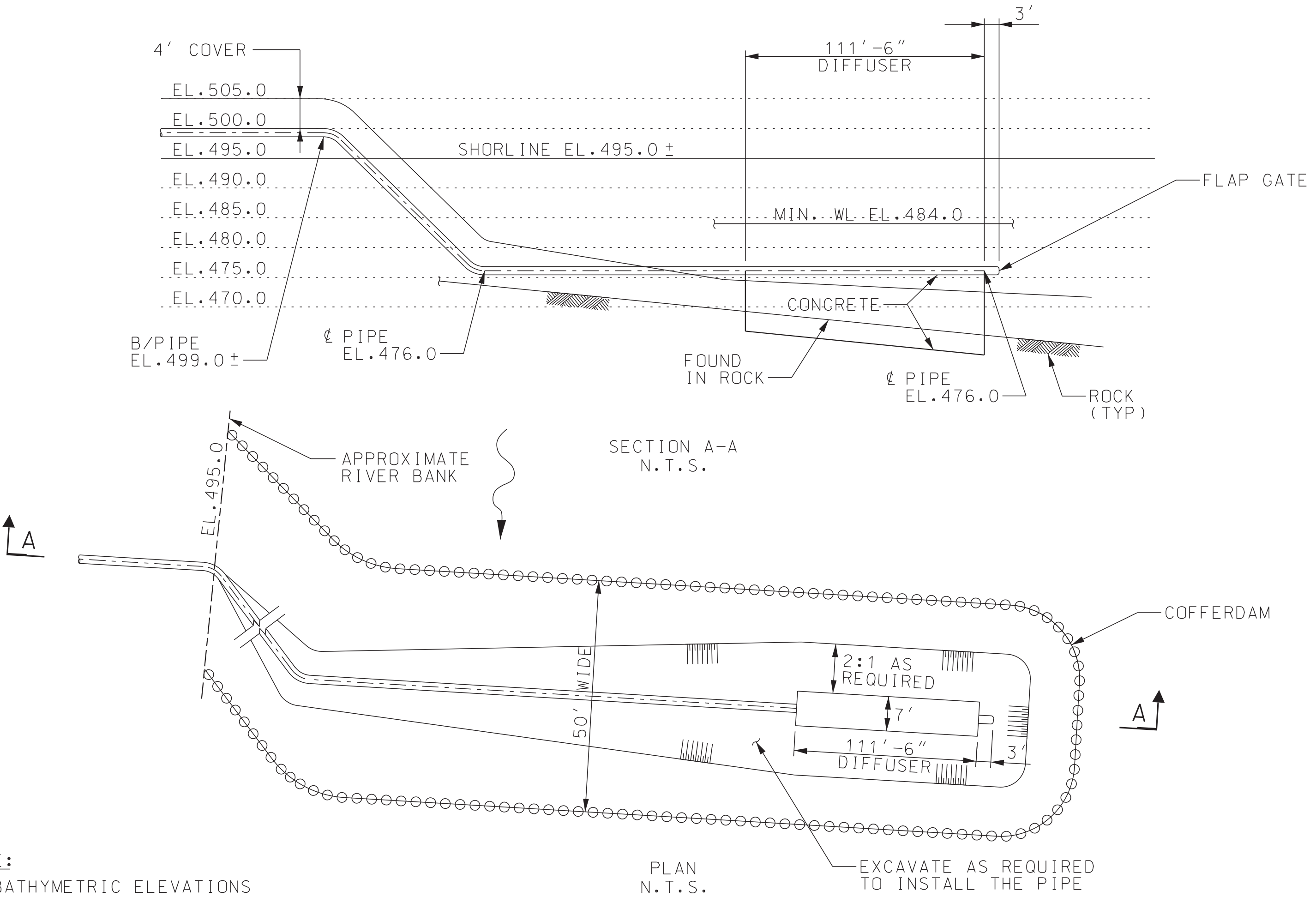
1. SEE DRAWING S1000 FOR GENERAL NOTES.

Figure 3.4-11— BBNPP Intake Structure Construction Cofferdam



NOTES:
1. THIS DIMENSION WAS DETERMINED USING A MODEL SET UP BY AREVA.

Figure 3.4-12— End of Blowdown Line



NOTE:

1. BATHYMETRIC ELEVATIONS ARE APPROXIMATE. A SURVEY TO DETERMINE UNDERWATER TOPOGRAPHY AND BORINGS WILL BE PERFORMED PRIOR TO DESIGN.

3.5 RADWASTE SYSTEMS AND SOURCE TERMS

The generation of power within the reactor results in the presence of radioactive materials in various forms and quantities within the reactor core, reactor coolant system and associated systems and components. The vast majority of the radioactivity produced (fission products) is completely contained within the clad fuel rods and is therefore not available for release to fluid systems or to the environment. However, if imperfections in the cladding are present a small fraction of these fission products escapes from the affected fuel rods to the reactor coolant. The other main source of radioactivity to the reactor coolant is the corrosion of primary system surfaces and irradiation of the corrosion products within the reactor core.

Fission and activated corrosion product radionuclides within the reactor coolant system constitute the source of radioactivity to associated systems and components. This radioactivity appears in letdown and leakage from these systems and components which, in turn, forms the source of radioactivity in liquid and gaseous discharges from the plant site and in solid waste materials generated within the plant. System effluents are collected, processed, monitored and directed for either reuse or release to the environment by the radioactive waste treatment systems. Solid radioactive wastes are collected and packaged for temporary storage, shipment and offsite disposal.

The design and operational objective of the BBNPP radioactive waste treatment systems is to maintain, during normal operation, the radioactivity content of liquid and gaseous effluents from the site such that the dose guidelines expressed in Appendix I to 10 CFR Part 50 (10 CFR 50.34a) (CFR, 2007a), 40 CFR Part 190 (CFR, 2007b), and 10 CFR 20.1301(d) (CFR, 2007c) are met. The following descriptions of the design and operation of the radioactive waste treatment systems and presentations of the estimated radioactivity content of plant effluents serve to quantify the magnitudes and characteristics of the releases. These releases are then used as the sources for the radiological environmental impact analyses during normal operation, which are presented in Section 5.4 and demonstrate that the radioactive waste treatment systems are designed to keep doses to the public as low as reasonably achievable (ALARA). The dose to the public from radwaste systems during plant operation will meet the dose limits for individual members of the public as specified in 10 CFR 20.1301 (CFR, 2007c).

3.5.1 Source Terms

Source terms used in the evaluation of radwaste systems and effluent releases are discussed in this section. A power level of 4,612 MW(t) is used to calculate source terms based on the guaranteed core thermal output of 4,590 MW(t) plus a 22 MW(t) (approximately 0.5%) uncertainty allowance for heat balance measurements.

3.5.1.1 Primary and Secondary Coolant Source Terms

Two sets of source terms (reactor coolant radionuclide concentrations) have been determined. The first is a conservative design basis used for waste system performance calculations. This source term is based on the assumption that the primary coolant radionuclide concentrations are made up of a combination of proposed technical specification limits for halogens (1 µCi/gm Dose Equivalent (DE)-I-131 in primary coolant) and noble gases (210 µCi/gm DE-Xe133). Activation products and tritium concentrations are derived from the ANSI/ANS 18.1-1999 standard (ANS, 1999). Since the activated corrosion products are independent of failed fuel fraction, design basis and realistic basis concentrations for activated corrosion products are assumed to be the same. Design basis values for the remaining fission product radionuclides are calculated based on a 1.0% failed fuel fraction. The mathematical model used is described in the U.S. EPR Final Safety Analysis Report (FSAR), Tier 2, Section 11.1. Table 3.5-1 lists key design basis parameters used in the source term calculation for the primary coolant.

Table 3.5-2 summarizes the design basis reactor coolant concentration results. Design basis secondary coolant concentrations are based on an assumed primary to secondary leak rate totaling 600 gpd (2,271 L/d) from all four steam generators. Table 3.5-3 summarizes the secondary coolant liquid and steam phase radioactivity concentrations for design basis conditions.

The second source term is based on a realistic model in which the reactor coolant radionuclide concentrations are based on observed industry experience. The model used is described in Regulatory Guide 1.112 (NRC, 2007a), with the source term calculated using NUREG-0017, Revision 1 (NRC, 1985), which contains the Nuclear Regulatory Commission Pressurized Water Reactor (PWR) Gale Code. Specific parameters used in the calculation are provided in Table 3.5-4.

The resulting radioactivity concentrations in the reactor coolant are listed in Table 3.5-2. The inventories calculated in this manner represent "expected basis" activities and are used for the evaluation of environmental impacts during routine operation, including anticipated operational occurrences. The data presented in Table 3.5-2 do not include a shutdown iodine spike. Design basis accident analyses include iodine spikes and are discussed in Section 7.1.

Tritium is produced in the reactor mainly through the interaction of neutrons with soluble boron in the coolant. Additional contributions come from the ternary fissions and from the interaction of neutrons with burnable poison rods, lithium and deuterium. Some of the tritium formed within fuel materials will be present in the reactor coolant due to diffusion and leakage through the fuel cladding. For the U.S. EPR design, the expected tritium production rate in the Reactor Coolant System is approximated by the sum of the liquid tritium release rate of 1,660 Ci/yr (6.14E+13 Bq/yr) (U.S. EPR FSAR, Table 11.2-4) and the gaseous tritium release rate of 180 Ci/yr (6.66E+12 Bq/yr) (U.S. EPR FSAR, Table 11.3-3), which is 1,840 Ci/year. The concentration of tritium in the reactor coolant is provided in Table 3.5-2.

Radioactivity enters the spent fuel pool due to contamination by reactor coolant during refueling operations and possible fission product releases from spent fuel during the storage period. These radionuclides are continuously removed through the spent fuel pool purification train and the building ventilation filtration system. Therefore, the radioactivity in the spent fuel pool area is not a major source of environmental releases (except for tritium and noble gases). Activity concentrations in the fuel pool and atmosphere are listed in Table 3.5-5.

See the U.S. EPR FSAR, Tier 2, Section 11.1 for further information regarding the development of the source term.

3.5.1.2 Transported Source Terms

The radioactivity in the reactor is transported to various locations in the plant through plant fluid systems and leakages. A schematic diagram of the radwaste effluent flow paths is provided on Figure 3.5-1.

Normal plant operation is anticipated to result in a certain degree of radioactivity within the secondary coolant systems through primary-to-secondary steam generator tube leakage. With steam generator tube defects present, radioactivity will be released to the environment through steam leakage, condensate leakage, and main condenser off gases. The concentrations of radionuclides in the secondary coolant system are based on ANSI/ANS-18.1-1999 (ANS, 1999) for the reference PWR with U-tube steam generators. The results are shown in Table 3.5-3. The radioactivity present in the reactor coolant and secondary coolant is further transported through various radwaste systems and become source terms for environmental releases.

Liquid Source Terms

The following sources are considered in calculating the release of radioactive materials in liquid effluents from normal operations:

a. Processed water generated from the boron recovery system to maintain plant water balance and for tritium control,

b. Processed liquid waste from the containment building sump, floor drains from the auxiliary building, spent fuel building and radwaste building, laboratory drains, sampling drains, and other controlled area drains, and miscellaneous waste,

c. Unprocessed liquid waste from the turbine building floor drain sumps.

The radioactivity input to the liquid radwaste treatment system is based on the flow rates of the liquid waste streams and their radioactivity levels expressed as a fraction of the primary coolant activity. Table 3.5-6 shows the liquid waste flow rate and activity level. The table indicates radioactivity in each stream as a fraction of primary coolant activity prior to treatment and the decontamination factors applied to waste processing and effective decay time while passing through treatment systems.

Isotopic distribution for various waste streams is shown in Table 3.5-7 for the liquid waste system.

Gaseous Source Terms

The following sources are considered in calculating the releases of radioactive materials (noble gases, iodines and particulates) in gaseous effluents from normal operation:

Containment purges (continuous),

Non-condensable gases from the gaseous waste system,

Nuclear auxiliary building(s) ventilation,

Radwaste, Spent Fuel and Safeguard Buildings, Ventilation

Turbine building ventilation,

Main condenser evacuation exhaust.

Any leakage of primary coolant or the process stream either in the containment or in the auxiliary buildings are collected in the buildings and vented through filtration systems to the environment. Any steam/water leakages in the turbine building are directly vented to the environment. The non-condensable gases will be also discharged through the main condenser evacuation system exhaust to the plant stack.

The estimated releases, by isotope, from each source are shown in Table 3.5-8 for normal operation. This table is based on the expected basis source term information presented above and assumptions and parameters in Table 3.5-4.

Solid Source Terms

The following sources are considered in calculating the solid waste generated within the plant. Solidified radioactive waste results from the processing of materials from the following sources:

a. Evaporator concentrates from:

    Liquid waste evaporator

    Boron recovery evaporator

    Liquid waste centrifuge

b. Spent resin from:

    Spent fuel pool demineralizer

    Reactor coolant purification treatment ion exchangers

    Liquid waste system demineralizers

    Boron recycle system ion exchanger

c. Liquid from decontamination solutions

d. Spent radioactive filter cartridges from various plant filtering systems and other solid non- compressible radioactive waste.

In addition to solid materials extracted from liquid processing systems, dry active waste (DAW) solids are also generated as the result of collecting low activity compressible waste such as paper, rags (cloth) and polyethylene bags from inside the radiation control area. Non-compressible DAW can include such materials as scrap metal, glass, wood, and soil. Table 3.5-10 summarizes as bounding estimates the annual solid wastes generated.

3.5.2 Radioactive Liquid Processing System

The primary design functions of the Liquid Waste Storage System and the Liquid Waste Processing System are to receive radioactive liquid wastes collected from the various systems and buildings in which they were generated, to process those liquid wastes in a manner that reduces the activity present in the aggregate liquid wastes such that discharges to the environment can be controlled to stay below 10 CFR 20, Appendix B, Table 2 concentration limits (CFR, 2007d), and the ALARA design dose objectives of 10 CFR 50, Appendix I (CFR, 2007a) for members of the public. Discharges to the environment must also meet state and federal limits specified in discharge permits.

Normal plant operation also has the potential to result in a certain degree of radioactivity within the secondary coolant systems due to primary-to-secondary steam generator tube leakage. Blowdown and leakage of secondary coolant then constitutes radioactive liquid sources, the radioactivity contents of which are reduced and/ or accounted for by the steam generator blowdown processing system and the condensate leakage collection system.

Figure 3.5-2 provides a simplified drawing of the Liquid Waste Storage System and the Liquid Waste Processing System. Figure 3.5-3 provides a simplified drawing of the liquid waste treatment system showing the evaporator and centrifuge. Figure 3.5-4 provides a simplified drawing of the Liquid Waste Treatment System showing the vendor supplied demineralizer system.

The discussions that follow describe the design and operation of each of these systems; greater detail can be found in U.S. EPR FSAR, Tier 2, Section 11.2.

3.5.2.1 Liquid Waste System

The U.S. EPR Liquid Waste Storage System and Liquid Waste Processing System are used to manage liquid wastes generated by the plant during all modes of operation. The Liquid Waste Storage System collects and segregates incoming waste streams, provides initial chemical treatment of those wastes and delivers them to one or more of the processing systems. The Liquid Waste Processing System uses evaporation, centrifugal separation, or demineralization and filtration to separate the waste water from the radioactive and chemical contaminants, and to concentrate those contaminants. The cleaned water is returned to one of two waste monitoring tanks in the liquid waste storage system where it is isolated and recirculated to ensure representative samples can be taken and analyzed prior to release to the environment. Once the monitoring tank contents are deemed suitable to be released, the processed liquid is discharged from the monitoring tank to the Susquehanna River via a discharge line with a radiation monitor that will stop the release if unexpected or high radioactivity is detected. The radwaste discharge line for BBNPP connects to the Combined Waste Water Retention Pond discharge line downstream of the basin for added dilution flow before release in the Susquehanna River. The concentrates are also returned to the Liquid Waste Storage System for further concentration and eventual transfer to the radioactive concentrates processing system.

The Liquid Waste Storage System collects liquid wastes from the plant, segregates the wastes based on their expected radioactivity and chemical composition, and stores them in the liquid waste storage tanks accordingly.

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

- water from the Fuel Pool Cooling System and Fuel Pool Purification System transferred through the floor drains of the Nuclear Auxiliary Building,
- waste water from sampling and from process drains and sumps collected in the Nuclear Auxiliary Building,
- waste water drained from the evaporator column in the Liquid Waste Processing System,
- waste water decanted from the concentrate tanks and waste water returned from the radioactive concentrates processing system, and
- waste water collected from the floor drains of the radioactive waste processing building.

Group I wastes are directed to the Group I liquid waste storage tanks.

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

- waste water collected from floor drains and sumps of the Nuclear Auxiliary Building,
- waste water from the hot laboratory transferred through the sumps of the Nuclear Auxiliary Building,
- waste water from the showers and washrooms in the Nuclear Auxiliary Building,
- distillate from the Reactor Coolant Treatment System, and
- treated water returned from the centrifugal separator in the Liquid Waste Processing System.

Provisions exist for collection of Group II wastes from the Steam Generator Blowdown Demineralizing System flushing water. Group II wastes are directed to the Group II liquid waste storage tanks.

Group III wastes are those liquid wastes expected to contain no radioactivity, but some organic or inorganic chemicals, under normal plant operating conditions. Group III waste collection headers are shared with some of the Group II collection headers; the wastes carried in these headers normally are directed to the Group III liquid waste storage tank provided that there are no indications that the waste water contains radioactivity. The "shared" sources are the wastes from the Steam Generator Blowdown Demineralizing System flushing water, and treated water returned from the centrifugal separator in the Liquid Waste Processing System. Provisions also exist for the collection of wastes from some of the floor drains in the radioactive waste processing building.

Since Group III waste liquids normally will have very little or no radioactivity, several of the Group III waste water streams may be routed directly to the monitor tanks in the liquid waste storage system. The Steam Generator Blowdown Demineralizing System flushing water wastes, and the treated water returned from the centrifuge separator in the Liquid Waste Processing System each can be routed directly to the monitor tanks instead of the Group III liquid waste storage tank.

The Liquid Waste Storage System and the Liquid Waste Processing System operate independently of the operating modes of the plant. The systems provide sufficient storage and treatment capacity to process the daily inputs produced during all plant startup, normal operation, plant shutdown, maintenance, and refueling periods. The systems are operated on an as-needed basis throughout the plant operating cycle. From operating experience, the peak volume demand occurs during plant outages, when increased volumes of waste water, in particular the Group II waste water streams, are generated by increased maintenance activities.

The liquid waste storage system includes liquid waste storage tanks, concentrates tanks, and monitoring tanks which temporarily store the liquid wastes at various stages of treatment. It also includes recirculation pumps, a sludge pump, a concentrates pump, and recirculation/ discharge pumps to move the liquid waste between the various tanks. Chemical tanks and chemical proportioning pumps are included to permit the precise mixing and injection of chemicals to treat the liquid waste. Piping and control valves route the liquid wastes between the different tanks and pumps, as well as to several interfaces within the liquid waste processing system.

The liquid waste processing system consists of three separate sections. The evaporator section employs a vapor-compressor type evaporator with a separate evaporator column. The evaporator section also includes evaporator feed pumps, a forced recirculation pump, and a distillate pump to move liquid waste through the evaporation process, several heat exchangers to condition the liquid waste at various stages of the process, and a distillate tank to collect the treated waste water for return to the Liquid Waste Storage System.

The centrifuge section employs both a decanter and a centrifugal separator to separate organic and inorganic contaminants from the waste water. The contaminant 'sludge' is collected in a sludge tank, then pumped to a waste drum for collection and processing as solid waste. The treated water is returned to the Liquid Waste Storage System.

The demineralizer and filtration section includes a demineralizer and an ultra-filtration unit. Piping and control valves allow liquid wastes to be passed through either unit or through both units consecutively; contaminants are retained and the cleaned waste water is returned to the Liquid Waste Storage System. The capacity of the Liquid Waste Processing System is sufficient to process the average quantity of liquid wastes produced weekly in less than half that period of time. The Liquid Waste Processing System consists of three different subsystems, each of which applies a unique process to concentrate and remove radioactive material from liquid wastes. The processes used are evaporation, centrifugal separation, and demineralization/filtration. Because they contains little or no organics and solids, the Group I wastes are processed by evaporation. The evaporator design provides for a flow that is sufficient to allow processing of 1,050 g/hr (3,975 l/hr). This is sufficient capacity to process the entire weekly Group I liquid waste volume in slightly more than 25 hours. Because they contain organics and solids, but little or no activity, the Group II and III waste streams are processed by centrifugal separator. The separator is capable of processing approximately 1,300 g/hr (approximately 4,900 l/hr). This is sufficient capacity to process the entire weekly Group II and Group III liquid waste volume in 63 hours. The demineralizer is capable of processing approximately 2,400 g/hr (approximately 9,100 l/hr) of liquid waste. This is sufficient to process the combined weekly volume of the Group I, II, and III waste streams in about 40 hours.

Both the Liquid Waste Storage System and the Liquid Waste Processing System are located entirely within the radioactive waste processing building. Interfacing system piping delivers influent liquid wastes that originate in the plant drains with potential to contain liquid radioactive waste. Table 3.5-11 lists the storage capacity for each of the liquid waste collection and process tanks. Table 3.5-12 provides expected process rates for components in the waste processing system. Table 3.5-13 provides the flow rates and activity for each main grouping of liquid radioactive waste.

Coolant Treatment System

Normal operating modes of the Coolant Treatment System purify and recycle reactor coolant and separate boron for reuse. However, the control of tritium levels in the Reactor Coolant System necessitates the periodic discharge of reactor coolant letdown after processing by the Coolant Treatment System for the removal of boron and the degasification of noble gas activity. The volume of processed reactor coolant to be discharged from the plant is administratively controlled to maintain tritium concentrations in the coolant system within a selected range. This processed liquid is discharged to the Liquid Waste Storage System and the Liquid Waste Processing System before being released to the environment instead of being recycled. This treatment option is performed in order to maintain reactor coolant tritium levels such that containment entry during both power operation and shutdowns is not unduly limited.

Steam Generator Blowdown Processing System

Control of the steam generator secondary side liquid chemistry is achieved by blowdown and demineralized water makeup. The radioactivity content of this blowdown is dependent on reactor coolant radioactivity levels and the primary-to-secondary leakage rate. The estimated average primary-to-secondary steam generator tube leakage reflected in the GALE source term estimates is 75 lb per day (34 kg per day) (NRC, 1985). The steam generator secondary side blowdown rate associated with this leakage level is 218,400 lbm/hr (99,065 kgm/hr) total for all four steam generators.

The blowdown liquid is routed to the blowdown flash tank. As a result of pressure reduction, approximately 29% of the liquid mass flashes to steam. The steam-water mixture is separated in the flash tank. The overhead steam is directed to the deaerator (also called the feedwater tank). The remaining 71% of the flash tank inlet mass (liquid condensate) is routed through two stages of letdown cooling before being processed by the Steam Generator Blowdown Demineralizer System located in the Nuclear Auxiliary Building for cleanup and return to the turbine condenser.

Secondary System Condensate Leakage Collection and Discharge

With radioactivity present in the secondary sides of the steam generators, moisture carryover brings some radioactivity to the remainder of the secondary coolant system. Consequently, leakage of secondary system condensate forms a potential radioactive liquid release source. The amount of radioactivity reaching condensate leakage points is minimized by the high quality of the steam exiting the steam generators so that no processing of condensate leakage before discharge is required. The estimated average volumetric generation rate of this liquid is 5 gpm (19 lpm) at main steam activity. This liquid is discharged from the plant unprocessed, which results in an estimated annual release of 0.00033 curies/yr (1.2E+7 Bq/yr), not including tritium. A central collection point within turbine building is provided to allow sampling and analysis for radioactivity content. The liquid is released from the plant via a monitored pathway (with alarm and trip function on detected high radioactivity) to the Combined Waste Water Retention Pond discharge line down stream of the pond before release to the Susquehanna River.

It is assumed, per the GALE code, that the turbine building floor drains will collect leakage of 7,200 gpd (27,255 lpd) at main steam activity (NRC, 1985). The leakage collected in the floor drain sump is directly discharged to the environment without treatment. Should monitors detect excess radiation in the sump, the sump is isolated for evaluation.

3.5.2.2 Liquid Release to the Environment

The radioactivity inputs to the liquid waste system release calculations are provided in Table 3.5-6. The expected annual liquid release source terms based on the U.S. EPR GALE code model are summarized in Table 3.5-7.

Releases from Anticipated Operational Occurrences

Liquid effluent annual average radioactivity releases due to anticipated operational occurrences are summarized in Table 3.5-15. The additional unplanned liquid release due to anticipated operational occurrences is estimated to be 0.16 Ci/year for the U.S. EPR design based on reactor operating data presented in NUREG 0017 (NRC, 1985). These releases were evaluated to determine the frequency and extent of unplanned liquid release and are assumed to have the same isotopic distributions for the calculated source term of the liquid wastes. The total releases from the anticipated operational occurrences are shown in Table 3.5-16 and are included as part of the "total liquid release source term".

Summary of Radioactive Liquid Release from Normal Operations

Discharge concentrations are listed in Table 3.5-16 and are calculated using a 8,665 gpm (32, 797 lpm) discharge flow rate. The discharge concentrations are compared with effluent concentration limits given in Table 2, column 2 of 10CFR20, Appendix B (CFR, 2007d).

Due to the impracticality of removing tritium on the scale necessary, some tritium present in the reactor coolant system will be released to the environment during plant life time. From the experiences gained at operating PWRs, the total tritium release is estimated to about 0.4 Curies/MWt/year (NRC, 1985). The quantity of tritium released through the liquid pathway is based on the calculated volume of liquid released, excluding secondary system waste, with a primary coolant tritium concentration of 1 µCi/ml up to a maximum of 90% of the total quantity of tritium calculated to be available for release. It is assumed that the remainder of tritium produced is released as a gas from building ventilation exhaust systems. Hence, 1,660 curies (6.14E13 Bq) of tritium are expected to be released to the environment via liquid effluents from BBNPP each year.

3.5.2.3 Liquid Waste System Cost-Benefit Analysis

In addition to meeting the numerical As Low As Reasonably Achievable (ALARA) design objective dose values for effluents released from a light water reactor as stipulated in 10CFR50, Appendix I (CFR, 2007a), the regulation also requires that plant designs include all items of reasonably demonstrated cleanup technology that when added to the liquid waste processing system sequentially and in order of diminishing cost-benefit return, can, at a favorable cost-benefit ratio, effect reductions in dose to the population reasonably expected to be within 50 mi (80 km) of the reactor. Although not required by NRC Regulations, values of $2,000 per person-rem, and $2,000 per person-thyroid-rem are conservatively used as a favorable cost benefit threshold based on NUREG-1530 (NRC, 1995). The source term for each equipment configuration option was generated using the same GALE code as described in Section 3.5.1 along with the same plant specific parameters modified only to accommodate the changes in the waste stream decontamination factor afforded by the design options simulated.

For BBNPP, the dose reduction effects for the sequential addition of the next logical liquid waste processing component (i.e., waste demineralizer) results in a reduction in the 50 mi (80 km) population total body exposure of 0.23 person-rem (0.0023 person-sievert).Section 5.4 describes the population dose calculation for both the base system case of processing liquid waste with an evaporator and centrifuge for Group I and II waste streams, and the augmented system configuration that adds a vendor supplied waste demineralizer for additional processing of the distillate produced by the evaporator and centrifuge. Table 3.5-17 illustrates the relative population dose associated with both base equipment configuration and that associated with the addition of the waste demineralizer subsystem. Table 3.5-18 compares the estimated total body dose reduction or savings achieved for the addition of the demineralizer subsystem along with a conservative estimated cost for the purchase, operating and maintenance (O&M) of the equipment. The cost basis for the equipment option is taken from Regulatory Guide 1.110 (NRC, 1976) and reported in 1975 non-escalated dollars which provides a conservatively low estimate of the equipment cost to today's dollars. A 40 year operating time frame is used although the U.S. EPR is designed for a 60 year operating life. The BBNPP plant license submittal is for 40 years. The site area population within 50 mi (80 km) is based on a projected population in 2060, over 40 years from the estimated start of plant operations. Using the population at the end of plant life is conservative in that it maximizes the collective dose from plant effluents.

For the total body dose reduction, Table 3.5-18 illustrates that the favorable benefit in reduced dose associated with the addition of waste demineralizer system had a dollar equivalent benefit value of $18,400. However, the estimated cost to purchase, operate and maintain this equipment over its operating life was approximately $534,000, thereby resulting in a total body effective benefit to cost ratio of less than 1.0 (not justified on an ALARA basis of dose savings to the public).

In consideration of the collective thyroid dose reduction, Table 3.5-19 illustrates that the favorable benefit in reduced dose associated with the addition of waste demineralizer system had a dollar equivalent benefit value of $12,000. However, the estimated cost to purchase, operate and maintain this equipment over its operating life is the same as shown for the total body dose assessment above, approximately $534,000. This result in a thyroid effective benefit to cost ratio of also less than 1.0 (not justified on an ALARA basis of dose savings to the public).

In assessing if there are any demonstrated technologies that could be added to the plant design at a favorable cost-benefit ratio, a bounding assessment has also been performed which demonstrates that there is insufficient collective dose available to be saved that would warrant additional equipment cost. For the bounding total body collective dose estimate, if an equipment option could reduce the base case population dose to zero, the maximum potential savings in collective dose would be equivalent to $2,000 per person-rem (reference value for favorable benefit from NUREG-1530 (NRC, 1995)) times the life time integrated total body population dose associated with base condition (i.e., 0.385 person-rem/yr x 40 yrs x $2,000 per person-rem = $30,800). For the thyroid collective dose, the savings would be equivalent to $2,000 per person-rem times the life time integrated thyroid population dose associated with base condition (i.e., 0.291 person-rem/yr x 40 yrs x $2,000 per person-rem = $23,280). The assumption of achieving a zero dose does not take into account that tritium in effluents contributes to the dose and that currently available treatment options are ineffective to remove it.

Since the benefit value for both the total body and thyroid to reduce the dose to zero is significantly less than the direct and 40 year O&M cost of the waste demineralizer subsystem option or other options from Regulatory Guide 1.110 (NRC, 1976) not already incorporated in the plant design, the bounding assessment indicates that there are no likely equipment additions that could be justified on an ALARA basis for liquid waste processing.

It should be noted that even though not warranted on a population dose savings basis, a vendor supplied waste demineralizer subsystem skid has been added to the plant design to provide plant operators greater flexibility to process waste liquids by different processes to best match waste stream characteristics, such as chemical form, with the waste process treatment method that best handles the waste from an economics standpoint.

3.5.3 Radioactive Gaseous Treatment Systems

Radioactive gases (such as xenon, krypton and iodine) created as fission products during reactor operation can be released to the reactor coolant through fuel cladding defects along with hydrogen and oxygen that is generated by radiolytic decomposition of the reactor coolant. Since these gases are dissolved in the reactor coolant, they are transported to various systems in the plant by process fluid interchanges. Subsequent reactor coolant leakage releases a portion of these gases and any entrained particulate radioactivity to the ambient building atmosphere.

Fission product and radiolytic decomposition gases released from reactor coolant within the various process systems are handled by the Gaseous Waste Processing System. Radioactive gases or airborne particulates released to the ambient atmosphere in one of the buildings due to system leakage from the process system piping is managed by the combined operation of the Containment Ventilation System, Safeguards Building Controlled Area Ventilation System, Fuel Building Ventilation System, Nuclear Auxiliary Building Ventilation System, and Sampling Activity Monitoring Systems.

The discussions that follow describe the design and operation of each of these systems; greater detail can be found in U.S. EPR FSAR, Tier 2, Section 11.3.

3.5.3.1 System Description and Operations

The Gaseous Waste Processing System and sources are provided in Figure 3.5-5. The Gaseous Waste Processing System combines a quasi-closed loop purge section with a discharge path provided through a carbon bed delay section. The purge section recycles the majority of purge gas after it has been processed. This limits the system demand for makeup purge gas, and also limits the amount of gas that must be discharged through the delay section to the environment.

The purge section includes waste gas compressors, purge gas pre-driers, several purge gas reducing stations, purge gas supply piping to tanks in a number of interfacing systems, purge gas return piping from those tanks, purge gas driers, recombiners, and gas coolers. The purge section also includes a gas supply subsystem, gas measuring subsystems, and compressor sealing subsystems. The purge gas stream consists of nitrogen with small quantities of hydrogen and oxygen, and trace quantities of noble gas fission products.

The carbon bed delay section includes a gel drier, delay beds, a gas filter, and a discharge gas reducing station. The delay section discharges processed gaseous waste to the Nuclear Auxiliary Building Ventilation System for release to the environment via the ventilation exhaust stack.

All the components of the Gaseous Waste Processing System and the majority of the components of connected systems are located in the Nuclear Auxiliary Building. However, there are some connected components that are continually swept by gaseous waste processing purge gas flow that are located in other buildings. The volume control tank and two of seven nuclear island drain and vent systems primary effluent tanks are located in the Fuel Building. Four more nuclear island drain and vent systems primary effluent tanks are located in the four safeguard buildings. The pressurizer relief tank and the reactor coolant drain tank are located in the Reactor Building. Gaseous Waste Processing System piping is routed among the buildings.

The Gaseous Waste Processing System is designed to operate continuously during normal plant operation. For the majority of this time, with the plant operating at full power, the Gaseous Waste Processing System will operate in a steady state mode, with a constant flow rate (0.19 lbm/sec (0.86 kg/sec) for two compressors running), through the purge section, and a small (0.00015 lbm/sec (0.068 gm/sec)), constant discharge rate from the delay section. Figure 3.5-6 depicts the Gaseous Waste Treatment System.

Normal Operation - Purge Section

The circulation of purge gas is maintained by the operation of one or both waste gas compressors. The Gaseous Waste Processing System operates at positive pressures from the waste gas compressors to the reducing stations and the volume control tank, and at sub-atmospheric pressure downstream of the reducing stations through the various connected tanks and the gaseous radwaste processing equipment that returns the purge flow to the suction of the waste gas compressor.

Radioactive fission product gases are collected from the pressurizer relief tank, the reactor coolant drain tank, and the volume control tank. The primary influent source is expected to be the Coolant Degasification System, which extracts both hydrogen and fission product gases from the reactor coolant on a continuous basis. The other major source of influent to the Gaseous Waste Processing System is the reactor coolant drain tank.

Gaseous Waste Processing System purge gas drawn from the connected components is routed through the gaseous radwaste processing equipment. First, the gas drier treats the returning purge gas. The gas drier uses a cooling process to reduce the moisture content in the purge gas.

The recombiner uses a catalytic process at elevated temperature to recombine the free hydrogen and oxygen entrained in the purge gas stream.

The gas cooler cools the purge gas stream at the recombiner outlet. A filter assures that no particulates are carried forward to the waste gas compressor.

The waste gas compressor compresses the incoming purge gas flow, and discharges to the sealing liquid tank.

The sealing liquid tank separates the gaseous and liquid phases from each other. The purge gas leaving the sealing liquid tank is routed to the pre-drier. The pre-drier cools the purge gas to reduce its moisture content by condensation.

The Gaseous Waste Processing System piping branches downstream of the pre-drier, dividing the purge gas flow. One branch supplies purge gas to the pressurizer relief tank and the reactor coolant drain tank. A second branch supplies purge gas flow to the volume control tank. The third branch connects to the delay section.

The purge gas flow in the third branch is joined by the purge gas discharged from the volume control tank, and is then distributed to four parallel paths. These four paths purge radioactive fission product gases from the coolant supply and storage system tanks, the reactor boron and water makeup system, the coolant purification system, the coolant treatment system, the coolant degasification system, the various nuclear island vent and drain system primary effluent tanks (in the Safeguards Buildings, the Fuel Building, and the Nuclear Auxiliary Building), and the Nuclear Sampling System active liquid samples subsystem.

Normal Operation - Delay Section

Only a small quantity of purge flow is sent to the delay beds under normal operating conditions. The remaining quantity is recycled.

The delay beds retain the radioactive fission product gases that enter the delay section. These gases (e.g. xenon and krypton) are dynamically adsorbed by the activated charcoal media in the delay beds, which provides the residence times required for natural decay. For normal operations, the dynamic adsorption coefficients are 70 cm^3/gm (2,000 in^3/lb) for Krypton and 1,160 cm^3/gm (32,110 in^3/lb) for Xenon (NRC, 1985). This equates to an estimated holdup time of 27.7 days for Xenon and 40 hours for Krypton.

The delay beds consist of three vertical pressure vessels connected in series which are maintained at a constant positive pressure to improve the adsorption of waste gases in the activated charcoal media. Two moisture sensors are configured in parallel upstream of the delay beds to provide warning and protective interlock signals if the moisture content of waste gas entering the delay beds exceeds acceptable levels. A radiation sensor is also located upstream of the delay beds to monitor influent activity levels. Two pressure sensors monitor pressure upstream of the delay beds to provide warning signals for high or low operating pressure conditions, and to provide protective interlock signals.

Surge Gas Operation

Operations that transfer large quantities of primary coolant in the systems purged by the Gaseous Waste Processing System automatically place the system into surge gas operation mode. The Gaseous Waste Processing System operates in surge gas mode primarily during plant startup or shutdown.

Surge Gas Operation - Purge Section

Operation of the Gaseous Waste Processing System purge section is not significantly altered by plant operating mode. Purge flow through the components connected to the Gaseous Waste Processing System continues as in normal operating conditions.

Surge Gas Operation - Delay Section

During conditions of excess gas generation, the flow volume to the delay section automatically increases. This increased flow volume is automatically sensed and shifts the section to surge gas operation mode. Surge gas operation mode automatically stops waste gas releases from the Gaseous Waste Processing System via the Nuclear Auxiliary Building Ventilation System until the system is manually reset.

The capacity of the delay section adapts to the increased flow rate during surge gas operation mode because surge gas mode elevates delay section pressure. Higher pressure increases the storage capacity of the delay section and improves the adsorption capabilities of the activated charcoal.

The delay section maintains the required residence time for natural decay of the fission product gases during surge gas operation mode by virtue of the increased capacity arising from the elevated operating pressure.

Surge gas operation continues for a predetermined period of time sufficient to achieve the required residence times for the fission product gases. When this time period expires, delay section pressure reduction is manually initiated and gradually reduces the pressure in the delay section.

Steam Generator Blowdown Flash Tank Venting

During normal operations, the blowdown liquid is routed to the blowdown flash tank. As a result of pressure reduction, a portion of the liquid mass flashes to steam. The steam-water mixture is separated in the flash tank, with the overhead steam directed to the deaerator (also called the feedwater tank). Non-condensable gases from the deaerator are sent to the main turbine condensers and are removed by the main condenser evacuation system for release to the plant stack.

