Shearon Harris Nuclear Power Plant Units 2 and 3
COL Application
Part 3, Environmental Report

CHAPTER 3
PLANT DESCRIPTION

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
$\mu Ci/cm^3$	microCuries per cubic centimeter
µS/cm	microSiemens per centimeter
AC	alternating current
ac.	acre
ACSR	aluminum conductor steel reinforced
ALARA	as low as reasonably achievable
ANSI/IEEE	American National Standards Institute/Institute of Electrical and Electronics Engineers
AP600	Westinghouse Electric Company, LLC’s AP600 Reactor
AP1000	Westinghouse Electric Company, LLC’s AP1000 Reactor
ASS	auxiliary steam system
Btu/hr	British thermal units per hour
Btu/kWh	British thermal units per kilowatt hour
BWR	boiling water reactor
CCS	component cooling water system
CDS	condensate system
CFR	Code of Federal Regulations
CFS	chemical feed system
Ci/yr	Curies per year
cm	centimeter
m^3/s	cubic meter per second
CO_2	carbon dioxide

ACRONYMS AND ABBREVIATIONS (CONTINUED)

COL	Combined License
COLA	Combined License Application
CP&L	Carolina Power & Light Company
CSA	control support area
CTMU	Cooling Tower Makeup
CVS	chemical and volume control system
CWS	circulating water system
DAW	dry active waste
DC	direct current
DCD	Westinghouse Electric Company, LLC, AP1000 Design Control Document
DCD T-2	Design Control Document Tier 2 Material
D-EHC	digital electrohydraulic
DIT	Design Information Transmittal
DTS	demineralized water treatment system
DWS	demineralized water transfer and storage system
E&SCP	Erosion and Sedimentation Control Plan
EAB	exclusion area boundary
ECL	effluent concentration limit
EIS	environmental impact statement
EHV	extra high voltage
EMF	electromagnetic field
ER	Environmental Report

ACRONYMS AND ABBREVIATIONS (CONTINUED)

ESF	engineered safety features
FERC	Federal Energy Regulatory Commission
FES	Final Environmental Statement
fps	foot per second
ft.	foot
ft^2	square foot
ft^3/s	cubic foot per second
ft^3/yr	cubic foot per year
FWS	feedwater system
FY	fiscal year
G	gauss
gpm	gallon per minute
gph	gallon per hour
ha	hectare
HAR	proposed Shearon Harris Nuclear Power Plant Units 2 and 3
HAR 2	proposed Shearon Harris Nuclear Power Plant Unit 2
HAR 3	proposed Shearon Harris Nuclear Power Plant Unit 3
Harris Lake	Harris Reservoir and the Auxiliary Reservoir
HgA	Mercury Atmospheric
HIC	high integrity containers
HNP	existing Shearon Harris Nuclear Power Plant Unit 1

ACRONYMS AND ABBREVIATIONS (CONTINUED)

HVAC	heating, ventilation, and air conditioning
in.	inch
kcmil	thousand circular mils
kg	kilogram
km	kilometer
km/h	kilometers per hour
km^2	square kilometer
kV	kilovolt
kVA	kilovolt ampere
kV/m	kilovolt per meter
kW	kilowatt
lb/gal	pound per gallon
lb/yr	pound per year
l/min	liter per minute
l/hr	liter per hour
LOCA	loss of coolant accident
LSB	last stage blade
LWC	light-water-cooled
LWR	light-water reactor
m	meter
m/s	meter per second
m^3/min	cubic meter per minute
m^3/s	cubic meter per second

ACRONYMS AND ABBREVIATIONS (CONTINUED)

m^3/yr	cubic meter per year
MCR	main control room
mgd	million gallons per day
mi.	mile
$mi.^2$	square mile
mph	miles per hour
MSR	moisture separator/reheaters
MVA	megavolt amperes
MW	megawatt
MWd/MTU	megawatt-days per metric ton of uranium
MWe	megawatt electric
MWt	megawatt thermal
NaClO	sodium hypochlorite
NCDENR	North Carolina Department of Environment and Natural Resources
NESC	National Electrical Safety Code
NH_4OH	ammonium chloride
NHS	Normal Plant Heat Sink
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPSH	net positive suction head
NRC	U.S. Nuclear Regulatory Commission
NSSS	nuclear steam supply system

ACRONYMS AND ABBREVIATIONS (CONTINUED)

NVGD29	National Geodetic Vertical Datum of 1929
PEC	Progress Energy Carolinas, Inc.
PF	power factor
ppb	parts per billion
ppm	parts per million
PPMVD	parts per million, volumetric dry
psi	pounds per square inch
psig	pounds per square inch gauge
PWR	pressurized water reactor
PWS	potable water system
PXS	passive core cooling system
RAT	reserve auxiliary transformer
RCA	radiologically controlled area
RCS	reactor coolant system
RI	radio interference
RNS	normal residual heat removal system
RO	reverse osmosis
ROW	right-of-way
rpm	revolutions per minute
RTO	Regional Transmission Organization
RWS	raw water system
RTP	Research Triangle Park
SDS	sanitary drainage system

ACRONYMS AND ABBREVIATIONS (CONTINUED)

SERC	Southeastern Electric Reliability Council
SGS	steam generator system
SO_x	sulphur oxides
SSC	structure, system, and component
SWS	service water system
SWPPP	Stormwater Pollution Prevention Plan
TCS	turbine building closed cooling water system
TSC	technical support center
TVI	television interference
UHS	ultimate heat sink
UO_2	uranium dioxide
USDOE	U.S. Department of Energy
USDOT	U.S. Department of Transportation
USEPA	U.S. Environmental Protection Agency
VACAR	Virginia-Carolinas
VWS	central chilled water system
VYS	hot water heating system
Westinghouse	Westinghouse Electric Company, LLC
WGS	gaseous radwaste system
WLS	liquid radwaste system
WSS	solid radwaste system
WWS	wastewater system

3.0 PLANT DESCRIPTION

This chapter has been prepared in accordance with the requirements specified in NUREG-1555, Environmental Standard Review Plan. The chapter provides site-specific information about the proposed Shearon Harris Nuclear Power Plant Units 2 and 3 (HAR) that will be constructed by Progress Energy Carolinas, Inc. (PEC) at the existing Shearon Harris Nuclear Power Plant Unit 1 (HNP). The following information is discussed in the sections that follow:

- Section 3.1 — External Appearance and Plant Layout
- Section 3.2 — Reactor Power Conversion System
- Section 3.3 — Plant Water Use
- Section 3.4 — Cooling System
- Section 3.5 — Radioactive Waste Management Systems
- Section 3.6 — Nonradioactive Waste Management Systems
- Section 3.7 — Power Transmission System
- Section 3.8 — Transportation of Radioactive Materials

3.1 EXTERNAL APPEARANCE AND PLANT LAYOUT

The HAR site is located in the extreme southwestern corner of Wake County, North Carolina, and the southeastern corner of Chatham County, North Carolina. The City of Raleigh, North Carolina, is approximately 34.9 kilometers (km) (21.7 miles [mi.]) northeast of the HAR, and the City of Sanford, North Carolina, is approximately 26.5 km (16.5 mi.) southwest of the HAR (Reference 3.1-001). Figure 3.1-1 shows the HAR site location.

Carolina Power & Light Company (CP&L), the predecessor of PEC, constructed a dam on Buckhorn Creek, known as the Main Dam, about 4 km (2.5 mi.) north of its confluence with the Cape Fear River. The Main Dam created the Main Reservoir or Harris Reservoir (Reference 3.1-001). The Main Reservoir will be used for cooling tower and service water tower makeup requirements for the HAR. The Auxiliary Reservoir that is used for HNP emergency core cooling will not be used by the HAR. Figure 3.1-2 shows the location of the HAR in relation to its location within Wake County.

Figure 3.1-3 is an aerial photograph showing the HAR structures and cooling towers, and Figure 3.1-4 is a topographic map of the HAR site area in relation to the HNP. Figure 3.1-5 is an architect's rendition of a Westinghouse Electric Company, LLC's AP1000 Reactor facility. The HNP encompasses approximately 4371 hectares (ha) (10,800 acres [ac.] or 16.88 square miles [$mi.^2$]). PEC owns all land within the HAR site boundary lines. There are no private, residential, industrial, institutional, or commercial structures (other than those related to plant operation) within this area (Reference 3.1-001). However, as recreational usage increases at the Main Reservoir, some recreational structures may be constructed in accordance with PEC's land use policy.

The distance to, and direction from, the HAR to an exclusion area boundary (EAB) with the highest X/Q is 1245 meters (m) (4085 feet [ft.]), south-southwest (Reference 3.1-002).

U.S. Highway 1 passes north of the HAR site. Several state-maintained roads traverse the area, allowing access to the plant and Main Reservoir. The CSX Corporation Railroad passes north of the plant, and the Norfolk Southern Railroad crosses south of the Main Dam. Railway access to the plant is provided by a PEC rail spur that connects to the CSX Corporation Railroad (Reference 3.1-001).

The Cape Fear River lies adjacent to the HAR site. Use of the river near the plant is limited to small, recreational boating activities and industrial/municipal water uses (Reference 3.1-001).

3.1.1 PLANNED PHYSICAL ACTIVITIES

Under 10 Code of Federal Regulations (CFR) 50.10(a)(2), certain site work activities are allowed before the Combined License Application (COLA) is issued. These activities include the following:

- Temporary land use changes for public recreational purposes.
- Site exploration activities, including necessary borings to determine foundation conditions or other preconstruction monitoring to establish background information related to the suitability of the site, the environmental impacts of construction or operation, or the protection of environmental values.
- Site preparation for facility construction, including site clearing, grading, installation of drainage, erosion and other environmental mitigation measures, and construction of temporary roads and borrow areas.
- Erection of fences and other access control measures.
- Excavation activities.
- Erection of support buildings during facility construction, including storage sheds for construction equipment, warehouse and shop facilities, utilities, concrete mixing plants, docking and unloading facilities, and office buildings.

- Building of service facilities, such as paved roads, parking lots, railroad spurs, exterior utility and lighting systems, potable water systems, sanitary sewerage treatment facilities, and transmission lines.

- (viii) Procurement or fabrication of components or portions of the proposed facility occurring at other than the final, in-place location at the facility.

Planned pre-construction activities at the HAR site may include the following specific activities allowed by 10 CFR 50.10(a)(2):

- Site preparation for plant construction, including site clearing, grading, and construction of temporary access roads and borrow areas.

- Installation of temporary construction support facilities, including warehouse and shop facilities, utilities, concrete mixing facilities, docking and unloading facilities, and construction support buildings.

- Excavation activities.

- Construction of service facilities, including roadways, paving, railroad spurs, fencing, exterior utility and lighting systems, transmission lines, and sanitary sewerage treatment facilities.

- Construction of structures, systems, and components (SSCs) that do not prevent or mitigate the consequences of postulated accidents and that could cause undue risk to the health and safety of the public.

- Drilling of sample/monitoring wells or additional geophysical borings.

- Construction of plant cooling tower structures that are nonsafety-related.

- Construction of plant intake structures that are nonsafety-related.

- Installation of nonsafety-related fire detection and protection equipment.

- Expansion of the HNP switchyard to accommodate the construction of the proposed Shearon Harris Nuclear Power Plant Unit 2 (HAR 2), and the construction of a new switch yard to accommodate the proposed Shearon Harris Nuclear Power Plant Unit 3 (HAR 3).

- Expansion of the HNP transmission system to accommodate the construction of the HAR facility.

- Construction of a new discharge line to accommodate the HAR facility outflow.

- Installation of a new outfall structure on Harris Reservoir to accommodate makeup water from the Cape Fear River.
- Construction (and/or modification of the existing plant) of a new wastewater treatment and discharge system, as necessary.
- Construction of any other additional SSC, which do not prevent or mitigate the consequences of postulated accidents that could cause undue risk to the health and safety of the public, or SSC that are not included in the program for monitoring the effectiveness of maintenance at nuclear power plants, as defined in 10 CFR 50.65 (b).

Although not specifically mentioned in the regulations, operations at the HAR will require additional makeup water from Harris Reservoir. Water from the Cape Fear River will be used to maintain the level of Harris Reservoir to provide adequate cooling tower makeup water to support the new units. This will require infrastructure such as roads, parks, boat ramps, and bridges to be adjusted to accommodate the new reservoir level and mitigate associated effects. To prevent further mitigation effects, if the Combined License (COL) expires before construction begins, the reservoir will be maintained at the new level of 73.2 m National Geodetic Vertical Datum of 1929 (NGVD29) (240 ft. NGVD29) and will continue to support HNP operations. The reservoir level will not be returned to the pre-COL 67.1-m (220-ft.) elevation.

3.1.2 STATION LAYOUT AND APPEARANCE

The HAR facility will be a large industrial facility similar in general appearance to most reactor plants. With the exception of the parking area, the entire facility is contained within a 427-m by 236-m (1400-ft. by 775-ft.) perimeter.

Westinghouse Electric Company, LLC, AP1000 Design Control Document (DCD) provides the following information about plant arrangement:

> The plant arrangement (for each unit) is comprised of five principal building structures:
>
> - Nuclear island.
> - Turbine building.
> - Annex building.
> - Diesel generator building.
> - Radwaste building.
>
> The overall plant arrangement uses building configurations and structural designs to minimize the building volumes and quantities of bulk materials

consistent with safety, operational maintenance, and structural requirements.

The plant arrangement provides separation between safety-related and non-safety-related systems to preclude adverse interaction between safety-related and non-safety-related equipment which is normally provided by concrete walls.

The plant arrangement provides separation for radioactive and non-radioactive equipment as well as separate pathways to these areas for personnel access.

Pathways through the plant are designed to accommodate equipment maintenance and equipment removal from the plant. The size of the pathways is dictated by the size of the largest appropriate piece of equipment that may have to be removed or installed after initial installation. Where required, a laydown space is provided for disassembling large pieces of equipment to accommodate the removal or installation process.

Adequate space is provided for equipment maintenance, laydown, removal, and inspection. Hatches, monorails, hoists, and removable shield walls are provided to facilitate maintenance.

3.1.2.1 Nuclear Island

The DCD provides the following information about the nuclear island:

The nuclear island consists of a free-standing steel containment building, a concrete shield building, and an auxiliary building. The foundation for the nuclear island is an integral basemat which supports these buildings.

The nuclear island structures are designed to withstand the effects of natural phenomena such as hurricanes, floods, tornadoes, tsunamis, and earthquakes without loss of capability to perform safety functions.

3.1.2.1.1 Containment Building

The DCD provides the following information about the containment building:

The containment building is an integral part of the overall containment system with the functions of containing the release of airborne radioactivity following postulated design-basis accidents and providing shielding for the reactor core and the reactor coolant system (RCS) during normal operations.

The containment building is designed to house the RCS and other related systems and provides a high degree of leak tightness.

> The containment building is a freestanding cylindrical steel containment vessel with elliptical upper and lower heads. It is surrounded by a seismic Category I reinforced concrete shield building.
>
> The containment vessel is an integral part of the passive containment cooling system. The containment vessel and the passive containment cooling system are designed to remove sufficient energy from the containment to prevent the containment from exceeding its design pressure following postulated design-basis accidents.
>
> The principal system located within the containment building is the RCS that consists of two main coolant loops, a reactor vessel, two steam generators (SGs), four sealless reactor coolant pumps, and a pressurizer.
>
> The main steam and feedwater lines are routed from the SGs to a horizontal run below the operating deck. The steam and feedwater lines penetrate the side of the containment vessel and are routed through the main steam isolation valve area in the auxiliary building to the turbine island.
>
> The passive core cooling system is also located in the containment building. The primary components of the passive core cooling system are two core makeup tanks, two accumulators, the refueling water storage tank, the passive residual heat removal heat exchanger, and two spargers.
>
> The chemical and volume control system (CVS) equipment module is located in the containment below the maintenance floor level. The reactor coolant drain tank, the reactor coolant drain tank heat exchanger, and the containment sump pumps are located in the compartment adjacent to the reactor vessel cavity.

3.1.2.1.2 Shield Building

The DCD provides the following information about the shield building:

> The, seismic-reinforced concrete, shield building is the structure that surrounds the containment vessel. During normal operations, a primary function of the shield building is to provide shielding for the containment vessel and the radioactive systems and components located in the containment building. The shield building, in conjunction with the internal structures of the containment building, provides the required shielding for the RCS and the other radioactive systems and components housed in the containment.
>
> Another function of the shield building is to protect the containment building from external events such as natural phenomena. During

accident conditions, the shield building provides the required shielding for radioactive airborne materials that may be dispersed in the containment as well as radioactive particles in the water distributed throughout the containment.

3.1.2.1.3 Auxiliary Building

The DCD provides the following information about the auxiliary building:

> The primary function of the auxiliary building is to provide protection and separation for the seismic Category I mechanical and electrical equipment located outside the containment building.
>
> The auxiliary building provides protection for the safety-related equipment against the consequences of either a postulated internal or external event. The auxiliary building also provides shielding for the radioactive equipment and piping that is housed within the building.
>
> The most significant equipment, systems, and functions contained within the auxiliary building are the following:
>
> - Main control room.
> - Instrumentation and control systems.
> - Electrical system.
> - Fuel handling area.
> - Mechanical equipment areas.
> - Containment penetration areas.
> - Main steam and Feedwater isolation valve compartment.
>
> In addition to providing protection and separation for the mechanical and electrical equipment located outside the containment building, resin and filtration media transfer lines from the various ion exchangers are routed to the spent resin tanks in the southwest corner of the auxiliary building. The spent resin system pumps, valves, and piping are located in shielded rooms near the spent resin tanks.
>
> Liquid radwaste system transfer lines to and from the radwaste building are routed to the south wall of the auxiliary building where they penetrate and enter into a shielded pipe pit in the base mat of the radwaste building.
>
> Access ways in the auxiliary building are used to move the filter transfer casks. This includes filter transfer cask handling from the containment

building, where the chemical and volume control filters are located, to the auxiliary building rail car bay, where the filter cartridges are stored and subsequently packaged using mobile equipment. These access ways are also used to move dry active waste from various collection locations to the radwaste building. An enclosed access way is provided between the auxiliary building and the radwaste building.