Radiation sensors on the Steam Generator Blowdown Sampling System continually monitor blowdown activity for indications of a steam generator tube leaks or rupture. If indications of tube rupture are detected, the affected steam generator is automatically isolated from the blowdown flash tank in the Steam Generator Blowdown System. Eventually, after a controlled plant shutdown and cooldown has been completed, the affected steam generator may be drained to the nuclear island vents and drains system, which is one of four normal destinations for steam generator draining (plant drains, clean drains, the condenser and the nuclear island vents and drains).

Main Condenser Evacuation System

The Main Condenser Evacuation System is designed to establish and maintain a vacuum in the condenser during startup, cooldown and normal operation by the use of mechanical vacuum pumps. Vacuum pumps remove air and non-condensable gases from the condenser and connected steam side systems and pass the steam and the air mixture through moisture separators. As a result of compression, the steam component condenses while the extracted air is vented through the vent system into the ventilation system of the Nuclear Auxiliary Building Ventilation System and released to the environment via the plant stack. The activity of the exhausted air is monitored.

Ventilation Filter Systems

Effluent discharged from the delay section of the Gaseous Waste Processing System is directed to the filtration section of the Nuclear Auxiliary Building Ventilation System. Exhaust air from the containment purge "full flow purge" (used only during plant outage periods), along with exhaust air from the Safeguards Building Controlled Area Ventilation, Fuel Pool Building Ventilation, and Nuclear Auxiliary Building Ventilation Systems, is also processed by the filtration section of the Nuclear Auxiliary Building Ventilation System before release from the stack. The ventilation flow paths (including containment "low flow purge" and "full flow purge") continuously exhaust to the Nuclear Auxiliary Building Ventilation System. Each exhaust flow path has a pre-filter and a HEPA filter. The filtered air is sent to the common exhaust plenum and removed via the stack. If radiation sensors in any of the rooms within the Nuclear Auxiliary Building, Reactor Building, Fuel Building, Safeguards Buildings, or the stack detect elevated radioactivity levels in exhaust gases, the associated flow paths are redirected to iodine-adsorbent activated charcoal delay beds and the filtered air is sent to the stack. The charcoal beds each have a downstream HEPA filter to remove potentially radioactive charcoal dust and particulates. The ventilation systems are shown in Figure 3.5-7.

3.5.3.2 Gaseous Release to the Environment

All gaseous effluents are released at the top of the plant stack. The stack height is approximately 197 ft (60 m) above plant grade, or about 6.56 ft (2 m) above the height of the adjacent Reactor Building. The normal stack flow rate is conservatively estimated at 260,000 cfm (7,362 m^3/min) (sum of exhaust ventilation flow rates from the Nuclear Auxiliary Building of 157,000 cfm (4,446 m^3/min), Radioactive Waste Processing Building of 94,000 cfm (2,662 m^3/min) and Access Building of 9,000 cfm (255 m^3/min)) with no credit for thermal buoyancy of the exit gas assumed (ambient temperature) and the low flow purge system assumed to not be operating. For the purpose of analyzing the effective stack height, a conservative stack flow rate of 242,458 cfm (6,865 m^3/min) was utilized in the atmospheric dispersion calculations. The stack diameter is 12.5 ft (3.8 m). The releases of radioactive effluent to the plant stack include contributions from:

- Gaseous Waste Processing System discharges via the carbon delay beds for noble gas holdup and decay.
- Containment purge ventilation discharges.
- Ventilation discharges from (1) the four Safeguards and Access Building controlled areas, (2) the Fuel Pool Building, (3) the Radwaste Building and (4) the Nuclear Auxiliary Building.
- Main Condenser air evacuation exhaust.

The annual average airborne releases of radionuclides from the plant were determined using the PWR GALE code (NRC, 1985). The GALE code models releases using realistic source terms derived from the experiences of many operating reactors, field and laboratory tests, and plant-specific design considerations incorporated to reduce the quantity of radioactive materials that may be released to the environment during normal operation, including anticipated operational occurrences. The code input values used in the analysis are provided in Table 3.5-9. There are two deviations from the U.S. EPR FSAR reflected in this COLA, the shim bleed and C-14 production. The shim bleed is adjusted to 2,160 gpd (8176 L/d) to reflect total letdown flow for boron control with all of the reactor coolant liquid being recycled. This deviates from the U.S. EPR FSAR where it is assumed that 5% of the letdown flow is sent to the liquid waste system for processing. This results in the calculated annual release of Kr-85 to drop from a very conservative estimate of 34,000 Ci (1.26E+15 Bq) to 2,800 Ci (1.04E+14 Bq) in gaseous effluents for BBNPP. The GALE code has a fixed annual release value for C-14 of 7.3 Ci (2.70E+11 Bq) regardless of the power output of the reactor and with no identification of the chemical form of the carbon in the waste gas. C-14 is primarily produced by the activation of O-17 in the coolant. The quantity released is proportional to the reactor core neutron flux. The larger power rating of the U.S. EPR results in a much higher C-14 production than the GALE code estimate. As a result, the annual release of C-14 is increased to 18.9 Ci (7.0E+11 Bq) and the chemical form is estimated to be 80% methane and 20% carbon dioxide. The expected annual releases from the plant are presented in Table 3.5-8 and the annual releases due to anticipated operational occurrences are presented in Table 3.5-20.

3.5.3.3 Gaseous Waste System Cost-Benefit Analysis

As with the liquid waste processing systems, the ALARA design objective dose values for effluents released from a light water reactor as stipulated in 10 CFR 50, Appendix I (CFR, 2007a) also requires that plant designs include all items of reasonably demonstrated cleanup technology that when added to the gaseous waste processing system sequentially and in order of diminishing cost-benefit return, can, at a favorable cost-benefit ratio, effect reductions in dose to the population reasonably expected to be within 50 mi (80 km) of the reactor. Although not required by NRC Regulations, values of $2,000 per person-rem, and $2,000 per person-thyroid-rem are conservatively used as a favorable cost benefit threshold based on NRC NUREG-1530 (NRC, 1995). The source term for each equipment configuration option was generated using the same GALE code as described in Section 3.5.1 along with the same plant specific parameters modified only to accommodate the changes in the waste stream decontamination factor afforded by the design options simulated.

For BBNPP, the dose reduction effects for the sequential addition of the next logical gaseous waste processing component (i.e., addition of an additional charcoal delay bed to the waste gas holdup subsystem)) results in a reduction in the 50 mi (80 km) population total body exposure of 0.05 person-rem (0.0005 person-sievert). Section 5.4 describes the population dose calculation for both the base case augmented charcoal delay bed holdup system for processing gaseous waste. Table 3.5-21 illustrates the relative population dose associated with both the base equipment configuration and that associated with the augmented holdup system. Table 3.5-22 compares the estimated total body and thyroid dose reduction or savings achieved for the addition of the extra delay bed along with a conservative estimated cost for the purchase. Operating and maintenance cost associated with this passive subsystem is negligible. The cost basis for the equipment option is taken from Regulatory Guide 1.110 (NRC, 1976) and reported in 1975 non-escalated dollars which provides a conservatively low estimate of the equipment cost to todays dollars. The site area population within 50 mi (80 km) is based a projected population in 2060, over 40 years from the estimated start of plant operations. Using the population at the end of plant life is conservative in that it maximizes the collective dose from plant effluents.

For both the total body and thyroid dose reduction, Table 3.5-22 illustrates that the favorable benefit in reduced dose associated with the additional charcoal delay bed had a dollar equivalent benefit value of $4,000. However, the estimated cost to purchase this equipment was approximately $67,000, thereby resulting in a total body effective benefit to cost ratio of less than 1.0 (not justified on an ALARA basis of dose savings to the public).

The total gas release from the plant is made up of several sources, of which the charcoal delay bed subsystem provides treatment for the process gas from primary side reactor system components only. As a consequence, assuming that the process gas stream release has a zero value does not result in a zero dose to the population. Ventilation system exhaust from the reactor building and other controlled area buildings, along with any secondary side process gas releases if primary to secondary leaks occur also contribute to the total release. Because these sources are distributed throughout the plant, no single system can be added that effectively reduces all sources of gas releases. However, beyond the waste gas processing that is accomplished by the charcoal delay beds, the existing controlled area ventilation systems already provide for HEPA filtration, and as needed charcoal filtration, to the major sources of gas released to the environment. As a result, no other treatment options not in use are available that could treat a significant fraction of the total release at a favorable cost to that shown for the charcoal delay bed.

3.5.4 Solid Radioactive Waste System

The Solid Waste Management System serves to collect, treat and store the solid radioactive wastes produced throughout the plant. There are several types of wet solid waste produced in the plant. These include spent resins, filter and centrifuge sludge's, sludge from the storage tank bottoms, and evaporator concentrates. There are also dry wastes such as paper, cloth, wood, plastic, rubber, glass and metal components that are contaminated.

The solid system consists of three parts; the radioactive concentrates processing system, the solid waste processing system and the solid waste storage system. Figure 3.5-8 provides a flow diagram of the inputs and processes associated with the solid waste system.

The radioactive concentrates processing system serves to process radioactive concentrates into a monolithic salt block by drying liquid radioactive waste from different systems. The liquid waste treated includes the concentrates left after the liquid waste has been treated in the evaporator of the Liquid Waste Processing System. It also treats the radioactive sludge from the liquid waste storage tanks of the Liquid Waste Storage System. The spent ion exchange resins from the Coolant Purification System or liquid waste processing demineralizer package are also sent to the concentrates processing system, after they have been stored for a period of time, to be processed with the other radioactive concentrates.

The Dry Solid Waste Processing System serves to collect and process the solid or DAW produced throughout the plant. This waste can include materials such as plastics, paper, clothing, glass, rubber, wood and metal. The waste is separated and processed separately depending upon size, activity and physical/chemical conditions. In-plant capability to separate, shred and compact DAW waste materials into disposable containers is provided. Alternately, DAW may be shipped in the "as collected" form to an offsite licensed processor for volume reduction treatment and final packaging and shipment to a disposal facility.

The Solid Waste Storage System serves to store the solid waste mentioned above both before and after processing. The untreated solid waste is stored near its producing area until it is ready to be processed. Wet solid waste shall be stored separately from DAW to prevent the transfer of excess moisture to DAW. Once treated, the solid waste, along with the treated concentrates, is stored in one of two areas. One area is a tubular shaft storage area for the high activity drums and the other is a temporary storage area for low to medium activity drums. Once the activity has reduced to a low enough level, the drums are transported to an offsite repository for final disposal.

The discussions that follow describe the design and operation of each of these systems; greater detail can be found in U.S. EPR FSAR, Tier 2, Section 11.4.

3.5.4.1 Radioactive Concentrates Processing System

The Radioactive Concentrates Processing System is used to produce a monolithic salt block inside a disposal drum by drying high solids content liquids from different systems.

Evaporator concentrates from the concentrate tanks and contaminated sludge from the liquid waste storage tanks of the liquid waste storage system are transferred to the concentrate buffer tank. These wastes are mixed, sampled and analyzed for proper pretreatment before leaving the concentrate buffer tank.

Spent resins are stored in the resin waste tanks of the coolant purification system for an extended length of time to allow short lived activity to decay away. When processed, these resins are transferred into the resin proportioning tank. Depending upon activity levels in the resin, a portion of the resins is transferred into the concentrate buffer tank with liquid waste where it is mixed to control the overall waste radioactivity concentration. Spent resin from the Liquid Waste Storage and Processing System demineralizer/ultra filtration skid may be sent directly to high integrity containers (HICs) for in-container dewatering or transferred to the concentrate buffer tank. This demineralizer system produces spent resins as well as a small amount of solid waste from the back flush of the ultra filtration system.

From the concentrate buffer tank, the liquid waste can be transferred into a storage drum in one of three drum drying stations where the water content is evaporated off. Alternatively, resin slurries can be transferred to HICs to be dewatered and sent to disposal. In the drum drying station, a seal is established on the drum and a vacuum is established. Then the heaters are energized to evaporate the water from the drum. The vacuum in the drum allows a lower required heating temperature to boil off the water. The water vapor is condensed and collected and volume counted before it is drained to the condensate collection tank. The air and non-condensable gases are routed to the Radioactive Waste Building Ventilation System for processing. After most of the liquid has been evaporated out of the drum, it is refilled with more waste from the concentrate buffer tank and the drying process is re-initiated. This filling and evaporation process is repeated until the drum is filled with a solid precipitated dry activity waste product. The solid drum drying process reduces the moisture content of the solid block to the level required for disposal at an offsite repository.

Once the residual moisture has been reached, the shell and bottom heaters are turned off and disengaged from the drum. After a set time, the vacuum unit is shut down and the drum drying station is directly vented to the Radioactive Waste Building Ventilation System. While the drum is still connected to the Radioactive Waste Building Ventilation System, the product is allowed to cool to a less than 212°F (100°C).

The whole drying process is performed automatically which means that the system can operate 24 hours a day and unattended. Only during the drum exchange process does an operator have to be at the control panel to perform the different drum exchange steps. This process is done remotely.

Once the product cools down, the drum is lowered and transferred to the pickup position outside the filling station. In this position the drum is picked up by the drum handling device, and is lowered to the pickup position conveyor (part of the drum transfer device (DTD)). The DTD transfers the filled uncapped drum to the sampling position for dried waste for taking samples from the content of the drum as far as defined in a semi-automatic mode (the sample is taken automatically while insertion and removal of the shielded drill is performed manually). In the next step the drum is routed to the drum capping device for capping the filled drum.

The drum capping device operates automatically. After the drum reaches the capping position, a start button is pressed and a lid is automatically placed on the drum. The drum is automatically capped and once complete, a release signal allows the further transport of the drum to the drum input/output position. From the input/output position, the drum is moved by the drum store crane to the drum measuring device.

In the drum measuring device, the weight, the dose rate and the main radionuclides of the drum content are measured. A gamma spectroscopy measurement with a Ge-detector is used to determine radionuclides and their activity. The drum is arranged on a turntable which is slowly rotated during the measurement process. The drum measuring device operates automatically. Once the measuring process is complete, the drum is picked up by the drum store crane and moved to the drum store for storage.

3.5.4.2 Solid Waste Processing System

DAW is collected in suitable containers such as plastic bags, drums or bins that are placed in various locations throughout the controlled areas of the plant at such points as step-off pads at exits from contaminated areas. Once full, these collection bags or bins are sent to the solid waste processing area for sorting, compaction if suitable, and final packaging for temporary storage in-plant or for shipment to a licensed disposal facility offsite or licensed waste processor for additional processing before final disposal.

The in-plant treatment facilities include a sorting box for sorting waste into compressible and non-compressible fractions, a drying box for drying of wet materials that might have greater than incidental moisture before further treatment, a shredder for treating large bulky combustible and compressible waste before being compacted, and a compactor for in-drum compaction of compressible waste. Filter cartridges are loaded in high integrity containers with other wastes for disposal.

3.5.4.3 Solid Waste Storage System

The different properties, sizes, materials and activity of the solid radioactive waste are considered while collecting the waste in different containers so as to simplify both handling and storage of the waste in the plant and its transport.

Various storage areas are provided in the Radioactive Waste Building for the different types of solid waste and contaminated components. The Radioactive Waste Processing Building includes a tubular storage area for higher activity waste. This area would provide capacity to store on the order of five to six years of Class B and C waste (using the conservative waste volumes estimated in the U.S. EPR FSAR) without further waste minimization and volume reduction efforts. In the event that no offsite disposal facility is available to accept Class B and C waste from BBNPP when it commences operation, additional waste minimization measures would be implemented to reduce or eliminate the generation of Class B and C waste.

These measures could include the reducing the service run length for resin beds, short loading media volumes in ion exchange vessels, and other techniques discussed in the EPRI Waste Class B/C Reduction Guide (EPRI, 2007b) and EPRI Operational Strategies to Reduce Class B/C Wastes (EPRI 2007a). These measures could extend the capacity of the Radioactive Waste Processing Building to store Class B and C waste to over ten years. This would provide ample time for offsite disposal capability to be developed or additional onsite capacity to be added. Continued storage of Class B and C waste in the Radioactive Waste Processing Building would maintain occupational exposures within permissible limits and result in no additional environmental impacts.

If additional storage capacity for Class B and C were necessary, BBNPP would implement the applicable NRC guidance, including Appendix 11.4-A of the Standard Review Plan NUREG-0800, "Design Guidance for Temporary Storage of Low-Level Waste," (NRC, 2007b). Such a facility would be located in a previously disturbed area in the vicinity of the power block, and in a location that would not affect wetlands. The impacts of constructing such a facility would be minimal. The operation of a storage facility meeting the standards in Appendix 11.4-A would provide appropriate protection against releases, maintain exposures to workers and the public below applicable limits, and result in no significant environmental impact.

The system is able to handle and store the waste generated in the different controlled areas of the plant independent from the plant operating conditions. Storage space is provided for collected untreated waste waiting for treatment. Additional space is provided for treated and packaged low activity waste, such as DAW, as well as higher activity waste in a tubular shaft storage arrangement that provides shielding for operating staff. The tubular shaft store is part of the permanent building structure formed in the shape of tubes. The higher activity waste includes items such as the radioactive concentrates treated in the radioactive concentrates processing system and the spent filter cartridges. The drum store is located in the Radioactive Waste Processing Building in an area used for temporary storage of low level radioactive waste treated by the solid waste processing system. The drums can be stacked a maximum of 5 drums high to optimize the available storage space. The drums are stored for a sufficient time to allow the short lived radionuclides to decay thereby reducing the radiation levels to keep radiation exposures ALARA.

The drums containing the spent filter cartridges are placed in a shielded cask and are brought to the drum transfer station. Once at the drum transfer station, the vehicle entrance crane lifts the lid off the cask and the drum store crane takes the drum to the tubular shaft store for storage. The lid is then placed back on the cask and the cask is returned to the Nuclear Auxiliary Building to the filter changing area.

The drums containing the medium activity waste such as spent filter cartridges, spent resins and the concentrates wastes from the radioactive concentrates processing system are transported to a final repository after being temporarily stored in the tubular shaft storage area. This is done by using the drum storage crane to remove the drums from the tubular shaft and place them in the drum transfer position. They are placed in a shielding cask and lifted to the vehicle entrance area by the vehicle entrance crane. Once in the vehicle entrance area, each drum is removed from the cask and placed into an approved shipping container to be moved to the offsite facility.

3.5.4.4 Expected Volumes

The volume of solid radioactive waste estimated to be generated by BBNPP is approximately 7,900 ft^3 (225 m^3) per year (including compressible waste). Table 3.5-10 delineates the expected annual volume by waste type. For liquid waste streams, the maximum volume reduction is achieved by converting liquid waste concentrates to dried salt deposits in the waste drum drying subsystem. Final drum drying is expected to achieve a volume reduction (VR) factor of about 5 over the concentrate stream. After dewatering, spent demineralizer resins are assumed to have the same volume as the initial resin volume used (i.e., no VR). Table 3.5-10 presents the final volume of processed concentrates ready for storage or shipment to a disposal facility. For DAW, Table 3.5-10 indicates the "as collected" volumes and assumes that no onsite volume reduction to these waste are applied. These materials are expected to be sent to an off site licensed waste processor for sorting and treatment for volume reduction before shipment to a disposal facility. If onsite compaction of compressible DAW is performed, a VR factor of 5 or more is expected assuming:

a. Each non-regenerable ion-exchanger is changed annually; and

b. Approximately 15 spent filter cartridges from all process systems combined are generated annually with a package volume of approximately 120 ft^3 (3.40 m^3) (one filter element per disposal drum).

Curie content associated with this waste volume is also delineated in Table 3.5-10. The radioactive concentrations vary considerably depending upon plant operating conditions.

However, radiation monitoring (and related interlocks) within the solidification system insure that all shipments will comply with federal and state regulations (i.e., radiation levels and gross weight of shipping vehicle).

3.5.4.5 Solid Release to the Environment

Solid wastes will be shipped from the site for burial at a NRC licensed burial site. The containers used for solid waste shipments will meet the requirements of 49 CFR Parts 171 through 180 (Department of Transportation, Hazardous Materials Regulations) (CFR, 2007e), and 10 CFR Part 71 (Packaging of Radioactive Materials for Transport) (CFR, 2007f).

Table 3.5-10 summarizes the annual total solid radioactive waste generated at BBNPP.

3.5.4.6 Independent Spent Fuel Storage Installation

Because of the need for additional storage capacity for spent fuel being generated by the operations of Susquehanna Steam Electric Station (SSES) Units 1 and 2, an Independent Spent Fuel Storage Installation (ISFSI) was constructed on the SSES site approximately 300 ft (91 m) west of SSES Units 1 and 2. The first dry fuel storage canister was loaded into the ISFSI in 1999, with additional canisters loaded in subsequent years. The ISFSI is situated approximately 4,500 ft (1,372 m) east of the BBNPP containment (PPL, 2006). It will contribute to on-site exposure at BBNPP (BBNPP FSAR Section 12.3.5.1.2).

3.5.5 Process and Effluent Monitoring

For routine operations, the process and effluent radiological monitoring and sampling systems monitor, record and (for certain subsystems) control the release of radioactive materials that may be generated during normal operation, including anticipated operational occurrences.

The process and effluent radiological monitoring systems consist of radiation detectors connected to local microprocessors. Each microprocessor processes the detector signal in digital form, computes average radioactivity levels, stores data, performs alarm or control functions, and transmits the digital signal to one of the control room information and control systems. Monitoring systems alarm when setpoint limits are exceeded and if the system becomes inoperable. Alarms are indicated both locally and in the control room.

For gaseous waste, all compartment ventilation exhaust air from controlled areas (i.e., Reactor Building, Fuel Building, Safeguard Buildings, Waste Building and Nuclear Auxiliary Building) and the gaseous waste system exhaust air is discharged to and monitored in the plant vent stack. Effluent sampling systems also monitor the Reactor Building, Fuel Building, the Nuclear Auxiliary Building and the mechanical area of the Safeguard Buildings, as well as the vent stack. Samples are also taken and monitored from the exhaust air of the Access Building and the Waste Building. These two buildings are not part of the controlled area and do not vent to the vent stack. Sampling of these two buildings provides assurance that an inadvertent release of radioactivity to the environment will be monitored. Gaseous effluent monitoring systems utilized at BBNPP are discussed in the following sections.

The liquid radioactive waste effluent monitoring system measures the concentration of radioactive materials in liquids released to the environment to ensure that radionuclide concentration limits specified in 10 CFR 20 are complied with. Process line monitors provide operating personnel indication of system performance and the existence of leaks from contaminated systems to clean systems or subsystems of lower expected radioactivity.

The process and effluent monitors are discussed below by the plant system that is being monitored. Table 3.5-23 has been arranged by the radioisotopes monitored to make it more convenient to compare monitors that perform a similar function. The monitors in Table 3.5-23 are grouped by categories for noble gas effluent, gaseous iodine and aerosol (halogen and particulate) effluent, process monitoring (area radiation levels, personnel and equipment contamination, system leakage from the primary side to nuclear island buildings or secondary systems), liquid effluent, and airborne radiation levels.

The discussions that follow describe the design and operation of each of these systems; greater detail can be found in U.S. EPR FSAR, Tier 2, Section 11.5.

3.5.5.1 Vent Stack

Vent stack gaseous effluent monitoring is accomplished by the use of continuously operating measurement devices for noble gas, aerosol, and iodine. Samples are also collected that may be utilized for laboratory determination of tritium. Two independent systems provide system redundancy and permits maintenance on one train while continually monitoring effluents with the other train. Each sampling system consists of a sampling nozzle array designed to provide a representative sample, two 100% capacity rotary sampling pumps, and specially designed interconnecting tubing running between a sampling nozzle array, sampling pumps, and radiation monitoring instrumentation. Gaseous samples exiting the monitoring instrumentation are returned to the vent stack. The vent stack effluent monitoring system has the following general characteristics:

- Noble gas activity is monitored with beta-sensitive detectors. The gross output of the monitor is periodically normalized to the radionuclide composition by performing a gamma-spectroscopic analysis on a representative grab sample.
- Aerosol activity is monitored with the use of a particulate filter through which sample flow is continuously maintained. Aerosol particles are removed by the filter, which is continuously monitored by a gamma-sensitive detector.
- Iodine activity is monitored with the use of a dual filter for organic and inorganic iodine. Each filter is continuously monitored by a gamma-sensitive detector.

For both particulate and iodine monitoring, the gross outputs of the monitors are normalized by laboratory analysis of a duplicate set of filters installed in parallel with the primary ones. The vent stack gaseous effluent monitoring system does not perform any automatic actions. The system monitors, records, and alarms in the control room in the event that monitored radiation levels increase beyond specified setpoints. Measurement ranges of noble gas, aerosol, and iodine monitors are shown in Table 3.5-23.

3.5.5.2 Gaseous Waste Carbon Delay Beds

The gaseous waste delay bed process stream is continuously monitored prior to waste flow being directed to the plant vent stack. One gamma-sensitive radiation detector is located up-stream of the delay beds and one beta-sensitive radiation detector downstream of the beds outlet. The upstream detector provides plant personnel with an indication of the amount of radioactivity entering the system. The downstream detector is a beta-sensitive instrument, as Krypton-85 generally forms the main constituent (about 95%) of the normal radioactive noble gas waste stream, and provides personnel a means to compare the reduction in radioactivity afforded by the delay bed system. The gaseous waste monitoring system provides control room and local indication and an alarm in the main control room terminates release to the plant vent stack by closing the discharge valve. Measuring ranges of the gaseous waste disposal radiation monitoring system are shown in Table 3.5-23.

3.5.5.3 Condenser Air Removal Monitor

Non-condensable gases (air and noble gases) in the secondary system are continuously removed during operation by the condenser air removal system. These gases are exhausted to the vent stack. The function of the condenser air removal radiation monitor is to provide local and control room alarm in the event that noble gas radioactivity is detected in the secondary system. This would be an indication of a breach of fuel cladding, primary coolant boundary, or containment leak. Measuring ranges of the condenser air removal radiation monitoring system are shown in Table 3.5-23. No automatic actions are initiated by this system.

3.5.5.4 Main Steam Radiation Monitoring System

Radioactivity releases from the reactor coolant system to the main steam system (nitrogen-16 (N-16), noble gases) can occur as a result of steam generator tube leakage. Radioactivity in the main steam system is monitored over a wide power range by four redundant measuring arrangements per steam line (16 total for the system). The gamma sensitive detectors are mounted adjacent to the monitored main steam lines within the main steam and feedwater valve compartments. At low power levels, radioactivity will be detected in the main steam due to noble gas. At high power levels, the detectors detect the strong gamma from N-16. Shielding of detectors ensures that detectors on other main steam lines do not erroneously respond. The redundant measurement signals are processed, and provide alarm in the control room upon detection of radioactivity. The main steam radiation monitoring system is utilized in conjunction with the condenser air removal and steam generator blowdown radiation monitoring systems to identify a defective steam generator. The main steam radiation monitoring system does not initiate any automatic actions. Isolation of a defective steam generator is performed by manual operator actions. Measuring ranges of the main steam radiation monitoring system are shown in Table 3.5-23.

3.5.5.5 Reactor Coolant Radiation Monitor and Sampling System

The noble gas radioactivity concentration of the primary coolant is determined by monitoring the noble gas activity concentration in the gaseous volume flow prior to discharge to the Nuclear Sampling System degasifier. Monitoring is accomplished with a beta-sensitive measuring arrangement located immediately adjacent to the sampling line. This measuring point allows early detection of fuel element failures. The measurement range for this radiation monitoring system is shown in Table 3.5-23.

3.5.5.6 Containment Atmosphere Radiation Monitor

The containment atmosphere radiation monitor measures the radioactive gaseous concentrations in the containment atmosphere. The containment atmosphere radiation monitor is a part of a reactor coolant pressure boundary leak detection system. The presence of gaseous radioactivity in the containment atmosphere is an indication of reactor coolant pressure boundary leakage. The measurement range for this radiation monitoring system is shown in Table 3.5-23.

3.5.5.7 Containment Ventilation System Radiation Monitor

The containment ventilation system air filtration exhaust radiation monitor measures the concentration of radioactive materials in the containment purge exhaust air. The monitor provides an alarm in the main control room when the concentration of radioactive gases in the exhaust exceeds a predetermined setpoint.

The containment ventilation system air filtration exhaust radiation monitor is to be an inline monitor that uses a beta-sensitive scintillation detector. The measurement range for this radiation monitoring system is shown in Table 3.5-23.

3.5.5.8 Liquid Waste Tank Monitors

The liquid radioactive waste monitoring system measures the concentration of radioactive materials in liquids released to the environment to ensure that radionuclide concentration limits specified in 10 CFR 20 and dose requirements specified in 10 CFR 50 are complied with. Liquid radioactive waste is discharged in batches. Prior to release of a liquid radioactive waste tank, a representative sample is taken and radiochemically analyzed. Results of this analysis are utilized in conjunction with dilution factor data to determine a release setpoint for the liquid waste monitoring system. Two continuously operating radiation sensors monitor the release line from the tanks. Release is automatically terminated if a set limit is exceeded or if the monitoring system is inoperable. Measurement ranges of the liquid radioactive waste monitoring system are shown in Table 3.5-23.

3.5.5.9 Primary Component Cooling Liquid Monitors

The component cooling water system consists of a closed loop used to transfer heat from nuclear components to service water by the use of coolers (heat exchangers). The closed nature of this system constitutes a barrier against the release of radioactivity to the service water and thus to the environment in the event of leaks in the associated coolers.

The Component Cooling Water Radiation Monitoring System consists of two subsystems. The general component cooling water monitoring system utilizes gamma-sensitive radiation detectors in the four separate safety-related trains of the Component Cooling Water System to monitor the fluid for any escape of radioactivity from the various radioactivity containing systems that make up the nuclear components served by the component cooling circuits. This subsystem provides local and control alarm in the event that component cooling water gamma radiation levels exceed the monitor setpoint. No automatic actions are initiated by this subsystem.

The second subsystem consists of two gamma-sensitive radiation detectors upstream and two gamma-sensitive radiation detectors downstream on the component cooling water lines feeding/exiting the two high-pressure (HP) coolers of the Volume Control System. In the event of a leak in a HP cooler with high-activity primary coolant leaking into the component cooling water system, the radiation detector downstream of the defective cooler indicates the entry of radioactivity from this HP cooler into the component cooling loop that is running at the time. If the radioactivity exceeds a pre-determined limit, the defective HP cooler is automatically isolated, with associated control room alarm, on the primary side. This automatic action is suppressed if the limit value of the radiation detector at the inlet of the cooler has already triggered a high activity signal and during in-service inspection of the measuring points.

The component cooling water radiation monitoring system utilizes lead-shielded gamma-sensitive detectors installed adjacent to the piping. Measuring ranges of the Component Cooling Water Radiation Monitoring System are shown in Table 3.5-23.

3.5.5.10 Steam Generator Blowdown Sample Monitors

The evaporation process within the steam generator results in the concentration of contaminants in the liquid phase. These contaminants include any non-gaseous radioactive substances that have entered the secondary system from the reactor coolant system as a result of tube leakage in a steam generator.

Sampling lines extract blowdown water from the individual blowdown lines for chemical analysis. These lines are located ahead of the primary isolation valve within the reactor containment. Flow is continuously extracted from each of these lines and fed to gamma activity measurement equipment. This allows each steam generator to be monitored separately and continuously for radioactivity carryover to the secondary side. These monitors enable the identification or verification of a steam generator tube leak. Measuring ranges of the Steam Generator Radiation Monitoring System are shown in Table 3.5-23.

3.5.5.11 Turbine Building Drains Effluent Monitor

Turbine Building waste liquid is released from the plant via a monitored pathway to the Combined Waste Water Retention Pond before release to the Susquehanna River. The effluent monitor provides alarm and trip function on the discharge flow if unexpected levels of radioactivity are detected in the release. Measuring ranges of the turbine building drains effluent monitor is shown in Table 3.5-23.

3.5.6 References

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Table 3.5-1— Parameters Used in the Calculation of Fission Product Activity in Reactor (Design Basis)

	Parameter	Value
1.	Total core thermal power, including measurement uncertainty [MWt]	4,612
2.	Clad defects, as a percent of rated core thermal power being generated by rods with clad defects [%]	1.0
3.	Volume of reactor coolant system and pressurizer [ft^3] (m^3)	15,009 (425)
4.	Reactor coolant full power average temperature [°F](C)	594. (312.2)
5.	Purification flow rate (normal) [lbm/hr] (kg/hr)	79,400 (36,000)
6.	Effective cation demineralizer flow [gpm]	NA
7.	Fission product escape rate coefficients:	
	a. Noble gas isotopes [sec^{-1}]	6.5E-08
	b. Br, Rb, I and Cs isotopes [sec^{-1}]	1.3E-08
	c. Te isotopes [sec^{-1}]	1.0E-09
	d. Mo isotopes [sec^{-1}]	2.0E-09
	e. Sr and Ba isotopes [sec^{-1}]	1.0E-11
	f. Y, Zr, Nb, Ru, Rh, La, Ce, Pr, Nd and Pm isotopes [sec^{-1}]	1.6E-12
8.	Purification mixed bed demineralizer decontamination factors(fractions removed):	
	a. Noble gases and N-16, H-3	0.0
	b. Cs, Rb	0.5
	c. Anion / others	0.99 / 0.98
9.	Cation bed demineralizer decontamination factor	NA
10.	Degasifier noble gas stripping fractions	1.0

Table 3.5-2— Reactor Coolant Radionuclide Concentrations

(Page 1 of 3)

	Design Basis		Realistic Source Term (GALE)	
Radionuclide	**µCi/gm**	**Bq/gm**	**µCi/gm**	**Bq/gm**
Noble Gases$^{(a)}$				
Kr-83m	1.3E-01	4.8E+03		
Kr-85m*	5.7E-01	2.1E+04	1.8E-02	6.8E+02
Kr-85*	5.3E+00	2.0E+05	5.8E-01	2.1E+04
Kr-87*	3.3E-01	1.2E+04	2.0E-02	7.4E+02
Kr-88*	1.0E+00	3.7E+04	2.1E-02	7.8E+02
Kr-89	2.4E-02	8.9E+02		
Xe-131m*	1.1E+00	4.1E+02	8.8E-01	3.3E+04
Xe-133m*	1.4E+00	5.2E+04	8.2E-02	3.0E+03
Xe-133*	9.5E+01	3.5E+06	3.4E-02	1.3E+03
Xe-135m*	2.0E-01	7.4E+03	1.5E-01	5.6E+03
Xe-135*	3.4E+00	1.3E+05	7.7E-02	2.8E+03
Xe-137	4.6E-02	1.7E+03	3.9E-02	1.4E+03
Xe-138*	1.6E-01	5.9E+03	7.0E-02	2.6E+03
Halogens$^{(b)}$				
Br-83	3.2E-02	1.2E+03		
Br-84	1.7E-02	6.3E+02	1.8E-02	6.7E+02
Br-85	2.0E-03	7.4E+01		
I-129	4.6E-08	1.7E-03		
I-130	5.0E-02	1.9E+03		
I-131*	7.4E-01	2.7E+04	1.37E-03	4.8E+01
I-132*	3.7E-01	1.4E+04	6.0E-02	2.2E+03
I-133*	1.3E+00	4.8E+04	1.9E-02	7.0E+02
I-134*	2.4E-01	8.9E+03	1.1E-01	4.1E+03
I-135*	7.9E-01	2.9E+04	4.8E-02	1.8E+03
Rubidium, Cesium$^{(c)}$				
Rb-86m	1.2E-06	4.4E-02		
Rb-86	7.7E-03	2.8E+02		
Rb-88	4.1E+00	1.5E+05	2.2E-01	8.1E+03
Rb-89	1.9E-01	7.0E+03		
Cs-134	6.8E-01	2.5E+04	2.6E-05	9.6E-01
Cs-136	2.1E-01	7.8E+03	6.2E-04	2.3E+01
Cs-137	4.3E-01	1.6E+04	3.7E-05	1.4E+00
Cs-138	8.8E-01	3.3E+04		
Miscellaneous Nuclides$^{(c)}$				
Sr-89	2.5E-03	9.3E+01	8.9E-05	3.3E+00
Sr-90	1.3E-04	4.8E+00	7.6E-06	2.8E-01
Sr-91	4.1E-03	1.5E+02	8.0E-04	3.0E+01
Sr-92	6.9E-04	2.6E+01		
Y-90	3.1E-05	1.1E+00		
Y-91M	2.1E-03	7.8E+01	5.0E-04	1.9E+01
Y-91	3.2E-04	1.2E+01	3.3E-06	1.2E-01
Y-92	5.6E-04	2.1E+01		
Y-93	2.6E-04	9.6E+00	3.5E-03	1.3E+02
Zr-95	3.7E-04	1.4E+01	2.5E-04	9.3E+00

Table 3.5-2— Reactor Coolant Radionuclide Concentrations

(Page 2 of 3)

	Design Basis		Realistic Source Term (GALE)	
Radionuclide	**µCi/gm**	**Bq/gm**	**µCi/gm**	**Bq/gm**
Zr-97	2.7E-04	1.0E+01		
Nb-95	3.7E-04	1.4E+01	1.8E-04	6.7E+00
Mo-99	4.3E-01	1.6E+04	4.3E-03	1.6E+02
Tc-99M	1.9E-01	7.0E+03	4.2E-03	1.6E+02
Ru-103	3.1E-04	1.1E+01	4.8E-03	1.8E+02
Ru-105	3.8E-04	1.4E+01		
Ru-106	1.1E-04	4.1E+00	5.7E-02	2.1E+03
Rh-103M	2.7E-04	1.0E+01		
Rh-105	1.8E-04	6.7E+00		
Rh-106	1.1E-04	4.1E+00		
Ag-110M	7.9E-07	2.9E-02	8.2E-04	3.0E+01
Ag-110	4.4E-08	1.6E-03		
Sb-125	3.2E-06	1.2E-01		
Sb-127	2.0E-05	7.4E-01		
Sb-129	2.7E-05	1.0E+00		
Te-127M	1.8E-03	6.7E+01		
Te-127	8.7E-03	3.2E+02		
Te-129M	5.8E-03	2.1E+02	1.2E-04	4.4E+00
Te-129	9.6E-03	3.6E+02	2.6E-02	9.6E+02
Te-131M	1.5E-02	5.6E+02	1.1E-03	4.1E+01
Te-131	1.0E-02	3.7E+02	8.6E-03	3.2E+02
Te-132	1.6E-01	5.9E+03	1.1E-03	4.1E+01
Te-134	2.7E-02	1.0E+03		
Ba-137M	4.1E-01	1.5E+04		
Ba-139	8.6E-02	3.2E+03		
Ba-140	2.5E-03	9.3E+01	8.4E-03	3.1E+02
La-140	6.4E-04	2.4E+01	1.8E-02	6.5E+02
La-141	2.1E-04	7.8E+00		
La-142	1.3E-04	4.8E+00		
Ce-141	3.5E-04	1.3E+01	9.6E-05	3.6E+00
Ce-143	3.0E-04	1.1E+01	2.0E-03	7.4E+01
Ce-144	2.8E-04	1.0E+01	2.5E-03	9.3E+01
Pr-143	3.5E-04	1.3E+01		
Pr-144	2.8E-04	1.0E+01		
Nd-147	1.4E-04	5.2E+00		
Np-239	3.5E-03	1.3E+02	1.5E-03	5.6E+01
Pu-238	7.9E-07	2.9E-02		
Pu-239	8.1E-08	3.0E-03		
Pu-240	1.1E-07	4.1E-03		
Pu-241	2.8E-05	1.0E+00		
Am-241	3.1E-08	1.1E-03		
Cm-242	7.5E-06	2.8E-01		
Cm-244	4.1E-07	1.5E-02		
Activation Products[d]				
Na-24	3.7E-02	1.4E+03	3.7E-02	1.4E+03

Table 3.5-2— Reactor Coolant Radionuclide Concentrations

(Page 3 of 3)

	Design Basis		**Realistic Source Term (GALE)**	
Radionuclide	**µCi/gm**	**Bq/gm**	**µCi/gm**	**Bq/gm**
Cr-51	2.0E-03	7.4E+01	2.0E-03	7.4E+01
Mn-54	1.0E-03	3.7E+01	1.0E-03	3.7E+01
Fe-55	7.6E-04	2.8E+01	7.6E-04	2.8E+01
Fe-59	1.9E-04	7.0E+00	1.9E-04	7.0E+00
Co-58	2.9E-03	1.1E+02	2.9E-03	1.1E+02
Co-60	3.4E-04	1.3E+01	3.4E-04	1.3E+01
Zn-65	3.2E-04	1.2E+01	3.2E-04	1.2E+01
W-187	1.8E-03	6.7E+01	1.8E-03	6.7E+01
Tritium				
H-3	4.0	1.5E+05	1.0E+00	3.7E+04
Nitrogen				
N-16	69.4	2.6E+06	4.0E+01	1.5E+06

Notes:

For Design Basis concentrations, the following conditions apply;

(a) The noble gas concentrations are at the U.S. EPR Standard Technical Specification limit of 210 µCi/gm DE-Xe-133

(b) The halogen concentrations are at the U.S. EPR proposed Standard Technical Specification limit of 1 µCi/gm DE-I-131

(c) The concentrations for this group are based on 1.0% failed fuel fraction.

(d) The concentration of activation products based on ANSI/ANS-18.1-1999.

* Radionuclide concentration controlled by proposed Technical Specifications

Table 3.5-3— Secondary Coolant Radionuclide Concentrations

(Page 1 of 3)

Radionuclide	Design Basis Source Term Liquid		Design Basis Source Term Steam		Realistic Source Term Liquid(e)		Realistic Source Term Steam(e)	
	µCi/gm	Bq/gm	µCi/gm	Bq/gm	µCi/gm	Bq/gm	µCi/gm	Bq/gm
Noble Gases[(a)]								
Kr-83m	N/A	N/A	2.1E-05	7.8E-01				
Kr-85	N/A	N/A	5.3E-05	2.0E+00			9.5E-08	3.5E-03
Kr-85m	N/A	N/A	5.8E-06	2.1E-01			3.1E-09	1.1E-04
Kr-87	N/A	N/A	3.3E-06	1.2E-01			9.1E-09	3.4E-04
Kr-88	N/A	N/A	1.0E-05	3.7E-01			3.5E-09	1.3E-04
Kr-89	N/A	N/A	2.4E-07	8.9E-03				
Xe-131m	N/A	N/A	1.1E-05	4.1E-01			1.4E-07	5.2E-03
Xe-133	N/A	N/A	9.7E-04	3.6E+01			5.6E-09	2.1E-04
Xe-133m	N/A	N/A	1.5E-05	5.6E-01			1.4E-08	5.2E-04
Xe-135	N/A	N/A	1.6E-04	5.9E+00			1.3E-08	4.8E-04
Xe-135m	N/A	N/A	8.2E-04	3.0E+01			2.5E-08	9.3E-04
Xe-137	N/A	N/A	4.6E-07	1.7E-02			6.5E-09	2.4E-04
Xe-138	N/A	N/A	1.7E-06	6.3E-02			1.2E-08	4.4E-04
Halogens[(b)]								
Br-83	1.6E-03	5.9E+01	1.6E-05	5.9E-01				
Br-84	3.1E-04	1.1E+01	3.1E-06	1.1E-01	5.8E-08	2.1E-03	5.8E-10	2.1E-05
Br-85	3.9E-06	1.4E-01	3.9E-08	1.4E-03				
I-129	4.8E-09	1.8E-04	4.8E-11	1.8E-06				
I-130	4.3E-03	1.6E+02	4.3E-05	1.6E+00				
I-131	7.7E-02	2.8E+03	7.7E-04	2.8E+01	4.1E-08	1.5E-03	4.1E-10	1.5E-05
I-132	2.3E-02	8.5E+02	2.3E-04	8.5E+00	6.5E-07	2.4E-02	6.5E-09	2.4E-04
I-133	1.2E-01	4.4E+03	1.2E-03	4.4E+01	5.2E-07	1.9E-02	5.2E-09	1.9E-04
I-134	6.7E-03	2.5E+02	6.7E-05	2.5E+00	5.5E-07	2.0E-02	5.5E-09	2.0E-04
I-135	6.0E-02	2.2E+03	6.0E-04	2.2E+01	9.2E-07	3.4E-02	9.2E-09	3.4E-04
Rb-86	1.5E-05	5.7E-01	7.7E-08	2.8E-03				
Rb-86m	9.0E-12	3.3E-07	4.5E-14	1.7E-09				
Rb-88	5.0E-04	1.9E+01	2.5E-06	9.3E-02	4.2E-07	1.6E-02	2.1E-09	7.8E-05
Rb-89	2.0E-05	7.4E-01	1.0E-07	3.7E-03				
Cs-134	1.4E-03	5.1E+01	6.9E-06	2.6E-01	9.3E-10	3.4E-05	4.9E-12	1.8E-07
Cs-136	4.2E-04	1.6E+01	2.1E-06	7.8E-02	2.2E-08	8.1E-04	1.1E-10	4.1E-06
Cs-137	8.7E-04	3.2E+01	4.3E-06	1.6E-01	1.4E-09	5.2E-05	6.6E-12	2.4E-07
Cs-138	1.9E-04	6.9E+00	9.4E-07	3.5E-02				
Miscellaneous Radionuclides[(c)]								
Sr-89	2.9E-06	1.1E-01	1.4E-08	5.2E-04	2.9E-09	1.1E-04	1.5E-11	5.6E-07
Sr-90	1.4E-07	5.4E-03	7.2E-10	2.7E-05	2.5E-10	9.3E-06	1.2E-12	4.4E-08
Sr-91	3.6E-06	1.3E-01	1.8E-08	6.7E-04	1.8E-08	6.7E-04	8.8E-11	3.3E-06
Sr-92	4.0E-07	1.5E-02	2.0E-09	7.4E-05				
Y-90	3.8E-08	1.4E-03	1.9E-10	7.0E-06				
Y-91	3.7E-07	1.4E-02	1.8E-09	6.7E-05	1.1E-10	4.1E-06	5.5E-13	2.0E-08
Y-91m	2.2E-06	8.1E-02	1.1E-08	4.1E-04	2.5E-09	9.3E-05	1.2E-11	4.4E-07
Y-92	5.3E-07	2.0E-02	2.7E-09	1.0E-04				
Y-93	2.3E-07	8.5E-03	1.2E-09	4.4E-05	7.5E-08	2.8E-03	3.8E-10	1.4E-05
Zr-95	4.1E-07	1.5E-02	2.1E-09	7.8E-05	8.0E-09	3.0E-04	4.0E-11	1.5E-06
Zr-97	2.6E-07	9.6E-03	1.3E-09	4.8E-05				

Table 3.5-3— Secondary Coolant Radionuclide Concentrations

(Page 2 of 3)

Radionuclide	Design Basis Source Term Liquid		Design Basis Source Term Steam		Realistic Source Term Liquid(e)		Realistic Source Term Steam(e)	
	µCi/gm	Bq/gm	µCi/gm	Bq/gm	µCi/gm	Bq/gm	µCi/gm	Bq/gm
Nb-95	4.2E-07	1.6E-02	2.1E-09	7.8E-05	5.5E-09	2.0E-04	2.9E-11	1.1E-06
Mo-99	4.6E-04	1.7E+01	1.7E-11	6.3E-07	1.3E-07	4.8E-03	6.3E-10	2.3E-05
Tc-99m	2.6E-04	9.6E+00	1.3E-06	4.8E-02	7.3E-08	2.7E-03	3.8E-10	1.4E-05
Ru-103	3.4E-07	1.3E-02	1.7E-09	6.3E-05	1.6E-07	5.9E-03	8.0E-10	3.0E-05
Ru-105	2.8E-07	1.0E-02	1.4E-09	5.2E-05				
Ru-106	1.2E-07	4.4E-03	6.0E-10	2.2E-05	1.9E-06	7.0E-02	9.0E-09	3.3E-04
Rh-103m	3.1E-07	1.1E-02	1.5E-09	5.6E-05				
Rh-105	2.0E-07	7.4E-03	1.0E-09	3.7E-05				
Rh-106	1.2E-07	4.4E-03	6.0E-10	2.2E-05				
Ag-110	1.2E-11	4.4E-07	5.9E-14	2.2E-09				
Ag-110m	8.8E-10	3.3E-05	4.4E-12	1.6E-07	2.7E-08	1.0E-03	1.4E-10	5.2E-06
Sb-125	3.5E-09	1.3E-04	1.8E-11	6.7E-07				
Sb-127	2.2E-08	8.1E-04	1.1E-10	4.1E-06				
Sb-129	1.9E-08	7.0E-04	9.6E-11	3.6E-06				
Te-127	8.1E-06	3.0E-01	4.0E-08	1.5E-03				
Te-127m	2.0E-06	7.4E-02	9.8E-09	3.6E-04				
Te-129	6.3E-06	2.3E-01	3.1E-08	1.1E-03	1.7E-07	6.3E-03	8.3E-10	3.1E-05
Te-129m	6.4E-06	2.4E-01	3.2E-08	1.2E-03	3.9E-09	1.4E-04	2.0E-11	7.4E-07
Te-131	4.6E-06	1.7E-01	2.3E-08	8.5E-04	2.3E-08	8.5E-04	1.2E-10	4.4E-06
Te-131m	1.5E-05	5.6E-01	7.7E-08	2.8E-03	3.0E-08	1.1E-03	1.5E-10	5.6E-06
Te-132	1.8E-04	6.7E+00	8.8E-07	3.3E-02	3.5E-08	1.3E-03	1.7E-10	6.3E-06
Te-134	6.4E-06	2.4E-01	3.2E-08	1.2E-03				
Ba-137m	8.1E-04	3.0E+01	4.1E-06	1.5E-01				
Ba-139	3.9E-05	1.4E+00	1.9E-07	7.0E-03				
Ba-140	2.7E-06	1.0E-01	1.4E-08	5.2E-04	2.6E-07	9.6E-03	1.3E-09	4.8E-05
La-140	8.4E-07	3.1E-02	4.2E-09	1.6E-04	5.1E-07	1.9E-02	2.5E-09	9.3E-05
La-141	1.5E-07	5.6E-03	7.4E-10	2.7E-05				
La-142	5.6E-08	2.1E-03	2.8E-10	1.0E-05				
Ce-141	3.9E-07	1.4E-02	2.0E-09	7.4E-05	3.1E-09	1.1E-04	1.6E-11	5.9E-07
Ce-143	3.1E-07	1.1E-02	1.6E-09	5.9E-05	5.5E-08	2.0E-03	2.8E-10	1.0E-05
Ce-144	3.1E-07	1.1E-02	1.5E-09	5.6E-05	8.0E-08	3.0E-03	4.1E-10	1.5E-05
Pr-143	3.9E-07	1.4E-02	2.0E-09	7.4E-05				
Pr-144	3.1E-07	1.1E-02	1.5E-09	5.6E-05	8.0E-08	3.0E-03	4.1E-10	1.5E-05
Nd-147	1.5E-07	5.6E-03	7.5E-10	2.8E-05				
Np-239	3.7E-06	1.4E-01	1.9E-08	7.0E-04	4.5E-08	1.7E-03	2.2E-10	8.1E-06
Pu-238	8.9E-10	3.3E-05	4.4E-12	1.6E-07				
Pu-239	9.0E-11	3.3E-06	4.5E-13	1.7E-08				
Pu-240	1.2E-10	4.4E-06	6.2E-13	2.3E-08				
Pu-241	3.1E-08	1.1E-03	1.5E-10	5.6E-06				
Am-241	3.5E-11	1.3E-06	1.7E-13	6.3E-09				
Cm-242	8.3E-09	3.1E-04	4.2E-11	1.6E-06				
Cm-244	4.5E-10	1.7E-05	2.3E-12	8.5E-08				
Activation Products(d)								
Na-24	3.5E-05	1.3E+00	1.8E-07	6.7E-03	8.9E-07	3.3E-02	4.5E-09	1.7E-04
Cr-51	2.2E-06	8.1E-02	1.1E-08	4.1E-04	6.5E-08	2.4E-03	3.2E-10	1.2E-05

Table 3.5-3— Secondary Coolant Radionuclide Concentrations

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Radionuclide	Design Basis Source Term Liquid		Design Basis Source Term Steam		Realistic Source Term Liquid(e)		Realistic Source Term Steam(e)	
	µCi/gm	Bq/gm	µCi/gm	Bq/gm	µCi/gm	Bq/gm	µCi/gm	Bq/gm
Mn-54	1.1E-06	4.1E-02	5.6E-09	2.1E-04	3.3E-08	1.2E-03	1.7E-10	6.3E-06
Fe-55	8.5E-07	3.1E-02	4.2E-09	1.6E-04	2.5E-08	9.3E-04	1.3E-10	4.8E-06
Fe-59	2.1E-07	7.8E-03	1.1E-09	4.1E-05	6.0E-09	2.2E-04	3.1E-11	1.1E-06
Co-58	3.2E-06	1.2E-01	1.6E-08	5.9E-04	9.5E-08	3.5E-03	4.7E-10	1.7E-05
Co-60	3.8E-07	1.4E-02	1.9E-09	7.0E-05	1.1E-08	4.1E-04	5.5E-11	2.0E-06
Zn-65	3.6E-07	1.3E-02	1.8E-09	6.7E-05	1.1E-08	4.1E-04	5.0E-11	1.9E-06
W-187	1.8E-06	6.7E-02	9.1E-09	3.4E-04	4.9E-08	1.8E-03	2.5E-10	9.3E-06
Nitrogen								
N-16					6.9E-07	2.6E-02	6.9E-08	2.6E-03
Tritium[d]								
H-3	4.0E+00	1.5E+05	4.0E+00	1.5E+05	1.0E-03	3.7E+01	1.0E-03	3.7E+01

Notes:

For design basis concentrations, the following conditions apply:

(a) The noble gases are assumed to enter the steam phase instantly.

(b) The halogen concentrations are at the U.S. EPR Standard Technical Specification limit of 0.1 µCuries/gram DE-I-131.

(c) The concentrations for this group are based on 1.0% failed fuel fraction.

(d) The concentration of activation products conservatively assumed to be same concentration as in primary coolant.

(e) Normal operation coolant concentrations for the ANSI/ANS-18.1-1999 reference PWR with U tube steam generators

Table 3.5-4— Principal Parameters Used In Estimating Realistic Releases of Radioactive Materials in Effluents (GALE Code Input Parameters)

(Page 1 of 4)

Item	GALE Input Parameter	Value
1	Thermal Power Level (MWth) (4,590 MWth + 22 MWth measurement uncertainty)	4,612 MWth (4,612E9 J/sec)
2	Mass of Coolant in Primary System (RCS dry nominal volume - not including the pressurizer) (13,596 ft^3/0.02290 ft^3/lbm)	5.937E5 lbm (2.693E5 kg)
3	Primary System Letdown Rate (7.94E+04 lbm/h x 0.0229 ft^3/lbm x 7.48 gal/ft^3 x 1 min/60 sec = 226.7 gpm)	226.7 gpm (0.858 m^3/min)
4	Letdown Cation Demineralizer Flow Rate (No purification system cation demineralizer)	0 gpm (0 l/min)
5	Number of steam generators	4
6	Total steam flow rate (Nominal 4 x 5.168E+06 = 20.67E+06 lbm/hr Increase by 1.05 to account for higher thermal power = 21.71E+06 lbm/hr)	2.171E7 lbm/hr (9.845E6 kg/hr)
7	Mass of liquid in secondary side of each steam generator (SG)	1.6977E5 lbm (7.7006E5 kg)
8	SG Blowdown rate (Nominal 4 x 0.052E+06 lbm/hr = 208E+03 lbm/hr Adjust by 1.05 to account for higher thermal power 208 x 1.05 = 218.4E+03)	2.184E5 lbm/hr (9.906E4E4 kg/hr)
9	Blowdown Treatment Method (Full blowdown flow processed by Blowdown System and recycled to condensate system.)	0
10	Condensate Demineralizer Regeneration Time (days) (Regeneration not used)	0
11	Condensate Demineralizer Flow Fraction	0.33
12	Shim Bleed Flow Rate (gpd) (Shim bleed is letdown flow for boron control and the liquid is recycled. The nominal flow is: 500 lbm/hr x 0.0229 ft^3/lbm x 7.48 gal/ft^3 x 24 hr/day = 2,056 gpd Adjusting by 1.05 to account for higher thermal power yields 2,158 gpd. The analysis will conservatively assume that 5 percent of the processed shim bleed flow of 2,158 gpd. rounded to 2160 gpd.	2160 gpd (8170 l/day)
13	Shim Bleed DF for Iodine (With Liquid Waste Storage and Processing System Demineralizer)	1.0E4
14	Shim Bleed DF for Cesium and Rubidium (With Liquid Waste Storage and Processing System Demineralizer)	1.0E7
15	Shim Bleed DF for Other Nuclides (With Liquid Waste Storage and Processing System Demineralizer)	1.0E7
16	Shim Bleed Collection Time(days) $\frac{18500\ \text{gal}}{\left(\frac{(1728)\text{gal}}{day}\right)} \times 0.8 = 8.56$ (The collection time is for one tank. The collection time includes 1,728 gpd (6,541 lpd) from equipment drains.)	8.56 days
17	Shim Bleed Processing and Discharge Times (days) $\frac{18500\ \text{gal}}{\left(\frac{1.1\text{kg}}{\text{sec}}\right) \times \left(\frac{1\text{E-3m}^3}{1\ \text{kg}}\right) \times \left(\frac{8.64\text{E4 sec}}{\text{d}}\right)} \times 0.8 = 0.589\ \text{days}$	0.589 days
18	Shim Bleed Average Fraction of Waste to be Discharged (Shim Bleed liquid is recycled.)	0.0

Table 3.5-4— Principal Parameters Used In Estimating Realistic Releases of Radioactive Materials in Effluents (GALE Code Input Parameters)

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Item	GALE Input Parameter	Value
19	Equipment Drains Input (gpd) (Based on U.S. EPR Standard Technical Specification limit on unidentified leakage of 1 gpm (3.79 lpm). Assumes collected by floor drains. Twenty percent added for conservatism.)	1,728 gal/day 6,541 l/day
20	Equipment Drains Primary Coolant Activity (PCA)	1.0
21	Equipment Drains DF for Iodine (With Liquid Waste Storage and Processing System Demineralizer)	1.0E4
22	Equipment Drains DF for Cesium and Rubidium (With Liquid Waste Storage and Processing System Demineralizer)	1.0E7
23	Equipment Drains DF for Other Nuclides (With Liquid Waste Storage and Processing System Demineralizer)	1.0E7
24	Equipment Drains Collection Time (days) (Includes 110 gpd (416.4 lpd) from shim bleed.) $$\frac{70\ \mathrm{m}^3}{\left(\frac{1728\ \mathrm{gal}}{\mathrm{day}}\right)\times\left(\frac{\mathrm{m}^3}{264.17\ \mathrm{gal}}\right)}\times 0.8 = 8.56\ \mathrm{days}$$	8.56 days
25	Equipment Drains Processing and Discharge Times (days) $$\frac{70\ \mathrm{m}^3}{\left(\frac{1.1\ \mathrm{kg}}{\mathrm{sec}}\right)\times\left(\frac{1E-3\mathrm{m}^3}{1\ \mathrm{kg}}\right)\times\left(\frac{8.64\mathrm{E}4\ \mathrm{sec}}{\mathrm{day}}\right)}\times 0.8 = 0.589\ \mathrm{days}$$	0.589 days
26	Equipment Drains Average Fraction of Waste to be Discharged (There is no recycling of liquid radioactive waste.)	1.0
27	Clean Waste Input (gpd) (Clean Waste included as Group II.) (Conservative - 66,000 gal/week / 7 day/week = 9,428 gallons per day)	9,428 gal/day 35,690 l/day
28	Clean Waste PCA	0.001
29	Clean Waste DF for Iodine (With Liquid Waste Storage and Processing System Demineralizer)	1.0E2
30	Clean Waste DF for Cesium and Rubidium (With Liquid Waste Storage and Processing System Demineralizer)	1.0E2
31	Clean Waste DF for Other Nuclides (With Liquid Waste Storage and Processing System Demineralizer)	1.0E2
32	Clean Waste Collection Time (days) $$\frac{70\ \mathrm{m}^3}{\left(\frac{250\ \mathrm{m}^3}{\mathrm{week}}\right)\times\left(\frac{week}{7\ \mathrm{d}}\right)}\times 0.8 = 1.6\ \mathrm{days}$$	1.6 days
33	Clean Waste Processing and Discharge Times (days) $$\frac{70\ \mathrm{m}^3}{\left(\frac{1.4\ \mathrm{kg}}{\mathrm{sec}}\right)\times\left(\frac{1E-3\mathrm{m}^3}{1\ \mathrm{kg}}\right)\times\left(\frac{8.64\mathrm{E}4\ \mathrm{sec}}{\mathrm{day}}\right)}\times 0.8 = 0.463\ \mathrm{days}$$	0.463
34	Clean Waste Average Fraction of Waste to be Discharged (There is no recycling of liquid radioactive waste.)	1.0
35	Dirty Waste Input (gpd) (Group III waste is normally not radioactive and it is neglected to maximize concentrations)	0 gal/day (0 l/day)

Table 3.5-4— Principal Parameters Used In Estimating Realistic Releases of Radioactive Materials in Effluents (GALE Code Input Parameters)

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Item	GALE Input Parameter	Value
36	Dirty Waste PCA (N/A since input is 0 gallons.per day)	0.1
37	Dirty Waste DF for Iodine (N/A since input is 0 gallons.per day)	1.0E2
38	Dirty Waste DF for Cesium and Rubidium (N/A since input is 0 gallons.per day)	1.0E3
39	Dirty Waste DF for Other Nuclides (N/A since input is 0 gallons.per day)	1.0E3
40	Dirty Waste Collection Time (days) (N/A since input is 0 gallons.per day)	0
41	Dirty Waste Processing and Discharge Times (days) (N/A since input is 0 gallons.per day)	0
42	Dirty Waste Average Fraction of Waste to be Discharged (There is no recycling of liquid radioactive waste.)	1.0
43	Blowdown Fraction Processed	1.0
44	Blowdown DF for Iodine (1 in the cation bed x 100 in the mixed bed = 100 overall)	1.0E+02
45	Blowdown DF for Cesium and Rubidium (10 in the cation bed x 10 in the mixed bed = 100 overall)	1.0E+02
46	Blowdown DF for Other Nuclides (10 in the cation bed x 100 in the mixed bed = 100 overall)	1.0E+03
47	Blowdown Collection Time (days)	0 days
48	Blowdown Processing and Discharge Times (days)	0 days
49	Blowdown Average Fraction of Waste to be Discharged	0.0
50	Regenerant Flow Rate (gpd) (Regeneration not used)	0.0
51	Regenerant DF for Iodine	1.0
52	Regenerant DF for Cesium and Rubidium	1.0
53	Regenerant DF for Other Nuclides	1.0
54	Regenerant Collection Time (days)	0.0
55	Regenerant Processing and Discharge Times (days)	0.0
56	Regenerant Average Fraction of Waste to be Discharged	0.0
57	Is There Continuous Stripping of Full Letdown Flow? (The degasification is normally operated prior to refueling, prior to maintenance of the reactor coolant circuit or if required to decrease the concentration of gaseous reactivity. Value of ‘	No
58	Holdup Time for Xenon (days)	27.7 days
59	Holdup Time for Krypton (days)	1.67 days
60	Fill Time of Decay Tanks for the Gas Stripper (Days) (Discharged directly to the stack.)	0 days
61	Waste Gas System Particulate Releases HEPA Efficiency (%)	99 %
62	Fuel Handling Building Releases: Charcoal Efficiency (%) (HEPA and Charcoal efficiencies for non-ESF systems taken to be the same as Gaseous Waste Processing System)	90 %
63	Fuel Handling Building Releases: HEPA Efficiency (%) (HEPA and Charcoal efficiencies for non-ESF systems taken to be the same as Gaseous Waste Processing System)	99 %
64	Auxiliary Building Releases: Charcoal Efficiency (%) (HEPA and Charcoal efficiencies for non-ESF systems taken to be the same as Gaseous Waste Processing System)	90 %
65	Auxiliary Building Releases: HEPA Efficiency (%) (HEPA and Charcoal efficiencies for non-ESF systems taken to be the same as Gaseous Waste Processing System)	99 %

Table 3.5-4— Principal Parameters Used In Estimating Realistic Releases of Radioactive Materials in Effluents (GALE Code Input Parameters)

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Item	GALE Input Parameter	Value
66	Containment Free Volume.	2.8E+06 ft^3 (7.9E+4 m^3)
67	Containment Internal Cleanup System: Charcoal Efficiency (%) (HEPA and Charcoal efficiencies for non-ESF systems taken to be the same as Gaseous Waste Processing System)	90 %
68	Containment Internal Cleanup System: HEPA Efficiency (%) (HEPA and Charcoal efficiencies for non-ESF systems taken to be the same as Gaseous Waste Processing System)	99 %
69	Containment Internal Cleanup System: Flow Rate	4.1 E+03 cfm (1.9 m^3/sec)
70	Containment High Volume Purge: Charcoal Efficiency (%) (HEPA and Charcoal efficiencies for non-ESF systems taken to be the same as Gaseous Waste Processing System)	90%
71	Containment High Volume Purge: HEPA Efficiency (%) (HEPA and Charcoal efficiencies for non-ESF systems taken to be the same as Gaseous Waste Processing System)	99%
72	Containment High Volume Purge: Purges per Year	0
73	Containment Low Volume Purge: Charcoal Efficiency (%)	90%
74	Containment Low Volume Purge: HEPA Efficiency (%)	99%
75	Containment Low Volume Purge: Flow Rate (cfm)	3,210 cfm (1.51 m^3/sec)
76	Percent of Iodine Released from Blowdown Tank Vent	0.0%
77	Percent of Iodine Removed from Air Ejector Release (No condenser air ejectors, mechanical vacuum pumps vent to stack without treatment)	0.0%
78	Detergent Waste PF (No onsite laundry)	0.0
79	SG blowdown flash tank gases vented via main condenser air ejector?	No
80	Condenser air ejector offgas released without treatment? (No condenser air ejectors, mechanical vacuum pumps vent to stack without treatment)	Yes
81	Condenser air ejector offgas processed via charcoal adsorbers prior to release? (No condenser air ejectors, mechanical vacuum pumps vent to stack without treatment)	No
82	Average flow rate of water used to dilute liquid waste discharged to the environment.	100 cfs (2.83 m^3/sec)
83	Number of Main Condenser Water Boxes	3
84	Main Condenser Water Box liquid volume (each) (nominal operating conditions) (ft^3) (m^3)	6,357 ft^3 (180 m^3)
85	Main Condenser Water Box temperature (nominal operating conditions) (°F) (°C)	69.4 °F (20.8 °C)
86	Main Condenser Water Box pressure (nominal operating conditions) (millibars)	24.7

Table 3.5-5— Average Radioactivity Concentrations in the Spent Fuel Pool (SFP) Area

(Page 1 of 2)

Radionuclide	SFP Water Activity		SFP Airborne Activity	
	(μCi/cm^3)	**(MBq/cm^3)**	**(μCi/cm^3)**	**(MBq/cm^3)**
H- 3	5.90E-01	2.18E-02	2.67E-06	9.88E-08
Na-24	1.13E-06	4.18E-08	5.10E-12	1.89E-13
Cr-51	6.01E-06	2.22E-07	2.72E-11	1.01E-12
Mn-54	3.40E-06	1.26E-07	1.54E-11	5.70E-13
Fe-55	2.57E-06	9.51E-08	1.17E-11	4.33E-13
Fe-59	6.06E-07	2.24E-08	2.75E-12	1.02E-13
Co-58	9.50E-06	3.52E-07	4.30E-11	1.59E-12
Co-60	1.14E-06	4.22E-08	5.15E-12	1.91E-13
Zn-65	1.08E-06	4.00E-08	4.91E-12	1.82E-13
Br-83	2.43E-17	8.99E-19	1.07E-22	3.96E-24
Kr-83M	4.87E-16	1.80E-17	2.13E-21	7.88E-23
Kr-85M	1.18E-10	4.37E-12	5.28E-16	1.95E-17
Kr-85	4.33E-03	1.60E-04	1.96E-08	7.25E-10
Kr-87	3.71E-26	1.37E-27	1.60E-31	5.92E-33
Kr-88	6.73E-14	2.49E-15	2.98E-19	1.10E-20
Rb-88	6.79E-14	2.51E-15	3.06E-19	1.13E-20
Sr-89	1.52E-07	5.62E-09	6.89E-13	2.55E-14
Sr-90	1.69E-08	6.25E-10	7.67E-14	2.84E-15
Sr-91	1.42E-10	5.25E-12	6.39E-16	2.36E-17
Sr-92	4.58E-18	1.69E-19	2.02E-23	7.47E-25
Y-90	4.69E-09	1.74E-10	2.13E-14	7.88E-16
Y-91M	7.84E-11	2.90E-12	3.56E-16	1.32E-17
Y-91	3.01E-08	1.11E-09	1.36E-13	5.03E-15
Y-92	8.42E-16	3.12E-17	3.75E-21	1.39E-22
Y-93	3.95E-11	1.46E-12	1.78E-16	6.59E-18
Zr-95	3.50E-08	1.30E-09	1.59E-13	5.88E-15
Nb-95	3.67E-08	1.36E-09	1.66E-13	6.14E-15
Mo-99	1.75E-05	6.48E-07	7.92E-11	2.93E-12
Tc-99M	9.60E-06	3.55E-07	4.38E-11	1.62E-12
Ru-103	3.59E-08	1.33E-09	1.63E-13	6.03E-15
Ru-106	2.27E-08	8.40E-10	1.03E-13	3.81E-15
Rh-103M	3.24E-08	1.20E-09	1.47E-13	5.44E-15
Rh-106	2.27E-08	8.40E-10	1.03E-13	3.81E-15
Ag-110M	3.83E-10	1.42E-11	1.74E-15	6.44E-17
Te-127M	2.41E-07	8.92E-09	1.09E-12	4.03E-14
Te-129M	6.52E-07	2.41E-08	2.95E-12	1.09E-13
Te-129	4.24E-07	1.57E-08	1.92E-12	7.10E-14
Te-131M	1.92E-07	7.10E-09	8.70E-13	3.22E-14
Te-131	4.33E-08	1.60E-09	1.96E-13	7.52E-15
Te-132	7.92E-06	2.93E-07	3.59E-11	1.33E-12
Te-134	2.09E-45	7.73E-47	8.64E-51	3.20E-52
I-129	1.08E-11	4.00E-13	4.87E-17	1.80E-18
I-130	6.09E-08	2.25E-09	2.74E-13	1.01E-14
I-131	1.26E-04	4.66E-06	5.72E-10	2.12E-11
I-132	2.87E-05	1.06E-06	1.27E-10	4.70E-12

Table 3.5-5— Average Radioactivity Concentrations in the Spent Fuel Pool (SFP) Area

(Page 2 of 2)

Radionuclide	SFP Water Activity		SFP Airborne Activity	
	(µCi/cm^3)	**(MBq/cm^3)**	**(µCi/cm^3)**	**(MBq/cm^3)**
I-133	1.29E-05	4.77E-07	5.83E-11	2.16E-12
I-134	1.67E-35	6.18E-37	7.03E-41	2.60E-42
I-135	1.11E-08	4.11E-10	4.69E-14	1.84E-15
Xe-131M	2.81E-04	1.04E-05	1.27E-09	4.70E-11
Xe-133M	1.39E-04	5.14E-06	6.30E-10	2.33E-11
Xe-133	1.67E-02	6.18E-04	7.54E-08	2.79E-09
Xe-135M	3.39E-09	1.25E-10	1.37E-14	5.07E-16
Xe-135	4.68E-06	1.73E-07	2.11E-11	7.81E-13
Cs-134	1.64E-04	6.07E-06	7.44E-10	2.75E-11
Cs-136	3.16E-05	1.17E-06	1.43E-10	5.29E-12
Cs-137	6.29E-05	2.33E-06	2.85E-10	1.05E-11
Ba-137M	5.92E-05	2.19E-06	2.69E-10	9.95E-12
Ba-140	2.00E-07	7.40E-09	9.04E-13	3.34E-14
La-140	6.93E-08	2.56E-09	3.15E-13	1.17E-14
Ce-141	3.29E-08	1.22E-09	1.49E-13	5.51E-15
Ce-143	4.26E-09	1.58E-10	1.93E-14	7.14E-16
Ce-144	2.70E-08	9.99E-10	1.22E-13	4.51E-15
Pr-143	3.19E-08	1.18E-09	1.44E-13	5.33E-15
Pr-144	2.70E-08	9.99E-10	1.22E-13	4.51E-15
W-187	3.17E-07	1.17E-08	1.43E-12	5.29E-14
Np-239	1.73E-07	6.40E-09	7.81E-13	2.89E-14
Total (Excluding Tritium)	2.20E-02	8.14E-04	9.94E-08	3.68E-09
Iodines	1.68E-04	6.22E-06	7.58E-10	2.80E-11
Particulates	2.58E-05	9.55E-07	1.17E-10	4.33E-12
Noble Gases	2.14E-02	7.92E-04	9.70E-08	3.59E-09

Note:
MBq/cm^3 = 1.0E6 Bq/cm^3
1 micro Ci/cm^3 = 3.7E+04 Bq/cm^3
1 micro Ci/cm^3 = 3.7E-02 MBq/cm^3

Table 3.5-6— Liquid Waste Release Source Term Inputs

Liquid Waste Inputs								
Stream	Flow Rate gal/day (l/day)	Fraction of Primary Coolant Activity	Fraction Discharged	Collection Time (days)	Decay Time (days)	Decontamination Factors		
						I	Cs	Others
Shim Bleed Rate	2.16E+03 (8.18 E+03)	1.0	0.0	8.6	0.589	1.0E+04	1.0E+07	1.0E+07
Equipment Drains	1.73E+03 (6.55E+03)	1.0	1.0	8.6	0.589	1.0E+04	1.0E+07	1.0E+07
Clean Waste Input	9.43E+03 (3.57E+04)	0.001	1.0	1.6	0.463	1.0E+02	1.0E+02	1.0E+02
Dirty Wastes	0.00E+00 (0.00E+00)	0.1	1.0	0.0	0.0	1.0E+02	1.0E+03	1.0E+03
Blowdown	6.28E+05 (2.38E+06)		0.0	0.0	0.0	1.0E+02	1.0E+02	1.0E+03
Untreated Blowdown	0.00E+00 (0.00E+00)		1.0	0.0	0.0	1.0E+00	1.0E+00	1.0E+00
Regenerant Sols.	0.00E+00 (0.00E+00)		0.0	0.0	0.0	1.0E+00	1.0E+00	1.0E+00

Table 3.5-7— Annual Liquid Effluent Releases (English Units)

(Page 1 of 2)

Radionuclide	Half-Life (days)	Primary µCi per ml	Secondary µCi per ml	Boron Recovery System (Ci)	Misc Wastes (Ci)	Secondary (Ci)	Turbine Building (Ci)	Total Liquid Waste Sources (Ci)	Adjusted Total (Ci/yr)	Detergent Wastes (Ci/yr)	Total (Ci/yr)
Activated Corrosion Products											
Na-24	6.25E-01	2.84E-02	3.40E-07	.00000	.00104	.00000	.00001	.00105	.00616	.00000	.00620
Cr-51	2.78E+01	1.39E-03	1.96E-08	.00000	.00018	.00000	.00000	.00018	.00104	.00000	.00100
Mn-54	3.03E+02	7.09E-04	9.66E-09	.00000	.00009	.00000	.00000	.00009	.00054	.00000	.00054
Fe-55	9.50E+02	5.31E-04	7.28E-09	.00000	.00007	.00000	.00000	.00007	.00041	.00000	.00041
Fe-59	4.50E+01	1.34E-04	1.80E-09	.00000	.00002	.00000	.00000	.00002	.00010	.00000	.00010
Co-58	7.13E+01	2.04E-03	2.84E-08	.00000	.00026	.00000	.00000	.00027	.00156	.00000	.00160
Co-60	1.92E+03	2.35E-04	3.27E-09	.00000	.00003	.00000	.00000	.00003	.00018	.00000	.00018
Zn-65	2.45E+02	2.26E-04	3.12E-09	.00000	.00003	.00000	.00000	.00003	.00017	.00000	.00017
W-187	9.96E-01	1.38E-03	1.73E-08	.00000	.00008	.00000	.00000	.00008	.00047	.00000	.00047
Np-239	2.35E+00	1.08E-03	1.44E-08	.00000	.00010	.00000	.00000	.00010	.00058	.00000	.00058
Fission Products											
Sr-89	5.20E+01	6.23E-05	8.52E-10	.00000	.00001	.00000	.00000	.00001	.00005	.00000	.00005
Sr-91	4.03E-01	6.41E-04	7.35E-09	.00000	.00001	.00000	.00000	.00001	.00008	.00000	.00008
Y-91M	3.47E-02	5.09E-04	2.01E-09	.00000	.00001	.00000	.00000	.00001	.00005	.00000	.00005
Y- 93	4.25E-01	2.77E-03	3.09E-08	.00000	.00006	.00000	.00000	.00006	.00036	.00000	.00036
Zr-95	6.50E+01	1.73E-04	2.39E-09	.00000	.00002	.00000	.00000	.00002	.00013	.00000	.00013
Nb-95	3.50E+01	1.25E-04	1.65E-09	.00000	.00002	.00000	.00000	.00002	.00010	.00000	.00010
Mo-99	2.79E+00	3.11E-03	4.19E-08	.00000	.00030	.00000	.00000	.00030	.00176	.00000	.00180
Tc-99m	2.50E-01	3.54E-03	3.47E-08	.00000	.00029	.00000	.00000	.00029	.00171	.00000	.00170
Ru-103	3.96E+01	3.34E-03	4.64E-08	.00000	.00043	.00000	.00000	.00043	.00252	.00000	.00250
Rh-103m	3.96E-02	0.00E+00	0.00E+00	.00000	.00043	.00000	.00000	.00043	.00252	.00000	.00250
Ru-106	3.67E+02	3.99E-02	5.50E-07	.00001	.00518	.00000	.00003	.00522	.03065	.00000	.03100
Rh-106	3.47E-04	0.00E+00	0.00E+00	.00001	.00518	.00000	.00003	.00522	.03065	.00000	.03100
Ag-110m	2.53E+02	5.76E-04	7.88E-09	.00000	.00007	.00000	.00000	.00008	.00044	.00000	.00044
Ag-110	2.82E-04	0.00E+00	0.00E+00	.00000	.00001	.00000	.00000	.00001	.00006	.00000	.00006
Te-129m	3.40E+01	8.48E-05	1.17E-09	.00000	.00001	.00000	.00000	.00001	.00006	.00000	.00006
Te-129	4.79E-02	2.55E-02	1.28E-07	.00000	.00001	.00000	.00000	.00001	.00004	.00000	.00004
Te-131m	1.25E+00	7.98E-04	1.02E-08	.00000	.00005	.00000	.00000	.00005	.00032	.00000	.00032
Te-131	1.74E-02	9.04E-03	2.07E-08	.00000	.00001	.00000	.00000	.00001	.00006	.00000	.00006
I-131	8.05E+00	2.07E-02	2.49E-07	.00334	.00243	.00000	.00002	.00580	.03406	.00000	.03400

Table 3.5-7— Annual Liquid Effluent Releases (English Units)

(Page 2 of 2)

Radionuclide	Half-Life (days)	Primary µCi per ml	Secondary µCi per ml	Boron Recovery System (Ci)	Misc Wastes (Ci)	Secondary (Ci)	Turbine Building (Ci)	Total Liquid Waste Sources (Ci)	Adjusted Total (Ci/yr)	Detergent Wastes (Ci/yr)	Total (Ci/yr)
Te-132	3.25E+00	8.15E-04	1.09E-08	.00000	.00008	.00000	.00000	.00008	.00048	.00000	.00048
I-132	9.58E-02	1.98E-01	1.34E-06	.00001	.00016	.00000	.00002	.00020	.00116	.00000	.00120
I-133	8.75E-01	7.92E-02	8.87E-07	.00175	.00405	.00000	.00007	.00587	.03447	.00000	.03400
Cs-134	7.49E+02	3.43E-03	4.84E-08	.00000	.00045	.00000	.00000	.00045	.00264	.00000	.00260
I-135	2.79E-01	1.90E-01	1.81E-06	.00050	.00194	.00000	.00010	.00253	.01487	.00000	.01500
Cs-136	1.30E+01	4.36E-04	6.12E-09	.00000	.00005	.00000	.00000	.00005	.00031	.00000	.00031
Cs-137	1.10E+04	4.54E-03	6.45E-08	.00000	.00059	.00000	.00000	.00060	.00350	.00000	.00350
Ba-137m	1.77E-03	0.00E+00	0.00E+00	.00000	.00055	.00000	.00000	.00056	.00327	.00000	.00330
Ba-140	1.28E+01	5.88E-03	7.94E-08	.00000	.00072	.00000	.00000	.00072	.00423	.00000	.00420
La-140	1.68E+00	1.28E-02	1.67E-07	.00000	.00130	.00000	.00001	.00131	.00767	.00000	.00770
Ce-141	3.24E+01	6.70E-05	9.16E-10	.00000	.00001	.00000	.00000	.00001	.00005	.00000	.00005
Ce-143	1.38E+00	1.47E-03	1.86E-08	.00000	.00010	.00000	.00000	.00010	.00062	.00000	.00062
Pr-143	1.37E+01	0.00E+00	0.00E+00	.00000	.00001	.00000	.00000	.00001	.00005	.00000	.00005
Ce-144	2.84E+02	1.73E-03	2.38E-08	.00000	.00022	.00000	.00000	.00023	.00133	.00000	.00130
Pr-144	1.20E-02	0.00E+00	0.00E+00	.00000	.00022	.00000	.00000	.00023	.00133	.00000	.00130
All Others		6.25E-01	1.89E-06	.00000	.00000	.00000	.00000	.00000	.00002	.00000	.00002
Total (Except Tritium)		1.27E+00	7.93E-06	.00563	.02689	.00000	.00033	.03284	.19284	.00000	.19000
Tritium Release		1.66E+03 Curies per year									
Note: 0.00000 indicates that the value is less than 1.0E-05.											