The spent fuel storage facility is also located within the auxiliary building fuel handling area.

3.1.2.2 Turbine Building

The DCD provides the following information about the turbine building:

> The turbine building is supported on a single basemat foundation.
>
> The turbine building houses the main turbine, generator, and associated fluid and electrical systems. It provides weather protection for the laydown and maintenance of major turbine/generator components. The turbine building also houses the makeup water purification system.

3.1.2.3 Annex Building

The DCD provides the following information about the annex building:

> The annex building provides the main personnel entrance to the power generation complex. It includes access ways for personnel and equipment to the clean areas of the nuclear island in the auxiliary building and to the radiological control area. The building includes the health physics facilities for the control of entry to and exit from the radiological control area as well as personnel support facilities such as locker rooms. The building also contains the alternating current (ac) and direct current (dc) electric power systems, the ancillary diesel generators and their fuel supply, other electrical equipment, the control support area, and various heating, ventilating, and air conditioning systems.
>
> The building also includes a hot machine shop for servicing the radiological control area equipment. The hot machine shop includes decontamination facilities including a portable decontamination system that may be used for decontamination operations throughout the nuclear island.

3.1.2.4 Diesel Generator Building

The DCD provides the following information about the diesel generator building:

> The diesel generator building houses the two identical, side-by-side, diesel generators and their associated heating, ventilating, and air

conditioning equipment, none of which are required for the safe shutdown of the plant. These generators provide backup power for plant operation in the event of disruption of normal power sources.

3.1.2.5 Radwaste Building

The DCD provides the following information about the radwaste building:

> The radwaste building includes facilities for segregated storage of various categories of waste prior to processing, for processing by mobile systems, and for storing processed waste in shipping and disposal containers. Dedicated floor areas and trailer parking space for mobile processing systems are provided for the following:
>
> - Contaminated laundry shipping for off-site processing.
> - Dry waste processing and packaging.
> - Hazardous/mixed waste shipping for off-site processing.
> - Chemical waste treatment.
> - Empty waste container receiving and storage.
> - Storage and loading of packaged wastes for shipment.

3.1.3 PLANT LOCATION

The proposed plan for the HAR site includes the installation of two of Westinghouse's AP1000 Reactor (AP1000) units. It was assumed that the center of the distance between HAR 2 and HAR 3 reactor buildings would be used as the center point for the radii and sector grid. The radii were expanded by half of the distance between the two reactor buildings for HAR 2 and HAR 3. The HAR 2 and HAR 3 reactor buildings are centered at the following coordinates (Reference 3.1-003):

HAR 2	Latitude (North): 35°38'23.90" Longitude (West): -78°57'34.71"
HAR 3	Latitude (North): 35°38'15.39" Longitude (West): -78°57'29.81"

Figures 3.1-3 and 3.1-4 present a plan view of the HAR 2 and HAR 3 in relationship to the HNP.

3.1.4 PLANT DESCRIPTION

The HAR facility will consist of two AP1000 units.

The DCD provides the following information about the overall plant:

> The (AP1000) plant is designed with significantly fewer components and significantly fewer safety-related components than a current pressurized water reactor (PWR) of comparable size.

3.1.4.1 Cooling Water Intake Structure

Operations at the HAR will require additional makeup water from Harris Reservoir. The construction of a Harris Lake makeup water system intake structure and Harris Lake makeup water system pumphouse on the Cape Fear River is proposed (Figure 3.3-4). A new makeup water pipeline will be constructed that will provide makeup water from the Cape Fear River to Harris Reservoir to support HAR operations. The pipeline will be constructed in an existing right-of-way (ROW) (Figures 4.0-1, 4.0-4, and 4.0-10).

A new outfall structure will be constructed on Harris Reservoir (Figure 3.3-4). Water from the Cape Fear River will be used to maintain the level of Harris Reservoir to provide adequate cooling tower makeup water to support the new units (Figure 4.0-1).

HAR 2 and HAR 3 will collect cooling tower makeup water at the proposed raw water pumphouse located on the Thomas Creek arm of the Main Reservoir east of the site and approximately 975.4 m (3200 ft.) north of the HNP cooling tower makeup water intake channel (Figure 4.0-1). An illustration of the intake structure is provided as Figure 3.3-5.

Makeup water will be obtained from the Cape Fear River to maintain the proposed operating level of the Main Reservoir. The Harris Lake makeup water system has been designed to maintain the required reservoir level. This system includes the intake channel in the Cape Fear River, the Harris Lake makeup water system pumphouse on the Cape Fear River, the Harris Lake makeup water system pipeline from the Cape Fear River to the Main Reservoir, and the Harris Lake makeup water system discharge structure on the Main Reservoir. The total maximum flow capacity from the Harris Lake makeup water system pumphouse to the Main Reservoir is 3.79 cubic meters per second (m^3/s) (133.68 cubic feet per second [ft^3/s]) or 60,000 gallon per minute (gpm) (Figures 4.0-1 and 4.0-5).

A new Harris Lake makeup water system intake structure, Harris Lake makeup water system pumphouse, and Harris Lake makeup water system pipeline will be required to move water from the Cape Fear River to Harris Reservoir (Figures 4.0-1 and 4.0-5). The Harris Lake makeup water system intake structure will be constructed immediately upstream of the Buckhorn Dam within a dredged intake channel to the Cape Fear River main channel. The Harris Lake makeup water system pumphouse will be on the eastern bank of the Cape Fear River north of the Buckhorn Dam adjacent to the existing Cape Fear Steam Plant's discharge canal. The proposed Harris Lake makeup water system pipeline will extend along existing ROWs to the shore of Harris Reservoir.

The Harris Lake makeup water system pumphouse is proposed to be located in a small cove on the east side of the Cape Fear River, just north of Buckhorn Dam (Figure 4.0-5). An intake channel, with a width of approximately 10.7 m (35 ft.), will be dredged into the cove. The channel will consist of reinforced concrete slab with sloped riprap sides. The Harris Lake makeup water system intake structure and Harris Lake makeup water system pumphouse will encompass approximately 1.4 ha (3.4 ac. or 0.0053 mi.^{2}) (Figure 4.0-5).

3.1.4.2 Nuclear Supply System

The DCD provides the following information about the reactor type, power output, and containment type:

> The nuclear steam supply system (NSSS) for the AP1000 is a Westinghouse-designed PWR. The plant's net producible electrical power to the grid is at least 1,000 megawatt electric (MWe), with a core power rating of 3,400 megawatt thermal (MWt) (core plus reactor coolant pump heat).
>
> The containment building is a freestanding, cylindrical, steel containment vessel with elliptical upper and lower heads. It is surrounded by a seismic Category I reinforced concrete shield building. The containment vessel is an integral part of the passive containment cooling system. The vessel provides the safety-related interface with the ultimate heat sink (UHS), which is the surrounding atmosphere.

3.1.4.3 Gaseous Release Sources and Vent Locations

The DCD provides the following information about the gaseous waste management system:

> During reactor operation, radioactive isotopes of xenon, krypton, and iodine are created as fission products. A portion of these radionuclides are released to the reactor coolant because of a small number of fuel cladding defects. Leakage of reactor coolant thus results in a release to the containment atmosphere of the noble gases. Airborne releases can be limited both by restricting reactor coolant leakage and by limiting the concentrations of radioactive noble gases and iodine in the RCS.
>
> The AP1000 gaseous radwaste system (WGS) is designed to perform the following major functions:
>
> - Collect gaseous wastes that are radioactive or hydrogen bearing.

- Process and discharge the waste gas, keeping off-site releases of radioactivity within acceptable limits.

Releases from the gaseous radwaste system are continuously monitored by a radiation detector in the discharge line. In addition, the system includes provisions for taking grab samples of the discharge flow stream for analysis.

Airborne effluents are normally released through the plant vent or the turbine building vent. The plant vent provides the release path for containment venting releases, auxiliary building ventilation releases, annex building releases, radwaste building releases, and gaseous radwaste system discharge. The turbine building vents provide the release path for the condenser air removal system, gland seal condenser exhaust, and the turbine building ventilation releases.

Releases of radioactive effluent by way of the atmospheric pathway occur due to the following:

- Venting of the containment which contains activity as a result of leakage of reactor coolant.
- Ventilation discharges from the auxiliary building which contains activity as a result of leakage from process streams.
- Ventilation discharges from the turbine building.
- Condenser air removal system (gaseous activity entering the secondary coolant as a result of primary to secondary leakage is released via this pathway).
- Gaseous radwaste system discharges.

3.1.5 PLANT DESIGN LIFE

The DCD provides the following information about the overall plant:

The plant design objective is 60 years without the planned replacement of the reactor vessel which has a 60-year design objective based on conservative assumptions. The design also provides for the potential replacement of other major components, including the SGs.

3.1.6 TRANSFORMERS

The DCD provides the following information about the HAR site description:

The transformer area is located immediately adjacent to and north of the turbine building. The unit auxiliary transformers, the reserve auxiliary transformer, and the main step-up transformers are located in the transformer area.

3.1.7 AESTHETIC APPEARANCE

3.1.7.1 Reactor Containment Structure

Typically, the reactor containment structure will be a steel-lined, reinforced-concrete structure approximately in the shape of a 140-m (225-ft.) high by 81-m (130-ft.) diameter cylinder, capped with a hemispheric dome.

3.1.7.2 Heat Dissipation System

The heat dissipation system (two main cooling towers) could have a height of up to 182 m (600 ft.), similar to the HNP cooling tower, and would slightly alter the visual aesthetics of the HAR site (Figure 3.1-6).

Any visual effects from the visible plumes from the facility would be similar to those associated with the other nuclear power plants and that of the present cooling tower for the HNP.

3.1.7.3 AP1000 Plant Layout

A depiction of the HAR plant layout in relationship to the HNP is presented in Figures 3.1-3 and 3.1-4 of this ER.

3.1.7.4 Viewshed of the Facility

The viewshed of the facility is limited to a few residences and recreational users in the vicinity. Because the HAR site will have visual effects similar to those of HNP facilities (with the exception of the potential additional plumes from the heat dissipation system for the two additional units), the HAR site will have a minor impact on aesthetic quality for nearby residences and recreational users of the constructed reservoir. Therefore, no mitigation will be provided.

The effects of seasonal changes on the vegetation that would affect the viewshed surrounding HNP and HAR (three cooling towers versus one) are considered minor as there is already a nuclear plant with an associated cooling tower operating in the area. A conceptual depiction of the three cooling towers and their associated plumes is provided as Figure 3.1-6.

3.1.7.5 Power Transmission

ER Section 3.7 provides a general discussion of the electric transmission system that will be constructed for the facility. This transmission system would be required to support facility operations.

3.1.8 REFERENCES

3.1-001 Carolina Power & Light Company, "Shearon Harris Nuclear Power Plant Final Safety Analysis Report," Amendment 48, 1983.

3.1-002 Progress Energy Carolinas, Inc., “Long Term X/Q Modeling Request,” JVT – Request for Information (RFI) # 129, January 12, 2007.

3.1-003 Sargent & Lundy, LLC, “New Plant Site,” 2006.

3.2 REACTOR POWER CONVERSION SYSTEM

The reactor systems described in this section are for one AP1000 unit unless two units are specifically stated otherwise.

3.2.1 CERTIFICATION STATUS

Westinghouse's AP1000, which is a certified design in accordance with 10 CFR 52, Appendix D, is an upgrade to Westinghouse's AP600 Reactor (AP600).

3.2.2 AP1000 DESIGN

The DCD provides the following information about Westinghouse:

> Westinghouse is responsible for the overall design and design certification of the AP1000 (PWR) nuclear power plant. A significant portion of the AP1000 design is the same as the design of AP600. Westinghouse was also responsible for the overall design and design certification of AP600.
>
> Under the direction of Westinghouse, a number of highly qualified organizations provide design and analysis in support of the AP600 and AP1000. Each has a specific responsibility to Westinghouse as defined by various contracts and agreements.
>
> These subcontractors include Bechtel North American Power Corporation, Southern Electric International, Burns & Roe Company, Washington Group (MK-Ferguson Company), Avondale Industries, Inc., and Chicago Bridge & Iron Services, Inc.

Two AP1000s are proposed for the Shearon Harris site. For the HAR project, the architect-engineer is Shaw-Stone & Webster (The Shaw Group).

As presented in Table 3.2-1, some of the NUREG-1555 requirements are presented regarding core thermal power, gross electrical output, and net electrical output. These requirements, in their entirety, cannot be met because these data are not available in the DCD.

3.2.3 TRANSPORTATION OF FUEL AND RADIOACTIVE WASTES

ER Section 3.8 addresses the uranium fuel cycle effects and transportation issues associated with siting and operating the AP1000. Section 3.8 also provides a detailed point-by-point discussion that compares the AP1000 reactor characteristics to the requirements specified in 10 CFR 51.52 (i.e., reactor core thermal power, fuel form, fuel enrichment, fuel encapsulation, average fuel irradiation, time after discharge of irradiated fuel before shipment, mode of transport of unirradiated fuel, and mode of transport for irradiated fuel).

3.2.4 FUEL ASSEMBLY, FUEL ROD, AND FUEL PELLET DESCRIPTION

3.2.4.1 Fuel Assemblies

The DCD provides the following information about the AP1000 fuel assemblies:

> The reactor contains a matrix of fuel rods assembled into mechanically identical fuel assemblies along with control and structural elements. The assemblies, containing various fuel enrichments, are configured into the core arrangement located and supported by the reactor internals.
>
> The reactor internals also direct the flow of the coolant past the fuel rods. The fuel, internals, and coolant are contained within a heavy, walled reactor pressure vessel.
>
> There are 157 fuel assemblies in the core. An AP1000 fuel assembly consists of 264 fuel rods in a 17 x 17 square array. The center position in the fuel assembly has a guide thimble that is reserved for in-core instrumentation. The remaining 24 positions in the fuel assembly also have guide thimbles. The guide thimbles are joined to the top and bottom nozzles of the fuel assembly and provide the supporting structure for the fuel grids.
>
> The fuel grids consist of an egg-crate arrangement of interlocked straps that maintain lateral spacing between the rods. The grid straps have spring fingers and dimples that grip and support the fuel rods.
>
> The AP1000 fuel assemblies are similar to the 17 x 17 Robust and 17 x 17 XL Robust fuel assemblies. The 17 x 17 XL Robust fuel assemblies have an active fuel length of 14 feet with no intermediate flow mixing grids.

3.2.4.2 Fuel Rods

The DCD provides the following information about the AP1000 fuel rods:

> The fuel rods consist of enriched uranium, in the form of cylindrical pellets of sintered uranium dioxide (UO_2), contained in ZIRLO^{TM} tubing. The rods have an outside dimension of 0.94996 centimeter (cm) (0.374 inch [in.]), a dimensional gap of 0.01651 cm (0.0065 in.), and a cladding thickness of 0.05715 cm (0.0225 in.). The core contains 95,975 kilogram (kg) (211,588 pounds [lbs.]) of enriched UO_2 fuel. There are approximately 41,448 rods contained in the core.
>
> The tubing is plugged and seal welded at the ends to encapsulate the fuel pellets. An axial blanket comprised of fuel pellets with reduced

enrichment may be placed at each end of the enriched fuel pellet stack to reduce the neutron leakage and to improve fuel utilization.

The fuel rods are pressurized internally with helium during fabrication to reduce clad creepdown during operation and thereby prevent clad flattening. The fuel rods in the AP1000 fuel assemblies contain additional gas space below the fuel pellets, compared to the 17 x 17 Robust, 17 x 17 XL Robust, and other previous fuel assembly designs, to allow for increased fission gas production due to high fuel burnups.

3.2.4.3 Fuel Pellets

The DCD provides the following information about the AP1000 fuel pellets:

The fuel pellets are comprised of sintered UO_2 with a density of 95.5 (percent of theoretical) and a diameter of 0.81915 cm (0.3225 in.). They are approximately 0.98298 cm (0.387 in.) long. First cycle fuel enrichment (weight percent) for Region 1, Region 2, and Region 3 is 2.35, 3.40, and 4.45, respectively. The total weight of UO_2 is 95,975 kg (211,588 lbs).

3.2.4.4 Average Burnup

The AP1000 has an average maximum burnup of 60,000 megawatt-days per metric ton of uranium (MWd/MTU) for the peak rod. The extended burnup is 62,000 MWd/MTU.

3.2.5 STEAM AND POWER CONVERSION

The power conversion system used by the AP1000 is a water-cooled reactor plant, which uses a steam turbine. A simplified flow diagram of the reactor power conversion system is presented in Figure 3.2-1.

The DCD provides the following information about steam and power conversion:

The turbine-generator has an output of approximately 1,199,500 kilowatts (kW) for the Westinghouse NSSS thermal output of 3,415 MWt.

The steam generated in the two SGs is supplied to the high-pressure turbine by the main steam system. After expansion through the high-pressure turbine, the steam passes through the two moisture separator/reheaters (MSRs) and is then admitted to the three low-pressure turbines. A portion of the steam is extracted from the high- and low-pressure turbines for seven stages of feedwater heating.

Exhaust steam from the low-pressure turbines is condensed and deaerated in the main condenser. The heat rejected in the main condenser is removed by the circulating water system (CWS). The

> condensate pumps take suction from the condenser hotwell and deliver the condensate through four stages of low-pressure closed feedwater heaters to the fifth stage, open deaerating heater. Condensate then flows to the suction of the SG feedwater booster pump and is discharged to the suction of the main feedwater pump. The SG feedwater pumps discharge the feedwater through two stages of high-pressure feedwater heating to the two SGs.

3.2.5.1 Condensate and Feedwater System

The DCD provides the following information about the condensate and feedwater system (FWS):

> The condensate and FWS provides feedwater at the required temperature, pressure, and flow rate to the SGs. Condensate is pumped from the main condenser hotwell by the condensate pumps, passes through the low-pressure feedwater heaters to the feedwater pumps, and is then pumped through the high-pressure feedwater heaters to the SGs.
>
> The condensate and FWS is composed of components from the condensate system (CDS), main and startup FWS, and steam generator system (SGS).

3.2.5.2 Steam Generators

Each plant will have two AP1000 SGs. The DCD provides the following information about the SGs:

> The basic function of the AP1000 SGs is to transfer heat from the single-phase reactor coolant water through the U-shaped heat exchanger tubes to the boiling, two-phase steam mixture in the secondary side of the SG. The SGs separate dry steam, saturated steam from the boiling mixture, and deliver the steam to a nozzle from which it is delivered to the turbine. Water from the FWS replenishes the SG water inventory by entering the SG through a feedwater inlet nozzle and feedring.
>
> The AP1000 SG is a vertical shell and U-tube evaporator with integral moisture-separating equipment and a heat transfer area of 123,538 ft^2. Design enhancements include nickel-chromium-iron Alloy 690 thermally treated tubes on a triangular pitch, improved antivibration bars, single-tier separators, enhanced maintenance features, and a primary-side channel head design that allows for easy access and maintenance by robotic tooling. The AP1000 SG employs tube supports utilizing a broached hole support plate design.

Table 3.2-1 presents significant design features and performance characteristics for the SGs and turbines.

3.2.5.3 Turbines

The DCD provides the following information about turbines:

> The turbine is an 1,800-revolutions per minute (rpm), tandem-compound, six-flow, reheat unit with 132 cm (52-in.) last-stage blades (TC6F 52-in. LSB). The high-pressure turbine element includes one double-flow, high-pressure turbine. The low-pressure turbine elements include three double-flow, low-pressure turbines and two external MSRs with two stages of reheating. The single direct-driven generator is hydrogen gas and de-ionized water cooled and rated at 1,375 megavolt amperes (MVA) at 0.90 power factor (PF). Other related system components include a complete turbine-generator bearing lubrication oil system, a digital electrohydraulic (D-EHC) control system with supervisory instrumentation, a turbine steam sealing system, overspeed protective devices, turning gear, a stator cooling water system, a generator hydrogen and seal oil system, a generator carbon dioxide (CO_2) system, a rectifier section, an exciter transformer, and a voltage regulator.
>
> Steam from each of two SGs enters the high-pressure turbine through four stop valves and four governing control valves; each stop valve is in series with one control valve. Crossties are provided upstream of the turbine stop valves to provide pressure equalization with one or more stop valves closed. After expanding through the high-pressure turbine, exhaust steam flows through two external MSR vessels. The external moisture separators reduce the moisture content of the high-pressure exhaust steam from approximately 10 to 13 percent at the rated load to 0.5-percent moisture or less.
>
> The AP1000 employs a two-stage reheater, of which the first stage reheater uses the extraction steam from the high pressure turbine and the second reheater uses a portion of the main steam supply to reheat the steam to superheated conditions. The reheated steam flows through separate reheat stop and intercept valves in each of six reheat steam lines leading to the inlets of the three low-pressure turbines. Turbine steam extraction connections are provided for seven stages of feedwater heating. Steam from the extraction point of the high-pressure turbine is supplied to high-pressure feedwater heater No. 6 and No. 7. The high-pressure turbine exhaust also supplies steam to the deaerating feedwater heater. The low-pressure turbine third, fourth, fifth, and sixth extraction points supply steam to the low-pressure feedwater heaters No. 4, 3, 2, and 1, respectively.
>
> Moisture is removed at a number of locations in the blade path. The no-return drain catchers provided at the nozzle diaphragms (stationary blade rings) accumulate the water fraction of the wet steam, and the accumulated water discharges into each extract, reheat, and exhaust lines directly or through drainage holes drilled through the nozzle

> diaphragms. A few grooves are provided on the rotating blades near the last stage of the low-pressure turbine to capture the large water droplets of the wet stream and to enhance the moisture removal effectiveness.
>
> The external MSRs use multiple vane chevron banks (shell side) for moisture removal. The moisture removed by the external MSRs drains to a moisture separator drain tank and is pumped to the deaerator.
>
> Condensed steam in the reheater (tube side) is drained to the reheater drain tank, flows into the shell side of the No. 7 feedwater heater, and cascades to the No. 6 feedwater heater.

Table 3.2-2 contains information on the turbine-generator and auxiliaries design parameters.

3.2.5.4 Main Condenser

The DCD provides the following information about the main condenser:

> The main condenser functions as the steam cycle heat sink, receiving and condensing exhaust steam from the main turbine and the turbine bypass system. The main condenser is designed to receive and condense the full-load main steamflow exhausted from the main turbine and serves as a collection point for vents and drains from various components of the steam cycle system.

Table 3.2-3 presents the main condenser design data.

The DCD provides the following additional information about the main condenser:

> The main condenser is a three-shell, single-pass, multipressure spring-supported unit. Each shell is located beneath its respective low-pressure turbine. The condenser is equipped with titanium or stainless steel tubes. The titanium material provides good corrosion and erosion resisting properties. Freshwater cooled plants do not require the high level corrosion and erosion resistance provided by titanium, therefore 304L, 316L, 904L, or AL-6X may be substituted if desired.
>
> The main condenser is designed to receive and condense steam bypass flows up to 40 percent of plant full load steam flow while condensing the remaining low-pressure turbine steam flow. This condensing action is accomplished without exceeding the maximum allowable condenser backpressure for main turbine operation.
>
> The main condenser is designed to deaerate the condensate so that the dissolved oxygen content of the condensate remains under 10 parts per billion (ppb) during normal full power operation.

The main condenser is part of the AP1000 CDS. The CDS is designed to condense and collect steam from the low-pressure turbines and turbine steam bypass systems and then, transfer this condensate from the main condenser to the deaerator.

3.2.5.5 Main Steam Supply System

The DCD provides the following information about the main steam supply system:

The main steam supply system includes the following major components:

- Main steam piping from the SG outlet steam nozzles to the main turbine stop valves.
- One main steam isolation valve and one main steam isolation valve bypass valve per main steam line.
- Main steam safety valves.
- Power-operated atmospheric relief valves and upstream isolation valves.

3.2.5.5.1 Main Steam Piping

The DCD provides the following information about the main steam piping:

The main steam lines deliver a steamflow from the secondary side of the two SGs. A portion of the main steamflow is directed to the reheater and steam seals, with the turbine receiving the remaining steamflow. Each of the main steam lines from the SGs is anchored at the auxiliary building wall and has sufficient flexibility to accommodate thermal expansion.

Branch connections are provided from the main steam system to perform various functions. Upstream of the main steam isolation valves, there are connections for the power-operated atmospheric relief valves, main steam safety valves, low point drains, high point vents, and nitrogen blanketing. Branch piping downstream of the main steam line isolation valves includes connections for the two stage reheaters, gland seal system, turbine bypass system, auxiliary steam system (Mass), and low point drains.

3.2.5.5.2 Main Steam Safety Valves

The DCD provides the following information about the main steam safety valves:

> Main steam safety valves with sufficient rated capacity are provided to prevent the steam pressure from exceeding 110 percent of the main steam system design pressure:
>
> - Following a turbine trip without a reactor trip and with main feedwater flow maintained.
> - Following a turbine trip with a delayed reactor trip and with the loss of main feedwater flow.
>
> Six safety valves are provided per main steam line for the plant. The main steam supply system safety valves are located in the safety-related portion of the main steam piping upstream of the main steam isolation valves and outside the containment in the auxiliary building.
>
> Each safety valve is connected to vent stacks by an open umbrella-type transition piece. The vent stacks are designed for the following:
>
> - Direct the relieved steam away from adjoining structures.
> - Prevent backflow of relieved steam through the umbrella-type transition section.
> - Draw a small quantity of ambient air through the umbrella-type transition section and mix with the total steam flow which leaves the vent stack outlet.
> - Minimize the backpressure on the valve outlet so that it does not restrict the valve's rated capacity.

3.2.5.5.3 Power-Operated Atmospheric Relief Valves

The DCD provides the following information about the power-operated atmospheric relief valves:

> A power-operated atmospheric relief valve is installed on the outlet piping from each SG to provide for controlled removal of reactor decay heat during normal reactor cooldown when the main steam isolation valves are closed or the turbine bypass system is not available. The maximum capacity of the relief valve at design pressure is limited to reduce the magnitude of a reactor transient if one valve would inadvertently open and remain open.

Each power-operated relief valve is located outside the containment in the auxiliary building upstream of the main steam isolation valves, in the safety-related portion of the main steam line associated with each SG. This location permits valve operation following transient conditions, including those which could result in closure of the main steam isolation valves.

The operation of the power-operated relief valves is automatically controlled by steam line pressure during plant operations. The power-operated relief valves automatically modulate open and exhaust to atmosphere whenever the steam line pressure exceeds a predetermined setpoint. As steam line pressure decreases, the relief valves modulate closed, reseating at a pressure at least 10 pounds per square in. (psi) below the opening pressure. The setpoint is selected between no-load steam pressure and the set pressure of the lowest set safety valves.

The SG power-operated atmospheric relief valves provide a non-safety-related means for plant cooldown by discharging steam to the atmosphere when the turbine bypass system is not available. Under such circumstances, the relief valves (in conjunction with the startup FWS) allow the plant to be cooled down at a controlled cooldown rate from the pressure setpoint of the lowest set of safety valves down to the point where the normal residual heat removal system (RNS) can remove the reactor heat.

For their use during plant cooldown, the power-operated atmospheric relief valves are automatically controlled by steam line pressure, with remote manual adjustment of the pressure setpoint from the control room or the remote shutdown workstation. To affect a plant cooldown, the operator manually adjusts the pressure setpoint downward in a step-wise fashion. The maximum cooldown rate achievable is limited by the flow-passing capability of the relief valves, the number of SGs in service (and hence, the number of relief valves), the available startup feedwater pumping capacity, and by the desire to either maintain or recover SG water levels during the cooldown.

The power-operated atmospheric relief valves also help to avoid actuation of the safety valves during certain transients and, following safety valve actuation, act to assist the safety valves to positively reseat by automatically reducing and regulating steam pressure to a value below the safety valve reseating pressure. The operation of each power-operated atmospheric relief valve is controlled in response to measurements of steam line pressure provided by four separate pressure taps on the associated steam line.

The valve operator is an air-operated modulating type, providing throttling capability over a range of steam pressures.

The atmospheric relief valves are controlled by non-safety-related control systems for the modulating steam relief function. The capability for remote manual valve operation is provided in the main control room (MCR) and at the remote shutdown workstation. A safety-related solenoid is provided to vent the air from the valve operator to terminate a steam line depressurization transient.

An isolation valve with remote controls is provided upstream of each power operated relief valve providing isolation of a leaking or stuck-open valve. The upstream location allows for maintenance on the power-operated relief valve operator at power. The motor-operated isolation valve employs a safety-related operator and closes automatically on low steam line pressure to terminate steam line depressurization transients.

3.2.5.5.4 Main Steam Isolation Valves

The DCD provides the following information about the main steam isolation valves:

The function of the main steam isolation valve is to limit blowdown to one SG in the event of a steam line break to:

- Limit the effect upon the reactor core to within specified fuel design limits.
- Limit containment pressure to a value less than design pressure.

Main steam isolation consists of one quick-acting gate valve in each main steam line and one associated globe main steam isolation bypass valve with associated actuators and instrumentation. These valves are located outside the containment, downstream of the SG safety valves and the atmospheric relief valve, in the auxiliary building. The isolation valves provide positive shutoff with minimum leakage during postulated line severance conditions either upstream or downstream of the valves.

The main steam isolation valves close fully upon receipt of a manual or automatic signal and remain fully closed. Upon receipt of the closing signal, the main steam isolation valves complete the closing cycle despite loss of normally required utility services for actuator and/or instrumentation. On loss of actuating hydraulic power, the valves fail to the closed position. On loss of electrical power the valves remain in their current position. Position indication and remote manual operation of the isolation valves are provided in the control room and remote shutdown workstation. Additionally, provisions are made for in-service inspection of the isolation valves.

Closure of the main steam isolation valves and main steam isolation bypass valves is initiated by the following:

- Low steam line pressure in one of two loops.
- High containment pressure.
- High negative steam pressure rate in one of two loops.
- Low T_{cold} in either reactor coolant loop.
- Manual actuation: There are four controls for main steam line actuation. Two of the controls provide system level actuation, that is, isolate both steam lines and two of the controls, one per loop, and provide isolation of a single steam line.
- Manual reset: In addition to the controls for manual isolation actuation, there are two controls for manual reset of the steam line isolation signal, one for each of the logic divisions associated with steam line controls, which can be used to manually reset that division's steam line isolation signal.

Each main steam isolation valve is a bidirectional wedge-type gate valve composed of a valve body that is welded into the system pipeline. The main steam isolation gate valve is provided with a hydraulic/pneumatic actuator. The valve actuator is supported by the yoke, which is attached to the top of the body. The valve actuator consists of a hydraulic cylinder with a stored energy system to provide emergency closure of the isolation valve. The energy to operate the valve is stored in the form of compressed nitrogen contained in one end of the actuator cylinder. The main steam isolation valve is maintained in a normally open position by high-pressure hydraulic fluid. For emergency closure, redundant solenoids are energized resulting in the high-pressure hydraulic fluid being dumped to a fluid reservoir.

The main steam isolation bypass valves are used to permit warming of the main steam lines prior to startup when the main steam isolation valves are closed. The bypass valves are modulating, air-operated globe valves. For emergency closure, redundant 1E solenoids are provided. Each solenoid is energized from a separate safety-related division.

3.2.5.6 Circulating Water System

The DCD provides the following information about the CWS:

For each AP1000 plant, the circulating water system consists of three 1/3-capacity circulating water pumps, one hyperbolic natural draft cooling tower, basin, and associated piping, valves, and instrumentation.

> Makeup water to the CWS is provided by the raw water system (RWS). In addition, water chemistry is controlled by the turbine island chemical feed system (CFS).

3.2.5.6.1 Circulating Water Pumps

The DCD provides the following information about the circulating water pumps:

> The three circulating water pumps are vertical, wet pit, single-stage, mixed-flow pumps driven by electric motors. The pumps are mounted in an intake structure, which is connected to the cooling tower by a canal. The three pump discharge lines connect to a common header which connects to the two inlet water boxes of the condenser and may also supply cooling water to the turbine building closed cooling water system (TCS) and condenser vacuum pump seal water heat exchangers. Each pump discharge line has a motor-operated butterfly valve located between the pump discharge and the main header. This permits isolation of one pump for maintenance and allows two-pump operation.

3.2.5.6.2 Cooling Tower Basin

The DCD provides the following information about the cooling tower basin:

> The cooling tower has a basin that serves as storage for the circulating water inventory and allows bypassing of the cooling tower during cold weather operations.

3.2.5.6.3 Cooling Tower Makeup and Blowdown

The DCD provides the following information about the cooling tower makeup and blowdown:

> The circulating water system makeup is provided by the RWS. Makeup to and blowdown from the circulating water system is controlled by the makeup and blowdown control valves. These valves, along with the turbine island CFS provide chemistry control in the circulating water in order to maintain a noncorrosive, nonscale-forming condition and limit biological growth in circulating water system components.

3.2.5.6.4 Piping and Valves

The DCD provides the following information about the piping and valves:

> The underground portions of the circulating water system piping are constructed of concrete pressure piping. The remainder is carbon steel, with an internal coating of a corrosion-resistant compound.
> Motor-operated butterfly valves are provided in each of the circulating

water lines at their inlet to and exit from the condenser shell to allow isolation of portions of the condenser. Control valves provide regulation of cooling tower blowdown and makeup.

The circulating water system is designed to withstand the maximum operating discharge pressure of the circulating water pumps. Piping includes the expansion joints, butterfly valves, condenser water boxes, and tube bundles.

3.2.5.6.5 Circulating Water Chemical Injection

The DCD provides the following information about circulating water chemical injection:

> Circulating water chemistry is maintained by the turbine island CFS. Turbine island chemical equipment injects the required chemicals into the circulating water downstream of the CWS pumps. This maintains a noncorrosive, nonscale-forming condition and limits the biological film formation that reduces the heat transfer rate in the condenser and the heat exchangers supplied by the circulating water system.
>
> The specific chemicals used within the system are determined by the site water conditions but can usually be divided into six categories based upon function: biocide, algaecide, pH adjuster, corrosion inhibitor, scale inhibitor, and a silt dispersant. The pH adjuster, corrosion inhibitor, scale inhibitor, and dispersant are metered into the system continuously or as required to maintain proper concentrations. The biocide application frequency may vary with seasons. The algaecide is applied, as necessary, to control algae formation on the cooling tower.
>
> Addition of biocide and water treatment chemicals is performed by turbine island chemical feed injection metering pumps and is adjusted as required. Chemical concentrations are measured through analysis of grab samples from the CWS. Residual chlorine is measured to monitor the effectiveness of the biocide treatment.
>
> Chemical injections are interlocked with each circulating water pump to prevent chemical injection when the circulating water pumps are not running.

3.2.6 REACTOR COOLANT SYSTEM

The DCD provides the following information about the RCS:

> The AP1000 RCS is designed to remove or enable the removal of heat from the reactor during all modes of operation, including shutdown and accident conditions.