Table 3.5-7— Annual Liquid Effluent Releases (SI Units)

(Page 1 of 2)

Radionuclide	Half-Life (days)	Primary Bq/ml	Secondary Bq/ml	Boron Recovery System (Bq)	Misc Wastes (Bq)	Secondary (Bq)	Turbine Building (Bq)	Total Liquid Waste Sources (Bq)	Adjusted Total (Bq/yr)	Detergent Wastes (Bq/yr)	Total (Bq/yr)
Activated Corrosion Products											
Na-24	6.25E-01	1.05E+03	1.26E-02	0.00E+00	3.85E+07	0.00E+00	3.70E+05	3.89E+07	2.28E+08	0.00E+00	2.29E+08
Cr-51	2.78E+01	5.14E+01	7.25E-04	0.00E+00	6.66E+06	0.00E+00	0.00E+00	6.66E+06	3.85E+07	0.00E+00	3.70E+07
Mn-54	3.03E+02	2.62E+01	3.57E-04	0.00E+00	3.33E+06	0.00E+00	0.00E+00	3.33E+06	2.00E+07	0.00E+00	2.00E+07
Fe-55	9.50E+02	1.96E+01	2.69E-04	0.00E+00	2.59E+06	0.00E+00	0.00E+00	2.59E+06	1.52E+07	0.00E+00	1.52E+07
Fe-59	4.50E+01	4.96E+00	6.66E-05	0.00E+00	7.40E+05	0.00E+00	0.00E+00	7.40E+05	3.70E+06	0.00E+00	3.70E+06
Co-58	7.13E+01	7.55E+01	1.05E-03	0.00E+00	9.62E+06	0.00E+00	0.00E+00	9.99E+06	5.77E+07	0.00E+00	5.92E+07
Co-60	1.92E+03	8.70E+00	1.21E-04	0.00E+00	1.11E+06	0.00E+00	0.00E+00	1.11E+06	6.66E+06	0.00E+00	6.66E+06
Zn-65	2.45E+02	8.36E+00	1.15E-04	0.00E+00	1.11E+06	0.00E+00	0.00E+00	1.11E+06	6.29E+06	0.00E+00	6.29E+06
W-187	9.96E-01	5.11E+01	6.40E-04	0.00E+00	2.96E+06	0.00E+00	0.00E+00	2.96E+06	1.74E+07	0.00E+00	1.74E+07
Np-239	2.35E+00	4.00E+01	5.33E-04	0.00E+00	3.70E+06	0.00E+00	0.00E+00	3.70E+06	2.15E+07	0.00E+00	2.15E+07
Fission Products											
Sr-89	5.20E+01	2.31E+00	3.15E-05	0.00E+00	3.70E+05	0.00E+00	0.00E+00	3.70E+05	1.85E+06	0.00E+00	1.85E+06
Sr-91	4.03E-01	2.37E+01	2.72E-04	0.00E+00	3.70E+05	0.00E+00	0.00E+00	3.70E+05	2.96E+06	0.00E+00	2.96E+06
Y-91M	3.47E-02	1.88E+01	7.44E-05	0.00E+00	3.70E+05	0.00E+00	0.00E+00	3.70E+05	1.85E+06	0.00E+00	1.85E+06
Y- 93	4.25E-01	1.02E+02	1.14E-03	0.00E+00	2.22E+06	0.00E+00	0.00E+00	2.22E+06	1.33E+07	0.00E+00	1.33E+07
Zr-95	6.50E+01	6.40E+00	8.84E-05	0.00E+00	7.40E+05	0.00E+00	0.00E+00	7.40E+05	4.81E+06	0.00E+00	4.81E+06
Nb-95	3.50E+01	4.63E+00	6.11E-05	0.00E+00	7.40E+05	0.00E+00	0.00E+00	7.40E+05	3.70E+06	0.00E+00	3.70E+06
Mo-99	2.79E+00	1.15E+02	1.55E-03	0.00E+00	1.11E+07	0.00E+00	0.00E+00	1.11E+07	6.51E+07	0.00E+00	6.66E+07
Tc-99m	2.50E-01	1.31E+02	1.28E-03	0.00E+00	1.07E+07	0.00E+00	0.00E+00	1.07E+07	6.33E+07	0.00E+00	6.29E+07
Ru-103	3.96E+01	1.24E+02	1.72E-03	0.00E+00	1.59E+07	0.00E+00	0.00E+00	1.59E+07	9.32E+07	0.00E+00	9.25E+07
Rh-103m	3.96E-02	0.00E+00	0.00E+00	0.00E+00	1.59E+07	0.00E+00	0.00E+00	1.59E+07	9.32E+07	0.00E+00	9.25E+07
Ru-106	3.67E+02	1.48E+03	2.04E-02	3.70E+05	1.92E+08	0.00E+00	1.11E+06	1.93E+08	1.13E+09	0.00E+00	1.15E+09
Rh-106	3.47E-04	0.00E+00	0.00E+00	3.70E+05	1.92E+08	0.00E+00	1.11E+06	1.93E+08	1.13E+09	0.00E+00	1.15E+09
Ag-110m	2.53E+02	2.13E+01	2.92E-04	0.00E+00	2.59E+06	0.00E+00	0.00E+00	2.96E+06	1.63E+07	0.00E+00	1.63E+07
Ag-110	2.82E-04	0.00E+00	0.00E+00	0.00E+00	3.70E+05	0.00E+00	0.00E+00	3.70E+05	2.22E+06	0.00E+00	2.22E+06
Te-129m	3.40E+01	3.14E+00	4.33E-05	0.00E+00	3.70E+05	0.00E+00	0.00E+00	3.70E+05	2.22E+06	0.00E+00	2.22E+06
Te-129	4.79E-02	9.44E+02	4.74E-03	0.00E+00	3.70E+05	0.00E+00	0.00E+00	3.70E+05	1.48E+06	0.00E+00	1.48E+06
Te-131m	1.25E+00	2.95E+01	3.77E-04	0.00E+00	1.85E+06	0.00E+00	0.00E+00	1.85E+06	1.18E+07	0.00E+00	1.18E+07
Te-131	1.74E-02	3.34E+02	7.66E-04	0.00E+00	3.70E+05	0.00E+00	0.00E+00	3.70E+05	2.22E+06	0.00E+00	2.22E+06

Table 3.5-7— Annual Liquid Effluent Releases (SI Units)

(Page 2 of 2)

Radionuclide	Half-Life (days)	Primary Bq/ml	Secondary Bq/ml	Boron Recovery System (Bq)	Misc Wastes (Bq)	Secondary (Bq)	Turbine Building (Bq)	Total Liquid Waste Sources (Bq)	Adjusted Total (Bq/yr)	Detergent Wastes (Bq/yr)	Total (Bq/yr)
I-131	8.05E+00	7.66E+02	9.21E-03	1.24E+08	8.99E+07	0.00E+00	7.40E+05	2.15E+08	1.26E+09	0.00E+00	1.26E+09
Te-132	3.25E+00	3.02E+01	4.03E-04	0.00E+00	2.96E+06	0.00E+00	0.00E+00	2.96E+06	1.78E+07	0.00E+00	1.78E+07
I-132	9.58E-02	7.33E+03	4.96E-02	3.70E+05	5.92E+06	0.00E+00	7.40E+05	7.40E+06	4.29E+07	0.00E+00	4.44E+07
I-133	8.75E-01	2.93E+03	3.28E-02	6.48E+07	1.50E+08	0.00E+00	2.59E+06	2.17E+08	1.28E+09	0.00E+00	1.26E+09
Cs-134	7.49E+02	1.27E+02	1.79E-03	0.00E+00	1.67E+07	0.00E+00	0.00E+00	1.67E+07	9.77E+07	0.00E+00	9.62E+07
I-135	2.79E-01	7.03E+03	6.70E-02	1.85E+07	7.18E+07	0.00E+00	3.70E+06	9.36E+07	5.50E+08	0.00E+00	5.55E+08
Cs-136	1.30E+01	1.61E+01	2.26E-04	0.00E+00	1.85E+06	0.00E+00	0.00E+00	1.85E+06	1.15E+07	0.00E+00	1.15E+07
Cs-137	1.10E+04	1.68E+02	2.39E-03	0.00E+00	2.18E+07	0.00E+00	0.00E+00	2.22E+07	1.30E+08	0.00E+00	1.30E+08
Ba-137m	1.77E-03	0.00E+00	0.00E+00	0.00E+00	2.04E+07	0.00E+00	0.00E+00	2.07E+07	1.21E+08	0.00E+00	1.22E+08
Ba-140	1.28E+01	2.18E+02	2.94E-03	0.00E+00	2.66E+07	0.00E+00	0.00E+00	2.66E+07	1.57E+08	0.00E+00	1.55E+08
La-140	1.68E+00	4.74E+02	6.18E-03	0.00E+00	4.81E+07	0.00E+00	3.70E+05	4.85E+07	2.84E+08	0.00E+00	2.85E+08
Ce-141	3.24E+01	2.48E+00	3.39E-05	0.00E+00	3.70E+05	0.00E+00	0.00E+00	3.70E+05	1.85E+06	0.00E+00	1.85E+06
Ce-143	1.38E+00	5.44E+01	6.88E-04	0.00E+00	3.70E+06	0.00E+00	0.00E+00	3.70E+06	2.29E+07	0.00E+00	2.29E+07
Pr-143	1.37E+01	0.00E+00	0.00E+00	0.00E+00	3.70E+05	0.00E+00	0.00E+00	3.70E+05	1.85E+06	0.00E+00	1.85E+06
Ce-144	2.84E+02	6.40E+01	8.81E-04	0.00E+00	8.14E+06	0.00E+00	0.00E+00	8.51E+06	4.92E+07	0.00E+00	4.81E+07
Pr-144	1.20E-02	0.00E+00	0.00E+00	0.00E+00	8.14E+06	0.00E+00	0.00E+00	8.51E+06	4.92E+07	0.00E+00	4.81E+07
All Others		2.31E+04	6.99E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.40E+05	0.00E+00	7.40E+05
Total (Except Tritium)		4.70E+04	2.93E-01	2.08E+08	9.95E+08	0.00E+00	1.22E+07	1.22E+09	7.14E+09	0.00E+00	7.03E+09
Tritium Release		6.14E+13 Becquerel per year									

Note: 0.00000 indicates that the value is less than 1.0E-05.

Table 3.5-8— Annual Gaseous Effluent Releases (English Units)

(Page 1 of 4)

Radionuclide	Primary Coolant	Secondary Coolant	Building Ventilation				Blowdown Vent. Offgas	Main Condenser Removal	Total
			Fuel	Reactor	Nuclear Auxiliary	Turbine			
	(µCi/gm)	(µCi/gm)	(Ci/yr)	(Ci/yr)	(Ci/yr)	(Ci/yr)	(Ci/yr)	(Ci/yr)	(Ci/yr)
I-131	2.070E-02	2.510E-07	2.7E-04	1.9E-03	6.6E-03	0.0E+00	0.0E+00	0.0E+00	8.8E-03
I-133	7.917E-02	8.929E-07	1.0E-03	5.9E-03	2.5E-02	0.0E+00	0.0E+00	0.0E+00	3.2E-02
H-3	Released via Gaseous Pathway								1.8E+02
C-14	Released via Gaseous Pathway [18.9 Ci/yr OL3, 20% is released as CO2]								3.8E+00
Ar-41	Released via Gaseous Pathway								3.4E+01

Radionuclide	Primary Coolant	Secondary Coolant	Gas Stripping		Building Ventilation			Blowdown Vent. Offgas	Main Condenser Removal	Total
			Shutdown	Continuous	Reactor	Nuclear Auxiliary	Turbine			
	(µCi/gm)	(µCi/gm)	(Ci/yr)	(Ci/yr)	(Ci/yr)	(Ci/yr)	(Ci/yr)	(Ci/yr)	(Ci/yr)	(Ci/yr)
Kr-85m	2.006E-01	2.945E-08	0.0E+00	2.0E+00	1.4E+02	4.0E+00	0.0E+00	0.0E+00	2.0E+00	1.5E+02
Kr-85	3.854E-01	5.512E-08	2.1E+02	1.7E+03	9.1E+02	8.0E+00	0.0E+00	0.0E+00	4.0E+00	2.8E+03
Kr-87	1.884E-01	2.603E-08	0.0E+00	0.0E+00	5.0E+01	4.0E+00	0.0E+00	0.0E+00	2.0E+00	5.6E+01
Kr-88	3.513E-01	5.115E-08	0.0E+00	0.0E+00	1.8E+02	7.0E+00	0.0E+00	0.0E+00	4.0E+00	1.9E+02
Xe-131m	8.272E-01	1.174E-07	8.8E+01	7.0E+02	1.9E+03	1.8E+01	0.0E+00	0.0E+00	8.0E+00	2.7E+03
Xe-133m	8.568E-02	1.269E-08	0.0E+00	0.0E+00	1.7E+02	2.0E+00	0.0E+00	0.0E+00	0.0E+00	1.7E+02
Xe-133	3.090E+00	4.435E-07	4.4E+01	3.5E+02	6.8E+03	6.6E+01	0.0E+00	0.0E+00	3.1E+01	7.3E+03
Xe-135m	1.633E-01	2.344E-08	0.0E+00	0.0E+00	1.0E+01	3.0E+00	0.0E+00	0.0E+00	2.0E+00	1.5E+01
Xe-135	1.063E+00	1.555E-07	0.0E+00	0.0E+00	1.2E+03	2.3E+01	0.0E+00	0.0E+00	1.1E+01	1.2E+03
Xe-137	4.272E-02	6.164E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xe-138	1.508E-01	2.170E-08	0.0E+00	0.0E+00	8.0E+00	3.0E+00	0.0E+00	0.0E+00	1.0E+00	1.2E+01
Total Noble Gases										1.5+04

Table 3.5-8— Annual Gaseous Effluent Releases (English Units)

(Page 2 of 4)

Radionuclide	Airborne Particulate Release Rate (Ci/yr)				
	Waste Gas System	**Reactor Building**	**Nuclear Auxiliary Building**	**Fuel Building**	**Total**
Cr-51	1.4E-07	9.2E-05	3.2E-06	1.8E-06	9.7E-05
Mn-54	2.1E-08	5.3E-05	7.8E-07	3.0E-06	5.7E-05
Co-57	0.0E+00	8.2E-06	0.0E+00	0.0E+00	8.2E-06
Co-58	8.7E-08	2.5E-04	1.9E-05	2.1E-04	4.8E-04
Co-60	1.4E-07	2.6E-05	5.1E-06	8.2E-05	1.1E-04
Fe-59	1.8E-08	2.7E-05	5.0E-07	0.0E+00	2.8E-05
Sr-89	4.4E-07	1.3E-04	7.5E-06	2.1E-05	1.6E-04
Sr-90	1.7E-07	5.2E-05	2.9E-06	8.0E-06	6.3E-05
Zr-95	4.8E-08	0.0E+00	1.0E-05	3.6E-08	1.0E-05
Nb-95	3.7E-08	1.8E-05	3.0E-07	2.4E-05	4.2E-05
Ru-103	3.2E-08	1.6E-05	2.3E-07	3.8E-07	1.7E-05
Ru-106	2.7E-08	0.0E+00	6.0E-08	6.9E-07	7.8E-07
Sb-125	0.0E+00	0.0E+00	3.9E-08	5.7E-07	6.1E-07
Cs-134	3.3E-07	2.5E-05	5.4E-06	1.7E-05	4.8E-05
Cs-136	5.3E-08	3.2E-05	4.8E-07	0.0E+00	3.3E-05
Cs-137	7.7E-07	5.5E-05	7.2E-06	2.7E-05	9.0E-05
Ba-140	2.3E-07	0.0E+00	4.0E-06	0.0E+00	4.2E-06
Ce-141	2.2E-08	1.3E-05	2.6E-07	4.4E-09	1.3E-05

Note:

0.0E+00 appearing in the table indicates release is less than 1.0 Ci/yr for Noble Gases, 0.0001 Ci/yr for Iodine.

Gaseous C-14 is released in the form of CO2. 20% of the C-14 is released as CO2. 0.7 TBq (18.9 Ci) are activated.

Table 3.5-8— Annual Gaseous Effluent Releases (SI Units)

(Page 3 of 4)

<table>
<tr><th rowspan="2">Radionuclide</th><th rowspan="2">Primary Coolant</th><th rowspan="2">Secondary Coolant</th><th colspan="4">Building Ventilation</th><th rowspan="2">Blowdown Vent. Offgas</th><th rowspan="2">Main Condenser Removal</th><th rowspan="2" colspan="2">Total</th></tr>
<tr><th>Fuel</th><th>Reactor</th><th>Nuclear Auxiliary</th><th>Turbine</th></tr>
<tr><td></td><td>(Bq/gm)</td><td>(Bq/gm)</td><td>(Bq/yr)</td><td>(Bq/yr)</td><td>(Bq/yr)</td><td>(Bq/yr)</td><td>(Bq/yr)</td><td>(Bq/yr)</td><td colspan="2">(Bq/yr)</td></tr>
<tr><td>I-131</td><td>7.66E+02</td><td>9.29E-03</td><td>1.00E+07</td><td>7.00E+07</td><td>2.40E+08</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td><td colspan="2">3.30E+08</td></tr>
<tr><td>I-133</td><td>2.93E+03</td><td>3.30E-02</td><td>3.70E+07</td><td>2.20E+08</td><td>9.30E+08</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td><td colspan="2">1.20E+09</td></tr>
<tr><td>H-3</td><td colspan="8">Released via Gaseous Pathway</td><td colspan="2">6.70E+12</td></tr>
<tr><td>C-14</td><td colspan="8">Released via Gaseous Pathway [7.0E+11 Bq/yr OL3, 20% is released as CO2]</td><td colspan="2">1.40E+11</td></tr>
<tr><td>Ar-41</td><td colspan="8">Released via Gaseous Pathway</td><td colspan="2">1.30E+12</td></tr>
<tr><th rowspan="2">Radionuclide</th><th rowspan="2">Primary Coolant</th><th rowspan="2">Secondary Coolant</th><th colspan="2">Gas Stripping</th><th colspan="3">Building Ventilation</th><th rowspan="2">Blowdown Vent. Offgas</th><th rowspan="2">Main Condenser Removal</th><th rowspan="2">Total</th></tr>
<tr><th>Shutdown</th><th>Continuous</th><th>Reactor</th><th>Nuclear Auxiliary</th><th>Turbine</th></tr>
<tr><td></td><td>(Bq/gm)</td><td>(Bq/gm)</td><td>(Bq/yr)</td><td>(Bq/yr)</td><td>(Bq/yr)</td><td>(Bq/yr)</td><td>(Bq/yr)</td><td>(Bq/yr)</td><td>(Bq/yr)</td><td>(Bq/yr)</td></tr>
<tr><td>Kr-85m</td><td>7.42E+03</td><td>1.09E-03</td><td>0.00E+00</td><td>7.40E+10</td><td>5.18E+12</td><td>1.48E+11</td><td>0.00E+00</td><td>0.00E+00</td><td>7.40E+10</td><td>5.55E+12</td></tr>
<tr><td>Kr-85</td><td>1.43E+04</td><td>2.04E-03</td><td>7.77E+12</td><td>6.29E+13</td><td>3.37E+13</td><td>2.96E+11</td><td>0.00E+00</td><td>0.00E+00</td><td>1.48E+11</td><td>1.04E+14</td></tr>
<tr><td>Kr-87</td><td>6.97E+03</td><td>9.63E-04</td><td>0.00E+00</td><td>0.00E+00</td><td>1.85E+12</td><td>1.48E+11</td><td>0.00E+00</td><td>0.00E+00</td><td>7.40E+10</td><td>2.07E+12</td></tr>
<tr><td>Kr-88</td><td>1.30E+04</td><td>1.89E-03</td><td>0.00E+00</td><td>0.00E+00</td><td>6.66E+12</td><td>2.59E+11</td><td>0.00E+00</td><td>0.00E+00</td><td>1.48E+11</td><td>7.03E+12</td></tr>
<tr><td>Xe-131m</td><td>3.06E+04</td><td>4.34E-03</td><td>3.26E+12</td><td>2.59E+13</td><td>7.03E+13</td><td>6.66E+11</td><td>0.00E+00</td><td>0.00E+00</td><td>2.96E+11</td><td>9.99E+13</td></tr>
<tr><td>Xe-133m</td><td>3.17E+03</td><td>4.70E-04</td><td>0.00E+00</td><td>0.00E+00</td><td>6.29E+12</td><td>7.40E+10</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td><td>6.29E+12</td></tr>
<tr><td>Xe-133</td><td>1.14E+05</td><td>1.64E-02</td><td>1.63E+12</td><td>1.30E+13</td><td>2.52E+14</td><td>2.44E+12</td><td>0.00E+00</td><td>0.00E+00</td><td>1.15E+12</td><td>2.70E+14</td></tr>
<tr><td>Xe-135m</td><td>6.04E+03</td><td>8.67E-04</td><td>0.00E+00</td><td>0.00E+00</td><td>3.70E+11</td><td>1.11E+11</td><td>0.00E+00</td><td>0.00E+00</td><td>7.40E+10</td><td>5.55E+11</td></tr>
<tr><td>Xe-135</td><td>3.93E+04</td><td>5.75E-03</td><td>0.00E+00</td><td>0.00E+00</td><td>4.44E+13</td><td>8.51E+11</td><td>0.00E+00</td><td>0.00E+00</td><td>4.07E+11</td><td>4.44E+13</td></tr>
<tr><td>Xe-137</td><td>1.58E+03</td><td>2.28E-04</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr>
<tr><td>Xe-138</td><td>5.58E+03</td><td>8.03E-04</td><td>0.00E+00</td><td>0.00E+00</td><td>2.96E+11</td><td>1.11E+11</td><td>0.00E+00</td><td>0.00E+00</td><td>3.70E+10</td><td>4.44E+11</td></tr>
<tr><td colspan="10">Total Noble Gases</td><td>5.60E+14</td></tr>
</table>

Table 3.5-8— Annual Gaseous Effluent Releases (SI Units)

(Page 4 of 4)

Radionuclide	Airborne Particulate Release Rate (Bq/yr)				
	Waste Gas System	Reactor Building	Nuclear Auxiliary Building	Fuel Building	Total
Cr-51	5.2E+03	3.4E+06	1.2E+05	6.7E+04	3.6E+06
Mn-54	7.8E+02	2.0E+06	2.9E+04	1.1E+05	2.1E+06
Co-57	0.0E+00	3.0E+05	0.0E+00	0.0E+00	3.0E+05
Co-58	3.2E+03	9.3E+06	7.0E+05	7.8E+06	1.8E+07
Co-60	5.2E+03	9.6E+05	1.9E+05	3.0E+06	4.1E+06
Fe-59	6.7E+02	1.0E+06	1.9E+04	0.0E+00	1.0E+06
Sr-89	1.6E+04	4.8E+06	2.8E+05	7.8E+05	5.9E+06
Sr-90	6.3E+03	1.9E+06	1.1E+05	3.0E+05	2.3E+06
Zr-95	1.8E+03	0.0E+00	3.7E+05	1.3E+03	3.7E+05
Nb-95	1.4E+03	6.7E+05	1.1E+04	8.9E+05	1.6E+06
Ru-103	1.2E+03	5.9E+05	8.5E+03	1.4E+04	6.3E+05
Ru-106	1.0E+03	0.0E+00	2.2E+03	2.6E+04	2.9E+04
Sb-125	0.0E+00	0.0E+00	1.4E+03	2.1E+04	2.3E+04
Cs-134	1.2E+04	9.3E+05	2.0E+05	6.3E+05	1.8E+06
Cs-136	2.0E+03	1.2E+06	1.8E+04	0.0E+00	1.2E+06
Cs-137	2.8E+04	2.0E+06	2.7E+05	1.0E+06	3.3E+06
Ba-140	8.5E+03	0.0E+00	1.5E+05	0.0E+00	1.6E+05
Ce-141	8.1E+02	4.8E+05	9.6E+03	1.6E+02	4.8E+05

Note:

0.0E+00 appearing in the table indicates release is less than 3.7E+10 Bq/yr for Noble Gases, 2.7E+06 Bq/yr for Iodine.

Table 3.5-9— Gaseous Waste Release Source Term Inputs

(Page 1 of 2)

Parameter	Value
1. Containment Purge:	
Purge Time of Containment	16 hours
Frequency of Containment Building High Volume Purge	2 times/year
Containment Volume	2.8 million ft^3 (79,287 m^3)
Containment High Volume Purge:	
Iodide Release Fraction	.01
Particulate Release Fraction	0.01
Charcoal Filter	90%
HEPA Filter	99%
Containment Low Volume Purge:	
Flow Rate	3,210 cfm (90,900 liters/min)
Iodide Release Fraction	0.1
Particulate Release Fraction	0.01
Charcoal Filter	90%
HEPA Filter	99%
Containment Atmospheric Cleanup:	
Flow Rate	4,100 cfm (116,100 liters/min)
Charcoal Filter	90%
HEPA Filter	99%
2. Nuclear Auxiliary Building:	
Primary Coolant Leakage to Auxiliary Building	160 lb_m/day (73 kg/day)
Iodide Release Fraction	0.1
Particulate Release Fraction	0.01
Charcoal Filter	90%
HEPA Filter	99%
3. Fuel Building	
Iodide Release Fraction	0.1
Particulate Release Fraction	0.01
Charcoal Filter	90%
HEPA Filter	99%
4. Turbine Building:	
Steam Leakage to Turbine Building	1,700 lb_m/hr (771 kg/hr)
Primary to Secondary Leak Rate	075 lb_m/hr (4.1 kg/hr)
Iodine Partition Factor (Gas/Liquid) in Steam Generator	0.01
Fraction of Iodine Released from Blowdown Tank Vent	0.0
Percent of Iodine Removed from air Ejector Release	0.0
Fraction of Iodine Bypassing condensate Demineralizer	0.67
5. Gaseous Waste Processing System:	
Flow Rate through Gas Stripper	2.7 gpm (10.2 liters/min)
Holdup Time for Xenon	27.7 days
Holdup time for Krypton	1.67 days

Table 3.5-9— Gaseous Waste Release Source Term Inputs

(Page 2 of 2)

Parameter	Value
Gaseous Waste Processing System: Particulate Release Fraction	0.01
Frequency of Primary Coolant Degassing	2 times/year
6. Laundry:	
There is no onsite laundry.	

Table 3.5-10— Annual Solid Waste Generation Volumes

(Page 1 of 2)

Waste Type	Quantity Generated ft^3 (m^3)	Curie (Becquerel) Content		Shipping Volume ft^3 (m^3)		Maximum Number of Containers			Average Expected Curies (Becquerels) per Container			Average Maximum Curies (Becquerels) per Container		
		Expected	Maximum	Expected	Maximum	55 gal (242 L) drums	90 ft^3 (2.5 m^3) HIC	SeaLand Containers (1000 ft^3 (28.3 m^3) box)	55 gal (242 L) drums	90 ft^3 (2.5 m^3) HIC	SeaLand Containers (1000 ft^3 (28.3 m^3) box)	55 gal (242 L) drums	90 ft^3 (2.5 m^3) HIC	SeaLand Containers (1000 ft^3 (28.3 m^3) box)
Evaporator Concentrate	710 (20.1)	1.50E+02 (5.55E+12)	9.12E+03 (3.37E+14)	varies	140 (4.0)	19.0	n/a	n/a	7.9E+00 (2.9E+11)	n/a	n/a	4.8E+02 (1.8E+13)	n/a	n/a
Radioactive Sludge	70 (2.0)	1.48E+01 (5.48E+11)	9.00E+02 (3.33E+13)	varies	35 (1.0)	4.8	0.4	n/a	3.1E+00 (1.1E+11)	3.7E+01 (1.4E+12)	n/a	1.9E+02 (6.9E+12)	2.3E+03 (8.3E+13)	n/a
Centrifuge Sludge	8 (0.2)	1.69E+00 (6.25E+10)	1.03E+02 (3.81E+12)	varies	8 (0.2)	1.1	n/a	n/a	1.5E+00 (5.7E+10)	n/a	n/a	9.4E+01 (3.5E+12)	n/a	n/a
Spent Coolant Purification System and Fuel Pool Purification Resins	90 (2.5)	1.07E+03 (3.96E+13)	5.23E+04 (1.94E+15)	90 (2.5)	90 (2.5)	12.2	1.0	n/a	8.8E+01 (3.2E+12)	1.1E+03 (4.0E+13)	n/a	4.3E+03 (1.6E+14)	5.2E+04 (1.9E+15)	n/a
Spent Radioactive Waste Demineralizer Resins	140 (4.0)	2.96E+01 (1.10E+12)	1.80E+03 (6.66E+13)	140 (4.0)	140 (4.0)	19.0	1.6	n/a	1.6E+00 (5.8E+10)	1.9E+01 (6.8E+11)	n/a	9.5E+01 (3.5E+12)	1.1E+03 (4.2E+13)	n/a
Spent Filter Cartridge	120 (3.4)	6.86E+02 (2.54E+13)	6.86E+02 (2.54E+13)	120 (3.4)	120 (3.4)	16.3	1.3	n/a	4.2E+01 (1.6E+12)	5.3E+02 (2.0E+13)	n/a	4.2E+01 (1.6E+12)	5.3E+02 (2.0E+13)	n/a
KPF Demineralizer Wet Waste	8 (0.2)	1.69E+00 (6.25E+10)	1.03E+02 (3.81E+12)	8 (0.2)	8 (0.2)	n/a	0.1	n/a	n/a	1.7E+01 (6.3E+11)	n/a	n/a	1.0E+03 (3.8E+13)	n/a
Combustible DAW	5300 (150.1)	3.19E+01 (1.18E+12)	1.94E+03 (7.18E+13)	5300 (150.1)	5300 (150.1)	720.8	n/a	5.3	4.4E-02 (1.6E+09)	n/a	6.0E+00 (2.2E+11)	2.7E+00 (1.0E+11)	n/a	3.7E+02 (1.4E+13)
Compressible DAW	1415 (40.1)	6.01E+00 (2.22E+11)	3.66E+02 (1.35E+13)	707 (20.0)	707 (20.0)	96.2	n/a	0.7	6.2E+02 (2.3E-09)	n/a	8.6E+00 (3.2E+11)	3.8E+00 (1.4E+11)	n/a	5.2E+02 (1.9E+13)
Non-Compressible DAW	70 (2.0)	2.97E-01 (1.10E+10)	1.81E+01 (6.7E+11)	70 (2.0)	70 (2.0)	9.5	n/a	0.1	3.1E-02 (1.2E+09)	n/a	3.0E+00 (1.1E+11)	1.9E+00 (7.0E+10)	n/a	1.8E+02 (6.7E+12)

Table 3.5-10— Annual Solid Waste Generation Volumes

(Page 2 of 2)

Waste Type	Quantity Generated ft^3 (m^3)	Curie (Becquerel) Content		Shipping Volume ft^3 (m^3)		Maximum Number of Containers			Average Expected Curies (Becquerels) per Container			Average Maximum Curies (Becquerels) per Container		
		Expected	Maximum	Expected	Maximum	55 gal (242 L) drums	90 ft^3 (2.5 m^3) HIC	SeaLand Containers (1000 ft^3 (28.3 m^3) box)	55 gal (242 L) drums	90 ft^3 (2.5 m^3) HIC	SeaLand Containers (1000 ft^3 (28.3 m^3) box)	55 gal (242 L) drums	90 ft^3 (2.5 m^3) HIC	SeaLand Containers (1000 ft^3 (28.3 m^3) box)
Mixed Waste	2 (0.1)	4.0E-02 (1.48E+09)	2.43E+00 (8.99E+10)	2 (0.1)	2 (0.1)	0.3	0.02	n/a	1.3E-01 (4.9E+09)	2.0E+00 (7.4E+10)	n/a	8.1E+00 (3.0E+11)	1.2E+02 (4.5E+12)	n/a
Totals	7933 (224.6)	1.99E+03 (7.36E+13)	6.73E+04 (2.49E+15)	6437 (182.3)	6620 (187.5)	899.3	4.4	6.1	2.2E+00 (8.2E+10)	4.5E+02 (1.7E+13)	3.3E+00 (1.2E+13)	7.5E+01 (2.8E+12)	1.5E+04 (5.7E+14)	1.1E+04 (4.1E+14)

Table 3.5-11— Liquid Waste Management System Tank Capacity

Description	Number of Tanks	Capacity per Tank gallons (liters)	Total Capacity Gallons (liters)
Liquid Waste Storage Tanks	2 (Group I waste) 2 (Group II waste) 1 (Group III waste)	18,500 (70,030) 18,500 (70,030) 18,500 (70,030)	37,000 (140,060) 37,000 (140,060) 18,500 (70,030)
Concentrate Tanks	3	9,000 (34,070)	27,000 (102,210)
Monitor Tanks	2	18,500 (70,030)	37,000 (140,060)

Table 3.5-12— Liquid Waste Management System Process Parameters

Parameter	Process Value
Design Process Capacity (Nominal) - Evaporator Section	~1,050 gal/hr (3,975 liters/hr)
Design Process Capacity (Nominal) - Centrifuge Section	~ 1,300 gal/hr (4,920 liters/hr)
Design Process Capacity (Nominal) - Demineralizer & Filtration Section	~2,400 gal/hr (9,085 liters/hr)
Maximum Group I Waste Influent Waste Stream	~26,500 gal/wk (100,310 liters/wk)
Maximum Group II Waste Influent Waste Stream	~66,000 gal/wk (249,840 liters/wk)
Maximum Group III Waste Influent Waste Stream	~17,200 gal/wk (65,110 liters/wk)

Table 3.5-13— Radioactivity Input to the Liquid Waste System

Source	Flow Rate	Activity
Shim Bleed	2160 gpd(8180 liters/day)	Primary Coolant Activity (PCA)
Equipment Drains	1,728 gpd(6,541 liters/day)	PCA
Clean Wastes	9,428 gpd(35,690 liters/day)	0.001 PCA
Dirty Wastes	0.0*	Not Applicable*
Steam Generator Blowdown	218,400 lbm/hr (99,065 kg/hr) 628,000 gpd (2,380,000 liters/day)	Steam Activity in the Secondary System (Table 3.5-3)
Primary to Secondary Leak Rate	75 lbm/day (34 kg/day)	Activity in the Secondary System (Table 3.5-3)
Condensate Demineralizer Flow Fraction	0.33	Activity in the Secondary System (Table 3.5-3)

Note:
* Group III waste is not normally radioactive and is being neglected to maximize concentrations.