The system consists of two heat transfer circuits, each with a SG, two reactor coolant pumps, a single hot leg, and two cold legs for circulating reactor coolant. In addition, the system includes a pressurizer, interconnecting piping, valves and instrumentation necessary for operational control and safeguards activation. All system equipment is located in the reactor containment.

During operation, the reactor coolant pumps circulate pressurized water through the reactor vessel and the SGs. The water (which serves as coolant, moderator, and solvent for boric acid [chemical shim control]), is heated as it passes through the core to the SGs where the heat is transferred to the steam system. The water is then returned to the reactor core by the pumps to repeat the process.

The RCS pressure is controlled by operation of the pressurizer, where water and steam are maintained in equilibrium by the activation of electrical heaters and/or a water spray. Steam is formed by the heaters or condensed by the water spray to control pressure variations due to expansion and contraction of the reactor coolant.

Overpressure protection for the RCS is provided by the spring-loaded safety valves installed on the pressurizer. These valves discharge to the containment atmosphere. The valves for the first three stages of automatic depressurization are also mounted on the pressurizer. These valves discharge steam through spargers to the in-containment refueling water storage tank. The discharged steam is condensed and cooled by mixing with water in the tank.

The RCS is also served by a number of auxiliary systems, including the CVS, the passive core cooling system, the spent fuel pit cooling system, the SGS, the primary sampling system, the liquid radwaste system, and the component cooling water system.

The core is designed for an 18-month fuel cycle (and to maintain the projected fuel cycles). The core is designed for a moderator temperature coefficient that is non-positive over the entire fuel cycle at any power level with the reactor coolant at the normal operating temperature.

3.2.6.1 Reactor Coolant System Components

The DCD provides the following information about RCS components:

The RCS includes the following:

- The reactor vessel, including control rod drive mechanism housings.

- The reactor coolant pumps, consisting of four sealless pumps that pump fluid through the entire reactor coolant and reactor systems. Two pumps that are coupled with each SG.

- The portion of the SGs containing reactor coolant, including the channel head, tubesheet, and tubes.

- The pressurizer which is attached by the surge line to one of the reactor coolant hot legs. With a combined steam and water volume, the pressurizer maintains the reactor system within a narrow pressure range.

- The safety and automatic depressurization system valves.

- The reactor vessel head vent isolation valves.

- The interconnecting piping and fittings between the preceding principal components.

- The piping, fittings, and valves leading to connecting auxiliary or support systems.

3.2.6.1.1 Reactor Vessel

The DCD provides the following information about the reactor vessel:

> The reactor vessel is cylindrical, with a hemispherical bottom head and removable, flanged, hemispherical upper head. The vessel contains the core, core support structures, control rods, and other parts directly associated with the core. The vessel interfaces with the reactor internals, the integrated head package, and reactor coolant loop piping and is supported on the containment building concrete structure.
>
> The design of the AP1000 reactor vessel closely matches the existing vessel designs of Westinghouse three-loop plants. New features for the AP1000 have been incorporated without departing from the proven features of existing vessel designs.
>
> The vessel has inlet and outlet nozzles positioned in two horizontal planes between the upper head flange and the top of the core. The nozzles are located in this configuration to provide an acceptable cross-flow velocity in the vessel outlet region and to facilitate optimum layout of the RCS equipment. The inlet and outlet nozzles are offset, with the inlet positioned above the outlet, to allow mid-loop operation for removal of a main coolant pump without discharge of the core.

> Coolant enters the vessel through the inlet nozzles and flows down the core barrel-vessel wall annulus, turns at the bottom, and flows up through the core to the outlet nozzles.

3.2.6.1.2 AP1000 Steam Generator

The DCD provides the following information about the AP1000 SG:

> The SG is a vertical shell and U-tube evaporator with integral moisture-separating equipment. The basic SG design and features have been proven in tests and in previous SGs including replacement SG designs.
>
> Design enhancements include nickel-chromium-iron Alloy 690 thermally treated tubes on a triangular pitch, improved antivibration bars, single-tier separators, enhanced maintenance features, and a primary-side channel head design that allows for easy access and maintenance by robotic tooling. The AP1000 SG employs tube supports utilizing a broached hole support plate design. All tubes in the SG are accessible for sleeving, if necessary. The design enhancements are based on proven technology.
>
> The basic function of the AP1000 SG is to transfer heat from the single-phase reactor coolant water through the U-shaped heat exchanger tubes to the boiling, two-phase steam mixture in the secondary side of the SG. The SG separates dry, saturated steam from the boiling mixture, and delivers the steam to a nozzle from which it is delivered to the turbine. Water from the FWS replenishes the SG water inventory by entering the SG through a feedwater inlet nozzle and feedring.
>
> In addition to its steady-state performance function, the SG secondary side provides a water inventory which is continuously available as a heat sink to absorb primary side high temperature transients.

3.2.6.1.3 Reactor Coolant Pumps

The DCD provides the following information about the reactor coolant pumps:

> The AP1000 reactor coolant pumps are high-inertia, high-reliability, low-maintenance, sealless pumps of either canned motor or wet winding motor design that circulate the reactor coolant through the reactor vessel, loop piping, and SGs. The pumps are integrated into the SG channel head.
>
> The integration of the pump suction into the bottom of the SG channel head eliminates the cross-over leg of coolant loop piping; reduces the loop pressure drop; simplifies the foundation and support system for the SG, pumps, and piping; and reduces the potential for uncovering of the

core by eliminating the need to clear the loop seal during a small loss of coolant accident.

The AP1000 design uses four pumps. Two pumps are coupled with each SG.

Each AP1000 reactor coolant pump is a vertical, single-stage centrifugal pump designed to pump large volumes of main coolant at high pressures and temperatures. Because of its sealless design, it is more tolerant of off-design conditions that could adversely affect shaft seal designs. The main impeller attaches to the rotor shaft of the driving motor, which is an electric induction motor. The main impeller attaches to the rotor shaft of the driving motor, which is an electric induction motor.

Primary coolant circulates between the stator and rotor which obviates the need for a seal around the motor shaft. Additionally, the motor bearings are lubricated by primary coolant. The motor is thus an integral part of the pump. The basic pump design has been proven by many years of service in other applications.

The pump motor size is minimized through the use of a variable frequency drive to provide speed control in order to reduce motor power requirements during pump startup from cold conditions. The variable frequency drive is used only during heatup and cooldown when the reactor trip breakers are open. During power operations, the drive is isolated and the pump is run at constant speed.

To provide the rotating inertia needed for flow coast-down, bi-metallic flywheel assemblies are attached to the pump shaft.

3.2.6.1.4 Primary Coolant Piping

The DCD provides the following information about primary coolant piping:

RCS piping is configured with two identical main coolant loops, each of which employs a single 78.74 cm (31 in.) inside diameter hot leg pipe to transport reactor coolant to a SG. The two reactor coolant pump suction nozzles are welded directly to the outlet nozzles on the bottom of the SG channel head. Two, 55.88 cm (22 in.) inside diameter cold leg pipes in each loop (one per pump) transport reactor coolant back to the reactor vessel to complete the circuit.

The loop configuration and material have been selected such that pipe stresses are sufficiently low for the primary loop and large auxiliary lines to meet the requirements to demonstrate "leak-before-break." Thus, pipe rupture restraints are not required, and the loop is analyzed for pipe ruptures only for small auxiliary lines that do not meet the leak-before-break requirements.

3.2.6.1.5 Pressurizer

The DCD provides the following information about the pressurizer:

> The AP1000 pressurizer is a principal component of the RCS pressure control system. It is a vertical, cylindrical vessel with hemispherical top and bottom heads, where liquid and vapor are maintained in equilibrium saturated conditions.
>
> One spray nozzle and two nozzles for connecting the safety and depressurization valve inlet headers are located in the top head. Electrical heaters are installed through the bottom head. The heaters are removable for replacement. The bottom head contains the nozzle for attaching the surge line. This line connects the pressurizer to a hot leg, and provides for the flow of reactor coolant into and out of the pressurizer during RCS thermal expansions and contractions.

3.2.6.1.6 Pressurizer Safety Valves

The DCD provides the following information about pressurizer safety valves:

> The pressurizer safety valves are spring loaded, self-actuated with back-pressure compensation. Their set pressure and combined capacity is based on not exceeding the RCS maximum pressure limit during the Level B service condition loss of load transient.

3.2.6.1.7 Reactor Coolant System Automatic Depressurization Valves

The DCD provides the following information about RCS automatic depressurization valves:

> Some of the functions of the AP1000 passive core cooling system (PXS) are dependent on depressurization of the RCS. This is accomplished by the automatically actuated depressurization valves. The automatic depressurization valves connected to the pressurizer are arranged in six parallel sets of two valves in series opening in three stages.
>
> A set of fourth-stage automatic depressurization valves is connected to each reactor coolant hot leg. Each set of valves consists of two parallel paths of two valves in series.
>
> To mitigate the consequences of the various accident scenarios, the controls are arranged to open the valves in a prescribed sequence based on core makeup tank level and a timer.

3.2.6.2 Cooling Water Makeup

Operations at the HAR will require additional makeup water from Harris Reservoir. The construction of a Harris Lake makeup water system intake structure and Harris Lake makeup water system pumphouse on the Cape Fear River is proposed (Figure 3.3-4). A new makeup water pipeline will be constructed that will provide makeup water from the Cape Fear River to Harris Reservoir to support HAR operations. The pipeline will be constructed in an existing ROW (Figures 4.0-1, 4.0-4, and 4.0-10).

A new outfall structure will be constructed on Harris Reservoir (Figure 3.3-4). Water from the Cape Fear River will be used to maintain the level of Harris Reservoir to provide adequate cooling tower makeup water to support the new units (Figure 4.0-1).

HAR 2 and HAR 3 will collect cooling tower makeup water at the proposed raw water pumphouse located on the Thomas Creek arm of the Main Reservoir east of the site and approximately 975.4 m (3200 ft.) north of the HNP cooling tower makeup water intake channel (Figure 4.0-1). An illustration of the intake structure is provided as Figure 3.3-5.

Makeup water will be obtained from the Cape Fear River to maintain the proposed operating level of the Main Reservoir. The Harris Lake makeup water system has been designed to maintain the required reservoir level. This system includes the intake channel in the Cape Fear River, the Harris Lake makeup water system pumphouse on the Cape Fear River, the Harris Lake makeup water system pipeline from the Cape Fear River to the Main Reservoir, and the Harris Lake makeup water system discharge structure on the Main Reservoir (Figures 4.0-1 and 4.0-5).

A new Harris Lake makeup water system intake structure, Harris Lake makeup water system pumphouse, and Harris Lake makeup water system pipeline will be required to move water from the Cape Fear River to Harris Reservoir (Figures 4.0-1 and 4.0-5). The Harris Lake makeup water system intake structure will be constructed immediately upstream of the Buckhorn Dam within a dredged intake channel to the Cape Fear River main channel. The Harris Lake makeup water system pumphouse will be on the eastern bank of the Cape Fear River north of the Buckhorn Dam adjacent to the existing Cape Fear Steam Plant's discharge canal. The proposed Harris Lake makeup water system pipeline will extend along existing ROWs to the shore of Harris Reservoir.

The Harris Lake makeup water system pumphouse is proposed to be located in a small cove on the east side of the Cape Fear River, just north of Buckhorn Dam (Figure 4.0-5). An intake channel, with a width of approximately 10.7 m (35 ft.), will be dredged into the cove. The channel will consist of reinforced concrete slab with sloped riprap sides. The Harris Lake makeup water system intake structure and Harris Lake makeup water system pumphouse will encompass approximately 1.4 ha (3.4 ac. or 0.0053 mi.^{2}) (Figure 4.0-5).

3.2.6.3 Main Cooling Towers

The plant main cooling tower-circulating water pump complex consists of a hyperbolic natural draft cooling tower, a pump basin, and circulating water pumps. The cooling towers could be as tall as 183 m (600 ft.) tall with a 122-m (400-ft.) diameter. The cooling tower basin serves as storage for the circulating water inventory and also allows bypassing of the cooling tower during cold weather operations. The circulating water pumps circulate the cooling water from the pump basin to the main condenser and back to the cooling tower through two precast concrete supply and return pipes that are below grade. These two circulating water pipes are between the main cooling tower and the turbine building.

As required by NUREG-1555, the average wet bulb discharge temperatures for each month of the year should be determined using vendor-provided performance curves. Presently, cooling tower performance curves are not available for the HAR cooling towers. However, it is expected that they would be of similar design and performance characteristics as the cooling tower used by the HNP. Based on the HNP cooling tower performance metrics obtained from January 2003 through October 2007, average wet bulb discharge temperatures ranged from a low of 23°C (73.4°F) during the colder months to a high of 25.2°C (95.3°F) during the warmer months. The 12 monthly averages over the approximate 5-year monitoring period were as follows:

- January 23.3°C (73.9°F)
- February 23.0°C (73.4°F)
- March 26.6°C (79.9°F)
- April 28.8°C (83.8°F)
- May 31.9°C (89.5°F)
- June 33.7°C (92.7°F)
- July 35.1°C (95.2°F)
- August 35.2°C (95.3°F)
- September 32.9°C (91.3°F)
- October 29.4°C (85.0°F)
- November 27.6°C (81.7°F)
- December 24.2°C (75.5°F)

These values were obtained in the discharge stream to the condenser that would be representative of the blowdown discharge.

3.2.7 ENGINEERED SAFETY FEATURES

The DCD provides the following information about engineered safety features (ESF):

> ESF protect the public and the environment in the event of an accidental release of radioactive fission products from the RCS. The ESF functions to localize, control, mitigate, and terminate such accidents and to maintain radiation exposure levels to the public below applicable limits and guidelines, such as 10 CFR 100.

3.2.7.1 Containment

The DCD provides the following information about containment:

> The containment vessel is a free standing cylindrical steel vessel with ellipsoidal upper and lower heads. The function of the containment vessel, as part of the overall containment system, is to contain the release of radioactivity following postulated design basis accidents. The containment vessel also functions as the safety-related UHS by transferring the heat associated with accident sources to the surrounding environment.

3.2.7.2 Passive Containment Cooling System

The DCD provides the following information about the passive containment cooling system:

> The function of the passive containment cooling system is to maintain the temperature below a maximum value and to reduce the containment temperature and pressure following a postulated design basis event. The passive containment cooling system removes thermal energy from the containment atmosphere. The passive containment cooling system also serves as the safety-related UHS for other design basis events and shutdowns. The passive containment cooling system limits the release of radioactive material to the environment by reducing the pressure differential between the containment atmosphere and the external environment. This diminishes the driving force for leakage of fission products from the containment to the atmosphere.

3.2.7.3 Containment Isolation System

The DCD provides the following information about the containment isolation system:

> The major function of the containment isolation system of the AP1000 is to provide containment isolation to allow the normal or emergency passage of fluids through the containment boundary while preserving the integrity of the containment boundary, if required. This prevents or limits the escape of fission products that may result from postulated accidents. Containment isolation provisions are designed so that fluid lines penetrating the primary containment boundary are isolated in the event of an accident. This minimizes the release of radioactivity to the environment.

3.2.7.4 Passive Core Cooling System

The DCD provides the following information about the passive core cooling system:

> The primary function of the passive core cooling system is to provide emergency core cooling following a postulated design basis events. The passive core cooling system provides RCS makeup and boration during transients or accidents where the normal RCS makeup supply from the CVS is lost or is insufficient. The passive core cooling system provides safety injection to the RCS to provide adequate core cooling for the complete range of loss of coolant accident events up to, and including, the double ended rupture of the largest primary loop RCS piping. The passive core cooling system provides core decay heat removal during transients, accidents, or whenever the normal heat removal paths are lost.

3.2.7.5 Main Control Room Emergency Habitability System

The DCD provides the following information about the MCR emergency habitability system:

> The MCR emergency habitability system is designed so that the MCR remains habitable following a postulated design basis event. With a loss of all ac power sources, the habitability system will maintain an acceptable environment for continued operating staff occupancy.

3.2.7.6 Fission Product Control

The DCD provides the following information about fission product control:

> Post-accident safety-related fission product control for the AP1000 is provided by natural removal processes inside containment, the

containment boundary, and the containment isolation system. The natural removal processes, including various aerosol removal processes and pool scrubbing, remove airborne particulates and elemental iodine from the containment atmosphere following a postulated design basis event.

Table 3.2-1
Significant Design Features and Performance Characteristics for the AP1000 Steam Generators and Turbines

Equipment	Characteristic
Nuclear Steam Supply System (Full Power Operation)	
NSSS Power Rating (core plus reactor coolant pump heat) (MWt)	3415
Rated Core Power (MWt)	3400
Net Electrical Power (MWe)	1000
Steam Generator Outlet Pressure (pounds per square inch gauge [psig])	823
Steam Generator Inlet Feedwater Temperature (^{o}F)	440
Maximum Steam Generator Outlet Steam Moisture (%)	0.25
Steam Generator Outlet Steam Temperature (^{o}F)	523
Quantity of Steam Generators	2
Flow Rate per Steam Generator (lb/hr)	7.49E+06
Turbine	
Nominal Output (kW)	1,199,500
Turbine Type	Tandem-compound, 6-flow, 52-in. last-stage blade
Turbine Elements	1 high pressure and 3 low pressure
Operating speed (rpm)	1800

Table 3.2-2
Turbine-Generator and Auxiliaries Design Parameters

Manufacturer Toshiba	
Turbine	
Type	TC6F 52-in. LSB
No. of elements	1 high pressure; 3 low pressure
Last-stage blade length (in.)	52
Operating speed (rpm)	1800
Condensing pressure (in. HgA)	2.9
Generator	
Generator rated output (kW)	1,237,500
Power factor	0.90
Generator rating (kVA)	1,375,000
Hydrogen pressure (psig)	75
Moisture separator/reheater	
Moisture separator	Chevron vanes
Reheater	U-tube
Number	2 shell
Stages of reheating	2

Notes:
kVA = kilovolt amperes

Table 3.2-3
Main Condenser Design Data

Condenser Data	Characteristic
Condenser type	Multipressure, Single pass
Hotwell storage capacity	3 minute
Heat transfer	7.54×10^9 Btu/hr
Design operating pressure (average of all shells)	2.9 in.-mercury
Shell pressure (design)	0 in.-mercury absolute to 15 psig
Circulating water flow	600,000 gpm
Water box pressure (design)	90 psig
Tube-side inlet temperature	91 °F
Approximate tube-side temperature rise	25.2°F
Condenser outlet temperature	116.2°F
Waterbox material	Carbon Steel
Tube Data	
Tube material (main section)	Titanium[a]
Tube size	1-in. O.D. — 23 BWG
Tube material (periphery)	Titanium[a]
Tube size	1-in. O.D. — 23 BWG
Tube sheet material	Titanium or Titanium Clad Carbon Steel[b]
Support plates	Modular Design/Carbon Steel

Notes:
a) For freshwater plants, an equivalent tube material such as 304L, 316L, 904L, or AL-6X may be substituted.

b) If one of the alternate tube materials is used, the tube sheet shall be carbon steel, clad with the same material as the tubes.

BWG = Birmingham Wire Gauge

3.3 PLANT WATER USE

This section provides information about the anticipated plant water usage for the HAR. These two units will be Westinghouse's AP1000 reactors. The plant use of water includes makeup to the cooling towers, service water tower, potable water, makeup water to the demineralizers, fire protection, and strainer/filter backwash. Figures 3.3-1 and 3.3-2 present Westinghouse's standard AP1000 plant water balance diagram for an individual plant for each system or component (this information is provided for reference only). Table 3.3-2, Table 3.3-3, and Figure 3.3-3 present the actual anticipated plant water usage and discharges for the two new AP1000 units. Filter and media backwash values were not included on Figure 3.3-3, as the amount of water withdrawn from the reservoir would be the same amount returned.

Raw water is required to support the needs of the new facilities during construction and operation, including the requirements of the normal heat sink main CWS and cooling water systems for plant auxiliary components (e.g., service water, fire protection, and demineralized water systems). Potable water is required for human consumption, sanitary and other domestic purposes.

The HAR will be located in close proximity to the HNP. The HNP is located between Tom Jack Creek and Thomas Creek. These creeks are two of the tributaries of White Oak Creek; White Oak Creek is a tributary of Buckhorn Creek (Reference 3.3-001). ER Section 2.1 provides a complete description of the site area. ER Section 3.1 presents the location of the site relative to the various tributaries of Buckhorn Creek and the Cape Fear River.

Operations at the HAR will require additional makeup water from Harris Reservoir. The construction of a Harris Lake makeup water system intake structure and Harris Lake makeup water system pumphouse on the Cape Fear River is proposed (Figure 3.3-4). A new makeup water pipeline will be constructed that will provide makeup water from the Cape Fear River to Harris Reservoir to support HAR operations. The pipeline will be constructed in an existing ROW (Figures 4.0-1, 4.0-4, and 4.0-10).

A new outfall structure will be constructed on Harris Reservoir (Figure 3.3-4). Water from the Cape Fear River will be used to maintain the level of Harris Reservoir to provide adequate cooling tower makeup water to support the new units (Figure 4.0-1).

HAR 2 and HAR 3 will collect cooling tower makeup water at the proposed raw water pumphouse located on the Thomas Creek arm of the Main Reservoir east of the site and approximately 975.4 m (3200 ft.) north of the HNP cooling tower makeup water intake channel (Figure 4.0-1). An illustration of the intake structure is provided as Figure 3.3-5.

Makeup water will be obtained from the Cape Fear River to maintain the proposed operating level of the Main Reservoir. The Harris Lake makeup water system has been designed to maintain the required reservoir level. This system includes the intake channel in the Cape Fear River, the Harris Lake makeup water pumphouse on the Cape Fear River, the Harris Lake makeup water system pipeline from the Cape Fear River to the Main Reservoir, and the Harris Lake makeup water system discharge structure on the Main Reservoir (Figures 4.0-1 and 4.0-5).

A new Harris Lake makeup water system intake structure, Harris Lake makeup water system pumphouse, and Harris Lake makeup water system pipeline will be required to move water from the Cape Fear River to Harris Reservoir (Figures 4.0-1 and 4.0-5). The Harris Lake makeup water system intake structure will be constructed immediately upstream of the Buckhorn Dam within a dredged intake channel to the Cape Fear River main channel. The Harris Lake makeup water system pumphouse will be on the eastern bank of the Cape Fear River north of the Buckhorn Dam adjacent to the existing Cape Fear Steam Plant's discharge canal. The proposed Harris Lake makeup water system pipeline will extend along existing ROWs to the shore of Harris Reservoir.

The Harris Lake makeup water system pumphouse is proposed to be located in a small cove on the east side of the Cape Fear River, just north of Buckhorn Dam (Figure 4.0-5). An intake channel, with a width of approximately 10.7 m (35 ft.), will be dredged into the cove. The channel will consist of reinforced concrete slab with sloped riprap sides. The Harris Lake makeup water system intake structure and Harris Lake makeup water system pumphouse will encompass approximately 1.4 ha (3.4 ac or 0.0053 mi.^{2}) (Figure 4.0-5).

It is expected that, based on releases from the HNP, normal releases of contaminants into the environment from the HAR facility will have negligible effects on surface and groundwater uses and will be in compliance with an approved National Pollutant Discharge Elimination System (NPDES) permit issued by the North Carolina Department of Environment and Natural Resources (NCDENR) (Reference 3.3-001). This permit will make certain that discharges are controlled from systems (such as discharge lines, sewage treatment facilities, radwaste treatment systems, activated carbon treatment systems, water treatment waste systems, facility service water, and stormwater runoff) to Harris Reservoir. The effect on water quality in Harris Reservoir due to the operation of the HAR facility will be monitored to ensure compliance with the issued NPDES permits for construction and operation.

Based on present HNP operation, should an accidental release of contaminants occur, adverse effects, if any, will be restricted to the area within the plant island. The only water user within the plant island is the plant itself. The use of water includes makeup to the cooling tower and service water towers, intermittent heating, ventilation, and air conditioning (HVAC) cooling water makeup, potable water, demineralizer makeup water, strainer/filter backwash, and fire protection. Dilution of contaminants, should they enter Harris Reservoir, will be great enough to reduce concentrations below the limits of 10 CFR 20 (Reference 3.3-001).

The following subsections include a discussion regarding the following:

- Subsection 3.3.1 — Plant Water Systems
- Subsection 3.3.2 — Water Consumption
- Subsection 3.3.3 — Water Treatment

The format does not follow the formatting presented in NUREG-1555 precisely as it was felt that a discussion should be presented that describes the plant water systems in detail. This discussion is presented first in this subsection.

3.3.1 PLANT WATER SYSTEMS

The following subsections provide brief system descriptions for each of the water systems that support the AP1000 reactor operations. The systems include the following:

- Subsection 3.3.1.1 — Service Water System
- Subsection 3.3.1.2 — Component Cooling Water System
- Subsection 3.3.1.3 — Demineralized Water Treatment System
- Subsection 3.3.1.4 — Demineralized Water Transfer and Storage System
- Subsection 3.3.1.5 — Potable Water System
- Subsection 3.3.1.6 — Sanitary Drainage System
- Subsection 3.3.1.7 — Central Chilled Water System
- Subsection 3.3.1.8 — Turbine Building Closed Cooling Water System
- Subsection 3.3.1.9 — Wastewater System
- Subsection 3.3.1.10 — Hot Water Heating System

3.3.1.1 Service Water System

Westinghouse's DCD provides the following information about the service water system (SWS):

> The system consists of two 100-percent capacity service water pumps, automatic backwash strainers, a cooling tower basin, and associated piping, valves, controls, and instrumentation.

> The service water pumps, located in the turbine building, take suction from piping which connects to the basin of the service water cooling tower. Service water is pumped through strainers to the component cooling water heat exchangers for removal of heat. Heated service water from the heat exchangers then returns through piping to a mechanical draft cooling tower where the system heat is rejected to the atmosphere. Cool water, collected in the tower basin, flows through fixed screens to the pump suction piping for recirculation through the system.
>
> A small portion of the service water flow is normally diverted to the circulating water system. This blowdown is used to control levels of solids concentration in the SWS. An alternate blowdown flow path is provided to the wastewater system (WWS).

Table 3.3-1 presents nominal service water flows for different operating modes.

The DCD provides the following additional information about the SWS:

> Temperatures in the system are moderate 89ºF and the pressure of the SWS fluid is kept above saturation at all locations.
>
> Service water system materials are compatible with the cooling water chemistry and the chemicals used for the control of long term corrosion products and organic fouling. Water chemistry is controlled by the turbine island CFS.
>
> The SWS, during normal power operation, provides cooling water at a maximum temperature of 93.5°F to the component cooling water heat exchanger in service. One service water pump and one cooling tower cell are in service.
>
> The standby service water pump is automatically started if the operating pump should fail, thereby providing a reliable source of cooling water. The system is designed so either pump can serve as the operating or standby pump.
>
> - *Plant Cooldown/Shutdown*. During the plant cooldown phase in which the normal residual heat removal system has been placed in service and is providing shutdown cooling, the service water cooling tower provides cooling water at a temperature of 88.5°F. Two service water pumps are normally used for plant cooldown, and the cross-connection valves between trains are normally closed. During these modes of operation the normal residual heat removal system and the component cooling water system remove sensible and decay heat from the RCS.
> - *Refueling*. During refueling, the SWS normally provides cooling water flow to both component cooling water system heat

exchangers. Two service water pumps normally provide flow through the system for refueling.

3.3.1.1.1 Component Description

3.3.1.1.1.1 Service Water Chemical Injection

The DCD provides the following information about service water chemical injection:

> The turbine island CFS equipment injects the required chemicals into the SWS. This injection maintains a noncorrosive, nonscale forming condition and limits biological film formation. Chemicals are injected into service water pump discharge piping located in the turbine building.
>
> The chemicals can be divided into six categories based upon function: biocide, algicide, pH adjustor, corrosion inhibitor, scale inhibitor, and silt dispersant. Specific chemicals used within the system, other than the biocide, are determined by the site water conditions. The pH adjustor, corrosion inhibitor, scale inhibitor, and dispersant are metered into the system continuously or as required to maintain proper concentrations. A sodium hypochlorite treatment system is provided for use as the biocide and controls microorganisms that cause fouling. The biocide application frequency may vary with seasons. Algicide is applied, as necessary, to control algae formation on the cooling tower.
>
> Chemical concentrations are measured through analysis of grab samples. Chlorine residual is measured to monitor the effectiveness of the biocide treatment. Addition of water treatment chemicals is performed by CFS injection metering pumps and is adjusted as required.
>
> Chemical injections are interlocked with each service water pump to prevent injection into a train when the associated service water pump is not running.

3.3.1.1.1.2 Service Water Cooling Tower

The DCD provides the following information about the service water cooling tower:

> The service water cooling tower is a rectilinear mechanical draft structure.
>
> The service water cooling tower is a counterflow, induced draft tower and is 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. Each fan is driven by a two speed electrical motor through a gear reducer. During normal power operation, one cell is inactive and water flow to that cell is shut off by a motor operated isolation valve. One

operating service water pump supplies flow to the operating cell. When the SWS is used to support plant shutdown cooling, both tower cells are normally placed in service along with both service water pumps, for increased cooling capacity.

The service water cooling tower cold water temperature is normally automatically controlled by operation of the tower fans. The fan in an active cell will be either on high speed, low speed or off, depending on the temperature of the heated service water returning to the cooling tower. When necessary, the water flow to each cooling tower cell can be diverted directly to the basin, bypassing the tower internals. This is achieved by opening a full flow bypass valve. The bypass can be used during plant startup in cold weather to maintain SWS temperature above 40°F.

After transiting through the cooling tower, cooled service water is collected in a basin located below the tower structure. The basin is partitioned into two halves, with each half collecting the segregated flow from one tower cell. An opening in the partition normally allows the two basin halves to communicate, but a stoplog can be inserted to allow one half of the basin to remain full while the other half is drained for maintenance. Raw water is automatically supplied to the basin to makeup for evaporation, drift and blowdown losses. An alternate makeup water supply is available by gravity flow from one of the fire protection storage tanks, using water that is not dedicated to fire protection purposes. With no makeup to the cooling tower basin, the storage capacity of the basin allows continued system operation for at least 12 hours under limiting conditions, provided that blowdown flow is isolated.

3.3.1.1.1.3 Service Water Strainers

The DCD provides the following information about service water strainers:

An automatic self-cleaning strainer is located in the service water supply piping to each component cooling water heat exchanger. The strainer is sized for a capacity compatible with the flow through the heat exchanger. When in service, each strainer will periodically backwash on a timed cycle, or will backwash if the differential pressure across the strainer exceeds a setpoint. The backwash cleaning features of the strainer can also be manually actuated. Backwash flow from the strainers is discharged to waste at the wastewater retention basins.

3.3.1.1.1.4 Service Water Pumps

The DCD provides the following information about service water pumps:

The SWS includes two service water pumps.

> The service water pumps are vertical, centrifugal, constant speed, electric motor-driven pumps. The pumping elements of each pump are enclosed within a suction barrel which connects to supply piping from the cooling tower basin. The suction barrel of each pump is located in the circulating water pipe trench area of the turbine building. The pumps are powered from the normal ac power system and are backed by the standby power source for occurrences of loss of normal ac power. Each pump provides 100 percent of the normal power operation flow requirements and is therefore capable of supporting normal power operation with one pump out of service for maintenance.
>
> The starting logic for the service water pumps requires at least one of the cooling tower valves to be open prior to pump start to provide a flow path through the cooling tower or tower bypass. The pump starting logic also interlocks with the motor operated valve at the discharge of each pump. The pump starts with the discharge valve closed and the valve then opens at a controlled rate to slowly admit water to the system while maintaining pump minimum flow. This feature results in reduced fluid velocities during system start to minimize transient effects that may occur as the system sweeps out air that may be present and obtains a water solid condition.

3.3.1.1.1.5 Piping

The DCD provides the following information about piping:

> Service water piping is made of carbon steel and is designed, fabricated, installed, and tested in accordance with the applicable American National Standards Institute (ANSI) standards. Nonmetallic piping may be used in accordance with the applicable ANSI standard and as demonstrated by evaluation. Cooling water supply and return piping is accessible for inspection and/or wall thickness determination. Cooling water supply and return piping that runs in the yard is either routed within trenches or may be inspected from the inside.
>
> The SWS is designed to accommodate transient effects that may be generated by the normal starting and stopping of pumps, opening and closing of valves, or other normal operating events. The system pumps water from the basin at the cooling tower, through piping and equipment, to a high point located at the cooling tower riser; the cooling water is then discharged in a spray fashion above the cooling tower basin. The system arrangement is such that high points in the system piping do not lead to the formation of vapor pressure voids upon loss of system pumping. Therefore, the potential for water hammer due to vapor collapse upon pump start is minimized.

3.3.1.1.1.6 Service Water System Valves

The DCD provides the following information about SWS valves:

> Manual isolation valves upstream and downstream of each component cooling water system heat exchanger can be used to isolate the heat exchanger and associated strainer from the SWS. The upstream valves are also normally used during power operation to align the SWS to the component cooling water heat exchanger in use by blocking flow to the inactive heat exchanger. Manual valves in the cross-connection lines between the two service water trains are normally open during power operation to allow the standby pump or standby cooling tower basin to quickly be placed in service if needed. The cross-connection valves are closed as necessary to isolate portions of the system for maintenance, and are normally closed when the system is configured for plant shutdown cooling with both trains in operation.
>
> A motor operated isolation valve downstream of each pump automatically closes when the associated pump stops and automatically opens when the pump starts.
>
> The service water strainers are provided with air-operated backwash valves which open during a backwash cycle. These valves fail closed upon loss of control air or electrical power.
>
> An air operated control valve is provided in the cooling tower blowdown line. This valve allows the plant operator to set the blowdown flowrate. The valve also provides automatic isolation of blowdown flow upon loss of off-site power. The valve fails closed upon loss of control air or electrical power.

3.3.1.1.1.7 Heat Exchangers

The DCD provides the following information about heat exchangers:

> The heat exchangers served by the SWS are part of the component cooling water system.

3.3.1.1.2 System Operation

The DCD provides the following information about system operation of the SWS:

> The SWS operates during normal modes of plant operation, including startup, power operation (full and partial loads), cooldown, shutdown, and refueling. The SWS is also available during loss of normal ac power conditions.

3.3.1.1.2.1 Service Water System Startup

The DCD provides the following information about SWS startup:

> For initial system startup, service water piping and equipment can be filled with raw water. Thereafter, at least one train normally remains in service. An inactive train is started by starting the associated pump and realigning valves as required.

3.3.1.1.2.2 Plant Startup

The DCD provides the following information about plant startup:

> During plant startup, the SWS normally provides service to both component cooling water system heat exchangers. This requires that both service water pumps, strainers and cooling tower basin be in service. At the end of this phase of operation, when one of the component cooling water system heat exchangers is removed from service, one of the service water pumps, strainers and cooling tower basin may also be removed from service.