Table 3.5-14— Radioactivity Input to the Liquid Waste System

(Page 1 of 2)

1.Containment Purge:	
Purge Time of Containment	16 hours
Frequency of Containment Building High Volume Purge	2 times/year
Containment Volume	2.8 million ft^3 (79,287 m^3)
Containment High Volume Purge:	
Iodide Release Fraction	0.1
Particulate Release Fraction	0.01
Filters:	
Charcoal	90%
HEPA	99%
Containment Low Volume Purge Rate	3,210 cfm (1.51 m^3/sec)
Containment Low Volume Purge:	
Iodide Release Fraction	0.1
Particulate Release Fraction	0.01
Filters:	
Charcoal	90%
HEPA	99%
Containment Atmospheric Cleanup:	
Flow Rate	4,100 cfm (11,609 liters/min)
Filters:	
Charcoal	90%
HEPA	99%
2.Auxiliary Building:	
Primary Coolant Leakage to Auxiliary Building	160 lbm/day (73 kg/day)
Iodide Release Fraction	0.1
Particulate Release Fraction	0.01
Filters:	
Charcoal	90%
HEPA	99%
3.Fuel Handling Building	
Iodide Release Fraction	0.1
Particulate Release Fraction	0.01
Filters:	
Charcoal	90%
HEPA	99%
4.Turbine Building:	
Steam Leakage to Turbine Building	1,700 lbm/hr (771 kg/hr)
Primary to Secondary Leak Rate	75 lbm/hr (34 kg/hr)
Iodine Partition Factor (Gas/Liquid) in Steam Generator	0.01
Fraction of Iodine Released from Blowdown Tank Vent	0.0
Percent of Iodine Removed from Air Ejector Release	0.0
Fraction of Iodine Bypassing condensate Demineralizer	0.67

Table 3.5-14— Radioactivity Input to the Liquid Waste System

(Page 2 of 2)

5.Waste Gas System:	
Flow Rate through Gas Stripper	1.276 gpm (4.832 l/min)
Holdup Time for Xenon	27.7 days
Holdup Time for Krypton	1.67 days
Gas Waste System: Particulate Release Fraction	0.01
Frequency of Primary Coolant Degassing	2 times/year
6.Laundry:	
There is no onsite laundry.	

Table 3.5-15— Radioactive Liquid Releases Due to Anticipated Operational Occurrences

(Page 1 of 2)

Radionuclide	Adjusted Total	
	(Ci/yr)	(Bq/yr)
Corrosion and Activation Products		
Na-24	6.16E-03	2.28E+08
Cr-51	1.04E-03	3.85E+07
Mn-54	5.40e-04	2.00E+07
Fe-55	4.10E-04	1.52E+07
Fe-59	1.00E-04	3.70E+06
Co-58	1.56E-03	5.77E+07
Co-60	1.80E-04	6.66E+06
Zn-65	1.70E-04	6.29E+06
W-187	4.70E-04	1.74E+07
Np-239	5.80E-04	2.15E+07
Fission Products		
Sr-89	5.00E-05	1.85E+06
Sr-91	8.00E-05	2.96E+06
Y-91M	5.00E-05	1.85E+06
Y-93	3.60E-04	1.33E+07
Zr-95	1.30E-04	4.81E+06
Nb-95	1.00E-04	3.70E+06
Mo-99	1.76E-03	6.51E+07
Tc-99M	1.71E-03	6.33E+07
Ru-103	2.52E-03	9.32E+07
Rh-103M	2.52E-03	9.32E+07
Ru-106	3.07E-02	1.14E+09
Rh-106	3.07E-02	1.14E+09
Ag-110M	4.40E-04	1.63E+07
Ag-110	6.00E-05	2.22E+06
Te-129M	6.00E-05	2.22E+06
Te-129	4.00E-05	1.48E+06
Te-131M	3.20E-04	1.18E+07
Te-131	6.00E-05	2.22E+06
I131	3.41E-02	1.26E+09
TE132	4.80E-04	1.78E+07
I132	1.16E-03	4.29E+07
I133	3.45E-02	1.28E+09
CS134	2.64E-03	9.77E+07
I135	1.49E-02	5.51E+08
CS136	3.10E-04	1.15E+07
CS137	3.50E-03	1.30E+08
BA137M	3.27E-03	1.21E+08
BA140	4.23E-03	1.57E+08
LA140	7.67E-03	2.84E+08
CE141	5.00E-05	1.85E+06
CE143	6.20E-04	2.29E+07
PR143	5.00E-05	1.85E+07
CE144	1.33E-03	4.92E+07

Table 3.5-15— Radioactive Liquid Releases Due to Anticipated Operational Occurrences

(Page 2 of 2)

Radionuclide	Adjusted Total	
	(Ci/yr)	**(Bq/yr)**
PR144	1.33E-03	4.92E+07
All Others	2.00E-05	7.40E+05
Total (except H-3)	1.93E-01	7.14E+09
H-3	1.66E+03	6.14E+13

Table 3.5-16— Summary of Radioactive Liquid Releases Including Anticipated Operational Occurrences

(Page 1 of 2)

Radio-nuclide	Total		Discharge Concentration		10 CFR 20 Appendix B Limits		Discharge Fraction of Limit
	(Ci/yr)	(Bq/yr)	(µCi/ml)	(Bq/ml)	(µCi/ml)	(Bq/ml)	
Activated Corrosion Products							
Na-24	6.2E-03	2.3E+08	3.6E-10	1.3E-05	5.0E-05	1.9E+00	7.2E-06
Cr-51	1.0E-03	3.9E+07	6.0E-11	2.2E-06	5.0E-04	1.9E+01	1.2E-07
Mn-54	5.4E-04	2.0E+07	3.1E-11	1.2E-06	3.0E-05	1.1E+00	1.0E-06
Fe-55	4.1E-04	1.5E+07	2.4E-11	8.8E-07	1.0E-04	3.7E+00	2.4E-07
Fe-59	1.0E-04	3.7E+06	5.8E-12	2.2E-07	1.0E-05	3.7E-01	5.8E-07
Co-58	1.6E-03	5.8E+07	9.1E-11	3.4E-06	2.0E-05	7.4E-01	4.5E-06
Co-60	1.8E-04	6.7E+06	1.0E-11	3.9E-07	3.0E-06	1.1E-01	3.5E-06
Zn-65	1.7E-04	6.3E+06	9.9E-12	3.7E-07	5.0E-06	1.9E-01	2.0E-06
W-187	4.7E-04	1.7E+07	2.7E-11	1.0E-06	3.0E-05	1.1E+00	9.1E-07
Np-239	5.8E-04	2.2E+07	3.4E-11	1.2E-06	2.0E-05	7.4E-01	1.7E-06
Fission Products							
Sr-89	5.0E-05	1.9E+06	2.9E-12	1.1E-07	8.0E-06	3.0E-01	3.6E-07
Sr-91	8.0E-05	3.0E+06	4.6E-12	1.7E-07	2.0E-05	7.4E-01	2.3E-07
Y-91m	5.0E-05	1.9E+06	2.9E-12	1.1E-07	2.0E-03	7.4E+01	1.5E-09
Y-93	3.6E-04	1.3E+07	2.1E-11	7.7E-07	2.0E-05	7.4E-01	1.0E-06
Zr-95	1.3E-04	4.8E+06	7.5E-12	2.8E-07	2.0E-05	7.4E-01	3.8E-07
N-95	1.0E-04	3.7E+06	5.8E-12	2.2E-07	3.0E-05	1.1E+00	1.9E-07
Mo-99	1.8E-03	6.5E+07	1.0E-10	3.8E-06	2.0E-05	7.4E-01	5.1E-06
Tc-99m	1.7E-03	6.3E+07	9.9E-11	3.7E-06	1.0E-03	3.7E+01	9.9E-08
Ru-103	2.5E-03	9.3E+07	1.5E-10	5.4E-06	3.0E-05	1.1E+00	4.9E-06
Rh-103m	2.5E-03	9.3E+07	1.5E-10	5.4E-06	6.0E-03	2.2E+02	2.4E-08
Ru-106	3.1E-02	1.1E+09	1.8E-09	6.6E-05	3.0E-06	1.1E-01	5.9E-04
Ag-110m	4.4E-04	1.6E+07	2.6E-11	9.4E-07	6.0E-06	2.2E-01	4.3E-06
Te-129m	6.0E-05	2.2E+06	3.5E-12	1.3E-07	7.0E-06	2.6E-01	5.0E-07
Te-129	4.0E-05	1.5E+06	2.3E-12	8.6E-08	4.0E-04	1.5E+01	5.8E-09
Te-131m	3.2E-04	1.2E+07	1.9E-11	6.9E-07	8.0E-06	3.0E-01	2.3E-06
Te-131	6.0E-05	2.2E+06	3.5E-12	1.3E-07	8.0E-05	3.0E+00	4.4E-08
I-131	3.4E-02	1.3E+09	2.0E-09	7.3E-05	1.0E-06	3.7E-02	2.0E-03
Te-132	4.8E-04	1.8E+07	2.8E-11	1.0E-06	9.0E-06	3.3E-01	3.1E-06
I-132	1.2E-03	4.3E+07	6.7E-11	2.5E-06	1.0E-04	3.7E+00	6.7E-07
I-133	3.5E-02	1.3E+09	2.0E-09	7.4E-05	7.0E-06	2.6E-01	2.9E-04
Cs-134	2.6E-03	9.8E+07	1.5E-10	5.7E-06	9.0E-07	3.3E-02	1.7E-04
I-135	1.5E-02	5.5E+08	8.6E-10	3.2E-05	3.0E-05	1.1E+00	2.9E-05
Cs-136	3.1E-04	1.2E+07	1.8E-11	6.7E-07	6.0E-06	2.2E-01	3.0E-06
Cs-137	3.5E-03	1.3E+08	2.0E-10	7.5E-06	1.0E-06	3.7E-02	2.0E-04
Ba-140	4.2E-03	1.6E+08	2.5E-10	9.1E-06	8.0E-06	3.0E-01	3.1E-05
La-140	7.7E-03	2.8E+08	4.5E-10	1.7E-05	9.0E-06	3.3E-01	4.9E-05
Ce-141	5.0E-05	1.9E+06	2.9E-12	1.1E-07	3.0E-05	1.1E+00	9.7E-08
Ce-143	6.2E-04	2.3E+07	3.6E-11	1.3E-06	2.0E-05	7.4E-01	1.8E-06
Pr-143	5.0E-05	1.9E+06	2.9E-12	1.1E-07	2.0E-05	7.4E-01	1.5E-07
Ce-144	1.3E-03	4.9E+07	7.7E-11	2.9E-06	3.0E-06	1.1E-01	2.6E-05
Pr-144	1.3E-03	4.9E+07	7.7E-11	2.9E-06	6.0E-04	2.2E+01	1.3E-07

Table 3.5-16— Summary of Radioactive Liquid Releases Including Anticipated Operational Occurrences

(Page 2 of 2)

Radio-nuclide	Total		Discharge Concentration		10 CFR 20 Appendix B Limits		Discharge Fraction of Limit
	(Ci/yr)	(Bq/yr)	(µCi/ml)	(Bq/ml)	(µCi/ml)	(Bq/ml)	
H-3	1.7E+03	6.1E+13	9.6E-05	3.6E+00	1.0E-03	3.7E+01	9.6E-02

Table 3.5-17— Obtainable Dose Benefits for Liquid Waste System Augment

Cases	Population Total Body Dose - Person-Rem (Person-Sievert)(1)	Population Thyroid Dose Person-Rem (Person-Sievert)(1)
Base Case Evaporator/Centrifuge only, no Waste Demineralizer	3.85E-01 (3.85E-03)	2.91E-01 (2.91E-03)
Additional Waste Demineralizer	1.54E-01 (1.54E-03)	1.37E-01 (1.37E-03)
Obtainable dose benefit	2.31E-01 (2.31E-03)	1.54E-01 (1.54E-03)

Note:
(1)Population dose estimates described in Section 5.4.

Table 3.5-18— Liquid Waste System Augment Total-Body Dose Cost-Benefit Analysis

Parameter	Value
Annual Total-body collective dose benefit to the population within 50 miles of the BBNPP site.	0.23 person-rem (0.0023 person-sievert)
Nominal total collective dose over 40 years of operation (0.23 person-rem x 40 yr = 9.2 person- rem)	9.2 person-rem (0.092 person-sievert)
Value for estimating impact based on NUREG-1530	\$2,000 per person-rem (\$200,000 per person-sievert)
Obtainable benefit from addition of radwaste processing and control option (9.2 person-rem x \$2,000/person-rem = \$18,400)	\$18,400
Cost Options for radwaste processing and control technology upgrade from Regulatory Guide 1.110	400 gpm demineralizer for clean waste processing [a]
Direct cost for option using methodology in Regulatory Guide 1.110, Table A-1 based on 1975 Dollars	\$146,000
Total O&M Annual Cost (From Regulatory Guide 1.110, Table A-2 based on 1975 Dollars)	\$9,700
Total cost over 40 years of operation (direct cost + O&M×40 years)	\$534,000
Benefit/Cost Ratio (Values greater than 1 should be included in plant system design) \$18,400 / \$534,000 = 0.03)	0.03

Note:

[a] The clean waste reflects the nomenclature in GALE and the sizing is based on the EPR GALE input Table 3.5-4.

Table 3.5-19— Liquid Waste System Augment Thyroid Dose Cost-Benefit Analysis

Parameter	Value
Annual thyroid collective dose benefit to the population within 50 miles of the BBNPP site.	0.15 person-rem (0.0015 person-sievert)
Nominal total collective dose over 40 years of operation (0.15 person-rem x 40 yr = 6.0 person- rem)	6.0 person-rem (0.060 person-sievert)
Value for estimating impact based on NUREG-1530 (Note: 10 CFR Part 50, Appendix I has $1,000 per person-rem)	$2,000 per person-rem ($200,000 per person-sievert)
Obtainable benefit from addition of radwaste processing and control options	$12,000
Cost Options for radwaste processing and control technology upgrade from Regulatory Guide 1.110	400 gpm demineralizer for clean waste processing [(a)]
Direct cost for option using methodology in Regulatory Guide 1.110 based on 1975 Dollars	$146,000
Total O&M Annual Cost (From Regulatory Guide 1.110, Table A-2 based on 1975 Dollars)	$9,700
Total cost over 40 years of operation (Direct cost + (O&M × 40 years))	$534,000
Benefit/Cost Ratio (Values greater than 1 should be included in plant system design) ($12,000 / $534,000 = 0.02)	0.02

Note:

[(a)] The clean waste reflects the nomenclature in GALE and the sizing is based on the EPR GALE input Table 3.5-4.

Table 3.5-20— Annual Radioactive Gaseous Releases Due to Anticipated Operational Occurrences

(Page 1 of 2)

	Condition 1		Condition 2		Condition 3		Condition 4	
	Total Off Normal for 0.5% Failed Fuel		Total Off Normal 500 gpd Primary-Secondary Tube Leak for 90 Days		Total Off Normal 1 gpm Reactor Coolant Leakage for 12 Days		Total Off Normal 200 gpd Reactor Coolant leakage to Nuc. Aux. Bldg for 90 Days	
Radionuclide	**(Ci/yr)**	**(Bq/yr)**	**(Ci/yr)**	**(Bq/yr)**	**(Ci/yr)**	**(Bq/yr)**	**(Ci/yr)**	**(Bq/yr)**
I-131	3.7E-02	1.4E+09	8.8E-03	3.2E+08	1.8E-02	6.5E+08	1.9E-02	7.0E+08
I-133	1.3E-01	4.9E+09	3.2E-02	1.2E+09	6.0E-02	2.2E+09	7.1E-02	2.6E+09
Kr-85m	6.3E+02	2.3E+13	1.7E+02	6.2E+12	8.1E+02	3.0E+13	1.5E+02	5.7E+12
Kr-85	1.2E+04	4.4E+14	2.9E+03	1.1E+14	7.1E+03	2.6E+14	2.8E+03	1.1E+14
Kr-87	2.3E+02	8.5E+12	7.4E+01	2.7E+12	2.9E+02	1.1E+13	6.2E+01	2.3E+12
Kr-88	7.9E+02	2.9E+13	2.3E+02	8.5E+12	1.0E+03	3.7E+13	2.0E+02	7.4E+12
Xe-131m	1.1E+04	4.2E+14	2.8E+03	1.0E+14	1.2E+04	4.3E+14	2.7E+03	1.0E+14
Xe-133m	7.1E+02	2.6E+13	1.7E+02	6.4E+12	9.7E+02	3.6E+13	1.8E+02	6.5E+12
Xe-133	3.0E+04	1.1E+15	7.6E+03	2.8E+14	3.9E+04	1.4E+15	7.4E+03	2.7E+14
Xe-135m	6.3E+01	2.3E+12	3.3E+01	1.2E+12	6.2E+01	2.3E+12	2.0E+01	7.4E+11
Xe-135	5.0E+03	1.9E+14	1.3E+03	4.9E+13	6.9E+03	2.5E+14	1.3E+03	4.7E+13
Xe-137	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Xe-138	5.0E+01	1.9E+12	2.1E+01	7.8E+11	5.0E+01	1.8E+12	1.7E+01	6.2E+11
Cr-51	4.0E-04	1.5E+07	9.7E-05	3.6E+06	5.3E-04	2.0E+07	1.0E-04	3.8E+06
Mn-54	2.4E-04	8.8E+06	5.7E-05	2.1E+06	3.1E-04	1.1E+07	5.8E-05	2.1E+06
Co-57	3.4E-05	1.3E+06	8.2E-06	3.0E+05	4.7E-05	1.7E+06	8.2E-06	3.0E+05
Co-58	2.0E-03	7.4E+07	4.8E-04	1.8E+07	1.7E-03	6.1E+07	5.1E-04	1.9E+07
Co-60	4.7E-04	1.7E+07	1.1E-04	4.2E+06	2.4E-04	8.7E+06	1.2E-04	4.5E+06
Fe-59	1.1E-04	4.2E+06	2.8E-05	1.0E+06	1.5E-04	5.7E+06	2.8E-05	1.0E+06
Sr-89	6.6E-04	2.5E+07	1.6E-04	5.9E+06	7.7E-04	2.8E+07	1.7E-04	6.3E+06
Sr-90	2.6E-04	9.7E+06	6.3E-05	2.3E+06	3.1E-04	1.1E+07	6.8E-05	2.5E+06
Zr-95	4.2E-05	1.6E+06	1.0E-05	3.7E+05	1.0E-05	3.7E+05	2.6E-05	9.5E+05
Nb-95	1.8E-04	6.5E+06	4.2E-05	1.6E+06	1.3E-04	4.7E+06	4.3E-05	1.6E+06
Ru-103	6.9E-05	2.6E+06	1.7E-05	6.2E+05	9.2E-05	3.4E+06	1.7E-05	6.3E+05
Ru-106	3.2E-06	1.2E+05	7.8E-07	2.9E+04	7.8E-07	2.9E+04	8.7E-07	3.2E+04
Sb-125	2.5E-06	9.4E+04	6.1E-07	2.3E+04	6.1E-07	2.3E+04	6.7E-07	2.5E+04
Cs-134	2.0E-04	7.4E+06	4.8E-05	1.8E+06	1.7E-04	6.1E+06	5.6E-05	2.1E+06
Cs-136	1.4E-04	5.0E+06	3.3E-05	1.2E+06	1.8E-04	6.8E+06	3.3E-05	1.2E+06
Cs-137	3.7E-04	1.4E+07	9.0E-05	3.3E+06	3.5E-04	1.3E+07	1.0E-04	3.7E+06

Table 3.5-20— Annual Radioactive Gaseous Releases Due to Anticipated Operational Occurrences

(Page 2 of 2)

	Condition 1		**Condition 2**		**Condition 3**		**Condition 4**	
	Total Off Normal for 0.5% Failed Fuel		**Total Off Normal 500 gpd Primary-Secondary Tube Leak for 90 Days**		**Total Off Normal 1 gpm Reactor Coolant Leakage for 12 Days**		**Total Off Normal 200 gpd Reactor Coolant leakage to Nuc. Aux. Bldg for 90 Days**	
Radionuclide	**(Ci/yr)**	**(Bq/yr)**	**(Ci/yr)**	**(Bq/yr)**	**(Ci/yr)**	**(Bq/yr)**	**(Ci/yr)**	**(Bq/yr)**
Ba-140	1.8E-05	6.5E+05	4.2E-06	1.6E+05	4.2E-06	1.6E+05	1.0E-05	3.9E+05
Ce-141	5.5E-05	2.0E+06	1.3E-05	4.9E+05	7.4E-05	2.8E+06	1.4E-05	5.1E+05

Note:

(a) Less than 1.0 Ci/yr for noble gases.

Table 3.5-21— Obtainable Dose Benefits for Gaseous Waste System Augment

Cases	**Population Total Body Dose[a]- Person-Rem (Person-Sievert)**	**Population Thyroid Dose[a] Person-Rem (Person-Sievert)**
Baseline Configuration	4.00E+00 (4.00E-02)	4.26E+00 (4.26E-02)
Extra Carbon Delay Bed	3.95E+00 (3.95E-02)	4.21E+00 (4.21E-02)
Obtainable dose benefit by augment	5.0E-02 (5.0E-04)	5.0E-02 (5.0E-04)

Note:

(a) Population dose estimates described in Section 5.4

Table 3.5-22— Gaseous Waste System Augment Total-Body / Thyroid Dose Cost Benefit Analysis

Parameter	Value[(a)]
Annual whole-body / Thyroid collective dose benefit to the population within 50 miles of the BBNPP site.	0.05 person-rem (0.0005 person-sievert)
Nominal total collective dose over 40 years of operation (0.05 person-rem x 40 yr = 2.0 person-rem)	2.0 person-rem (0.02 person-sievert)
Value for estimating impact based on NUREG-1530	$2,000 per person-rem ($200,000 per person-sievert)
Obtainable benefit from addition of radwaste processing and control option (2.0 person-rem x $2000/person-rem =$4,000)	$4,000
Cost Options for radwaste processing and control technology upgrade from Regulatory Guide 1.110	3-ton charcoal absorber
Direct cost for option (using methodology in Regulatory Guide 1.110, Table A-1 based on 1975 Dollars)	$67,000
Total O&M Annual Cost (From Regulatory Guide 1.110, Table A-2 based on 1975 Dollars	Negligible
Total cost over 40 years of operation (direct cost + O&M×40 years)	$67,000
Benefit/Cost Ratio (Values greater than 1 should be included in plant system design) ($4,000 / $67,000 = 0.06)	0.06

Note:
(a) Since the dose reduction benefit for both the total body and the thyroid give the same collective dose savings, the cost benefit results are directly applicable to both the total body and thyroid evaluations.

Table 3.5-23— Radiation Monitors

(Page 1 of 11)

Method	Monitoring Task	Radioisotopes	Range
Noble Gas Effluent Monitors			
Measurement with a beta-sensitive detector (β)	Monitor the noble gas radioactivity concentration of the primary coolant by measuring the noble gas activity concentration in the gaseous volume flow subsequently to the degasifier for primary coolant of the Nuclear Sampling System.	Kr-85, Xe-133	3E-7 – 3E-3 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the noble gas radioactivity in the exhaust air of KLE cell 1 ventilation systems of the Aux Bldg	Kr-85, Xe-133	3E-7 – 1E-2 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the noble gas radioactivity in the exhaust air of KLE cell 2 ventilation systems of the Aux Bldg.	Kr-85, Xe-133	3E-7 – 1E-2 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the noble gas radioactivity in the exhaust air of KLE cell 3 ventilation systems of the Aux Bldg.	Kr-85, Xe-133	3E-7 – 1E-2 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the noble gas radioactivity in the exhaust air of KLL cell 4 ventilation systems of the Fuel Bldg.	Kr-85, Xe-133	3E-7 – 1E-2 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the noble gas radioactivity in the exhaust air of KLL cell 5 ventilation systems of the Fuel Bldg.	Kr-85, Xe-133	3E-7 – 1E-2 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the noble gas radioactivity in the exhaust air of KLC cell 6 ventilation systems of the Safeguards Bldgs.	Kr-85, Xe-133	3E-7 – 1E-2 µCi/cc
Measurement with a beta-sensitive detector (β)	Three (3) detectors to monitor the noble gas radioactivity in the exhaust air KLA2 containment ventilation.	Kr-85, Xe-133	3E-7 – 1E-2 µCi/cc
Measurement with a beta-sensitive detector (β)	Three (3) detectors to monitor the noble gas activity in the vent stack.	Kr-85, Xe-133	3E-7 – 1E-4 µCi/cc 3E+4 – 1E+9 µCi/hr
Calculated	Three (3) noble gas activity release rate calculation modules using the measured values from the noble gas vent stack monitor and the air flow through the vent stack.	Kr-85, Xe-133	3E-7 – 1E-4 µCi/cc 3E+4 – 1E+9 µCi/hr
Laboratory evaluation of samples.	Monitor the vent stack exhaust air using a sample drawn on demand. Using a mobile high pressure compressor unit, the filtered air sample is filled into a gas bottle. The samples are analyzed in the radiochemical laboratory by gamma spectroscopic evaluation of the nuclide specific composition of the noble gases.		n/a
Laboratory evaluation of samples.	Monitor the vent stack exhaust air during and after accidents using a two (2) small sample cylinders drawn on demand. The samples are analyzed in the radiochemical laboratory by gamma spectroscopic evaluation of the nuclide specific composition of the noble gases.	Kr-85, Xe-133	n/a

Table 3.5-23— Radiation Monitors

(Page 2 of 11)

Method	Monitoring Task	Radioisotopes	Range
Measurement with gamma-sensitive detectors adjacent to the monitored air duct (γ)	Two (2) detectors to monitor the air of the annulus air extraction system downstream of the filters. The instruments are to function also during a severe accident.	Kr-85, Xe-133	1E-4 — 1E+4 rad/hr
Measurement with gamma-sensitive detectors adjacent to the monitored air duct (γ)	Two detectors to monitor the air of the safeguard building controlled-area ventilation system downstream of the filters. The instruments are intended to function also during a severe accident.	Kr-85,Xe-133	1E-4 — 1E+4 rad/hr
Measurement with gamma-sensitive detectors inside the stack (γ)	Two detectors to monitor dose rate of air in discharges during accidents. The instruments are intended to function also during a severe accident.	Kr-85, Xe-133	1E-4 — 1E+4 rad/hr
Measurement with a beta-sensitive detector (β)	Monitor the noble gas activity in the region of the refueling machine within the containment while moving fuel assemblies.	Kr-85, Xe-133	1E-6 – 1E-2 µCi/cc
Measurement with a beta-sensitive detector (β)	Monitor the noble gas activity in the region of the spent fuel mast bridge within the fuel building while moving fuel assemblies.	Kr-85, Xe-133	1E-6 – 1E-2 µCi/cc
Measurement with gamma-sensitive detectors adjacent to the monitored air duct (γ)	Two detectors to monitor the air of the annulus air extraction system downstream of the filters. The instruments are to function also during a severe accident.	Kr-85, Xe-133	1E-4 – 1E+4 rad/hr
Measurement with gamma-sensitive detectors adjacent to the monitored air duct (γ)	Two detectors to monitor the air of the safeguard building controlled-area ventilation system downstream of the filters. The instruments are intended to function also during a severe accident.	Kr-85, Xe-133	1E-4 – 1E+4 rad/hr
Measurement with gamma-sensitive detectors inside the stack (γ)	Two detectors to monitor gas activity discharges during accidents. The instruments are intended to function also during a severe accident.	Kr-85, Xe-133	1E-4 – 1E+4 rad/hr
Iodine and Aerosol (Halogen and Particulate) Monitoring			
Laboratory evaluation of samples.	Filter cartridge sampler for aerosol radioactivity in the air of the annulus air extraction system downstream of the filters. The filter cartridge is evaluated in the laboratory when required.	-	n/a
Laboratory evaluation of samples.	Filter cartridge sampler for gaseous radioiodine in the air of the annulus air extraction system downstream of the filters. The filter cartridge is evaluated in the laboratory when required.	-	n/s
Laboratory evaluation of samples.	Filter cartridge sampler for aerosol radioactivity in the air of the safeguard building controlled-area ventilation system downstream of the filters. The filter cartridge is evaluated in the laboratory when required.	-	n/s
Laboratory evaluation of samples.	Filter cartridge sampler for gaseous radioiodine in the air of the safeguard building controlled-area ventilation system downstream of the filters. The filter cartridge is evaluated in the laboratory when required.	-	n/s

Table 3.5-23— Radiation Monitors

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Method	Monitoring Task	Radioisotopes	Range
Laboratory evaluation of samples.	Filter cartridge sampler for aerosol radioactivity in the exhaust air of the access building. The filter cartridge is evaluated in the laboratory when required.	I-131	n/s
Laboratory evaluation of samples.	Filter cartridge sampler for gaseous radioiodine in the exhaust air of the access building. The filter cartridge is evaluated in the laboratory when required.	I-131	n/a
Laboratory evaluation of samples.	Filter cartridge sampler for aerosol radioactivity down-stream of filters of the laboratory exhaust air in the nuclear auxiliary building. The filter cartridge is evaluated in the laboratory when required.	I-131	n/a
Laboratory evaluation of samples.	Filter cartridge sampler for gaseous radioiodine down-stream of filters of the laboratory exhaust air in the nuclear auxiliary building. The filter cartridge is evaluated in the laboratory when required.	I-131	n/a
Laboratory evaluation of samples.	Filter cartridge sampler for aerosol radioactivity in the filtered system exhaust air of the radwaste building. The filter cartridge is evaluated in the laboratory when required..	–	
Laboratory evaluation of samples.	Filter cartridge sampler for gaseous radioiodine in the filtered system exhaust air of the radwaste building. The filter cartridge is evaluated in the laboratory when required.	-	
Measurement with a gamma-sensitive detector (γ)	Filter cartridge sampler for aerosol radioisotopes by continuous collection from a sample of the exhaust air on a particulate air filter and on a filter for gaseous iodine during and after accidents. Monitor the entire activity accumulated on the filters, the change of the entire activity accumulated on the filters with time, and the change of the entire iodine-131 activity accumulated on the filters with time.	I-131	5E-10 - 3E-2 μCi (entire activity) 5E-11 - 3E-7 μCi /cc (I-131) 3E-9 - 5E-3 μCi /cc (Iodine, less I-131)
Measurement with a gamma-sensitive detector (γ)	Filter cartridge sampler for gaseous radioiodine by continuous collection from a sample of the exhaust air on a particulate air filter and on a filter for gaseous radioiodine during and after accidents. Monitor the entire activity accumulated on the filters, the change of the entire activity accumulated on the filters with time, and the change of the entire iodine-131 activity accumulated on the filters with time.	I-131	5E-10 - 3E-2 μCi (entire activity) 5E-11 - 3E-7 μCi /cc (I-131) 3E-9 - 5E-3 μCi /cc (Iodine, less I-131)
Laboratory evaluation of samples	Two (2) filter cartridge samplers for aerosol radioactivity in the vent stack exhaust air. Each cartridge is to contain a particle filter and a dual element for organic and elemental iodine.	I-131	n/a
laboratory evaluation of samples	Two (2) filter cartridge samplers for gaseous radioiodine in the vent stack exhaust air. Each cartridge is to contain a particle filter and a dual element for organic and elemental iodine.	I-131	n/a
Laboratory evaluation of samples	Two (2) filter cartridge samplers for aerosol radioactivity in the vent stack exhaust air. Each cartridge is to contain a particle filter and a dual element for organic and elemental iodine. The instruments are intended to function before, during, and after an abnormal event.	I-131	n/a
Laboratory evaluation of samples	Two (2) filter cartridge samplers for gaseous radioiodine in the vent stack exhaust air. Each cartridge is to contain a particle filter and a dual element for organic and elemental iodine. The instruments are intended to function before, during, and after an abnormal event.	I-131	n/a

Table 3.5-23— Radiation Monitors

(Page 4 of 11)

Method	Monitoring Task	Radioisotopes	Range
Laboratory evaluation of samples	Two (2) filter cartridge samplers for the vent stack exhaust air including vapor, carbon dioxide, and the other carbon compounds continuously. Redundant samples are evaluated in the laboratory for H-3 and C-14.		n/a
Laboratory evaluation of samples	Two (2) filter cartridge samplers for aerosol radioactivity in the exhaust air of the containment ventilation system. The filter cartridges are evaluated in the laboratory when required.	I-131	n/a
Laboratory evaluation of samples	Three (3) filter cartridge samplers for aerosol radioactivity in the exhaust air of ventilation systems of the Aux Bldg. The filter cartridges are evaluated in the laboratory when required.	I-131	n/a
Laboratory evaluation of samples	Filter cartridge sampler for aerosol radioactivity in the exhaust air of the hot workshop in the Aux Bldg. The filter cartridge is evaluated in the laboratory when required.	I-131	n/a
Laboratory evaluation of samples	Two (2) filter cartridge samplers for aerosol radioactivity in the exhaust air of ventilation systems of the Fuel Bldg. The filter cartridges are evaluated in the laboratory when required.	I-131	n/a
Laboratory evaluation of samples	Filter cartridge sampler for aerosol radioactivity in the exhaust air of ventilation systems of the Safeguard Bldg. The filter cartridge is evaluated in the laboratory when required.	I-131	n/a
Laboratory evaluation of samples	Filter cartridge sampler for aerosol radioactivity in the exhaust air of the laboratory in the Aux Bldg. The filter cartridge is evaluated in the laboratory when required.	Cs-137	n/a
Laboratory evaluation of samples	Four (4) filter cartridge samplers for aerosol radioactivity in the exhaust air of ventilation systems of the Radwaste Bldg. The filter cartridges are evaluated in the laboratory when required.	I-131	n/a
Process Monitors			
Measurement with a gamma-sensitive detector (γ)	All small items, tools etc. brought out of the controlled area are measured and released by four (4) automatic release boxes.	Co-60, Cs-137	Co-60: 40% Cs-137: 22%
Measurement with alpha- and beta- sensitive contamination detectors and gamma-sensitive detectors. (α,β,γ)	All persons leaving the controlled area are controlled with regard to radioactive contamination with eight (8) two-step contamination monitors.	Co-60, Cs-137	Co-60: 28% Cs-137: 40%
Measurement with a gamma-sensitive electronic personnel dosimeter. (γ)	At the entrance and exit of the controlled area the personnel dosimeters are read by four (4) dosimeter readers.		60 keV - 6 MeV Energy range 1E-4 - 1E+3 rem Dose range
Measurement with a gamma-sensitive detector (γ)	Monitor the decontamination room for radiation.		1E-4 - 1E+1 rem/hr

Table 3.5-23— Radiation Monitors

(Page 5 of 11)

Method	Monitoring Task	Radioisotopes	Range
Integral gamma-measurement with a gamma-sensitive detector (threshold 100 keV) (γ)	Four (4) detectors monitor the component cooling loop for radiation.		1E-6 - 1E-3 μCi/ml
Measurement with a gamma-sensitive detectors (γ)	Four (4) detectors monitor the high-pressure coolers of the volume control system. The detectors are installed at the component cooling water inlet and outlet of each HP cooler. The purpose is to detect a leak from the primary side to the component cooling water side.		3E-5 - 3E+0 μCi/ml
Measurement with a gamma-sensitive detectors (γ)	The instrument monitors the dose rate level at the top of the drum (at 10 cm distance) while the drum is rotated slowly.		1E-4 — 1 rad/hr
Measurement with a gamma-sensitive detectors (γ)	The instrument monitors the dose rate level at the bottom of the drum (at 10 cm distance) while the drum is rotated slowly.		1E-4 — 1 rad/hr
Measurement with a gamma-sensitive detectors (γ)	The instrument monitors the dose rate level at the shell of the drum (upper area, at 10 cm distance) while the drum is rotated slowly.		1E-4 — 1 rad/hr
Measurement with a gamma-sensitive detectors (γ)	The instrument monitors the dose rate level at the shell of the drum (middle area, at 10 cm distance) while the drum is rotated slowly.		1E-4 — 1 rad/hr
Measurement with a gamma-sensitive detectors (γ)	The instrument monitors the dose rate level at the shell of the drum (lower area, at 10 cm distance) while the drum is rotated slowly.		1E-4 — 1 rad/hr
Measurement with a gamma-sensitive detectors (γ)	The instrument monitors the dose rate level at 1 meter distance of the drum while the drum is rotated slowly.		1E-4 — 1 rad/hr
Measurement with a gamma-sensitive detectors (γ)	The instrument monitors the dose rate level in the vicinity of the drum measuring equipment as background measurement (in absence of a waste drum).		1E-4 — 1 rad/hr
Gamma spectrometer with multi channel analyzer. (γ)	The device consists of a gamma spectroscopy system for the identification of gamma isotopes contained in a 200 liter drum.		1E-4 — 1 rad/hr
Measurement with a gamma-sensitive detector (γ)	Monitor the upstream activity entering the delay beds of the gaseous waste disposal system.	Kr-85, Xe-133	3E-7 - 1E-2 μCi/cc
Measurement with a beta-sensitive detector (β)	Monitor the activity concentration in the pipe leading from the gas delay line to the vent stack.	Kr-85, Xe-133	3E-7 - 1E+2 μCi/cc

Table 3.5-23— Radiation Monitors

(Page 6 of 11)