3.3.1.1.2.3 Power Operation

The DCD provides the following information about power operation:

> The SWS, during normal power operation, provides cooling water at a maximum temperature of 93.5°F to the component cooling water heat exchanger in service. One service water pump and one cooling tower basin is in service.
>
> The standby service water pump is automatically started if the operating pump should fail, thereby providing a reliable source of cooling water. The system is designed so either pump can serve as the operating or standby pump.

3.3.1.1.2.4 Plant Cooldown/Shutdown

The DCD provides the following information about the plant cooldown/shutdown phases:

> During the plant cooldown phase in which the normal residual heat removal system has been placed in service and is providing shutdown cooling, the service water cooling tower provides cooling water at a temperature of 88.5°F or less when operating at design heat load. Two service water pumps and cooling tower basin is normally used for plant cooldown, and the cross-connection valves between trains are normally closed. During these modes of operation, the normal residual heat removal system and the component cooling water system remove

> sensible and decay heat from the RCS. In the event of failure of a SWS pump, the cooldown time is extended.

3.3.1.1.2.5 Refueling

The DCD provides the following information about refueling:

> During refueling, the SWS normally provides cooling water flow to both component cooling water system heat exchangers. Two service water pumps normally provide flow through the system for refueling modes.

3.3.1.1.2.6 Loss of Normal AC Power Operation

The DCD provides the following information about loss of normal AC power operation:

> In the event of loss of normal ac power, the service water pumps along with the associated motor operated valves are automatically loaded onto their associated diesel bus. This includes isolation of cooling tower blowdown, which minimizes drain down of the system while both pumps are off. What drainage of system fluid that does occur is replaced by air without vapor cavities. The potential for water hammer on pump restart is minimized. Both pumps automatically start after power from the diesel generator is available. Following automatic start, the operator may return the system to the appropriate configuration.

3.3.1.2 Component Cooling Water System

The DCD provides the following information about the component cooling water system:

> The component cooling water system is a non-safety-related, closed loop cooling system that transfers heat from various plant components to the SWS during normal phases of operation. It removes heat from various components needed for plant operation and removes core decay heat and sensible heat for normal reactor shutdown and cooldown. The AP1000 component cooling water system provides a barrier to the release of radioactivity between the plant components being cooled that handle radioactive fluid and the environment. The component cooling water system also provides a barrier against leakage of service water into primary containment and reactor systems.
>
> The component cooling water system is designed to perform its operational functions in a reliable and failure tolerant manner. This reliability is achieved with the use of reliable and redundant equipment and with a simplified system design.

3.3.1.2.1 Normal Operation

The DCD provides the following information about normal operation:

> The component cooling water system transfers heat from various plant components needed to support normal power operation with a single active component failure. The component cooling water system is designed for normal operation in accordance with the following criteria:
>
> - The component cooling water supply temperature to plant components is not more than 99°F.
> - The minimum component cooling water supply temperature to plant components is 60°F.
> - The component cooling water system provides sufficient surge capacity to accept 50 gpm leakage into or out of the system for 30 minutes before any operator action is required.

3.3.1.2.2 Normal Plant Cooldown

The DCD provides the following information about normal plant cooldown:

> The first phase of plant cooldown is accomplished by transferring heat from the RCS via the SGs to the main steam systems.
>
> The component cooling water system, in conjunction with the normal residual heat removal system removes both residual and sensible heat from the core and the RCS and reduces the temperature of the RCS during the second phase of cooldown.
>
> The component cooling water system reduces the temperature of the RCS from 350°F at approximately 4 hours after reactor shutdown to 125°F within 96 hours after shutdown by providing cooling to the normal residual heat removal system heat exchangers. In addition to the cooldown time requirements, other system design criteria during cooldown are as follows:
>
> - Operation is consistent with the established RCS cooldown rates while maintaining the component cooling water supply below 110°F.
> - The system design prevents boiling in the component cooling water system during plant cooldown.
> - A single failure of an active component during normal cooldown will not cause an increase in RCS temperature above 350°F. Such a single failure also will not cause the RCS to boil once the reactor

vessel head has been removed and the refueling cavity flooded. The component cooling system continues to provide cooling water to the normal residual heat removal system throughout the shutdown after cooldown is complete.

3.3.1.2.3 Refueling

The DCD provides the following information about refueling:

> During fuel shuffling (partial core off-load) or a full core off-load, cooling water flow is provided to spent fuel pool heat exchangers to cool the spent fuel pool. For a full core off-load cooling water is also supplied to a normal residual heat removal heat exchanger as part of spent fuel pool cooling. The system design criteria during refueling are as follows:
>
> - System operation is with both component cooling water system mechanical trains available.
> - The component cooling water system maintains the spent fuel pool water temperature below 120°F.

3.3.1.2.4 Component Description

The following subsections provide general descriptions of the component cooling water system components.

3.3.1.2.4.1 Component Cooling Water Pumps

The DCD provides the following information about component cooling water pumps:

> The two component cooling water pumps are horizontal, centrifugal pumps. They have a coupled pump shaft driven by an ac powered induction motor. Each pump provides the flow required by its respective heat exchanger for removal of its heat load. The pumps are redundant for normal operation heat loads. Both pumps are required for the cooldown; however, an extended cooldown can be achieved with only one pump in operation. One pump can be out of service during normal plant operation.

3.3.1.2.4.2 Component Cooling Water Heat Exchangers

The DCD provides the following information about component cooling water heat exchangers:

> Two component cooling water heat exchangers provide redundant cooling for normal operation heat loads. Both heat exchangers are required to achieve the design cooldown rate; however, an extended cooldown can be achieved with one heat exchanger in operation. Either

heat exchanger can be aligned with either component cooling water pump allowing one heat exchanger to be out of service during normal plant operation.

The component cooling water heat exchangers are plate type heat exchangers. Component cooling water circulates through one side of the heat exchanger while service water circulates through the other side. Component cooling water in the heat exchanger is maintained at a higher pressure than the service water to prevent leakage of service water into the system.

3.3.1.2.4.3 Component Cooling Water Surge Tank

The DCD provides the following information about the component cooling water surge tank:

> The component cooling water system has a single surge tank. The surge tank accommodates changes in component cooling water volume due to changes in operating temperature. The tank is designed to accommodate a 50-gpm leakage into or out of the system for 30 minutes before any operator action is required. The tank is a cylindrical, vertical unit constructed of carbon steel.

3.3.1.2.4.4 Component Cooling Water System Valves

The DCD provides the following information about component cooling water system valves:

> Most of the valves in the component cooling water system are manual valves used to isolate cooling flow from components for which cooling is not required in a given plant operating mode.
>
> Three motor-operated isolations valves and a check valve provide containment isolation for the supply and return component cooling water system lines that penetrate the containment barrier. The motor-operated valves are normally open and are closed upon receipt of a safety injection signal. They are controlled from the MCR and fail as-is.
>
> A motor-operated isolation valve is located in the component cooling water discharge line from each reactor coolant pump. These valves, which are normally open, are closed on a high component cooling water flow signal. High flow in the component cooling water discharge line indicates significant reactor coolant leakage from the pump cooling coils or thermal barrier into the component cooling water system. Closing these valves prevents radioactive reactor coolant flow through the component cooling water system.

> Relief valves are provided in the cooling water outlet line from each reactor coolant pump. These valves are sized to protect the pump motor cooling jacket (design pressure 200 pounds per square inch gauge [psig]) and the component cooling water piping in the event of a tube rupture in the pump motor cooling coil or thermal barrier. A relief valve in the cooling water outlet line from the letdown heat exchanger also protects the component cooling water piping in the event of a tube rupture in the heat exchanger. Small relief valves are included in the cooling water outlet line from the other components to relieve the volumetric expansion which occurs if the cooling water lines to the component are isolated and the water temperature rises.

3.3.1.2.4.5 Piping Requirements

The DCD provides the following information about piping requirements:

> Component cooling water system piping is made of carbon steel.

3.3.1.3 Demineralized Water Treatment System

Table 3.3-2, Table 3.3-3, and Figure 3.3-3 provide information about the required raw water supply for and discharges from the demineralized water treatment system (DTS) based on two AP1000s.

The DCD provides the following information about the DTS:

> The DTS receives water from the RWS, processes this water to remove ionic impurities, and provides demineralized water to the demineralized water transfer and storage system (DWS).
>
> The system consists of the following major components:
>
> - Two reverse osmosis (RO) feed pumps.
> - Two 100-percent RO units normally operating in series for primary demineralization.
> - One electrodeionization unit for secondary demineralization.

3.3.1.4 Demineralized Water Transfer and Storage System

The DCD provides the following information about the DWS:

> The DWS receives water from the DTS, and provides a reservoir of demineralized water to supply the condensate storage tank and for distribution throughout the plant. Demineralized water is processed in the DWS to remove dissolved oxygen. In addition to supplying water for makeup of systems which require pure water, the demineralized water is

used to sluice spent radioactive resins from the ion exchange vessels in the CVS, the spent fuel pool cooling system, and the liquid radwaste system to the solid radwaste system.

The DCD provides the following additional information about the DWS:

- The DWS provides demineralized water through the demineralized water storage tank to fill the condensate storage tank and to meet required demands and usages of demineralized water in other plant systems.
- The demineralized water transfer pumps provide adequate capacity and head for the distribution of demineralized water.
- The demineralized water storage tank supplies a source of demineralized water to the chemical and volume control makeup pumps during startup and required boron dilution evolutions. The DWS supplies the required amount of water to the CVS for reactor water makeup.
- The oxygen content of water supplied to the demineralized water distribution system from the demineralized water storage tank is 100 ppb or less.
- Sufficient storage capacity is provided in the condensate storage tank to satisfy condenser makeup demand based on maximum SG blowdown operation during a plant startup duration.
- The condensate storage tank provides the water supply for the startup feedwater pumps during startup, hot standby, and shutdown conditions.
- The condensate storage tank provides a sufficient supply of water to the startup FWS to permit 8 hours of hot standby operation, followed by an orderly plant cooldown from normal operating temperature to conditions which permit operation of the normal residual heat removal system over a period of approximately 6 hours.
- The piping from the condensate storage tank to the startup feedwater pumps allows adequate net positive suction head (NPSH) at maximum tank water temperature and minimum water level.
- The condensate storage tank serves as a reservoir to supply or receive condensate as required by the condenser hotwell level control system.
- The oxygen content of water stored in the condensate storage tank is 100 ppb or less.

3.3.1.4.1 Component Description

3.3.1.4.1.1 Demineralized Water Storage Tank

The DCD provides the following information about the demineralized water storage tank:

> The demineralized water storage tank has a capacity of approximately 100,000 gallons. The tank is a vertical cylindrical tank constructed of stainless steel. The tank is provided with level and temperature instrumentation; level controls the operation of the DTS and sends a signal to the RO feed pumps to start and stop, thus supplying water to the storage tank. Tank temperature is monitored and controls an immersion-type electric heater to keep the tank contents from freezing.

3.3.1.4.1.2 Demineralized Water Transfer Pump

The DCD provides the following information about the demineralized water transfer pump:

> Two motor-driven, centrifugal, horizontal pumps, located near the demineralized water storage tank, provide the plant demineralized water distribution system pressure and capacity. Each pump provides full flow recirculation through the catalytic oxygen reduction unit as well as providing the required system demand.

3.3.1.4.1.3 Catalytic Oxygen Reduction Units

The DCD provides the following information about catalytic oxygen reduction units:

> Oxygen control of the demineralized water is performed by catalytic oxygen reduction units. Two catalytic oxygen reduction units are used in the AP1000 plant. One unit is provided for the demineralized water distribution system as water is pumped from the tank to the distribution system. The second unit is provided at the condensate storage tank to maintain a low-oxygen content within the tank and is used in a recirculation path around the tank.
>
> Each catalytic oxygen reduction unit consists of a mixing chamber, a catalytic resin vessel, and a resin trap. The mixing chamber is a stainless steel, in-line, static mixer where dissolution of the reducing agent occurs. Dissolved oxygen is removed chemically by mixing the effluent from the storage tank with hydrogen gas. Hydrogen is supplied from the plant gas system. The resin vessel is a rubber lined, carbon steel vessel containing catalytic resin. The stainless steel resin trap contains a cartridge filter to collect resin fines discharged from the resin vessel.

3.3.1.4.1.4 Condensate Storage Tank

The DCD provides the following information about the condensate storage tank:

> The condensate storage tank has a capacity of 485,000 gallons and is a vertical cylindrical tank constructed of stainless steel. Level and temperature instrumentation are provided with the tank level controlled by the makeup valve. Freeze protection is supplied by immersion-type electric heaters.

3.3.1.4.2 System Operation

3.3.1.4.2.1 Normal Operation

The DCD provides the following information about normal operation:

> The water level in the demineralized water storage tank controls the DTS. When the level in the demineralized water storage tank falls to a preset level, the pumps in the DTS start automatically. High water level in the tank stops operation of the DTS. This action, along with the capacitance in the tank, maintains the desired volume to supply the expected demands for demineralized water during normal plant operation.
>
> The demineralized water transfer pumps, taking suction from the demineralized water storage tank, supply water through a catalytic oxygen reduction unit to the demineralized water distribution header. From this header, demineralized water is supplied to the condensate storage tank, is supplied as makeup to the CVS pumps, and is distributed throughout the plant. The demineralized water distribution header pressure is maintained by the operation of one transfer pump. This pump recirculates water that exceeds system demand to the demineralized water storage tank. Controls are provided to automatically start the second pump upon failure of the first to maintain system pressure and demand. A low level alarm on the demineralized water storage tank signals the plant operator to isolate demands on the tank other than CVS supply. Demineralized water is distributed to the containment, auxiliary, radwaste, annex, and turbine buildings for system usage.
>
> The condensate storage tank level is maintained by a level control valve in the tank supply line. The valve opens when the water level in the tank drops to a specified level and closes when the level increases to a specified setpoint. When high oxygen levels exist in the condensate storage tank, an oxygen analyzer signal starts the catalytic oxygen reduction unit pump. The pump is shut off when low levels of oxygen are detected. Low oxygen demineralized water is circulated from the tank outlet connection, through the catalytic oxygen reduction unit, and is returned to the tank via the normal inlet supply line of the tank. An orifice controls the recirculation pressure and flow returning to the tank.

> Changes in the CDS inventory are controlled by the condenser hotwell level system. As level falls in the hotwell, makeup from the condensate storage tank is supplied to the hotwell by the makeup control valve. As level rises in the hotwell, condensate is rejected to the condensate storage tank via the condensate pump's discharge control valve.
>
> In the event the main FWS is unavailable to supply water to the SGs during startup, hot standby, or shutdown, the startup feedwater pumps may be activated and require water from the condensate storage tank.

3.3.1.5 Potable Water System

The DCD provides the following information about the potable water system (PWS):

> The PWS is designed to furnish water for domestic use and human consumption. It complies with the bacteriological and chemical quality requirements as referenced in U.S. Environmental Protection Agency ([US]EPA) "National Primary Drinking Water Standards," 40 CFR Part 141. The distribution of water by the system is in compliance with 29 CFR 1910, Occupational Safety and Health Standards, Part 141.

Table 3.3-2 and Figure 3.3-3 provides information about potable water use.

- Potable water is supplied to provide a quantity of 50 gallons/person/day for the largest number of persons expected to be at the station during a 24-hour period during normal plant power generation or outages. However, it should be noted that portable water will be supplied to the units at a rate specified in Table 3.3-2 and as presented in Figure 3.3-3.
- Water heaters provide a storage capacity equal to the probable hourly demand for potable hot water usage and provide hot water for the main lavatory, shower areas, and other locations where needed.
- A minimum pressure of 20 psig is maintained at the furthermost point in the distribution system.
- No interconnections exist between the PWS and any potentially radioactive system or any system using water for purposes other than domestic water service including any potentially radioactive system. The common supply from the on-site RWS is designed to use an air gap to prevent contamination of the PWS from other systems supplied by the RWS.
- The source of water for the PWS is the site-specific water system. The PWS consists of a distribution header around the power block, hot water storage heaters, and necessary interconnecting piping and valves.

3.3.1.5.1 Component Description

3.3.1.5.1.1 Hot Water Heaters

The DCD provides the following information about hot water heaters:

> Electric immersion heating elements located inside the potable water hot water tank are used to produce hot water. This hot water is routed to the shower and toilet areas and to other plumbing fixtures and equipment requiring domestic hot water service. Point of use, inline electric water heating elements are used to generate hot water for the MCR and the turbine building secondary sampling laboratory.

3.3.1.5.2 System Operation

The DCD provides the following information about system operation:

> Filtered water is supplied from a site-specific water source for the potable water distribution system. The onsite water supply system will maintain an appropriate pressure throughout the distribution system. Potable water is supplied to areas that have the potential to be contaminated radioactively. Where this potential for contamination exists, the PWS is protected by a reduced pressure zone type backflow prevention device. No interconnections exist between the PWS and any system using water for purposes other than domestic water service including any potentially radioactive system. The common supply from the onsite RWS is designed to use an air gap to prevent contamination of the PWS from other systems supplied by the RWS.

3.3.1.6 Sanitary Drainage System

The DCD provides the following information about the sanitary drainage system (SDS):

> The SDS is designed to collect the HAR site sanitary waste for treatment, dilution, and discharge. The system is designed to accommodate 25 gallons/person/day for up to 500 persons during a 24-hour period. However, it should be noted that the SDS will be designed to discharge to Harris Reservoir at the rate specified in Table 3.3-3 and as depicted in Figure 3.3-3.

Table 3.3-3 and Figure 3.3-3 provide information about sanitary waste discharges to Harris Reservoir (the supply reservoir) based on two AP1000s.

> The SDS collects sanitary waste from plant restrooms and locker room facilities in the turbine building, auxiliary building, and annex building, and carries this waste to the treatment plant where it is processed.

> The SDS does not service facilities in radiologically controlled areas (RCA).