Method	Monitoring Task	Radioisotopes	Range
Measurement with gamma-sensitive detectors (γ)	Monitor the N-16 radiation of the main steam to detect leakage in the steam generator (i.e., N-16, noble gases). This is monitored by four (4) redundant instruments on each main steam line, for a total of sixteen (16) detectors. The detectors are mounted adjacent to the monitored main steam lines within the main steam and feedwater valve compartments.	N-16	1E-8 – 1E-2 µCi/cc
Integral measurement with gamma-sensitive detector (threshold 100 keV) and ring vessel (γ)	Monitor the blowdown water of each individual steam generator (four (4) detectors total, one (1) on each steam generator).		3E-6 - 1E-2 µCi/ml
Measurement with beta/ gamma-sensitive detector (β,γ)	Possible remaining contamination on clothing after washing is monitored. This measurement is performed by a high sensitive laundry monitor.	Co-60, Cr-51	Beta: Co-60 — 13% Gamma: Cr-51 — 2%
Integral measurement with gamma-sensitive detector (γ)	Monitor the liquid effluent from the Plant Drainage System before it is discharged to the retention pond.		3E-6 - 1E-2 µCi/ml
Integral measurement with gamma-sensitive detector (γ)	Monitor the condensate polishing demineralizer.		3E-6 - 1E-2 µCi/ml
Airborne Monitoring			
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector. (β,γ)	Monitor the aerosol radioactivity in the exhaust air of containment ventilation.	Cs-137	3E-10 - 1E-6 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the gaseous iodine radioactivity in the exhaust air of containment ventilation.	I-131	3E-10 -5E-8 µCi/cc
Measurement with a beta-sensitive detector (β)	Monitor for tritium radioactivity in the exhaust air of containment ventilation.	H-3	3E-9 - 3E-4 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Two detectors monitor the dose rate from noble gases in air leaving the containment adjacent to monitored air duct KLA2. These redundant instruments provide input to a control function.		1E-5 - 1E+0 rad/hr

Table 3.5-23— Radiation Monitors

(Page 7 of 11)

Method	Monitoring Task	Radioisotopes	Range
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector (β,γ)	Monitor the aerosol radioactivity in the exhaust air of KLE cell 1 ventilation system in the Aux Bldg.		3E-10 - 1E-6 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the gaseous radioiodine in the exhaust air of KLE cell 1 ventilation system in the Aux Bldg.	I-131	3E-10 - 5E-8 µCi/cc
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector (β,γ)	Monitor the aerosol radioactivity in the exhaust air of KLE cell 2 ventilation system in the Aux Bldg.		3E-10 - 1E-6 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the gaseous radioiodine in the exhaust air of KLE cell 2 ventilation system in the Aux Bldg.	I-131	3E-10 - 5E-8 µCi/cc
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector (β,γ)	Monitor the aerosol radioactivity in the exhaust air of KLE cell 3 ventilation system in the Aux Bldg.		3E-10 - 1E-6 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the gaseous radioiodine in the exhaust air of KLE cell 3 ventilation system in the Aux Bldg.	I-131	3E-10 - 5E-8 µCi/cc

Table 3.5-23— Radiation Monitors

(Page 8 of 11)

Method	Monitoring Task	Radioisotopes	Range
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector (β,γ)	Monitor the aerosol radioactivity in the exhaust air of KLL cell 4 ventilation system in the Fuel Bldg.		3E-10 - 1E-6 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the gaseous radioiodine in the exhaust air of KLL cell 4 ventilation system in the Fuel Bldg.	I-131	3E-10 - 5E-8 µCi/cc
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector (β,γ)	Monitor the aerosol radioactivity in the exhaust air of KLL cell 5 ventilation system in the Fuel Bldg.	Cs-137	3E-10 - 1E-6 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the gaseous radioiodine in the exhaust air of KLL cell 5 ventilation system in the Fuel Bldg.	I-131	3E-10 - 5E-8 µCi/cc
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta sensitive detector (β,γ)	Monitor the aerosol radioactivity in the exhaust air of KLC cell 6 ventilation system in the Safeguard Bldg.		3E-10 - 1E-6 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the gaseous radioiodine in the exhaust air of KLC cell 6 ventilation system in the Safeguard Bldg.	I-131	3E-10 - 5E-6 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Two detectors monitor the air leaving the fuel handling area adjacent to the monitored air duct. These redundant instruments provide input to a control function.	n/a	1E-5 - 1E+0 rad/hr

Table 3.5-23— Radiation Monitors

(Page 9 of 11)

Method	Monitoring Task	Radioisotopes	Range
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector (β,γ)	Monitor the aerosol radioactivity in the laboratory room exhaust air before the filters.	n/a	3E-10 — 1E-6 µCi/cc Must be capable of detecting 10 DAC-hours
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector (β,γ)	Monitor the aerosol radioactivity in the exhaust air of the hot workshop before the filters.	n/a	3E-10 - 1E-6 µCi/cc Must be capable of detecting 10 DAC-hours
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector (β,γ)	Monitor the aerosol radioactivity in the exhaust air of KLF from the Radwaste Building.	Cs-137	3E-10 - 1E-6 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Two detectors monitor the gaseous iodine radioactivity in the exhaust air of KLF from the Radwaste Building.	n/a	3E-10 - 5E-8 µCi/cc
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector (β,γ)	Monitor the aerosol radioactivity in the exhaust air of KLF from the Radwaste Building.	n/a	3E-10 - 1E-6 µCi/cc

Table 3.5-23— Radiation Monitors

(Page 10 of 11)

Method	Monitoring Task	Radioisotopes	Range
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector (β,γ)	Monitor the aerosol radioactivity in the exhaust air of the decontamination room in the Radwaste Building.	n/a	3E-10 - 1E-6 µCi/cc Must be capable of detecting 10 DAC-hours
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector (β,γ)	Monitor the aerosol radioactivity in the exhaust air of the mechanical workshop in the Radwaste Building.	n/a	3E-10 — 1E-6 µCi/cc Must be capable of detecting 10 DAC-hours
Measurement with a gamma-sensitive detector (γ)	Two detectors monitor the radioactivity in the intake air of the main control room inside each of the two MCR intake air ventilation ducts.	-	1E-5 — 1E+1 rad/hr
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector (β,γ)	Monitor the aerosol activity in the vent stack.	Cs-137	1E-9 – 1E+2 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the gaseous radioiodine (I-131) in the vent stack.	I-131	5E-11 – 3E-07 µCi/cc
Calculated release	Calculate the I-131 release using the gamma-sensitive detector in the vent stack and the stack air flow.	n/a	n/a

Table 3.5-23— Radiation Monitors

(Page 11 of 11)

Method	Monitoring Task	Radioisotopes	Range
Measurement with a gamma-sensitive detector (threshold 350 keV). Alternatively aerosol radioactivity is monitored continuously by a beta-sensitive detector (β,γ)	Monitor the aerosol radioactivity in the exhaust air of containment ventilation.	Te-129, Ru-106, Rh- 106	3E-10 — 1E-6 µCi/cc
Measurement with a gamma-sensitive detector (γ)	Monitor the gaseous iodine radioactivity in the exhaust air of containment ventilation.	I-131	3E-10 — 5E-8 µCi/cc

Figure 3.5-1— Radwaste Effluent Flow Path

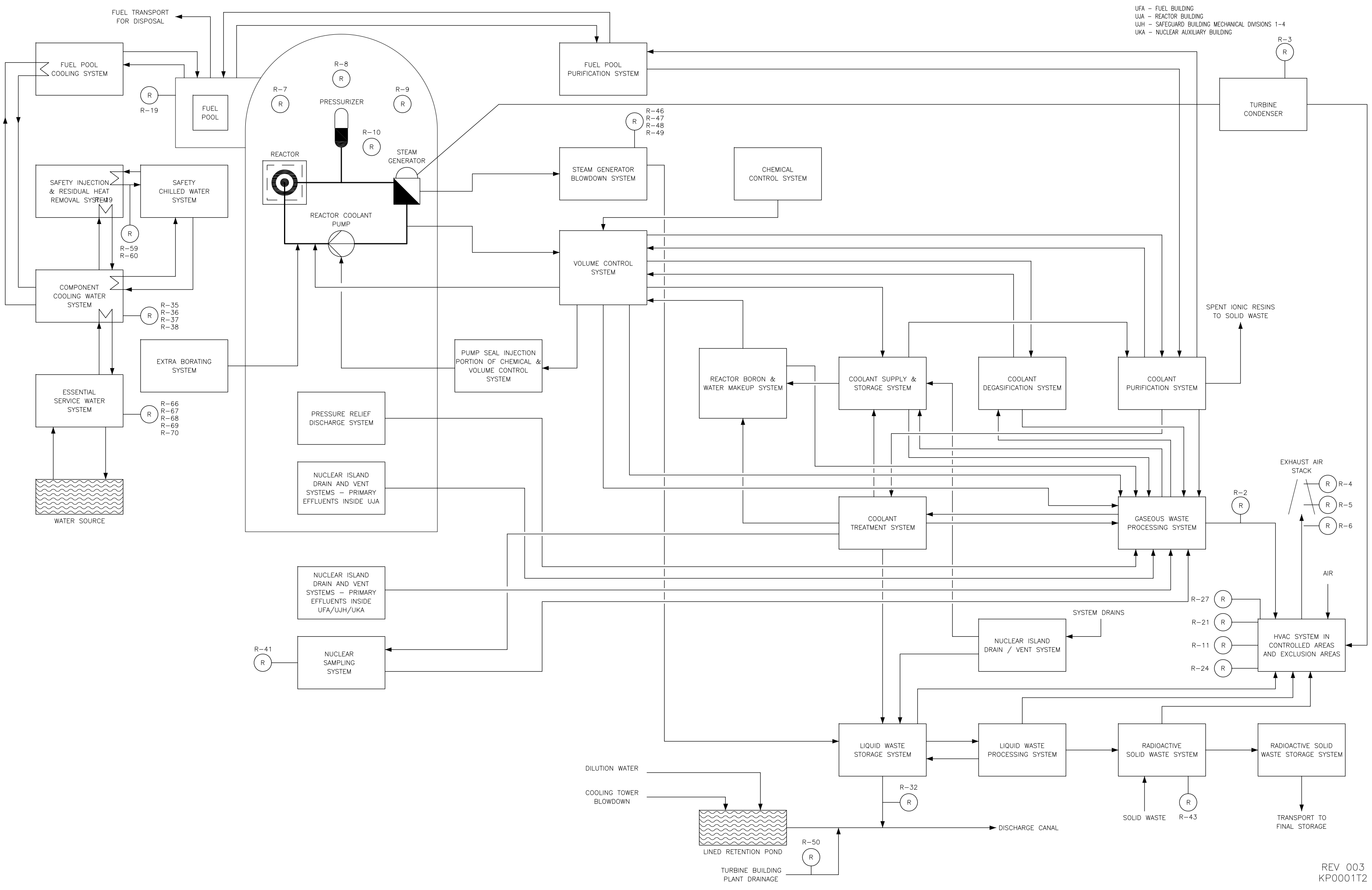

Figure 3.5-2— Liquid Radwaste Storage System

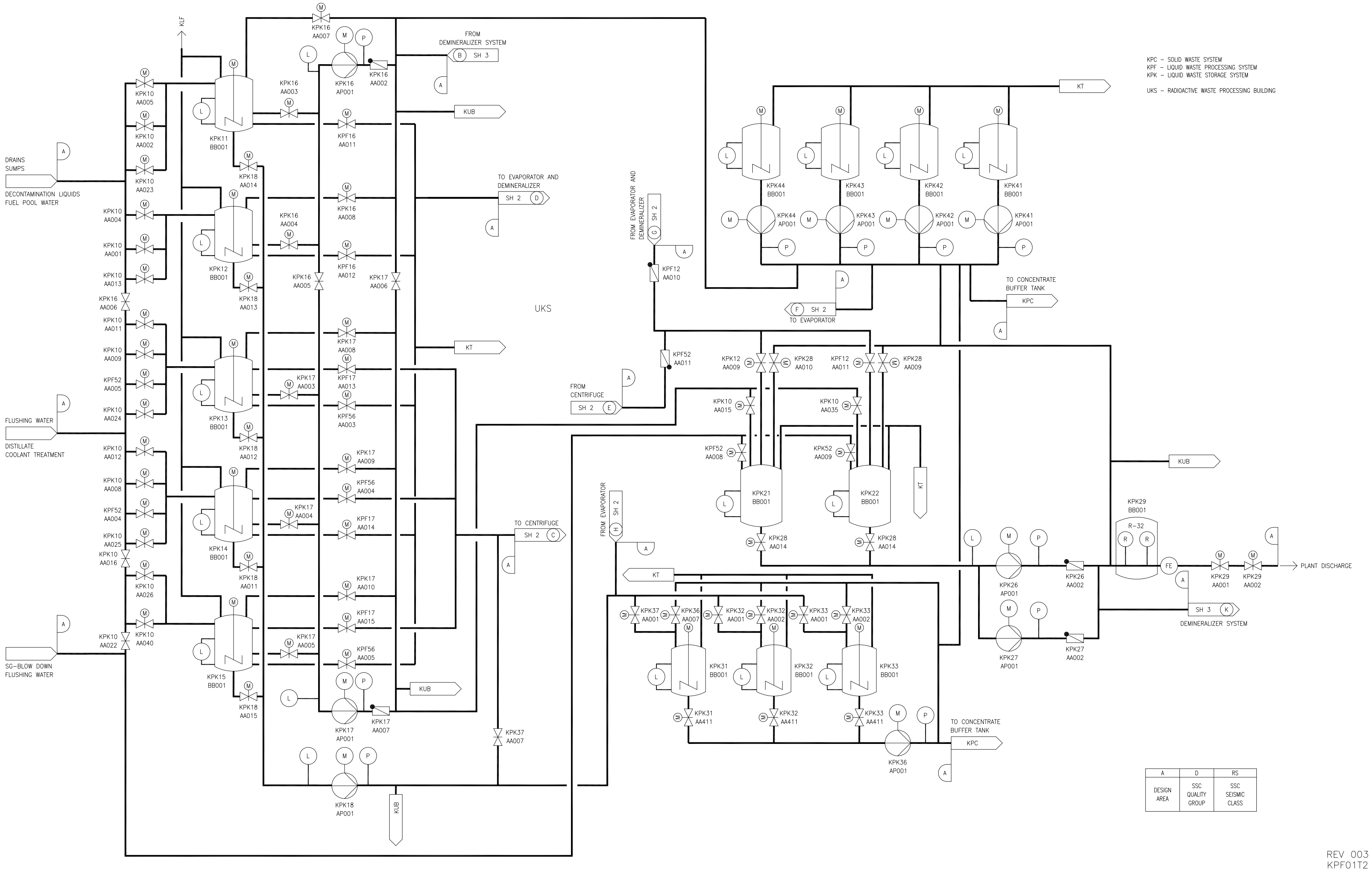

Figure 3.5-3— Liquid Waste Processing Evaporator and Centrifuge

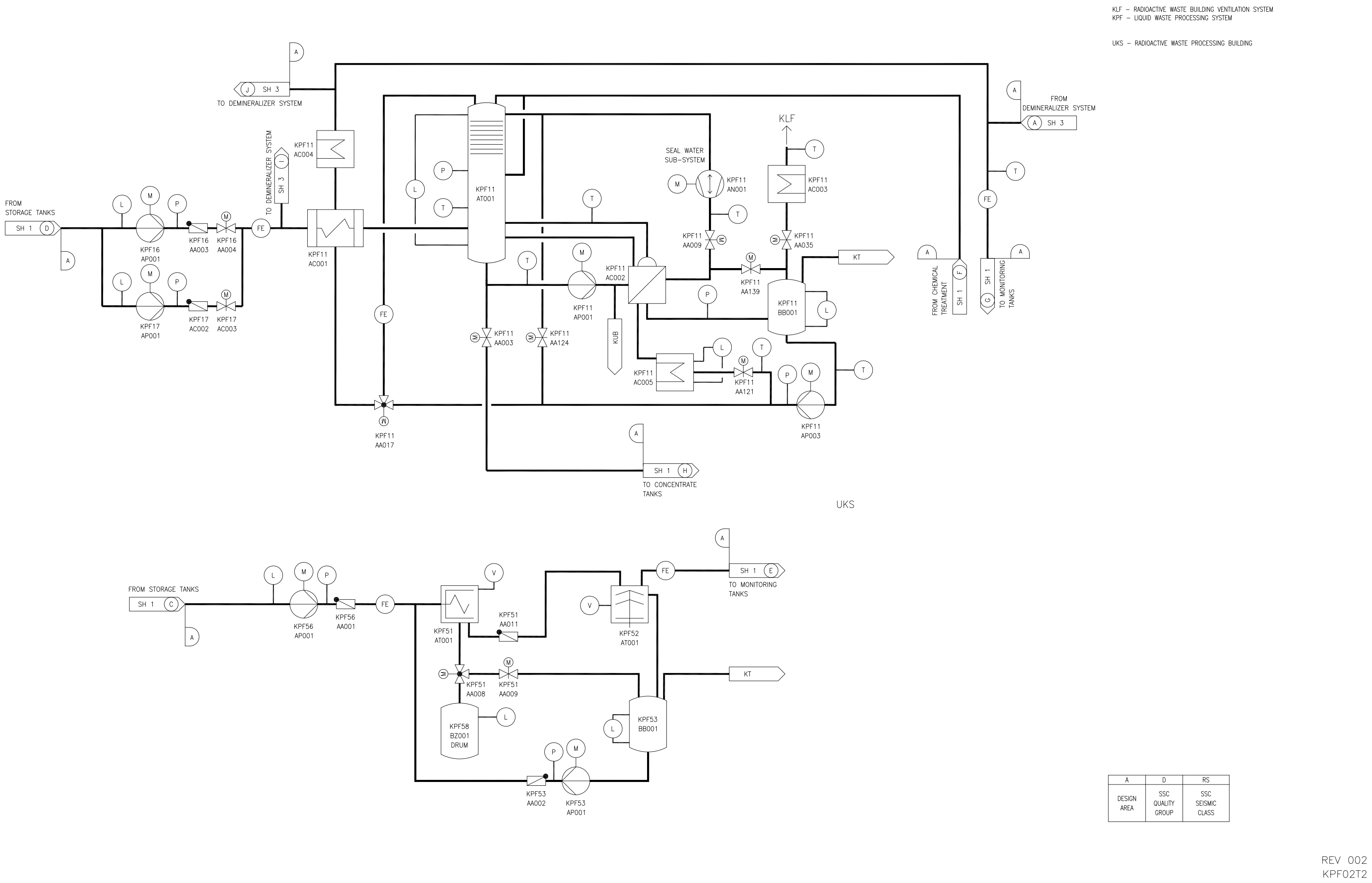

Figure 3.5-4— Liquid Radwaste Processing Demineralizer System

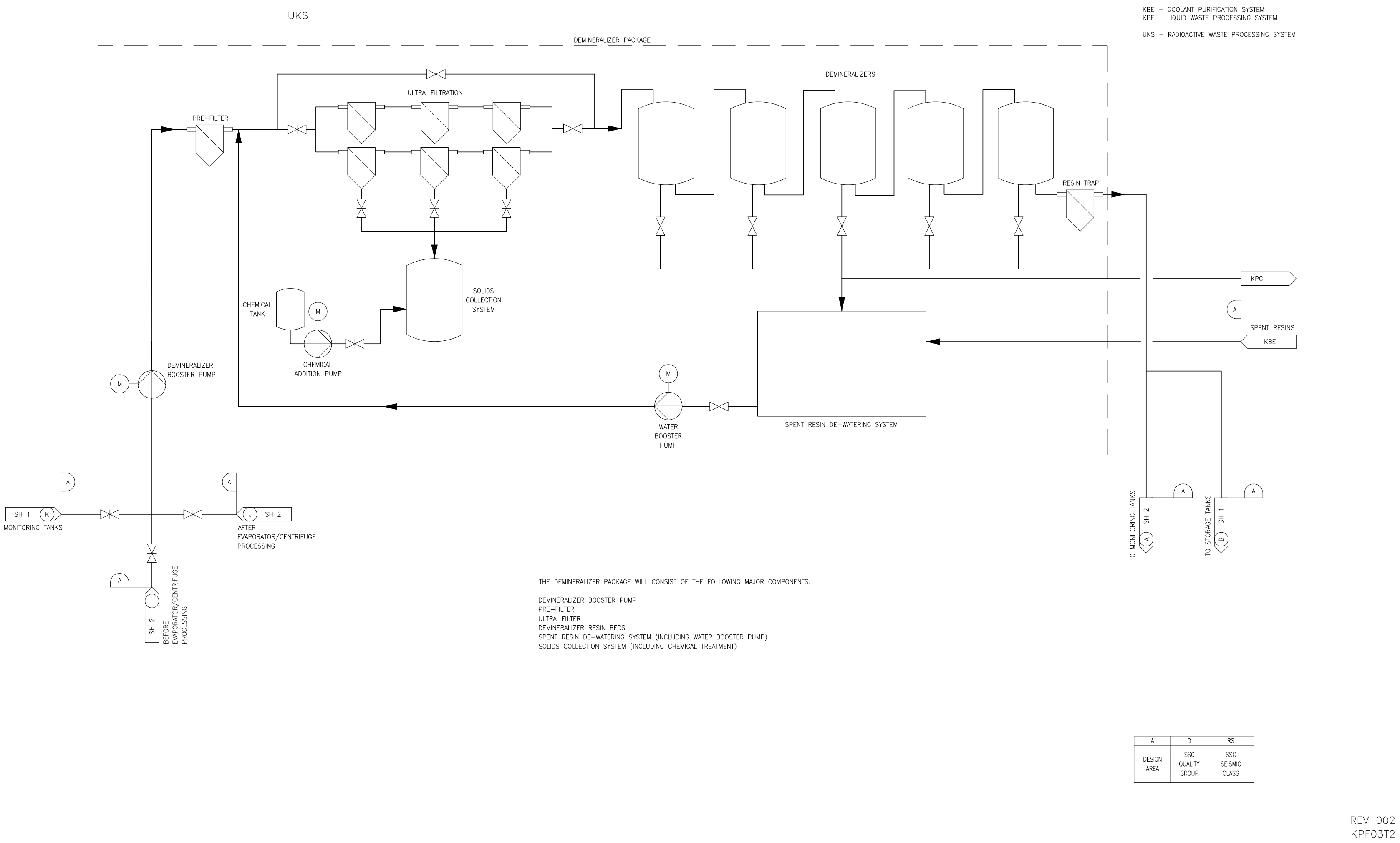

Figure 3.5-5— Gaseous Waste Processing and Sources

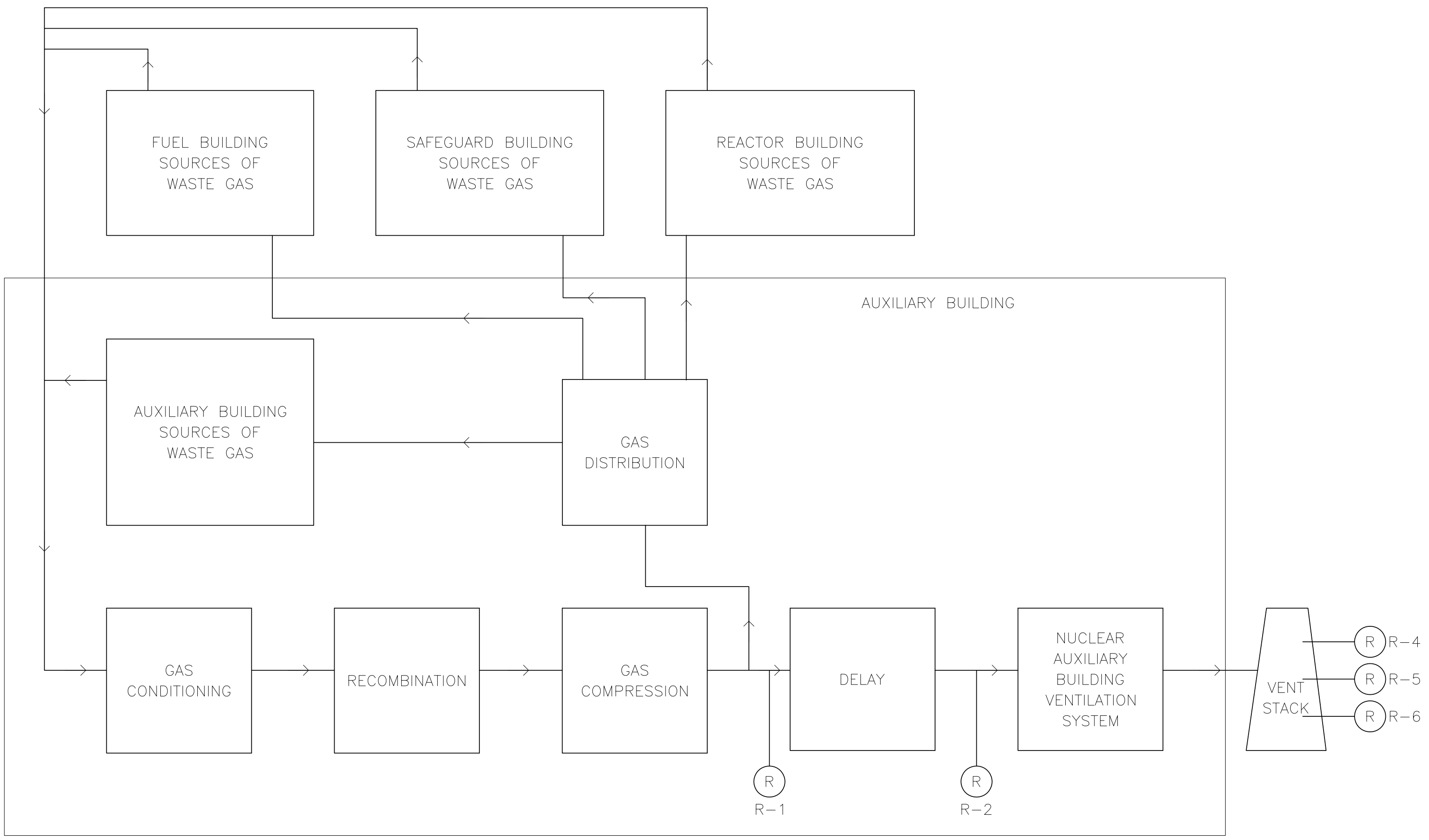

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Figure 3.5-6— Gaseous Waste Processing System

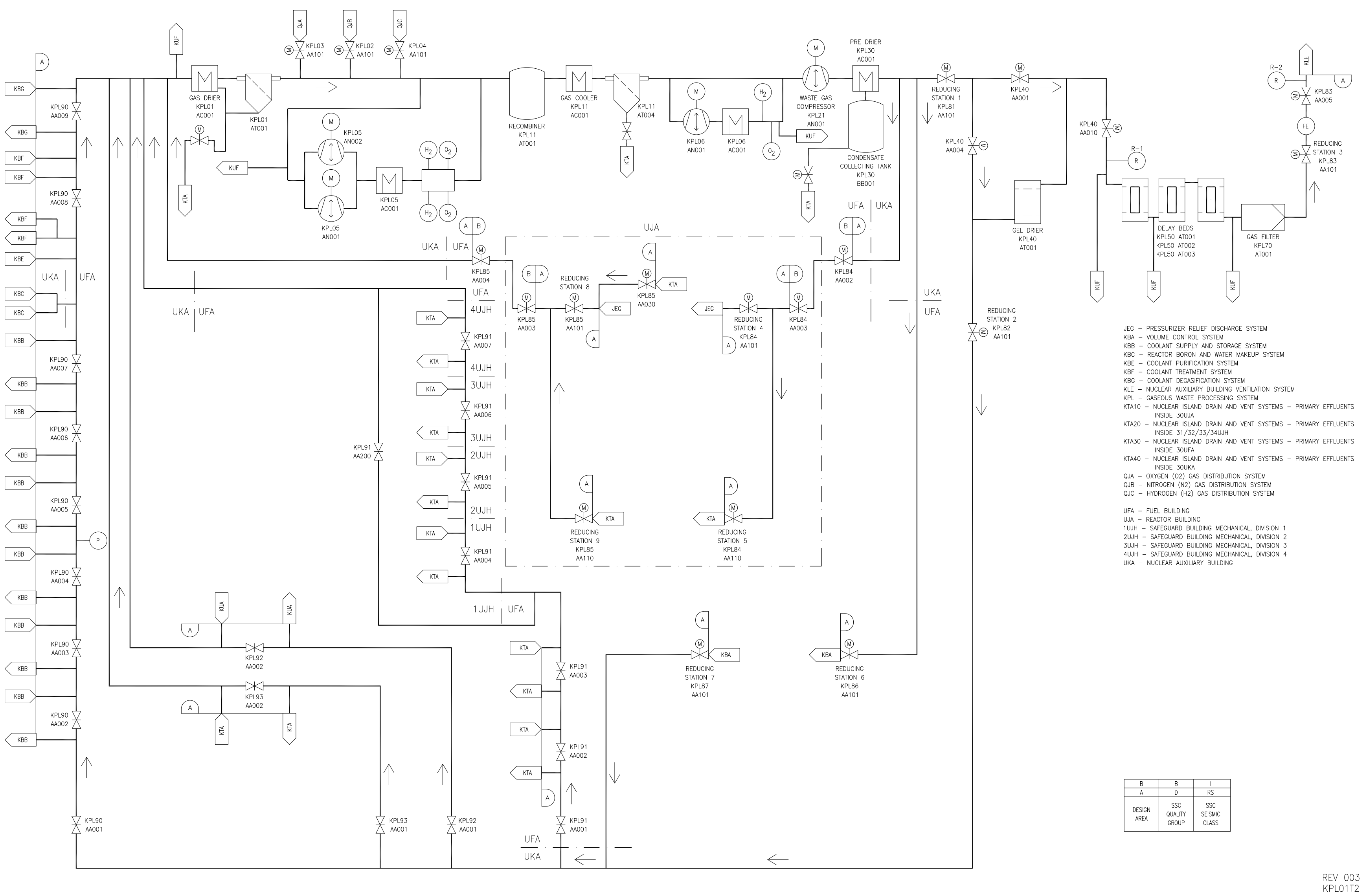
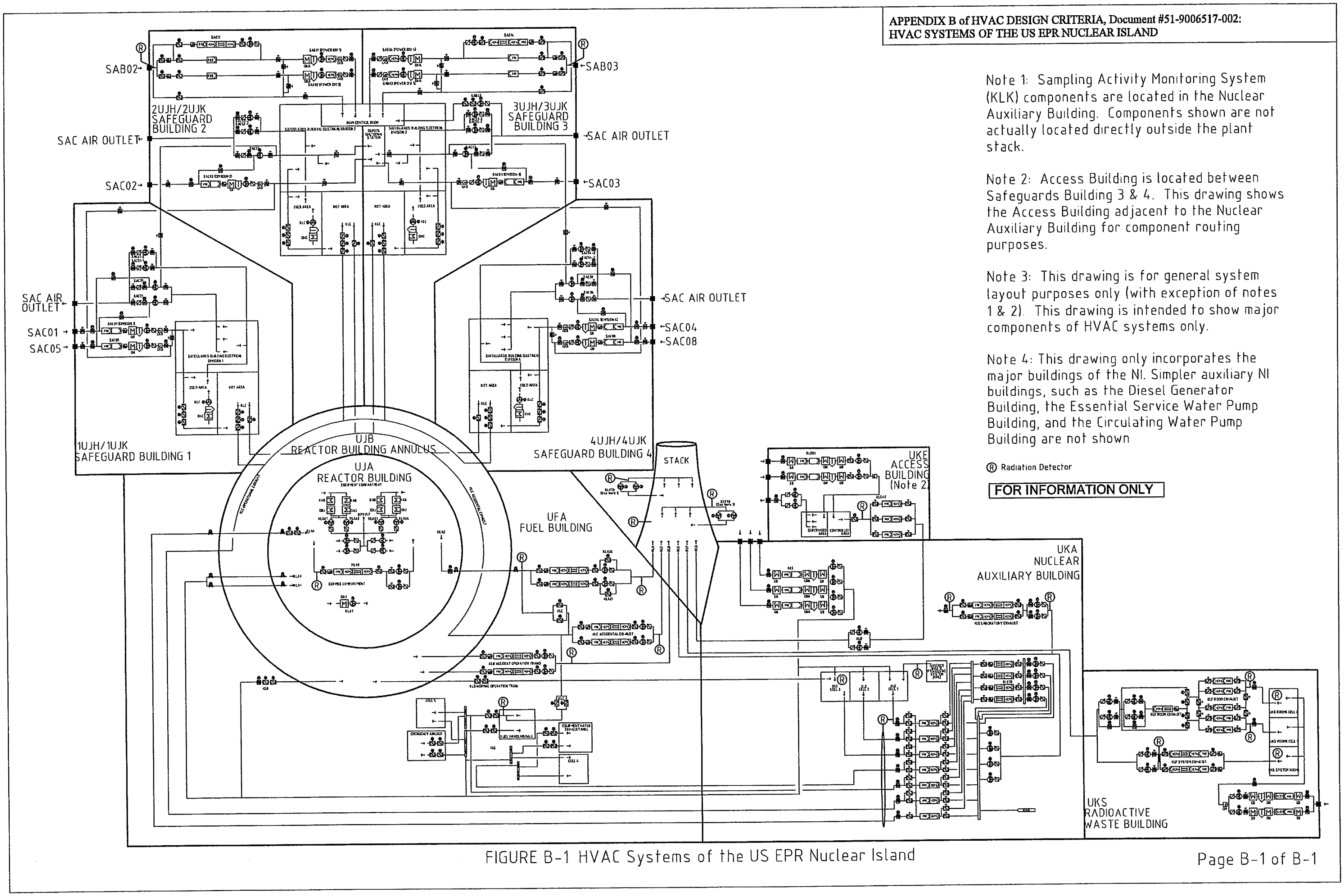


Figure 3.5-7— Controlled Area Ventilation Flow Diagram



APPENDIX B of HVAC DESIGN CRITERIA, Document #51-9006517-002:
HVAC SYSTEMS OF THE US EPR NUCLEAR ISLAND

Note 1: Sampling Activity Monitoring System (KLK) components are located in the Nuclear Auxiliary Building. Components shown are not actually located directly outside the plant stack.

Note 2: Access Building is located between Safeguards Building 3 & 4. This drawing shows the Access Building adjacent to the Nuclear Auxiliary Building for component routing purposes.

Note 3: This drawing is for general system layout purposes only (with exception of notes 1 & 2). This drawing is intended to show major components of HVAC systems only.

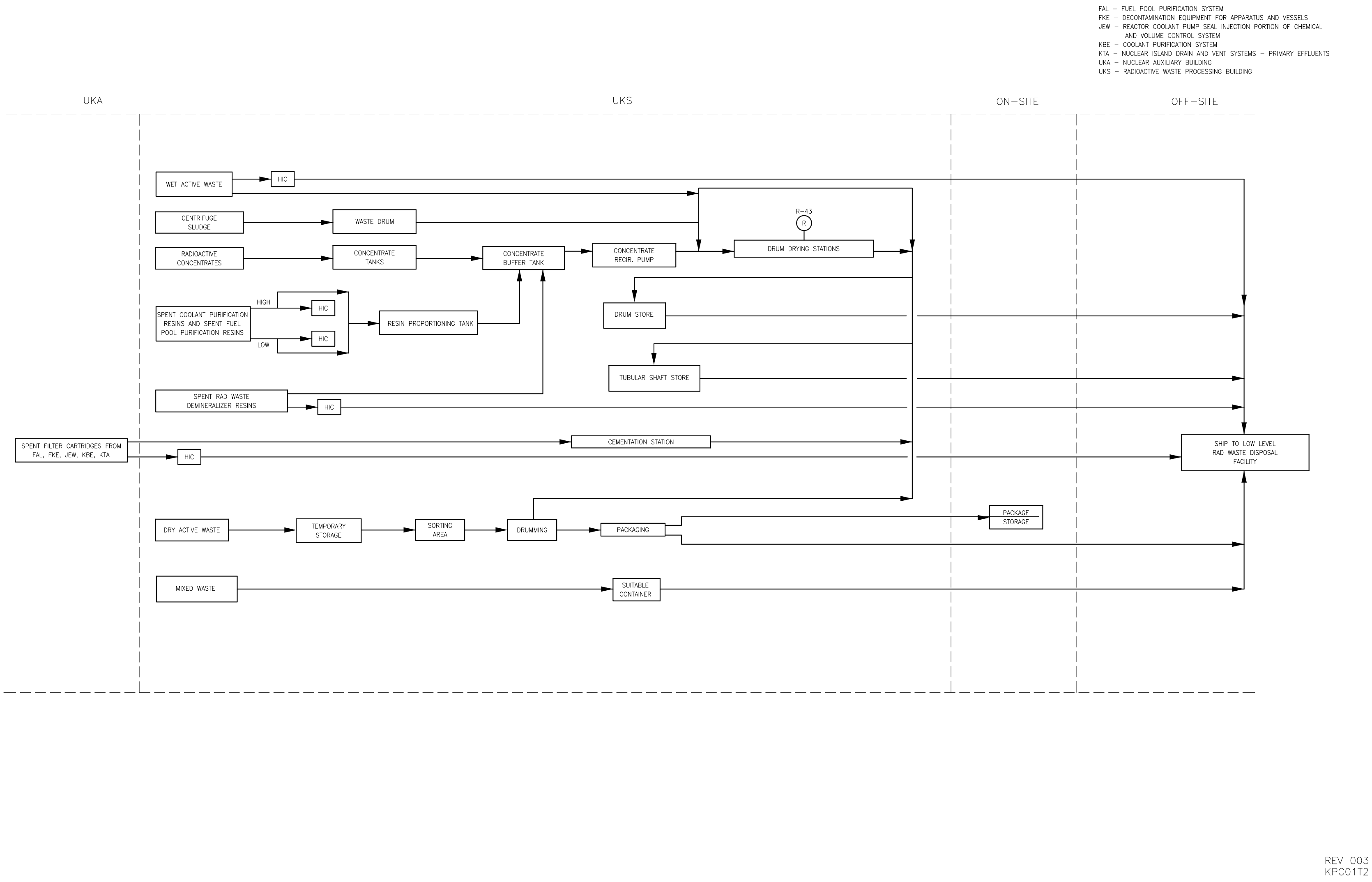
Note 4: This drawing only incorporates the major buildings of the NI. Simpler auxiliary NI buildings, such as the Diesel Generator Building, the Essential Service Water Pump Building, and the Circulating Water Pump Building are not shown

Ⓡ Radiation Detector

FOR INFORMATION ONLY

FIGURE B-1 HVAC Systems of the US EPR Nuclear Island

Figure 3.5-8— Solid Waste System Flow Diagram



3.6 NON-RADIOACTIVE WASTE SYSTEMS

This section provides a description of non-radioactive waste systems for BBNPP and the chemical and biocidal characteristics of each non-radioactive waste stream discharged from the unit. The non-radioactive waste streams include: (1) effluents containing chemicals or biocides; (2) sanitary system effluents; and (3) other effluents.

3.6.1 Effluents Containing Chemicals or Biocides

Chemicals are typically used to control water quality, scale, corrosion and biological fouling. Sources of non-radioactive effluents include plant blowdown, sanitary wastes, floor and equipment drains, and storm water runoff.

As described in Section 3.3.2, the treatment of non-radioactive effluents will be performed by the Circulating Water Treatment System, the Essential Service Water Treatment System, the Raw Water Supply System (RSWS) Water Treatment System, the Demineralized Water Treat System, and the Liquid Waste Processing System. Table 3.6-1 lists the various chemicals processed through these systems. Chemical concentrations within effluent streams from the plant will be controlled through engineering and operational/administrative controls in order to meet NPDES requirements at the time of construction and operation.

Naturally occurring substances (e.g., aquatic growth) will not be changed in form or concentration by plant operations. These naturally occurring substances will be removed and transferred offsite to a landfill, and not discharged in the effluent stream.

The Susquehanna River will supply cooling and plant makeup water for BBNPP. Table 3.6-3 provides for a list of principal constituents found in the river water. Susquehanna River water quality is discussed in Section 2.3.3.1.2. Estimated chemical parameters in the effluent streams discharging to the Combined Waste Water Retention Pond and/or Susquehanna River are shown on Table 3.6-2.

Evaporative cooling systems include the Circulating Water System and the Essential Service Water System (ESWS) (Ultimate Heat Sink). Some of the cooling water associated with these systems is lost through evaporation via their cooling towers as discussed in Section 3.3. During warm weather, when the difference between the air temperature and the water temperature is relatively small, cooling of the water is almost entirely the result of the extraction of heat through evaporation of water to the air. Under extreme winter conditions (e.g., below zero), when the air is much colder than the water, as much as half of the cooling may be the result of sensible heat transfer from the water to the air with the remainder of the cooling being through evaporation. The Circulating Water System and ESWS cooling towers are expected to be operated with at least three three cycles of concentration. Based on Susquehanna River chemistry, three cycles of concentration were conservatively selected for cooling tower operation. Estimated maximum cooling tower blowdown and makeup rates are based on three cycles of concentration. This is consistent with typical cooling tower operation of 3 to 5 cycles of concentration when using surface water makeup. No seasonal variations in cycles of concentration are expected.

Section 3.6.3.2 describes the effluent water chemical concentrations from other sources and the water treatment for general plant use and effluents from the resultant waste stream.

3.6.2 Sanitary System Effluents

The purpose of this section is to identify the anticipated volume and type of sanitary waste effluents generated during construction and operation of BBNPP. Sanitary waste systems installed during pre-construction and construction activities will likely include portable toilets supplied and serviced by a licensed sanitary waste treatment contractor. Based on an anticipated construction work force of 1,000 people in the first year of construction activities and 3,000 people in the second through fifth year of construction activities, the quantity of sanitary waste expected to be generated is 6,500 gallons per day (gpd) (24,605 liters per day (lpd)) for the first year, and 19,500 gpd (73,816 lpd) for years two through five, or 4.5 gpm (17.0 lpm) and 13.5 gpm (51.1 lpm), respectively. Sanitary waste will be removed offsite during construction and will not add to existing onsite discharge effluents.

During the Operations phase for BBNPP, a Sanitary Sewer System will be constructed to serve the facility. The Sanitary Sewer System will collect sanitary wastes during the operation of BBNPP. The sanitary wastes (sewage) will be discharged into the municipal sanitary sewer through a lift station that will pump the sewage into a sewer main that is located parallel to U.S. Highway 11. The sewage will be conveyed to a local publicly-owned treatment works operated by the Berwick Area Joint Sewer Authority. The Sanitary Sewer System will be designed for sanitary waste only, and will exclude industrial materials, such as chemical laboratory wastes. The system will be independent of SSES.

The Sanitary Sewer System will be sized to accommodate the needs of personnel associated with this unit.

Discharge of sewage from BBNPP into the municipal sanitary system will be done in accordance with local ordinances and permit requirements. The anticipated discharge limits for sanitary wastewater into the municipal sewer system is provided in Table 3.6-4.

3.6.3 Other Effluents

This section describes miscellaneous non-radioactive gaseous, liquid, or solid effluents not addressed in Sections 3.6.1 or 3.6.2.

3.6.3.1 Gaseous Effluents

Non-radioactive gaseous effluents result from testing and operating the diesel generators. These effluents commonly include particulates, sulfur oxides, carbon monoxide, hydrocarbons and nitrogen oxides. Gaseous effluent releases will comply with Federal, State, and local emissions standards. Table 1.3-1 lists the environmental-related permits and authorizations for BBNPP.

BBNPP will have six standby diesel generators (four Emergency Diesel Generators (EDGs), and two Station Blackout (SBO) diesel generators). The auxiliary boilers will use electric heating, and do not contribute directly to air emissions.

It is estimated that each EDG will be tested approximately 4 hours every month, plus an additional 24 to 48 hours once every 2 years. It is estimated that each SBO diesel generator will be tested approximately 4 hours every quarter, plus an additional 12 hours every year for maintenance activities. The SBO diesels will also be tested for an extended period of about 12 hours every 18 months.

Diesel generator emissions will be released from an exhaust stack located on top of the diesel generator buildings at an estimated elevation of 78 ft (23.8 m) above plant grade. Pre treatment of diesel generator exhaust will depend on future diesel technology that has yet to be determined. Diesel generator exhaust will meet Environmental Protection Agency (EPA) Tier 4 requirements when BBNPP is operational. Yearly emissions anticipated from the standby diesel generators are provided in Table 3.6-5, and assume a conservative run time for each diesel of 100 hours per year.

3.6.3.2 Liquid Effluents

Susquehanna River water will serve as the source of cooling water for the CWS. As described in Section 3.3, Susquehanna River water will also serve as the source of cooling water for the ESWS and for power plant makeup water. Under normal operating conditions, the RWSS will supply the ESWS and power plant with makeup water. Municipal water provided from Pennsylvania American Water (PAW) will serve as the source of water for potable and sanitary purposes and miscellaneous plant systems.

Circulating Water Makeup System Pumps (CWSMWS) will supply the CWS with water from the Susquehanna River. The BBNPP intake structure will be located on the west bank of the Susquehanna River and will house the CWS and RWSS makeup pumps. The intake structure will be protected by a bar grating and curtain walls to prevent floating debris from approaching the pumps. The bar grating will be cleared by trash rakes. The intake structure will be equipped with traveling screens to remove debris from the intake water. Trash basins will be installed to collect the debris. The CWSMWS will convey river water into a closed cooling system, which will utilize two natural draft cooling towers to remove heat from the water after it has passed through the plant's steam condenser. Evaporation in the CWS cooling towers increases the level of solids in the circulating water. To control solids, a portion of the recirculated water will be removed through the CWS blowdown and replaced with water through the CWSMWS.

The RWSS will supply water from the Susquehanna River to the Demineralized Water Distribution System (DWDS), Fire Water Distribution System (FWDS), ESWS, and the ESW Emergency Makeup System Retention Pond. The RWSS pumps located in the intake structure will pump water from the Susquehanna River to the plant. An automatic self-cleaning strainer will be located at the discharge of each raw RWSS pump to remove particulate matter prior to conveyance to the Water Treatment Building (WTB). Backwash water from the strainers will be returned to the river. Media filters located in the WTB will remove suspended solids from the raw water before it is distributed for use. The media filters will be backwashed to remove the collected solids and the backwash water will be discharged to the Combined Waste Water Retention Pond.

In addition to supplying the power plant with makeup water, the RWSS will convey Susquehanna River water to the ESWS, which will feature four, closed cooling systems. Each system will utilize an ESWS cooling tower to dissipate heat from the ESWS. A portion of the ESWS water flow will be constantly blown back down to the Combined Waste Water Retention Pond to control solids build-up in the ESWS.

Because of evaporative water losses in the cooling towers, the concentration of constituents in the raw river water influent to the cooling towers will increase, increasing the concentration of these constituents in the blowdown that will be discharged to the Combined Waste Water Retention Pond, where it will be mixed with other wastewater discharges. Refer to Table 3.6-6 and Table 3.6-7 for the estimated blowdown discharge concentrations in the effluent from the cooling tower systems, based on three cycles of concentration, as discussed in Section 3.6.1. The effluent from the cooling tower systems will also contain residual treatment chemicals used to prevent fouling and scaling. The estimated concentrations of these residual chemicals, based on vendor recommended treatment concentrations and three cycles of concentration are shown on Table 3.6-2 .

A portion of the power plant makeup water will be treated to supply the DWDS, which is used to produce pure water for various systems in the power plant. Constituents found in the raw feed water to the DWDS will be concentrated in the reject water from the DWDS reverse osmosis (RO) unit. The RO reject water will be discharged to the Combined Waste Water Retention Pond. The estimated concentrations of constituents in the RO reject water, based on the reject rate, are shown on Table 3.6-8.

The cooling water blowdown from the CWS and ESWS, along with other plant flows (DWDS RO reject water, RWSS filter backwash, and miscellaneous low volume waste) as shown in Table 3.3-1, will be directed into the Combined Waste Water Retention Pond to allow for settling of suspended solids and further chemical treatment, if necessary. Water in the Combined Waste Water Retention Pond will drain by gravity to the Susquehanna River for discharge through an offshore diffuser.

Non-radioactive liquid effluents that could potentially drain to the Susquehanna River will be limited under a NPDES wastewater discharge permit. There are three anticipated regulated outfalls for release of non-radioactive liquid effluents from BBNPP: one outfall for the gravity-drained discharge from the Combined Waste Water Retention Pond for plant effluents (e.g., cooling tower blowdown, effluent from RWSS water treatment, reject water from the DWDS, and miscellaneous low volume flows) via the offshore submerged diffuser; one outfall for stormwater via various surface outlets through the BBNPP site, and one outfall for intake screen backwash and RWSS pump strainer discharge.

Stormwater at BBNPP will be collected through a network of storm sewers and swales and drained to infiltration beds which will be located to maintain post-construction hydrological conditions as close to preconstruction conditions as possible. Infiltration beds will also help mitigate surface water temperatures. A temporary pond may be installed to manage runoff and suspended solids from the concrete batch plant and aggregate material storage areas. This pond would be removed after construction. Contaminants potentially present in the stormwater discharge from BBNPP are anticipated to be similar to those currently found in stormwater from SSES. SSES has been required to monitor stormwater discharges in the past for Total Suspended Solids (TSS), nitrate, oil and grease (O&G), biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, and total Kjeldahl nitrogen (TKN).

Discharge from the outfalls at BBNPP will be controlled under the BBNPP NPDES permit. Estimated BBNPP effluent water chemical concentrations are presented in Table 3.6-9.

Other non-radioactive liquid waste effluents from plant sources (i.e., Steam Generator Blowdown Demineralizing System) are managed and processed by the Liquid Waste Storage System and the Liquid Waste Processing System. These systems also manage and process radioactive liquid wastes. BBNPP non-radioactive liquid waste effluents will not be directly discharged. Non-radioactive liquid waste is first stored in a tank where it is pre-treated chemically or biologically. Chemical pre-treatment gives the waste an optimum pH value; biological pre-treatment allows organics to be consumed. If deemed cleaned, it can be routed directly to one of the monitoring tanks; otherwise, once pre-treated, the wastes are forwarded to the Liquid Waste Processing System for treatment. Treatment may consist of evaporation, centrifugation, demineralization/filtration, chemical precipitation (in connection with centrifugation), or organic decomposition (in connection with centrifugation). After the waste water has been treated, it is received in one of two monitoring tanks, which also receive treated liquid radwaste. Waste water is then sampled and analyzed and if within the limits for discharge, it can be released.

Miscellaneous low-volume wastewater includes non-radioactive floor drain and equipment discharges and other intermittent wastewater flows. Miscellaneous low-volume wastewater will not undergo separate treatment, but will be discharged into the Combined Waste Water Retention Pond where it will be combined with other wastewater flows, be sampled and treated as necessary.

3.6.3.3 Hazardous Wastes

Hazardous wastes are materials with properties that make them dangerous or potentially harmful to human health or the environment, or that exhibit at least one of the following characteristics: ignitability, corrosivity, reactivity or toxicity. Federal Resource Conservation and Recovery Act regulations govern the generation, treatment, storage and disposal of hazardous wastes. Hazardous waste is defined as any solid, liquid or gaseous waste that is not mixed waste, is listed as hazardous by any federal or state regulatory agency or meets the criteria of Subpart D of 40 CFR 261 (CFR, 2007) Code of Pennsylvania Regulation Title 25 Pennsylvania Code Section 261a (PA, 2008e).

A Hazardous Waste Minimization Plan will be developed and maintained that documents the current and planned efforts to reduce the amount or toxicity of the hazardous waste to be generated at BBNPP. Hazardous wastes will be collected and stored in a controlled access temporary storage area (TSA). A Hazardous Material and Oil Spill Response guideline will be maintained that defines HAZMAT team positions and duties. Procedures will be put in place to minimize the impact of any hazardous waste spills in the unlikely event of a spill. Containers of known hazardous waste received at a TSA will be transported offsite within 90 days of the containers accumulation date according to the applicable section/unit procedures. The Radiation Protection and Chemistry Manager will be responsible for coordinating the activities of waste transport disposal vendors or contractors while they are on site, ensuring that the transporter has an EPA identification number.

Table 3.6-10 lists the types and quantities of hazardous waste generated at SSES. The table is based on the SSES biennial hazardous waste reports submitted to the DEP for the years 2003, 2005 and 2007. The quantity of hazardous wastes generated at BBNPP is expected to be similar to or less than that at SSES.

If waste is not hazardous, such as garbage, refuse, discarded material or other waste, including solid, liquid, semisolid or contained gaseous materials resulting from industrial operations, it is regulated as Residual Waste in Pennsylvania. Generators of Residual Waste are required to develop a source reduction strategy and to maintain records of the types and amounts of Residual Waste generated, dates that wastes were shipped offsite or processed onsite, information on the transporters used to transport the waste offsite, and information on the processing, disposal facility or other location to which the waste was transported. (PA, 2008d)

BBNPP will develop a source reduction strategy and perform chemical analyses for Residual Waste streams generated at BBNPP. BBNPP will maintain the required records for Residual Waste generation, processing, transportation and disposal. Residual Wastes that will be generated by BBNPP are expected to be similar in nature and quantity to that of SSES. Table 3.6-11 presents a summary of Residual Wastes generated at SSES and the annual quantities shipped.

3.6.3.4 Mixed Wastes

Mixed waste includes hazardous waste that is intermixed with a low level radioactive source, special nuclear material, or byproduct material. Federal regulations governing generation, management, handling, storage, treatment, disposal, and protection requirements associated with these wastes are contained in 10 CFR (NRC regulations) and 40 CFR (Environmental Protection Agency regulations). Mixed waste is generated during routine maintenance activities, refueling outages, radiation and health protection activities and radiochemical laboratory practices. Section 5.5.2 discusses mixed waste impacts, including quantities of mixed waste generated. The quantity of mixed waste generated at BBNPP is expected to be small, as it is at other nuclear power plants.

Similar to SSES, the management of mixed waste at BBNPP will comply with the requirements of EPA's Mixed Waste Enforcement Policy and the Commonwealth of Pennsylvania Regulations (PA, 2008c) (USEPA, 1991). The existing plant currently ships mixed waste offsite to a permitted facility. This occurs infrequently, and is dependent on the waste matrix. Mixed waste streams include laboratory chemicals, lead paint debris, solvent-contaminated rags, lead penetration barrier debris, and waste phosphoric acid. It is expected that BBNPP will also infrequently ship some mixed waste to permitted facilities. Mixed wastes stored in the storage area will be inventoried and a list will be maintained according to BBNPP procedures, and weekly inspections of mixed waste will be conducted according to these same procedures.

3.6.3.5 Solid Effluents

Construction of BBNPP will involve the generation of construction debris, including earthen material such as clays, sands, gravels and silts; topsoil; tree stumps; root mats; brush and limbs; logs; vegetation; and rock. Construction debris will be managed in accordance with Pennsylvania regulations pertaining to solid waste.

Waste materials such as office paper, cardboard and aluminum cans will be recycled locally. Putrescible wastes will be disposed in a permitted offsite disposal facility.

The types of solid effluents that would be expected to be generated by the new unit include hazardous waste, mixed wastes, residual waste, construction and demolition (C&D) waste, metal and wood for recycle, and cooling waste intake debris. Hazardous waste and mixed waste generation are discussed in the preceding sections.

Disposal, recycling and recovery of solid wastes are described in Section 5.5.1. In summary:

- Non radioactive solid wastes (e.g., office waste, recyclables) are collected temporarily on the BBNPP site and disposed of at offsite, licensed disposal and recycling facilities.

- Debris (e.g., vegetation) collected on trash racks and screens at the water intake structure are disposed of as solid waste in accordance with the applicable NPDES permit.

- Scrap metal, used oil, antifreeze (ethylene or propylene glycol), and universal waste will be collected and stored temporarily on the BBNPP site and recycled or recovered at an offsite permitted recycling or recovery facility, as appropriate. Waste oil and antifreeze are not hazardous wastes in Pennsylvania (PA, 2008a) (PA, 2008b). Typically, used oil and antifreeze are recycled. If they are not recyclable or recoverable, they will be disposed of as a solid waste or hazardous waste in accordance with the applicable regulations.

3.6.4 References

CFR, 2007. Title 40, Code of Federal Regulations, Part 261, Identification and Listing of Hazardous Waste, 2007.

NRC, 1996. NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Nuclear Regulatory Commission, May 1996.

PA, 2008a. Title 25, Pennsylvania Code, Section 298, Management of Waste Oil.

PA, 2008b. Title 25, Pennsylvania Code, Article VII, Hazardous Waste Management.

PA, 2008c. Title 25, Pennsylvania Code, Article V, Radiological Health.

PA, 2008d. Title 25, Pennsylvania Code, Section 287, Residual Waste Management.

PA, 2008e. Title 25, Pennsylvania Code, Section 261a, Identification and Listing of Hazardous Waste.

USEPA, 1991. Volume 56, Federal Register, 42730-42734, U.S. EPA's 1991 Mixed Waste Enforcement Policy, August 29, 1991.

Table 3.6-1— Chemicals Used in Water Treatment Systems

(Page 1 of 2)

Water Treatment System	Operating Cycle(s)	Points of Addition	Chemical Processed	Estimated Total Amount Used per Year	Frequency Of Use
Circulating Water Treatment System [a]	Normal Operating Conditions and Normal Shutdown/ Cooldown	CWS Makeup/ Water Intake CWS Piping CWS Blowdown	Oxidizing Biocide	248,033 gal (938,805 l)	Intermittent
			Deposit Control Agent	172,929 lbs (78,440 kg)	Continuous
			Biofilm Control Agent	172,929 lbs (78,440 kg)	Continuous
			Sulfuric Acid [b]	3.43 million lbs (1.56 million kg)	Continuous
			Dechlorinator [g]	86,464 lbs (39,220 kg)	Continuous
ESWS Water Treatment System [a]	Normal Operating Conditions and Normal Shutdown/ Cooldown	ESWS Makeup/ Water Intake ESWS Piping ESWS Blowdown	Oxidizing Biocide	17,855 gal (67,581 l)	Intermittent
			Deposit Control Agent	12,411 lbs (5,630 kg)	Continuous
			Biofilm Control Agent	12,411 lbs (5,630 kg)	Continuous
			Sulfuric Acid [b]	246,740 lbs (112,154 kg)	Continuous
			Dechlorinator [g]	6,205 lbs (3,373 kg)	Continuous
RWSS Water Treatment System [c]	Normal Operating Conditions and Normal Shutdown/ Cooldown	RWSS Makeup/ Water Intake RWSS Filters	Oxidizing Biocide	2,190 gal (8,289 l)	Intermittent
Liquid Waste Storage System and Liquid Waste Processing Systems [d, e]	Normal Operating Conditions and Normal Shutdown/ Cooldown	Influent Waste Water	Sulfuric Acid	22,900 gal (86,686 l)	Intermittent
			Sodium Hydroxide	2,400 gal (9,085 l)	Intermittent
Demineralized Water Treatment System [f]	Normal Operating Conditions and Normal Shutdown/ Cooldown	Demineralized Water Distribution System Makeup	Sulfuric Acid	2,650 gal (10,031 l)	Continuous
			Sodium Hydroxide	2,400 gal (9,085 l)	Continuous

Table 3.6-1— Chemicals Used in Water Treatment Systems

(Page 2 of 2)

Water Treatment System	Operating Cycle(s)	Points of Addition	Chemical Processed	Estimated Total Amount Used per Year	Frequency Of Use

Key:
gal - gallons
l - liters
kg - kilograms
lbs - pounds
CWS - Circulating Water System
ESWS - Essential Service Water System

Notes:
a. The estimated dosage rates were calculated from vendor recommended values.
b. The concentration of sulfuric acid injected to control scale and adjust pH is 33 mg/l.
c. The estimated dosage rates are calculated.
d. Types and estimated quantities of chemical additives are based on those used at an existing plant.
e. An anti-foaming agent, complexing agent and/or precipitant may also be used to promote settling of precipitates.
f. The estimated quantities of chemical additives are based on the existing CCNPP Units 1 and 2 Demineralized Water Treatment System which uses the indicated chemicals for the regeneration of condensate demineralizers. The actual quantities of chemical additives will depend on how the demineralizer for BBNPP will be used (i.e., full-flow demineralizers use higher quantities).
g. Sodium bisulfite (dechlorination chemical) will be added to Combined Waste Water Retention Pond discharge.

Table 3.6-2— Estimated Concentrations of Chemical Additives and Byproducts in Water Treatment System Discharges

(Page 1 of 2)

System	Discharge Flow gpm (lpm)	Chemical Treatment	Chemical Additive	Additive Concentration	Additive Byproduct Concentration [d]	Anticipated Discharge Limits [e]
CWS Blowdown	7,928 (30,007)	Oxidizing Biocide	Sodium Hypochlorite	16.2 mg/l [a]	FAC - 0.5 mg/l [c] Sodium - 5.0 mg/l Chloride - 7.7 mg/l TDS - 12.7 mg/l	FAC - 0.2 mg/l daily max pH 6.0 - 9.0
		Deposit Control Agent	HEDP [b]	5 mg/l [a]	TDS - 5 mg/l	
		Biofilm Control Agent	Spectrus BD1500®	5 mg/l [a]	TDS - 5 mg/l	
		Dechlorinator [f]	Sodium Bisulfite	2.5 mg/l [a]	Sodium - 0.55 mg/l Sulfate - 2.3 mg/l TDS 2.85 mg/l	
		pH Adjust	Sulfuric Acid	33 mg/l [b]	Sulfate - 96 mg/l TDS - 96 mg/l	
ESWS Blowdown	569 (2,154)	Oxidizing Biocide	Sodium Hypochlorite	16.2 mg/l [a]	FAC - 0.5 mg/l [c] Sodium - 5.0 mg/l Chloride 7.7 mg/l TDS - 12.7 mg/l	FAC - 0.2 mg/l daily max pH 6.0 - 9.0
		Deposit Control Agent	HEDP [b]	5 mg/l [a]	TDS - 5 mg/l	
		Biofilm Control Agent	Spectrus BD1500®	5 mg/l [a]	TDS - 5 mg/l	
		Dechlorinator f	Sodium Bisulfite	2.5 mg/l [a]	Sodium - 0.55 mg/l Sufate - 2.3 mg/l TDS - 2.85 mg/l	
		pH Adjust / Alkalinity Control	Sulfuric Acid	33 mg/l [b]	Sulfate - 96 mg/l TDS - 96 mg/l[d]	
RWSS Filter Backwash	91 (344)	Oxidizing Biocide	Sodium Hypochlorite	5.4 mg/l [h]	FAC - 0.5 mg/l [b] Sodium - 1.7 mg/l Chloride - 2.6 mg/l TDS - 4.3 mg/l	FAC - 0.2 mg/l daily max pH 6.0 - 9.0 TSS [g] - 100 mg/l max
Liquid Waste Storage System and Liquid Waste Processing System Discharge	11 (42)	Neutralization	Sulfuric Acid	Not Applicable	Sufate - 8.8 mg/l [i] Sodium - 0.5 mg/l [i] TDS - 9.3 mg/l [i]	pH 6.0 - 9.0 TSS - 100 mg/l max O&G - 20 mg/l max
	11 (42)	Neutralization	Sodium Hydroxide	Not Applicable		

Table 3.6-2— Estimated Concentrations of Chemical Additives and Byproducts in Water Treatment System Discharges

(Page 2 of 2)

System	Discharge Flow gpm (lpm)	Chemical Treatment	Chemical Additive	Additive Concentration	Additive Byproduct Concentration ^{d}	Anticipated Discharge Limits ^{e}
Demineralized Water Treatment System Discharge	27 (102)	Ion exchange Regeneration and Neutralization	Sulfuric Acid	Not Applicable	Sufate - 1.0 mg/l ^{i}Sodium - 0.5 mg/l ^{i} TDS - 1.5 mg/l ^{i}	pH 6.0 - 9.0 TSS - 100 mg/l max O&G - 20 mg/l max
	27 (102)	Ion Exchange Regeneration and Neutralization	Sodium Hydroxide	Not Applicable		

Key:

mg/l - milligrams per liter
FAC - Free Available Chlorine
O&G - Oil & Grease
TDS - Total Dissolved Solids
TSS - Total Suspended Solids
HEDP - Bis-(1-hydroxyethylidine) Phosphonic Acid

Notes:

a. Circulating water concentrations based on vendor recommendations. The concentration of sodium hypochlorite was calculated from the recommended dosage of 1,500 gallons of a 15% sodium hypochlorite solution.
b. A cooling water makeup concentration of 33 mg/L of sulfuric acid is recommended to control scale and adjust pH. HEDP is recommended as a deposit control agent
c. FAC concentrations based on assumptions in vendor letter.
d. Concentrations based on 3 cycles of concentration.
e. Based on existing NPDES Permit for SSES
f. Sodium bisulfite (dechlorination chemical) will be added to Combined Waste Water Retention Pond discharge.
g. TSS limits would apply at Combined Waste Water Retention Pond Outfall.
h. The estimated concentration is calculated
i. As measured in discharge from Combined Waste Water Retention Pond.

Table 3.6-3— Intake Source Water Quality [a, b]

Parameter	Units	Maximum	Mean
Total Alkalinity	mg/l	94.0	59.8
Total Suspended Solids	mg/l	152.0	29.7
Silica (Silicon Dioxide)	mg/l	4.7	2.8
Bicarbonate as $CaCO_3$	mg/l	94.0	63.0
Chloride	mg/l	38.2	25.4
Fluoride	mg/l	0.1	0.1
Nitrate as NO_3	mg/l	3.4	2.1
Nitrate as N	mg/l	0.8	0.5
Phosphorus as PO_4	mg/l	0.736	0.2
Sulfate	mg/l	48.8	26.2
Aluminum, Total	µg/l	2,740	458.5
Barium, Total	µg/l	58.0	32.8
Calcium, Total	mg/l	38.5	26.3
Iron, Total	mg/l	5.9	1.3
Magnesium, Total	mg/l	10.0	6.2
Manganese, Total	µg/l	257.0	136.3
Potassium, Total	mg/l	2.2	1.6
Sodium, Total	mg/l	22.7	12.0
Strontium, Total	µg/l	167.0	101.1
Zinc, Total	µg/l	26.0	15.3
Arsenic, Total	µg/l	2.9	0.9
Lead, Total	µg/l	5.0	5.0
TDS	mg/l	195.7	141.6
Calcium Hardness	mg/l	96.1	65.8
Total Hardness	mg/l	131.0	91.2

Key:
mg/l - milligrams per liter
µg/l - micrograms per liter

Notes:
a. The source of cooling and plant makeup water is the Susquehanna River
b. River water quality taken from laboratory results of quarterly sampling of river water at the SSES intake location in 2006 and 2007.

Table 3.6-4— Sanitary Sewer Discharge Limits

Parameter	Maximum Discharge Limit [a] (mg/l)
Biochemical Oxygen Demand (BOD)	300
Total Suspended Solids (TSS)	350
Arsenic	0.08
Cadmium	0.005
Chromium	5.4
Copper	1.2
Cyanide	0.5
Lead	0.3
Mercury	0.03
Molybdenum	0.6
Nickel	0.7
Phenol	10.0
Selenium	0.2
Silver	1.3
Zinc	0.9
pH	6.0 - 10.5
Temperature	32-104 °F (0-40°C)

Key: mg/l - milligrams per liter

Notes:

a. Limits apply to wastewater discharges to the Berwick Area Joint Sewer Authority.

Table 3.6-5— Non-Radioactive Gaseous Effluents

EPA Tier Emission Data							
Emission Source	**Engine Power (Kw)**	**Emission (g/Kw-hr)**	**NOx**	**PM**	**CO**	**SOx (Note 6)**	
EDG	10130 (Note 1)		1.60	0.15	N/A	N/A	(Note 3)
SBO diesel	5000 (Note 2)	(Note 4)	9.80	0.50	5.00	N/A	(Note 4)
	Number of Hours per Year Each Generator is Operated = 100						(Note 5)
per EDG		**Lb/hr**	35.73	3.35	N/A	2.63	
		Lb/yr	3,573.19	334.99	N/A	262.93	
		Tpy	1.79	0.17	N/A	0.13	
per SBO		**Lb/hr**	108.02	5.51	55.11	0.04	
		lb/yr	10,802.47	551.15	5,511.46	4.16	
		Tpy	5.40	0.28	2.76	0.00	
Total (4xEDG)		**Lbs/yr**	14,293	1,340	N/A	1,052	
		Tpy	7.15	0.67	N/A	0.53	
(2xSBO)		**Lbs/yr**	21,605	1,102	11,023	8.31	
		Tpy	10.80	0.55	5.51	0.00	
(4xEDG+2xSBO)		**Lbs/yr**	35,898	2,442	11,023	1,060	
		Tpy	17.95	1.22	5.51	0.53	

Key:
N/A = Not Applicable
EDG=Emergency Diesel Generator
SBO = Station Blackout Generator
Note 1: 10,130 kW
Note 2: 5,000 kW
Note 3: Emission limits per FR Vol. 71, No. 132 dated 07/11/2006, page 39158 Section II.D.3.b and 40 CFR 60.4205(d)
Note 4: Emission limits per FR Vol. 71, No. 132 dated 07/11/2006, page 39157 Table 3, page 39174, and 40 CFR 60.4202
Note 5: Limit of hours of operation (testing) per 40 CFR 60.4211(e)
Note 6: No monitoring or limits for SOx is envisioned due to the planned use of low-sulfur fuel. FR Vol. 71, No. 132 dated 07/11/2006 page 39158 Section II.D.5

Table 3.6-6— Anticipated CWS Blowdown Concentrations

Parameter	Units	River Intake Water Parameter		CWS Blowdown Discharge Rate gpm (lpm)	CWS Blowdown Conc. Max [a]	CWS Blowdown Conc. Mean [a]
		Conc. Max	Conc. Mean			
Total Alkalinity	mg/l	94.0	59.8	7,928 (30,007)	181	78.4
Total Suspended Solids	mg/l	152.0	29.7	7,928 (30,007)	456	89.1
Silica (Silicon Dioxide)	mg/l	4.7	2.8	7,928 (30,007)	14.1	8.4
Bicarbonate as $CaCO_3$	mg/l	94.0	63.0	7,928 (30,007)	282	189
Chloride	mg/l	38.2	25.4	7,928 (30,007)	122.3	83.9
Fluoride	mg/l	0.1	0.1	7,928 (30,007)	0.3	0.3
Nitrate as NO_3	mg/l	3.4	2.1	7,928 (30,007)	10.2	6.3
Nitrate as N	mg/l	0.8	0.5	7,928 (30,007)	2.4	1.5
Phosphorus as PO_4	mg/l	0.736	0.2	7,928 (30,007)	2.4	0.8
Sulfate	mg/l	48.8	26.2	7,928 (30,007)	242.4	174.6
Aluminum, Total	µg/l	2,740	458.5	7,928 (30,007)	8,220	1375.5
Barium, Total	µg/l	58.0	32.8	7,928 (30,007)	174	98.4
Calcium, Total	mg/l	38.5	26.3	7,928 (30,007)	115.5	78.9
Iron, Total	mg/l	5.9	1.3	7,928 (30,007)	17.7	3.9
Magnesium, Total	mg/l	10.0	6.2	7,928 (30,007)	30	18.6
Manganese, Total	µg/l	257.0	136.3	7,928 (30,007)	771	408.9
Potassium, Total	mg/l	2.2	1.6	7,928 (30,007)	6.6	4.8
Sodium, Total	mg/l	22.7	12.0	7,928 (30,007)	73.1	41
Strontium, Total	µg/l	167.0	101.1	7,928 (30,007)	501	303
Zinc, Total	µg/l	26.0	15.3	7,928 (30,007)	78	45.9
Arsenic, Total	µg/l	2.9	0.9	7,928 (30,007)	8.7	2.7
Lead, Total	µg/l	5.0	5.0	7,928 (30,007)	15	15
TDS	mg/l	195.7	141.6	7,928 (30,007)	706	424.8
Calcium Hardness	mg/l	96.1	65.8	7,928 (30,007)	288.3	197.4
Total Hardness	mg/l	131.0	91.2	7,928 (30,007)	393	273.6
HEDP	mg/l	0	0	7,928 (30,007)	5	5
Dispersant	mg/l	0	0	7,928 (30,007)	5	5
Free Available Chlorine	mg/l	0	0	7,928 (30,007)	< 0.5	< 0.5

Key:

mg/l - milligrams per liter
µg/l - micrograms per liter
gpm- gallons per minute
lpm - liters per minute

Notes:

a. Concentrations are based on 3 cycles of concentration

Table 3.6-7— Anticipated ESWS Blowdown Concentrations

Parameter	Units	River Intake Water Parameter		ESWS Blowdown Discharge Rate gpm (lpm)	ESWS Blowdown Conc. Max [a]	ESWS Blowdown Conc. Mean [a]
		Conc. Max	Conc. Mean			
Total Alkalinity	mg/l	94.0	59.8	569 (2,154)	181	78.4
Total Suspended Solids	mg/l	152.0	29.7	569 (2,154)	45.6	8.91
Silica (Silicon Dioxide)	mg/l	4.7	2.8	569 (2,154)	14.1	8.4
Bicarbonate as $CaCO_3$	mg/l	94.0	63.0	569 (2,154)	282	189
Chloride	mg/l	38.2	25.4	569 (2,154)	122.3	83.9
Fluoride	mg/l	0.1	0.1	569 (2,154)	0.3	0.3
Nitrate as NO_3	mg/l	3.4	2.1	569 (2,154)	10.2	6.3
Nitrate as N	mg/l	0.8	0.5	569 (2,154)	2.4	1.5
Phosphorus as PO_4	mg/l	0.736	0.2	569 (2,154)	2.4	0.8
Sulfate	mg/l	48.8	26.2	569 (2,154)	242.4	174.6
Aluminum, Total	µg/l	2,740	458.5	569 (2,154)	8,220	1375.5
Barium, Total	µg/l	58.0	32.8	569 (2,154)	174	98.4
Calcium, Total	mg/l	38.5	26.3	569 (2,154)	115.5	78.9
Iron, Total	mg/l	5.9	1.3	569 (2,154)	17.7	3.9
Magnesium, Total	mg/l	10.0	6.2	569 (2,154)	30	18.6
Manganese, Total	µg/l	257.0	136.3	569 (2,154)	771	408.9
Potassium, Total	mg/l	2.2	1.6	569 (2,154)	6.6	4.8
Sodium, Total	mg/l	22.7	12.0	569 (2,154)	73.1	41
Strontium, Total	µg/l	167.0	101.1	569 (2,154)	501	303
Zinc, Total	µg/l	26.0	15.3	569 (2,154)	78	45.9
Arsenic, Total	µg/l	2.9	0.9	569 (2,154)	8.7	2.7
Lead, Total	µg/l	5.0	5.0	569 (2,154)	15	15
TDS	mg/l	195.7	141.6	569 (2,154)	706	424.8
Calcium Hardness	mg/l	96.1	65.8	569 (2,154)	288.3	197.4
Total Hardness	mg/l	131.0	91.2	569 (2,154)	393	273.6
HEDP	mg/l	0	0	569 (2,154)	5	5
Dispersant	mg/l	0	0	569 (2,154)	5	5
Free Available Chlorine	mg/l	0	0	569 (2,154)	< 0.5	< 0.5

Key:

mg/l - milligrams per liter
µg/l - micrograms per liter
gpm- gallons per minute
lpm - liters per minute

Notes:

a. Concentrations are based on 3 cycles of concentration

Table 3.6-8— Anticipated Reverse Osmosis Reject Concentrations

Parameter	Units	River Intake Water Parameter		RO Reject Discharge Rate gpm (lpm)	RO Reject Conc. Max [a, b]	RO Reject Conc. Mean [a, b]
		Conc. Max	Conc. Mean			
Total Alkalinity	mg/l	94.0	59.8	27 (102)	373	237
Total Suspended Solids	mg/l	152.0	29.7	27 (102)	60.2	11.8
Silica (Silicon Dioxide)	mg/l	4.7	2.8	27 (102)	19	11
Bicarbonate as $CaCO_3$	mg/l	94.0	63.0	27 (102)	373	250
Chloride	mg/l	38.2	25.4	27 (102)	162	111
Fluoride	mg/l	0.1	0.1	27 (102)	0.4	0.4
Nitrate as NO_3	mg/l	3.4	2.1	27 (102)	13.5	8.3
Nitrate as N	mg/l	0.8	0.5	27 (102)	3.2	2.0
Phosphorus as PO_4	mg/l	0.736	0.2	27 (102)	2.9	0.8
Sulfate	mg/l	48.8	26.2	27 (102)	193	104
Aluminum, Total	µg/l	2,740	458.5	27 (102)	10,858	1,817
Barium, Total	µg/l	58.0	32.8	27 (102)	230	130
Calcium, Total	mg/l	38.5	26.3	27 (102)	153	104
Iron, Total	mg/l	5.9	1.3	27 (102)	23.4	5.2
Magnesium, Total	µg/l	10.0	6.2	27 (102)	39.6	24.6
Manganese, Total	mg/l	257.0	136.3	27 (102)	1,018	540.1
Potassium, Total	mg/l	2.2	1.6	27 (102)	8.7	6.3
Sodium, Total	mg/l	22.7	12.0	27 (102)	96.7	54.3
Strontium, Total	µg/l	167.0	101.1	27 (102)	661.8	400.3
Zinc, Total	µg/l	26.0	15.3	27 (102)	103	61
Arsenic, Total	µg/l	2.9	0.9	27 (102)	11.5	3.6
Lead, Total	µg/l	5.0	5.0	27 (102)	19.8	19.8
TDS	mg/l	195.7	141.6	27 (102)	792.6	578.2
Calcium Hardness	mg/l	96.1	65.8	27 (102)	380.8	260.8
Total Hardness	mg/l	131.0	91.2	27 (102)	519.1	361.4

Key:

mg/l - milligrams per liter
µg/l - micrograms per liter
gpm- gallons per minute
lpm - liters per minute

Notes:

a. Makeup to Demineralized Water Treatment System is filtered river water from RWSS.

b. Reverse Osmosis (RO) reject concentrations calculated by multiplying filtered river water makeup concentrations by a ratio of 107:27 (based on the reverse osmosis (RO) reject rate)

Table 3.6-9— Anticipated Effluent Water Chemical Concentrations

(Page 1 of 2)

Outfall: Plant Effluent to Susquehanna River via Submerged Diffuser [a, b]			
Parameter	**Units**	**Maximum Concentration**	**Mean Concentration**
Total Alkalinity	mg/l	180	78
Total Suspended Solids	mg/l	447	87
Silica (Silicon Dioxide)	mg/l	14	8
Bicarbonate as $CaCO_3$	mg/l	279	187
Chloride	mg/l	121	83
Fluoride	mg/l	0.3	0.3
Nitrate as NO_3	mg/l	10	6
Nitrate as N	mg/l	2	1
Phosphorus as PO_4	mg/l	2	1
Sulfate	mg/l	253	186
Aluminum, Total	µg/l	8,123	1,359
Barium, Total	µg/l	172	97
Calcium, Total	mg/l	114	78
Iron, Total	mg/l	17	4
Magnesium, Total	mg/l	30	18
Manganese, Total	µg/l	762	331
Potassium, Total	mg/l	7	5
Sodium, Total	mg/l	74	43
Strontium, Total	µg/l	495	299
Zinc, Total	µg/l	77	45
Arsenic, Total	µg/l	9	3
Lead, Total	µg/l	15	15
Total Dissolved Solids	mg/l	713	553
Calcium Hardness	mg/l	285	195
Total Hardness	mg/l	388	270
HEDP	mg/l	5	5
Dispersant	mg/l	5	5
Free Available Chlorine	mg/l	< 0.2	< 0.2

Table 3.6-9— Anticipated Effluent Water Chemical Concentrations

(Page 2 of 2)

Outfall: Storm Water[c]	
Parameter	**Concentration**
Total Suspended Solids	9 mg/l>
Oil & Grease	None Detectable
Nitrate	1.78 mg/l
pH	7.55 s.u.
Outfall: RWSS Pump Strainer and Water Intake Screen Cleaning	
None [d]	None [d]

Key:

mg/l - milligrams per liter

µg/l - micrograms per liter

Notes:

a. The combined plant effluent discharged to the Susquehanna River includes: effluent from the Combined Waste Water Retention Pond, including the CWS cooling tower blowdown, ESWS cooling tower blowdown, miscellaneous low volume waste, RO wastewater, and RWSS filter backwash; and treated liquid radiological waste, which will be discharged downstream of the Combined Waste Water Retention Pond. b. Concentrations are based on 3 cycles of concentration. c. The parameters and concentrations are based on stormwater sampling conducted at SSES. d. The pump strainers and intake screens will only remove bulk debris and trash. Similar to the existing SSES NPDES permit, it is not anticipated that BBNPP will be required to monitor the discharge from its pump strainers or intake screen wash.