3.3.1.6.1 Component Description

3.3.1.6.1.1 Trunk Line

The DCD provides the following information about the trunk line:

> The trunk line is the primary line that the SDS piping connects into for transport of the sanitary drainage to the site treatment plant.

3.3.1.6.1.2 Branch Lines

The DCD provides the following information about branch lines:

> Branch lines are the sanitary drainage lines that connect the restroom facilities to the trunk line.

3.3.1.6.1.3 Manholes

The DCD provides the following information about manholes:

> Manholes are required in the trunk line at the connection of the branch lines into the trunk line, at the change in direction of the trunk line, or at the change in slope or direction of the trunk line. Quantity and location are site specific.

3.3.1.6.1.4 Lift Stations

The DCD provides the following information about lift stations:

> Lift stations are required in the trunk line when the uniform slope of the trunk line results in excessively deep and costly excavation. Quantity and location are site specific.

3.3.1.7 Central Chilled Water System

The DCD provides the following information about the central chilled water system (VWS):

> The plant HVAC systems require chilled water as a cooling medium to satisfy the ambient air temperature requirements for the plant. The VWS supplies chilled water to the HVAC systems and is functional during reactor full-power and shutdown operation.

The DCD provides the following additional information about the VWS:

> The VWS provides chilled water to the cooling coils of the supply air handling units and unit coolers of the plant HVAC systems. It also supplies chilled water to the liquid radwaste system, gaseous radwaste system, secondary sampling system, and the temporary air supply units of the containment leak rate test system.
>
> The system consists of two closed loop subsystems: a high cooling capacity subsystem and a low cooling capacity subsystem. The high capacity subsystem is the primary system used to provide chilled water to the majority of plant HVAC systems and other plant equipment requiring chilled water cooling. The low capacity subsystem is dedicated to the nuclear island nonradioactive ventilation system and the makeup pump and normal residual heat removal pump compartment unit coolers.
>
> The high capacity subsystem consists of two 100-percent capacity chilled water pumps, two 100-percent capacity water-cooled chillers, a chemical feed tank, an expansion tank, and associated valves, piping, and instrumentation. The subsystem is arranged in two parallel mechanical trains with common supply and return headers. Each train includes one pump and one chiller. A cross-connection at the discharge of each pump allows for either pump to feed a given chiller. A bypass line maintains a constant chiller flow rate as the load demand changes. The chiller condensers are supplied with cooling water from the component cooling water system. The high capacity subsystem components are located in the turbine building.
>
> The low capacity subsystem consists of two 100-percent capacity chilled water loops. Each loop consists of a chilled water pump, an air-cooled chiller, an expansion tank, and associated valves, piping, and instrumentation. The subsystem is arranged in two independent trains with separate supply and return headers. The subsystem is provided with a common chemical feed tank. The subsystem provides a reliable source of chilled water to the main control room (MCR) and control support area (CSA) HVAC system. This system configuration provides 100-percent redundancy during normal plant operation and following the loss of off-site power. The air-cooled chillers of the low capacity subsystem are located on the auxiliary building roof. The chilled water pumps and expansion tanks are located in the auxiliary building below the chillers.

3.3.1.7.1 Component Description

The DCD provides the following information about the component description:

> The general descriptions and summaries of the design requirements for the VWS components are provided below. The piping inside containment

has a design pressure of 200 psig and a design temperature of 320°F to accommodate both cooling and heating service.

3.3.1.7.1.1 Pumps

The DCD provides the following information about pumps:

> Four VWS pumps are provided. These pumps are single-stage, horizontal, centrifugal pumps. These pumps have an integral pump motor shaft driven by an ac-powered induction motor. The VWS pumps are constructed of cast iron and have flanged suction and discharge nozzles. Each pump is sized to provide the maximum water flow required by its respective chiller unit for removal of its associated design heat load.

3.3.1.7.1.2 Water-Cooled Chillers

The DCD provides the following information about water-cooled chillers:

> Two water cooled liquid chillers are provided. Each chiller unit consists of a compressor, condenser, evaporator, and associated piping and controls. Environmentally safe refrigerants will be used in these chillers.

3.3.1.7.1.3 Air-Cooled Chillers

The DCD provides the following information about air-cooled chillers:

> Two air-cooled liquid chillers are provided. Each chiller unit consists of a compressor, condenser, evaporator, and associated piping and controls. Environmentally safe refrigerants will be used in these chillers.

3.3.1.7.1.4 Expansion Tank

The DCD provides the following information about the expansion tank:

> One open and two closed expansion tanks are provided to maintain the pressure above saturation. The high capacity subsystem uses an open expansion tank which is located sufficiently above the high point of the system and connected to the suction side of the pump. The low capacity subsystem uses nitrogen charged expansion tanks on the suction side of the chilled water pumps. The expansion tanks maintain a positive suction pressure for the pumps. The tanks are sized to accommodate the volume of water expansion providing a space into which the noncompressible liquid can expand or contract as the liquid undergoes volumetric changes with changes in temperature.

3.3.1.7.1.5 Chemical Feed Tank

The DCD provides the following information about the chemical feed tank:

> The chemical feed tanks and the associated piping are used to add chemicals to each chilled water subsystem stream to maintain proper water quality. Antifreeze solution is added to the low capacity subsystem to prevent freezing during cold weather operation.

3.3.1.7.1.6 Valves

The DCD provides the following information about valves:

> Isolation valves are provided upstream and downstream of each pump/chiller train. These valves are butterfly valves and are used to isolate a train of the subsystem for maintenance. An interlock is provided between the downstream isolation valve and the pump/chiller controls.
>
> An isolation valve is provided in the line that cross-connects the pump discharge lines in the high capacity subsystem. This manual butterfly valve is normally closed and can be manually aligned to operate the standby chiller with the operating pump of either train.
>
> An air-operated isolation valve and check valve are provided in the chilled water supply and two air-operated isolation valves are provided in the chilled water return line that penetrates containment. The air-operated containment isolation valves automatically close upon receipt of a containment isolation signal. This isolation signal can be bypassed by the MCR operator to be able to restore containment recirculation system cooling with the containment isolated.
>
> Isolation valves are provided at the interconnection with the hot water heating system (VYS) to provide hot water through the coils of the containment recirculation cooling system for heating during refueling, maintenance, and testing activities under cold weather conditions.
>
> High capacity subsystem temperature control valves are located upstream of each cooling coil or group of coils, except for the containment recirculation cooling system coils. The containment recirculation cooling system coils are provided with three-way modulating valves. These valves bypass chilled water flow around the containment recirculation cooling system coils, as needed, to maintain the temperature within the design conditions. The flow control valves fail open upon loss of control air or electrical power. A pressure control valve is installed on the bypass line around the chiller system to maintain a constant chiller flow rate as the load demand changes. The bypass valve fails closed upon loss of control air or electrical power.

> Low capacity subsystem three-way modulating temperature control valves are provided for each group of nuclear island nonradioactive ventilation system cooling coils. These valves bypass chilled water flow around the coils, as needed, to maintain the temperature within the design conditions.

3.3.1.8 Turbine Building Closed Cooling Water System

The DCD provides the following information about the turbine building closed cooling water system:

> The turbine building closed cooling water system (TCS) provides chemically treated, demineralized cooling water for the removal of heat from non-safety-related heat exchangers in the turbine building and rejects the heat to the circulating water system.
>
> During power operation, the turbine building closed cooling water system provides a continuous supply of cooling water to turbine building equipment at a temperature of 105°F or less assuming a circulating water temperature of 100°F or less.
>
> The cooling water is treated with a corrosion inhibitor and uses demineralized water for makeup. The system is equipped with a chemical addition tank to add chemicals to the system.
>
> The heat sink for the turbine building closed cooling water system is the circulating water system. The heat is transferred to the circulating water through plate type heat exchangers which are components of the turbine building closed cooling water system.
>
> A surge tank is sized to accommodate thermal expansion and contraction of the fluid due to temperature changes in the system.
>
> One of the turbine building closed cooling system pumps or heat exchangers may be unavailable for operation or isolated for maintenance without impairing the function of the system.
>
> The turbine building closed cooling water pumps are provided ac power from the 6,900V switchgear bus. The pumps are not required during a loss of normal ac power.
>
> The system consists of two 100-percent capacity pumps, three 50-percent capacity heat exchangers (connected in parallel), one surge tank, one chemical addition tank, and associated piping, valves, controls, and instrumentation. Heat is removed from the turbine building closed cooling water system by the circulating water system via the heat exchangers.

> The pumps take suction from a single return header. Either of the two pumps can operate in conjunction with any two of the three heat exchangers. Discharge flows from the heat exchangers combine into a single supply header. Branch lines then distribute the cooling water to the various coolers in the turbine building. The flow rates to the individual coolers are controlled either by flow restricting orifices or by control valves, according to the requirements of the cooled systems. Individual coolers can be locally isolated, where required, to permit maintenance of the cooler while supplying the remaining components with cooling water. A bypass line with a manual valve is provided around the turbine building closed cooling water system heat exchangers to help avoid overcooling of components during startup/low-load conditions or cold weather operation.
>
> The system is kept full of demineralized water by a surge tank which is located at the highest point in the system. The surge tank connects to the system return header upstream of the pumps. The surge tank accommodates thermal expansion and contraction of cooling water resulting from temperature changes in the system. It also accommodates minor leakage into or out of the system. Water makeup to the surge tank, for initial system filling or to accommodate leakage from the system, is provided by the DWS. The surge tank is vented to the atmosphere.
>
> A line from the pump discharge header back to the pump suction header contains valves and a chemical addition tank to facilitate mixing chemicals into the closed loop system to inhibit corrosion in piping and components.
>
> A turbine building closed cooling water sample is periodically taken and analyzed to verify that water quality is maintained.

3.3.1.8.1 Component Description

3.3.1.8.1.1 Surge Tank

The DCD provides the following information about the surge tank:

> A surge tank accommodates changes in the cooling water volume due to changes in operating temperature. The tank also temporarily accommodates leakage into or out of the system. The tank is constructed of carbon steel.

3.3.1.8.1.2 Chemical Addition Tank

The DCD provides the following information about the chemical addition tank:

> The chemical addition tank is constructed of carbon steel. The tank is normally isolated from the system and is provided with a hinged closure for addition of chemicals.

3.3.1.8.1.3 Pumps

The DCD provides the following information about pumps:

> Two pumps are provided. Either pump provides the pumping capacity for circulation of cooling water throughout the system. The pumps are single stage, horizontal, centrifugal pumps, are constructed of carbon steel, and have flanged suction and discharge nozzles. Each pump is driven by an ac powered induction motor.

3.3.1.8.1.4 Heat Exchangers

The DCD provides the following information about heat exchangers:

> Three heat exchangers are arranged in a parallel configuration. Two of the heat exchangers are in use during normal power operation and turbine building closed cooling water flow divides between them.
>
> The heat exchangers are plate type heat exchangers. Turbine building closed cooling water circulates through one side of the heat exchanger while circulating water flows through the other side. During system operation, the turbine building closed cooling water in the heat exchanger is maintained at a higher pressure than the circulating water so leakage of circulating water into the closed cooling water system does not occur. The heat exchangers are constructed of titanium plates with a carbon steel frame.

3.3.1.8.1.5 Valves

The DCD provides the following information about valves:

> Manual isolation valves are provided upstream and downstream of each pump. The pump isolation valves are normally open but may be closed to isolate the non-operating pump and allow maintenance during system operation. Manual isolation valves are provided upstream and downstream of each turbine building closed cooling water heat exchanger. One heat exchanger is isolated from system flow during normal power operation. A manual bypass valve can be opened to bypass flow around the turbine building closed cooling water heat exchangers when necessary to avoid low cooling water supply temperatures.
>
> Flow control valves are provided to restrict or shut off cooling water flow to those cooled components where its function could be impaired by overcooling. The flow control valves are air operated and fail open upon loss of control air or electrical power. An air operated valve is provided to control demineralized makeup water to the surge tank for system filling

and for accommodating leakage from the system. The makeup valve fails closed upon loss of control air or electrical power.

Backwashable strainers are provided upstream of each TCS heat exchanger. They are actuated by a timer and have a backup starting sequence initiated by a high differential pressure across each individual strainer. The backwash can be manually activated.

3.3.1.8.1.6 Piping

The DCD provides the following information about piping:

System piping is made of carbon steel. Piping joints and connections are welded, except where flanged connections are used for accessibility and maintenance of components.

3.3.1.8.2 System Operation

The DCD provides the following information about system operation:

The turbine building closed cooling water system operates during normal power operation. The system does not operate with a loss of normal ac power.

3.3.1.8.2.1 Startup

The DCD provides the following information about startup:

The turbine building closed cooling water system is placed in operation during the plant startup sequence after the circulating water system is in operation but prior to the operation of systems that require turbine building closed cooling water flow. The system is filled by the DWS through a fill line to the surge tank. The system is placed in operation by starting one of the pumps.

3.3.1.8.2.2 Normal Operation

The DCD provides the following information about normal operation:

During normal operation, one turbine building closed cooling water system pump and two heat exchangers provide cooling to the components. The other pump is on standby and aligned to start automatically upon low discharge header pressure.

During normal operation, leakage from the system will be replaced by makeup from the DWS through the automatic makeup valve. Makeup can be controlled either manually, or automatically upon reaching low level in the surge tank.

3.3.1.8.2.3 Shutdown

The DCD provides the following information about shutdown:

> The system is taken out of service during plant shutdown when no longer needed by the components being cooled. The standby pump is taken out of automatic control, and the operating pump is stopped.

3.3.1.9 Wastewater System

The DCD provides the following information about the WWS:

> The WWS collects and processes equipment and floor drains from nonradioactive building areas. Primary functions of the system include the following:
>
> - Remove oil and/or suspended solids from miscellaneous waste streams generated from the plant.
> - Collect system flushing wastes during startup prior to treatment and discharge.
> - Collect and process fluid drained from equipment or systems during maintenance or inspection activities.
> - Direct nonradioactive equipment and floor drains which may contain oily waste to the building sumps and transfer their contents for proper waste disposal.
>
> The WWS is capable of handling the anticipated flow of wastewater during normal plant operation and during plant outages. Wastes from the turbine building floor and equipment drains (which include laboratory and sampling sink drains, oil storage room drains, the main steam isolation valve compartment, auxiliary building penetration area and the auxiliary building HVAC room) are collected in the two turbine building sumps. Drainage from the diesel generator building sumps, the auxiliary building sump – north (a nonradioactive sump) and the annex building sump is also collected in the turbine building sumps. The turbine building sumps provide a temporary storage capacity and a controlled source of fluid flow to the oil separator. In the event radioactivity is present in the turbine building sumps, the wastewater is diverted from the sumps to the liquid radwaste system (WLS) for processing and disposal. A radiation monitor located on the common discharge piping of the sump pumps provides an alarm upon detection of radioactivity in the wastewater. The radiation monitor also trips the sump pumps on detection of radioactivity to isolate the contaminated water. Provisions are included for sampling the sumps.

The turbine building sump pumps route the wastewater from either of the two sumps to the oil separator for removal of oily waste. The diesel fuel oil area sump pump also discharges wastewater to the oil separator. A bypass line allows for the oil separator to be out of service for maintenance. The oil separator has a small reservoir for storage of the separated oily waste which flows by gravity to the waste oil storage tank. The waste oil storage tank provides temporary storage prior to removal by truck for off-site disposal.

The wastewater from the oil separator flows by gravity to the wastewater retention basin for settling of suspended solids and treatment, if required, prior to discharge.

3.3.1.9.1 Component Description

3.3.1.9.1.1 Turbine Building Sumps

The DCD provides the following information about turbine building sumps:

> The two sumps collect wastewater from the floor and equipment drains, laboratory drains, sampling waste drains, and plant washdowns from the turbine building. Selected drains from both the annex and auxiliary buildings are also collected in these sumps.

3.3.1.9.1.2 Turbine Building Sump Pumps

The DCD provides the following information about turbine building sump pumps:

> Each sump has one pneumatic, double diaphragm pump which routes the wastewater to the oil separator. Interconnecting piping between the suction of the sump pumps allows for either pump to transfer wastewater from either or both sumps. The plant service air system provides the supply of air for operation of the pumps. Operation of the pump is automatic based on sump level with controls provided for manual operation.

3.3.1.9.1.3 Oil Separator

The DCD provides the following information about the oil separator:

> The oil separator has internal, vertical coalescing tubes for removal of oily waste and an oil holdup tank. Sampling provisions are included on the oil holdup tank to confirm that the oil does not require handling and disposal as a hazardous waste. A sampling connection is also provided at the discharge of the oil separator.

3.3.1.9.1.4 Waste Oil Storage Tank

The DCD provides the following information about the waste oil storage tank:

> Waste oil from the oil separator reservoir and other plant areas is stored in a waste oil storage tank. A sampling connection is provided on the tank to verify that the oil does not require handling and disposal as a hazardous material. A truck connection on the tank allows for removal of the waste oil from the tank for off-site disposal.

3.3.1.9.1.5 Wastewater Retention Basin

The DCD provides the following information about the wastewater retention basin:

> The wastewater retention basins and associated basin transfer pumps are site specific components.

3.3.1.9.1.6 Wastewater Sumps

The DCD provides the following information about wastewater sump pumps:

> Waste water collection sumps are provided for the auxiliary building, the diesel generator building, the annex building and the diesel fuel oil area. These collection sumps are drained by air operated pumps and the effluent from the sumps, (except the effluent from the diesel fuel oil area), is directed to the turbine building sumps for processing and release. The effluent from the diesel fuel oil area is pumped directly to the oil separator.

3.3.1.9.1.7 Sump Pumps

The DCD provides the following information about sump pumps:

> The wastewater sump pumps are pneumatic, double diaphragm pumps. The plant service air system provides the supply of air for operation of these pumps. Operation of the pumps is automatic based on sump level with controls provided for manual operation.