Table 3.6-10— Hazardous Waste Generation Rates at SSES

Hazardous Waste	Year/Quantity (lbs/kg)					
	2003		2005		2007	
	(lbs)	(kg)	(lbs)	(kg)	(lbs)	(kg)
Sulfuric Acid	2,855	1,296	N/A	N/A	N/A	N/A
Ignitable and Listed Solvents	942	428	N/A	N/A	N/A	N/A
Waste Paint, Ink, Lacquer, Varnish	4,225	1,918	2,785	1,264	12,750	5,788
Lead Debris	1,542	888	200	91	1,160	527
Lab Packs - No Acutely Hazardous	985	447	355	161	1,713	778
Solvent Contaminated Debris	N/A	54	130	59	590	268
Boresonic Inspection Solution	413	’188	N/A	N/A	N/A	N/A
Iron Oxalate Hexahydrate	N/A	N/A	650	295	1,200	545
Waste Paint, Solvents, Gasoline and Oil Mixture	N/A	N/A	560	254	640	290
Initiator Assemblies - Fire Suppression System	N/A	N/A	145	66	15	7
Aerosols	N/A	N/A	40	18	N/A	N/A
Lab Packs - With Acutely Hazardous	N/A	N/A	10	4	N/A	N/A
Radiological Contaminated Phosphoric Acid Filters and Debris	N/A	N/A	88	40	N/A	N/A
Concrete Sealer, Tectyl 506, Spectrus CT-1300	N/A	N/A	N/A	N/A	1,600	726
Dichlorofluoromethane, flammable aerosols	N/A	N/A	N/A	N/A	61	28
Broken Fluorescent Lamps	N/A	N/A	N/A	N/A	60	27
Radiological Contaminated Lead Debris	413	N/A	947	430	306	139
Radiological Contaminated Paint, Hydrocarbons	N/A	N/A	N/A	N/A	222	101
Radiological Contaminated Debris Solvents	119	N/A	N/A	N/A	130	59
Radiological Contaminated Lab Pack Chemicals	N/A	N/A	N/A	N/A	77	35
Total	11,494	5,218	5,910	2,683	20,524	9,318

Key:
N/A - Not Applicable
(lbs) - pounds
(kg) - kilogram

Table 3.6-11— Residual Waste Generation Rates at SSES

Waste Stream	Amount (tons)	Amount (metric tons)
Incidental Maintenance Waste (Plant and Office Trash)	526	477
Cooling Tower Sediment	286	259
Cooling Tower Fill	269	243
Waste Oil	125	113
Reactivator/Clarifier (inorganic) Sludge	39	35
Waste Tires	37	34
Discarded/Expired Chemicals	15	14
Alumina Oxide (Sandblasting Grit and Dessicant)	3	3
Oily Waste Debris	6	5
Power Coil Cleaning Solution	<1	<1
Spill Cleanup (Petroleum)	<1	<1
Spill Cleanup (Non-Petroleum)	<1	<1
Alkaline Batteries	<1	<1
Asbestos Containing Waste	<1	<1
PCB Containing Light Ballasts and Capacitors	<1	<1

3.7 POWER TRANSMISSION SYSTEM

The NRC criteria for review of power transmission systems are presented in Section 3.7 of NUREG-1555 (NRC, 1999) To address these criteria, this section of the Environmental Report describes the transmission system from the BBNPP substation to its connections with the existing PPL Electric Utilities Corporation (PPL EU) transmission systems, including lines, corridors, towers, substations, and communication stations. BBNPP, with an additional 1,600 MWe rating, would require the following new facilities and upgrades to connect to the existing transmission system:

- One new BBNPP 500 kV Switchyard, which is located in close proximity of the Turbine Building, to transmit power from the BBNPP,
- One new Susquehanna 500 kV Yard 2,
- The expansion of the existing Susquehanna 500 kV Yard,
- Two new 500 kV, 4,260 MVA (normal rating) circuits connecting the new BBNPP switchyard to the expansion of the existing Susquehanna 500 kV Yard, and the new Susquehanna 500 kV Yard 2:
- A switchyard control building located near the new BBNPP 500 kV Switchyard.

The BBNPP will be located within the operational jurisdiction of the PJM Regional Transmission Organization (RTO). As the RTO, PJM provides non-discriminatory access to the transmission network in accordance with its Federal Energy Regulatory Commission approved Open Access Transmission Tariff. PJM operates and manages the bulk power transmission network in order to facilitate competition among wholesale generators. PJM directly manages the interconnection of new generation and transmission projects, and monitors various energy product markets to ensure fairness and neutrality for all market participants. PJM is the registered entity Transmission Operator (TOP) for all bulk power transmission facilities (100 kV and above) in the proximity of BBNPP.

Within the PJM system, various transmission owners own segments of the transmission system. In the proximity of the BBNPP, PPL EU owns the transmission network and is the Transmission Owner (TO). PJM delegates to PPL EU, in their role as TO, certain specified activities for the physical operation of transmission facilities at the direction of PJM.

The BBNPP is located adjacent to the existing Susquehanna Steam Electric Station (SSES). As such, significant transmission infrastructure exists within close proximity to the BBNPP site (Figure 3.7-1). In addition to existing transmission infrastructure, PPL EU is developing a new 500 kV transmission line from Susquehanna to the Roseland Substation (New Jersey). This expansion effort is a PJM Regional Transmission Expansion Plan (RTEP) initiative. PJM has determined that this new 500 kV line is required for grid reliability in the region without considering whether BBNPP is constructed. The in-service date of the Susquehanna-Roseland RTEP project is planned for 2012 and is expected to precede the completion of construction of the Bell Bend Nuclear Power Plant.

Design of new transmission facilities (to include transmission tie-lines) is governed by PJM and PPL EU design standards. BBNPP will interconnect to the transmission system at a single voltage of 500 kV.

The existing transmission system, constructed and operated for the region, including SSES Units 1 and 2, was addressed in the Environmental Report submitted with the original SSES plant license application (SSES, 1978) and re-evaluated in the Environmental Report submitted with the SSES license renewal application (SSES, 2006).

The existing 500 kV transmission system consists of the Susquehanna 500 kV Yard adjacent to the SSES plant, and two 500 kV circuits (Sunbury, Wescosville). Additionally the Susquehanna 500 kV Yard is connected to the Susquehanna 230 kV Yard by a 500kV/230kV transformer.

The existing transmission system was not, and the PJM planned expansion project being pursued by PPL EU will not be, constructed for the specific purpose of connecting BBNPP to the transmission system. They are not within the scope of interest and will not be addressed in this section, except where they impact or are impacted by, the transmission facilities of the BBNPP. The routes for the existing and PJM planned circuits from the SSES are presented in Figure 3.7-2.

3.7.1 Substation and Connecting Circuits

3.7.1.1 BBNPP Substation

The 500 kV switchyard design for BBNPP will consist of a 500 kV gas insulated, six bay, breaker and a half/double breaker scheme. The switchyard will have fourteen 500 kV circuit breakers and associated disconnect switches, bus work, and equipment. The switchyard will provide for connections to the BBNPP generator main step-up transformer, the two Normal Auxiliary Transformers, the two Emergency Auxiliary Transformers, the 500 kV transmission lines to the new Susquehanna 500 kV Yard 2, and the expansion of the existing Susquehanna Yard. A Control Building will be located along the southern side of the BBNPP Switchyard.

The BBNPP Switchyard will occupy a tract of land of approximately 300 ft (91.4 m) by 846 ft (257.9 m), or 5.8 acres (2.4 hectares). The switchyard is located approximately 1400 ft (426.7 m) east of BBNPP containment, 2400 ft (731.5m) from the south plant boundary and 1800 ft (548.6 m) from the north plant boundary, and can be seen on Figure 3.7-2.

The BBNPP Switchyard will be electrically integrated with the existing 500 kV transmission network by installing two 500 kV 4,260 MVA circuits on individual towers.

The BBNPP Switchyard area, as detailed in Figure 3.7-2, will be graded level with removal of any vegetation which might be present. Areas under the transmission lines will be cleared of any vegetation that could pose a safety risk to the transmission system, either through arcing or reducing the structural integrity of towers.

Clearing vegetation and maintaining the corridors and right-of-ways are to be conducted in accordance with the existing PPL EU procedure.

3.7.1.2 Connecting Circuits

The BBNPP substation will be electrically integrated with the existing 500 kV Susquehanna Yard, and the 500 kV Susquehanna Yard 2 by constructing two 500 kV 4,260 MVA lines on individual towers. A topographic map showing the location of the connecting circuits between the two substations is presented in Figure 3.7-2.

No new offsite transmission corridors will be required. The only new corridor required is from the BBNPP Switchyard until it reaches the corridor for the planned Susquehanna-Roseland line, which will be utilized to the extent possible.

The detailed design of the new transmission lines has not begun, but the layout of the new lines will not have any impact on the existing offsite transmission corridor, and all new line construction will be under PJM jurisdiction.

The interconnection process in PJM is outlined in PJM's Open Access Transmission Tariff. To summarize, a merchant generation facility developer is responsible to provide a proposed interconnection design to PJM. The interconnection design will be subjected to PJM and Transmission Owner (PPL EU) studies. Actual physical placement of transmission lines, towers, etc., is worked out between the developer and the PPL EU to meet the needs of each party. NRC guidelines for physical separation of BBNPP transmission lines will be incorporated into the physical placement.

PPL EU will construct the necessary transmission network infrastructure. PPL Bell Bend, LLC will own the BBNPP Switchyard, and PPL EU will own the interconnecting transmission lines. Via delegation to PPL EU, PJM will operate the transmission lines connecting to the BBNPP Switchyard. Transmission lines interconnecting the BBNPP Switchyard to the transmission network will be sited according to PPL EU and PJM procedures and guidelines. Operation of the transmission system is governed by PJM and PPL EU procedures.

The design features consist of the following clearances and ratings:

Minimum phase-to-phase (metal to metal); 18 ft (5.5 m),

Minimum phase-to-ground; 12 ft 2 in (3.7 m),

Voltage; 500 kV,

Phases; 3,

Frequency; 60 Hertz

All new transmission lines in the PJM system require approval and authorization of PJM Interconnection. The permitting authority for transmission line routing is the PA Public Utility Commission, under Title 52 PA Code Section 57.71 (ER Section 1.0) (PA CODE, 2008).

Line routing would be conducted to avoid or minimize impact on wetlands, or threatened and endangered species identified in the local area. Regular inspections and maintenance of the transmission system and right-of-ways will be performed. These inspections and maintenance include patrols and maintenance of transmission line hardware on a periodic and as-needed basis. Vegetation maintenance may include tree trimming and minimal application of herbicide. Maintenance of the proposed onsite corridors including vegetation management will be implemented under the existing PPL EU procedure.

3.7.1.3 CORRIDORS

No new offsite transmission corridors are required to directly connect BBNPP to the transmission system. Corridor construction will be conducted to avoid or minimize impact on wetlands, or threatened and endangered species identified in the local area. Clearing vegetation and maintaining the corridors and right-of-ways are to be conducted in accordance with the existing PPL EU procedure.

Environmental species and habitat, cultural and historic resources that may be affected by the design of transmission corridors on the BBNPP site are addressed in ER Sections 2.4.1, 2.4.2, and 2.5.3.

3.7.2 Electrical Design Parameters

3.7.2.1 Circuit Design

The detailed design of the transmission lines has not begun but would include selection of the conductor and conductor configuration and the other design parameters specified by NUREG-1555 (NRC, 1999). Design and construction of transmission lines would be based on the guidance provided by the National Electric Safety Code (NESC) (ANSI/IEEE, applicable version), State and Local regulations , PPL EU, and PJM standards. While the detailed design of the transmission circuits has not begun, the conductors would be selected to meet the power delivery requirements of BBNPP. The two 500 kV lines connecting the BBNPP Switchyard to the existing 500 kV Susquehanna Yard, and the new 500 kV Susquehanna Yard 2, will be rated at 4,260 MVA (normal rating). Each proposed phase would use the same three sub-conductor bundles comprised of three 1,590 circular mills, 45/7 aluminum conductor, steel reinforced conductors with 18 in (0.5 m) separation. There would typically be two overhead ground wires of 19#9 Alumoweld® or 7#8 Alumoweld®, but the final design could specify optical ground wire fiber optic cable in place of the Alumoweld® ground wire. The new lines would be designed to preclude crossing of lines wherever possible.

3.7.2.2 Induced Current Analysis

The design of the new transmission circuits would consider the potential for induced current as a design criterion. The NESC has a provision that describes how to establish minimum vertical clearances to the ground for electric lines having voltages exceeding 98 kV alternating current to ground. The clearance must limit the induced current due to electrostatic effects to 5 mA if the largest anticipated truck, vehicle, or equipment were short-circuited to ground. For this determination, the NESC specifies that the lines be evaluated assuming a final unloaded sag at 120°F (49°C). The calculation is a two-step process in which the analyst first calculates the average field strength at 3.3 ft (1.0 m) above the ground beneath the minimum line clearance, and second calculates the steady-state current value. The design and construction of the BBNPP substation and transmission circuits would comply with this NESC provision. At a minimum, conductor clearances over the ground would equal or exceed 29 ft (8.8 m) phase-to-ground over surfaces that could support a large truck or farm machinery, while clearance over railroad lines would equal or exceed 37 ft (11.3 m) phase-to-ground.

3.7.3 Noise Levels

The noise impacts associated with the transmission system would be from three major sources: (1) corona from the transmission lines (a crackling or hissing noise); (2) operation of the substation transformers; and (3) maintenance work and vehicles.

3.7.3.1 Corona

Corona discharge is the electrical breakdown of air into charged particles caused by the electrical field at the surface of the conductors, and is increased by ambient weather conditions such as humidity, air density, wind, and precipitation and by irregularities on the energized surfaces. During wet conditions audible noise from the corona effect can exceed 50 dBA for a 500 kV line may range between 59 and 64 dBA. Corona noise for a 500 kV line has been estimated to be 59.3 dBA during a worst-case rain with heavy electrical loads (SCE, 2006). For reference, normal speech has a sound level of approximately 60 dB and a bulldozer idles at approximately 85 dB.

As shown in Figure 3.7-2, the proposed BBNPP 500 kV Switchyard and the transmission lines connecting the BBNPP Switchyard to the two Susquehanna 500 kV Switchyards will be constructed entirely within the BBNPP project area. The corona noise would be reduced at the project boundary from approximately 60 dBA near the conductors.

3.7.3.2 Substation Noise

Substations include transformer banks and circuit breakers that create "hum," normally around 60 dBA, and occasional instantaneous sounds in the range of 70 to 90 dBA during activation of circuit breakers (SCE, 2006). The new Switchyards will introduce new noise sources (transformers and circuit breakers) at their locations. The noise levels surrounding the Switchyards will likely be close to 60 dBA near the substation fence, but would be reduced near the project area boundary.

3.7.3.3 Maintenance Noise

Regular inspections and maintenance of the transmission system and right-of-ways are performed. A patrol is performed twice annually of all transmission corridors, while more comprehensive inspections are performed on a rotating 4-year schedule for the transmission system, and a rotating 3-year schedule for vegetation management. Maintenance is performed on an as-needed basis as dictated by the results of the line inspections and are generally performed on a 4-year schedule for the transmission system, and a rotating 3-year schedule for vegetation management. The noise levels for maintenance activities would typically be those associated with tree trimming, spraying, mowing and vehicle driving. Noise levels for maintenance in the new onsite corridor are expected to be similar to those currently generated by maintenance activities.

3.7.4 Structural Design

The existing 500 kV transmission towers are designed and constructed to NESC and current PPL EU standards. New towers added to support BBNPP which will be located on site, will also conform to these criteria. The new towers will be steel tubular or lattice designs, and will provide minimum clearances in accordance with the aforementioned standards. The two circuits connecting the BBNPP switchyard to the two 500 kV Switchyards will be carried on separate towers. All structures would be grounded with a combination of ground rods and a ring counterpoise system. If any transmission structures exceed a height of 200 ft (61 m) above ground surface Federal Aviation Administration permits will be required.

3.7.5 Inspection and Maintenance

Regular inspections and maintenance of the transmission system and right-of-ways will be performed. These inspections and maintenance include patrols and maintenance of transmission line hardware on a periodic and as-needed basis. Vegetation maintenance may include tree trimming and minimal application of herbicide. Maintenance of the proposed onsite corridors including vegetation management will be implemented under the existing PPL EU procedure.

3.7.6 Compliance and Siting

All new transmission lines in the PJM system require approval and authorization of PJM Interconnection. Additionally, the PA Public Utility Commission under 52 PA Code Section 57.71 is the state permitting agency for transmission lines. Construction, operation, and maintenance, including the mitigation of electric shock hazards, for the power transmission system will be in accordance with the Institure of Electrical and Electronic Engineers, Inc. NESC. Transmission line design and construction will be in compliance with all state and local standards and regulations as well as 18 CFR 35, Code of Federal Regulations, Title 18, Conservation of Power and Water Resources, "Filing of Rate Schedules and Tariffs."

In addition to existing transmission infrastructure, PPL EU is developing a new 500 kV transmission line from Susquehanna to the Roseland Substation (New Jersey), a distance of approximately 130 miles. This expansion effort is a PJM Regional Transmission Expansion Program (RTEP) initiative. The new PPL EU owned 500 kV substation No. 2 will be constructed on the SSES to facilitate interconnection of the Susquehanna-Roseland line. Commercial in service date of the Susquehanna-Roseland RTEP project is expected to precede the construction of the Bell Bend Nuclear Power Plant.

For the purpose of completing the PJM Interconnection studies, a conceptual design is utilized that meets the needs of the developer, transmission owner, and RTO. Detailed design of transmission infrastructure required to interconnect the BBNPP to the transmission network will take place after an Interconnection Service Agreement is executed between PJM Interconnection and BBNPP. The two (2) 500 kV tie lines to SSES 500 kV switchyards No. 1 and No. 2 will be designed in accordance with PJM Interconnection and PPL EU transmission line design standards. Any BBNPP specific design requirements (such as physical separation of structures) will also be incorporated into the final design.

Since no new off-site transmission corridors are required to facilitate the interconnection of BBNPP, no specific siting procedures are required specifically for the construction of the BBNPP transmission lines.

3.7.7 References

ANSI/IEEE, applicable version. National Electric Safety Code, ANSI/IEEE C2, version in effect at time of design, American National Standards Institute/Institute of Electrical and Electronics Engineers.

NRC, 1999. Environmental Standard Review Plan, NUREG-1555, Nuclear Regulatory Commission, October 1999.

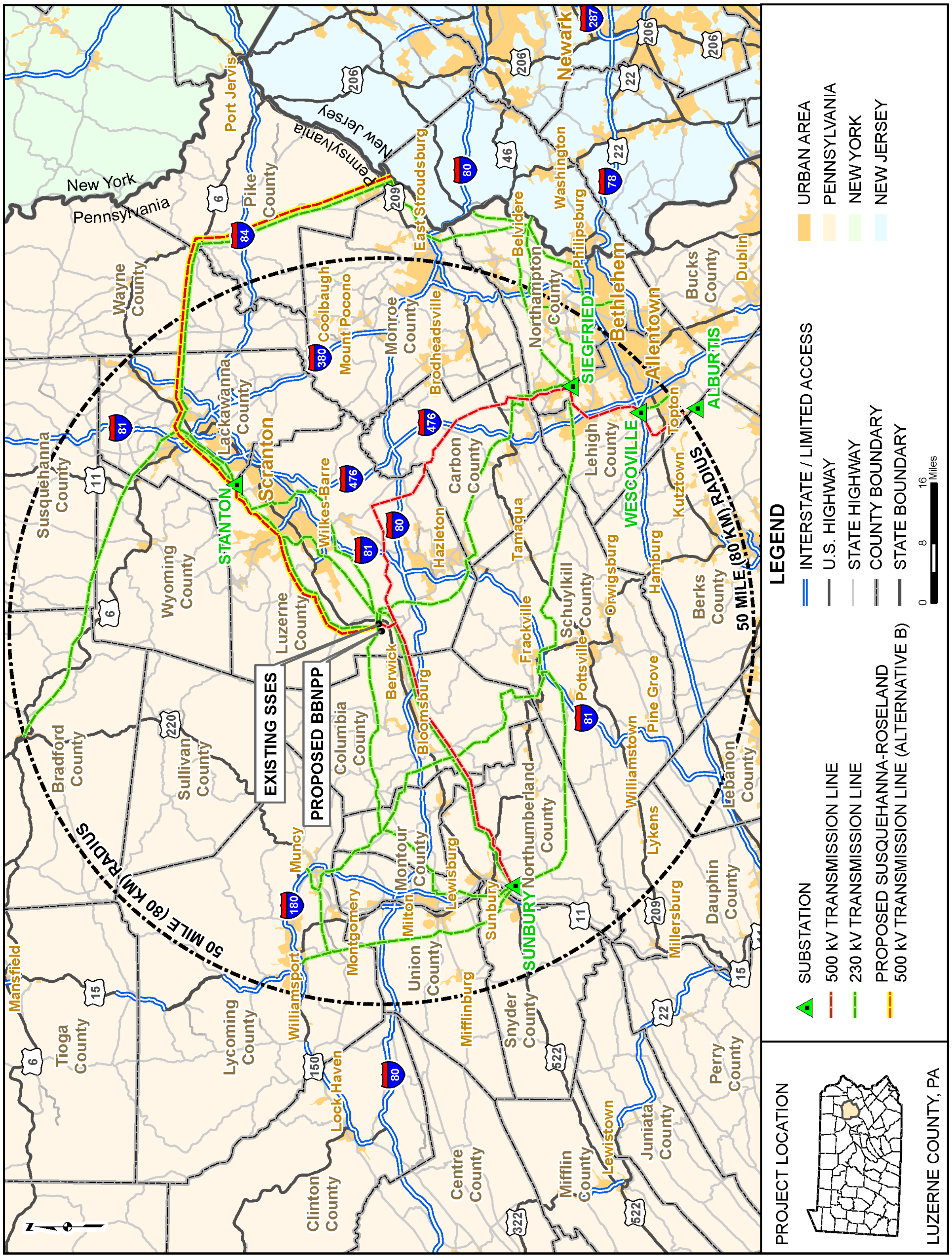
PA CODE, 2008. Title 52, Pennsylvania Code, Section 57.71, Electric Service - Commission Review of Siting and Construction of Electric Transmission Lines, 2008.

SCE, 2006. Devers-Palo Verde 500 kV No. Project (Application No. A.05-04-015), Final Environmental Impact Report/ Environmental Impact Statement, State of California Public Utilities Commission, Southern California Edison, October 2006.

SSES, 1978. Susquehanna Steam Electric Station Units 1 & 2, Environmental Report, PPL Susquehanna, LLC, May 1978.

SSES, 2006. Susquehanna Steam Electric Station Units 1 & 2, License Renewal Environmental Report, Appendix E, PPL Susquehanna, LLC, September 2006.

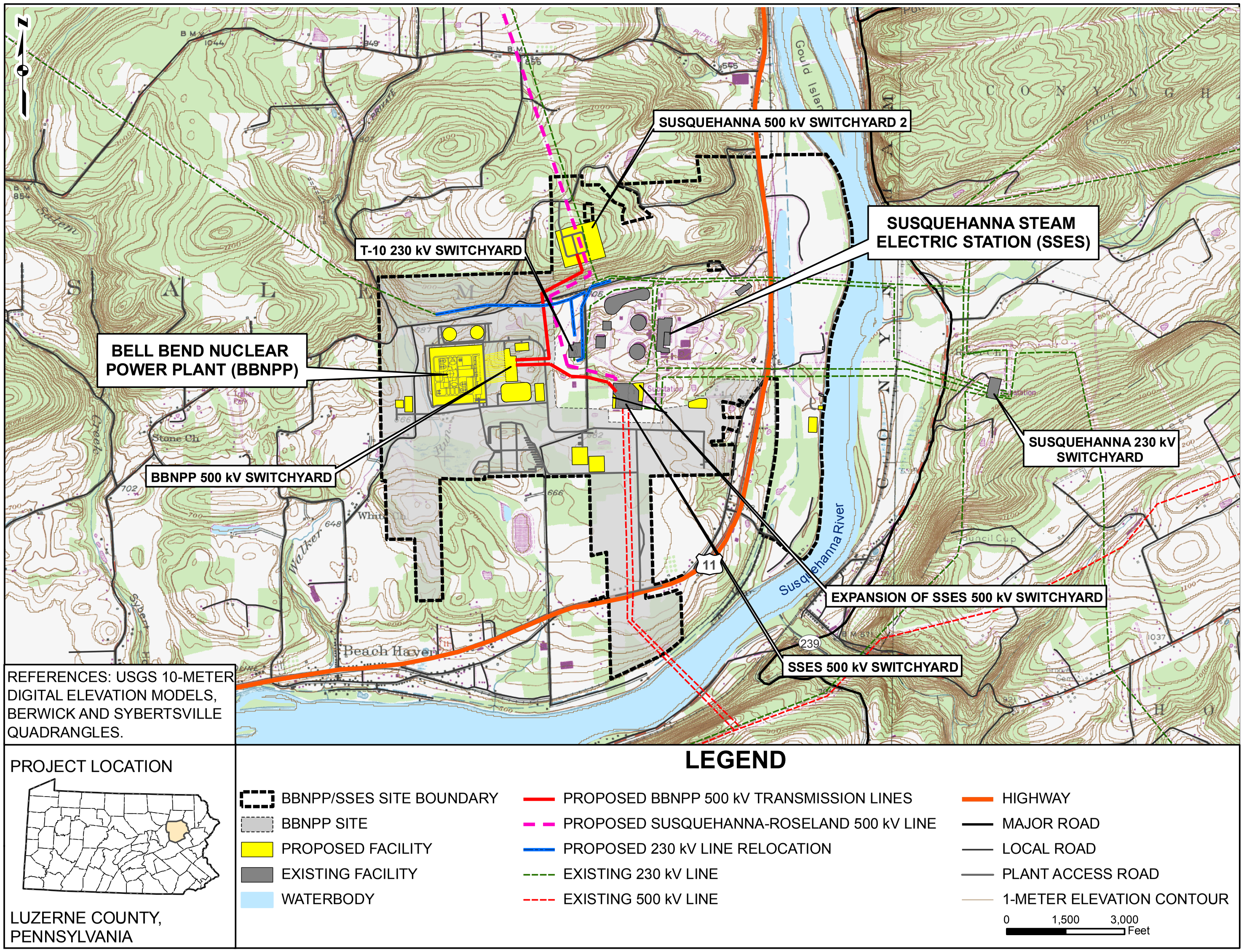
Figure 3.7-1— BBNPP Site 500 kV and 230 kV Regional Circuit Corridors



LEGEND

- ▲ SUBSTATION
- 500 kV TRANSMISSION LINE
- 230 kV TRANSMISSION LINE
- PROPOSED SUSQUEHANNA-ROSELAND 500 kV TRANSMISSION LINE (ALTERNATIVE B)
- INTERSTATE / LIMITED ACCESS
- U.S. HIGHWAY
- STATE HIGHWAY
- COUNTY BOUNDARY
- STATE BOUNDARY
- URBAN AREA
- PENNSYLVANIA
- NEW YORK
- NEW JERSEY

Figure 3.7-2— Site Topography and Generalized Transmission Line Corridor



3.8 TRANSPORTATION OF RADIOACTIVE MATERIALS

3.8.1 Reactor Data

The reactor for BBNPP has a rated core thermal power of 4,590 (MWt). Although the U.S. EPR is to be licensed for 40 years, the proposed operating life of the U.S. EPR is 60 years.

The reactor core consists of 241 fuel assemblies. The fuel assembly structure supports the fuel rod bundles. Inside the assembly, the fuel rods are vertically arranged according to a square lattice with a 17x17 array. There are 265 fuel rods per assembly.

The fuel rods are composed of enriched uranium dioxide sintered pellets contained in a cladding tube made of M5® advanced zirconium alloy. The percentage of uranium enrichment and total quantities of uranium for the reactor core is as follows:

- Cycle 1 (initial) - average batch enrichment is between 2.23 to 3.14 weight percent U-235 and 2.66 weight percent U-235 for core reload with an enriched uranium weight of 285,483 lbs (129,493 kg).
- Cycle 2 (transition) - average batch enrichment is between 4.04 to 4.11 weight percent U-235 and 4.07 weight percent U-235 for core reload with an enriched uranium weight of 141,909 lbs (64,369 kg).
- Cycle 3 (transition) - average batch enrichment is between 4.22 to 4.62 weight percent U-235 and 4.34 weight percent U-235 for core reload with an enriched uranium weight of 113,395 lbs (51,435 kg).
- Cycle 4 (equilibrium) - average batch enrichment is between 4.05 to 4.58 weight percent U-235 and 4.30 weight percent U-235 for core reload with an enriched uranium weight of 113,417 lbs (51,445 kg).

Average batch enrichment is the average enrichment for each fuel assembly comprising a batch of fuel. The enrichment for core reload is the average enrichment for all fuel assemblies loaded in the core which is derived from the mass weighted average for the batches of fuel. The above values are 'beginning of life' enrichment values. Discharged enrichment values will be less at the 'end of life' of the assembly. Assembly enrichment reduction is directly proportional to the assembly burnup.

Discharge burnups for equilibrium cores are approximately between 45,000 and 59,000 MWd/MTU. The batch average discharge burnup for equilibrium cores is about 52,000 MWd/MTU.

3.8.2 Onsite Storage Facilities for Irradiated Fuel

As discussed in Section 3.5.3, the spent fuel pool will be sized to accommodate at least 10 calendar years of wet storage, plus a full core offload. BBNPP will utilize a 5 year minimum decay period between removal from the reactor and transportation offsite, as required by the Department of Energy (DOE) and as prescribed under 10 CFR 961, Appendix E, (CFR, 2007c).

3.8.3 Treatment and Packaging of Radioactive Materials other than Irradiated Fuel

Solid low level waste (LLW) shipped offsite for processing and disposal include dry activated wastes (DAW), aqueous cartridge type filters, solidified evaporator concentrates, resin beads, irradiated hardware, and small amounts of mixed wastes. The waste streams, annual generated volumes, and shipments are summarized in Table 3.8-1.

The BBNPP waste-streams identified in Table 3.8-1 will be packaged in solid form in accordance with the requirements of 10 CFR 51.52(a)(4), 10 CFR 71, 49 CFR 173, and 49 CFR 178, (CFR 2007a, 2007b, 2007d, and 2007e), and as required for acceptance by the processor and disposal site's waste acceptance criteria.

3.8.4 Transportation System for Fuel and Other Radioactive Waste

Unirradiated fuel will be shipped to BBNPP by truck.

The DOE is responsible for irradiated fuel shipments from BBNPP to the repository. The DOE will make the decision regarding the mode of transport. It is anticipated that irradiated fuel will be shipped by truck, rail, or barge.

Radioactive waste from BBNPP will be shipped by truck or rail.

BBNPP will operate in accordance with carrier procedures and policies that comply with the requirements of 10 CFR 51.52(a)(4), 10 CFR 71, 49 CFR 173, and 49 CFR 178, (CFR 2007a, 2007b, 2007d, and 2007e). The procedures will be similar to those established for SSES Units 1 and 2.

3.8.5 Transportation Distance from the Plant to the Storage Facility

The detailed analysis of the transportation of fuel and wastes to and from the facility is provided in Sections 5.11 and 7.4. The discussion of the analysis includes the assumptions regarding the transportation distances to the appropriate storage facilities.

3.8.6 Conclusions

Table 3.8-2 compares the conditions in 10 CFR 51.52(a) (CFR, 2007a) with the design parameters for BBNPP. As noted in Table 3.8-2, the design for BBNPP will not meet all of the conditions of 10 CFR 51.52(a) (CFR, 2007a). Therefore, the environmental impact from the transportation of fuel and wastes to and from the facility are analyzed in Sections 5.11 and 7.4.

3.8.7 References

CFR, 2007a. Code of Federal Regulations, Title 10, 51.52, Environmental Effects of Transportation of Fuel and Waste - Table S-4, 2007.

CFR, 2007b. Code of Federal Regulations, Title 10, Part 71, Packaging and Transportation of Radioactive Material, 2007.

CFR, 2007c. Code of Federal Regulations, Title 10, Part 961, Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste, Appendix E, 2007.

CFR, 2007d. Code of Federal Regulations, Title 49, Part 173, Shippers - General Requirements for Shipments and Packagings, 2007.

CFR, 2007e. Code of Federal Regulations, Title 49, Part 178, Specifications for Packagings, 2007.

Table 3.8-1— Annual Solid Radioactive Wastes

Waste Type	Quantity (ft^3)	Activity Content (Ci)[(b)]		Shipping Volume (ft^3)	
		Expected	Maximum	Expected	Maximum
Evaporator Concentrates[a]	710	1.50E+02	9.12E+03	varies	140
Spend Resins (other)	90	1.07E+03	5.23E+04	90	
Spent Resins (Rad Waste Demineralizer System)	140	2.96E+01	1.80E+03	140	
Wet Waste from Demineralizers	8	1.69E+00	1.03E+02	8	
Waste Drum for Solids Collection from Centrifuge System of KFP	8	1.69E+00	1.03E+02	varies	8
Filters	120	6.86E+02		120	
Sludge	70	1.48E+01	9.00E+02	varies	35
Total Solid Waste Stored in Drums	1146	1.95E+03	6.50E+04	358	541
Mixed Waste	2	4.00E-02	2.43E+00	2	
Non-Compressible DAW	70	2.97E-01	1.81E+01	70	
Compressible DAW	1415	6.01E+00	3.66E+02	707	
Combustible DAW	5300	3.19E+01	1.94E+03	5300	
Total Dry Active Waste	6785	3.82E+01	2.32E+03	varies	
Overall Totals	7933	1.99E+03	6.73E+04	varies	

a The volume of evaporator concentrates and sludge, and the number of waste drums will be determined by the method of treatment.

b The activity content for evaporator concentrates, spent resins, wet waste, filters and sludge represents the waste activity after a defined decay period (i.e., 6 months) that coverson-site storage before shipping.

Table 3.8-2— Transportation Environmental Impact Comparison

10 CFR 51.52(a) Parameter	10 CFR 51.52(a) Condition	BBNPP
(1) Reactor Power Level, MWt	3,800	4,590
(2) Fuel Form and U235 Enrichment, weight percent	Zircaloy encapsulated sintered uranium dioxide pellets at 4.0	M5® advanced zirconium alloy encapsulated sintered uranium dioxide pellets at 4.58
(3) Average Irradiation Level and Minimum Decay, MWd/MTU	33,000 at 90 days decay	52,000 at 5 years decay
(4) Radioactive Waste Physical Form	Packaged as Solid	Packaged as Solid
(5) Transport Mode	New Fuel: Truck Irradiated Fuel: Truck, Rail, Barge LLW: Truck, Rail	New Fuel: Truck Irradiated Fuel: Truck LLW: Truck
(6) Environmental Impacts	Table S-4 of 10 CFR 51.52	Refer to Sections 5.11 and 7.4

Note:
LLW - Low Level Waste