3.3.1.10 Hot Water Heating System

The DCD provides the following information about the hot water heating system:

> The VYS supplies heated water to selected non-safety-related air handling units and unit heaters in the plant during cold weather operation and to the containment recirculating fans coil units during cold weather plant outages.

- During normal plant operation, the hot water heating system maintains acceptable design ambient air temperatures in various areas throughout the AP1000.

- During plant outages in cold weather, the hot water heating system supplies hot water to the plant chilled water piping serving the containment building recirculation fan coil units to maintain acceptable ambient air temperatures inside containment.

Major components of the heating system include heat exchangers, pumps, a surge tank, and provisions for chemical feed. The hot water heating system consists of a heat transfer package for the production of hot water and a distribution system to the various HVAC systems and unit heaters. The hot water heating system is a non-safety-related system.

During cold weather plant operation, the hot water heating system supplies hot water throughout the plant to protect equipment from freezing and for personnel comfort. During cold weather plant outages, the hot water heating system supplies hot water to the containment building recirculation fan coil units to maintain acceptable ambient air temperatures inside containment. During a loss of normal ac power, provisions are made to power the hot water heating system from the on-site diesel generators as an investment protection load. In this mode of operation, heating steam is supplied from the auxiliary steam supply system.

The hot water heating system, using a steam source from high-pressure turbine cross under piping or the auxiliary boiler, extracts heat energy from the steam through a heat exchanger and transfers this energy to heat water. The heated water is pumped in a closed loop system to hot water coils in the air conditioning systems. Condensate from the heat exchanger is level controlled and drained to the main condenser or auxiliary boiler FWS.

Two 50-percent capacity system pumps take suction from the return main of the closed loop system, pump water through two 50-percent capacity system heat exchangers, and supply hot water to the heating system main header. To match system heat load and maintain fluid system temperature, part of the water passes through the heater while the remainder is diverted through the heater bypass. To prevent flashing of the heated water into steam, the pump in combination with the system surge tank keeps the system pressure above saturation conditions. The surge tank uses both elevation and nitrogen overpressure to keep the minimum system pressure above saturation conditions at the pump suction. Demineralized water is supplied to the system for surge tank makeup.

During plant outages in cold weather, hot water flows to the containment building recirculation fan coil units to heat the containment atmosphere. The recirculation fan coil units, containment supply and return piping to these units, and the containment isolation valves are part of the VWS. During normal plant operation the hot water heating system is isolated from the containment recirculation fan coils.

The hot water heating system is a manually actuated system and may operate when the site ambient temperature is 73°F or below.

3.3.1.10.1 Component Description

3.3.1.10.1.1 Heat Exchanger

The DCD provides the following information about the heat exchanger:

Each heat exchanger is a horizontal, shell-and-tube type, with an integral drain cooler, and uses the heat of vaporization of low-pressure steam for the heating of water. The heat exchanger is located in the closed loop hot water heating system downstream of the system pumps in the turbine building. This heat exchanger provides heated water for selected air handling unit and unit heater hot water coils.

3.3.1.10.1.2 Pumps

The DCD provides the following information about pumps:

Two pumps distribute hot water to the various HVAC and unit heater systems. They are motor driven centrifugal pumps.

3.3.1.10.1.3 Surge Tank

The DCD provides the following information about the surge tank:

The surge tank maintains system pressure by allowing the water to expand when the water temperature increases and provides a volume to accept makeup water to the hot water heating system.

The tank is a carbon steel, welded, pressure vessel with nitrogen supply, tank recirculation, and instrument connections.

3.3.1.10.1.4 Chemical Feed Tank

The DCD provides the following information about the chemical feed tank:

The chemical feed tank provides a means of chemical mixing in the system. Addition of chemicals provides control of corrosion.

> The tank is a vertical cylinder of carbon steel construction with a capacity of less than 150 gallons and a top hinged opening for introducing the chemicals and side connections for transporting water through the chemical mixing tank from the pump discharge or the DWS supply.

3.3.1.10.2 System Operation

The DCD provides the following information about system operation:

> As the system is filled with demineralized water, samples are taken and the closed loop water chemistry adjusted with chemicals recirculated through the chemical mixing tank with the use of a single pump. A pump is started and steam is admitted to a hot water system heat exchanger and the system is gradually heated.
>
> The three-way diverting valve modulates hot water heating flow through each hot water heating system heat exchanger maintaining a constant heat exchanger outlet temperature, measured at the heat exchanger outlet.
>
> A condensate level is maintained in each system heat exchanger by throttling the heat exchanger discharge flow to the condenser. During a plant outage when extraction steam is shutdown and auxiliary steam is used from the auxiliary boiler, a manual block valve is opened to establish flow of condensate from each heat exchanger to the auxiliary steam supply system deaerator.
>
> Hot water flowing to individual heating coils is controlled either by flow balancing fixed orifices or by temperature controlled solenoid valves, according to the requirements of the heating system. Area temperatures are controlled by cycling the fans in unit heaters, by use of integral face/bypass dampers in air handling units, or by thermostats controlling hot water solenoids in heating coils of HVAC ducts. In the radwaste building, normally isolated hot water supply and return connections are provided for a mobile radwaste system.

3.3.2 WATER CONSUMPTION

The Normal Plant Heat Sink (NHS) is used to remove waste heat from the main condenser through the CWS. Makeup water from Harris Reservoir is used to replenish water losses due to evaporation, drift, and blowdown. Pumps for the makeup water will be located in a new Harris Lake makeup water system intake structure positioned in close proximity to the HNP intake structure.

3.3.2.1 Water Requirements

Table 3.3-2 and Figure 3.3-3 present the raw water requirements for HAR 2 and HAR 3. This is the total of the water usage for potable/sanitary water supply, demineralized water production, filtered water production, and the cooling system makeup. This quantity includes the water required from Harris Reservoir for the cooling tower makeup. The cooling tower makeup value presented is based on a conventional wet tower and represents the maximum expected value required during startup or adjustments to the blowdown in order to control water chemistry. Normal values presented in Table 3.3-2 and Figure 3.3-3 are the continuous water usage requirements. The maximum values are intermittent demands that may occur during system-upset conditions or startup.

On an average, the makeup requirement to the cooling tower from the Main Reservoir constitutes a major plant use during normal plant operation. Cooling tower makeup is estimated to be 2.54 cubic meters per second (m^3/s) (89.61 ft^3/s) or 40,220 gpm operating at peak evaporative rates (evaporation, blowdown, drift – based on two AP1000 units). Additional quantities of Harris Reservoir water pumped by the raw water intake pumps will be diverted for use as makeup water to compensate for raw water use, raw water to the demineralizers, fire protection, strainer backwash, and filter backwash. The net consumptive use of Harris Reservoir water is estimated to be 1.77 m^3/s (62.66 ft^3/s) or 28,122 gpm (that is, cooling tower makeup water + raw water use + service water tower makeup water, + demineralization makeup water – sanitary discharge – demineralization system water discharge – cooling tower blowdown – service tower blowdown – based on two AP1000 units). Total flow to the raw water intake structure from the Main Reservoir is anticipated to be 2.65 m^3/s (93.74 ft^3/s) or 42,074 gpm (cooling tower makeup water + raw water use +service tower makeup water + demineralization makeup water – based on two AP1000 units) (Reference 3.3-002).

In addition, the normal net consumptive water usage from Harris Reservoir to support the service water tower is estimated to be 0.07 m^3/s (2.46 ft^3/s) or 1102 gpm (evaporative losses plus raw water to demineralizers, plus potable water supply minus sanitary discharges minus demineralizer discharge). Total flow to the service water raw water intake structure from the reservoir is anticipated to be 0.23 m^3/s (8.14 ft^3/s) or 3654 gpm (service water tower make up water plus raw water to demineralizers plus potable water supply plus service water strainer backwash plus filter backwash) (Reference 3.3-002).

3.3.2.2 Cooling Water Discharges

Table 3.3-3 and Figure 3.3-3 present the cooling water thermal discharges into Harris Reservoir from the operation of the HAR facility. The information in this table sums the cooling system blowdown discharges from the cooling tower and the service water tower.

Normal values were used to determine continuous water discharge quantities to Harris Reservoir (the supply reservoir). The maximum values are intermittent flow rates that may occur during system-upset conditions, shutdown, or startup. The loss of water from the supply reservoir is the water supply requirement minus the discharges, because the discharges are returned to the supply reservoir.

Cooling tower blowdown is estimated at 0.83 m^3/s (29.41 ft^3/s) or 13,200 gpm (screen wash water, and strainer backwash are returned to Harris Reservoir) (Table 3.3-3 and Figure 3.3-3). The net consumptive use of Harris Reservoir water is estimated to be 1.77 m^3/s (62.66 ft^3/s) or 28,122 gpm (that is, cooling tower makeup water + raw water use+ service water tower makeup water + demineralizer makeup water – sanitary discharge – demineralizer water discharge – cooling tower blowdown – service tower blowdown – based on two AP1000 units) assuming all secondary services of the cooling tower makeup pumps are required simultaneously (Reference 3.3-002).

In addition, the service water tower blowdown to the reservoir is estimated to be 0.02 m^3/s (0.71 ft^3/s) or 317 gpm on the average and a maximum of 0.03 m^3/s (1.11 ft3/s) or 500 gpm. The normal net consumptive water usage from the reservoir to support the service water tower is estimated to be 0.07 m^3/s (2.46 ft3/s) or 1102 gpm (evaporative losses plus raw water to demineralizers, plus potable water supply minus sanitary discharges minus demineralizer discharge) (Reference 3.3-002).

3.3.2.3 Sanitary and other Effluent Discharges to Harris Reservoir

Table 3.3-3 and Figure 3.3-3 present the sanitary waste and other effluent discharges to Harris Reservoir.

3.3.3 WATER TREATMENT

The materials in the primary system of the AP1000 will typically be composed primarily of austenitic stainless steel and Zircaloy cladding. Reactor water chemistry limits will be established to provide an environment favorable to these materials. Design limits will be placed on conductivity and chloride concentrations. Operationally, the conductivity will be limited because it can be measured continuously and reliably. In addition, conductivity measurements will provide an indication of abnormal conditions and the presence of unusual materials in the coolant. Chloride limits will be specified to prevent stress corrosion cracking of stainless steel.

It should be noted that the service water chemical injection system, DTS, and potable water processing system operate the same in all plant operational modes (i.e., there is no difference in how the systems operate during full power plant operations, plant shutdown/refueling, and plant startup).

Each unit has a circulating CWS, a SWS, a PWS, a DTS, and a fire protection system. The description of the chemicals injected into these systems and the effect on the effluent discharged to Harris Reservoir is presented in Table 3.3-4.

For wastes discharged to surface waters, issuance of an NPDES permit for HAR will provide compliance. It is anticipated that the number of permitted outfalls will be reduced because the AP1000 design consolidates several facility liquid-waste streams from facility operations into a single discharge point that will discharge to Harris Reservoir through one NPDES permitted outfall. Chemicals that are added to cooling water for treatment are effective at low concentrations and are mostly consumed or broken down in application.

3.3.3.1 Service Water Chemical Injection

The DCD provides the following information about service water chemical injection:

> The turbine island CFS equipment injects the required chemicals into the SWS. This injection maintains a noncorrosive, nonscale forming condition and limits biological film formation.
>
> The chemicals can be divided into six categories based upon function: biocide, algicide, pH, adjustor, corrosion inhibitor, scale inhibitor, and silt dispersant. Specific chemicals used within the system, other than biocide, are determined based on the site water conditions. The pH adjustor, corrosion inhibitor, scale inhibitor, and dispersant are metered into the system continuously or as required to maintain the proper concentrations. A sodium hypochlorite treatment system is provided for use as the biocide and controls the microorganisms that cause fouling. The biocide application frequency may vary with seasons. Algicide is applied, as necessary, to control algae formation on the cooling tower.
>
> Chemical concentrations are measured through analysis of grab samples. Chlorine residual is measured to monitor the effectiveness of the biocide treatment. Addition of water treatment chemicals is performed by chemical feed injection metering pumps and is adjusted as required.

During colder months, it may be necessary to incorporate a deicing compound into the cooling water.

The chemicals used will be subject to review and approval for use by the NCDENR. The total residual chemical concentrations in the discharges to Harris Reservoir (the supply reservoir) will be subject to discharge permit limits established by the NCDENR in the approved NPDES permit.

3.3.3.2 Chemical and Volume Control System

The CVS provides RCS purification, RCS inventory control and makeup, chemical shim and chemical control, and oxygen control, filling and pressure testing the RCS, borated makeup to auxiliary equipment, and pressurizer auxiliary spray.

The DCD provides the following information about the CVS:

> The CVS is designed to perform the following major functions:

- *Purification.* Maintain RCS fluid purity and activity level within acceptable limits.
- *RCS Inventory Control and Makeup.* Maintain the required coolant inventory in the RCS; maintain the programmed pressurizer water level during normal plant operations.
- *Chemical Shim and Chemical Control.* Maintain the reactor coolant chemistry conditions by controlling the concentration of boron in the coolant for plant startups, normal dilution to compensate for fuel depletion and shutdown boration, and provide the means for controlling the RCS pH by maintaining the proper level of lithium hydroxide.
- *Oxygen Control.* Provide the means for maintaining the proper level of dissolved hydrogen in the reactor coolant during power operation and for achieving the proper oxygen level prior to startup after each shutdown.
- *Filling and Pressure Testing the RCS*. Provide the means for filling and pressure testing the RCS. The CVS does not perform hydrostatic testing of the RCS, which is only required prior to initial startup and after major, nonroutine maintenance, but provides connections for a temporary hydrostatic test pump.
- *Borated Makeup to Auxiliary Equipment.* Provide makeup water to the primary side systems that require borated reactor grade water.
- *Pressurizer Auxiliary Spray.* Provide pressurizer auxiliary spray water for depressurization.

3.3.3.2.1 Component Description

The DCD provides the following information about the CVS components:

3.3.3.2.1.1 Chemical and Volume Control System Makeup Pumps

The DCD provides the following information about the CVS makeup pumps:

> Two centrifugal makeup pumps are provided. These pumps are driven by ac motors, and flow is controlled by positioning a control valve in the common discharge line from the pumps. A cavitating venturi in the common discharge line limits the makeup flow and provides protection from excessive pump runout. Each pump has a recirculation loop with a heat exchanger and flow control orifice to provide adequate minimum flow for pump protection. The mini-flow heat exchanger is cooled by component cooling water.

> The makeup pumps are arranged in parallel with common suction and discharge headers. Each provides full capability for normal makeup; thus, there is redundancy for normal operations. The normal makeup pump suction fluid comes from the boric acid tank and the demineralized water connection. A three-way valve in the suction header is positioned to provide a full range of concentrations.
>
> One makeup pump is capable of maintaining normal RCS inventory with leaks up to a 3/8-in. inside diameter, without an actuation of the safety injection systems. The second pump can be manually started to provide additional reactor coolant makeup.
>
> These pumps are used to pressure test the RCS. Parts of the pump in contact with reactor coolant are constructed of austenitic stainless steel. The pump motor and lube oil are air-cooled.

3.3.3.2.1.2 Chemical and Volume Control System Heat Exchangers

The DCD provides the following information about the CVS heat exchangers:

> One single-shell pass U-tube letdown heat exchanger is provided. The heat exchanger is designed to cool the purification loop flow from the regenerative heat exchanger outlet temperature to the desired letdown temperature allowing the letdown to be processed by the demineralizers while maximizing the thermal efficiency of the CVS. The letdown heat exchanger outlet temperature is controlled by the operator by remotely positioning a component cooling system flow control valve. The reactor coolant in the purification loop flows through the tubes, which are stainless steel, and component cooling water flows through the shell, which is carbon steel.
>
> Two miniflow heat exchangers are provided, one in each makeup pump miniflow recirculation line. Each heat exchanger is designed to cool the flow through the CVS makeup pump minimum flow recirculation lines to the desired temperature for pump protection. The makeup water flows through the tubes, which are stainless steel, and component cooling water flows through the shell, which is carbon steel.
>
> One regenerative heat exchanger is provided. This heat exchanger is used to recover heat from the purification loop flow leaving the RCS by reheating the fluid entering the RCS. This provides increased thermal efficiency and also reduces thermal stresses on the RCS.
>
> The design basis for this heat exchanger is the last hour of plant heatup, when expansion of the RCS requires a net removal of inventory. For this case, the regenerative heat exchanger outlet temperature must be low enough to allow the letdown heat exchanger to cool the letdown to the

desired temperature with anticipated cooling water temperatures. The reactor coolant leaving the RCS flows through the tube side of this heat exchanger, and the returning fluid flows through the shell. This arrangement places the cleaner fluid on the shell side and the lower quality fluid on the tube side, where there are fewer crevices available for crud deposition.

3.3.3.2.1.3 Chemical and Volume Control System Tanks

The DCD provides the following information about the CVS tanks:

> One boric acid tank is provided. The tank is sized to allow for one shutdown to cold shutdown followed by a shutdown for refueling at the end of the fuel cycle. The tank is vented to the atmosphere. Relatively little boric acid is used during power operation, since load follow is accomplished with gray rods and without changes in the RCS boron concentration. Therefore, the boric acid which is injected has a negligible effect on the free oxygen level in the RCS.
>
> The tank is a free-standing stainless steel cylindrical design, located outside of the buildings, with only normal freeze protection required to maintain solubility of the 2.5 weight percent boric acid.
>
> One boric acid batching tank is provided and is a cylindrical tank with an immersion heater used in the preparation of 2.5 weight percent boric acid. A mixer is included with the tank. The tank is constructed of austenitic stainless steel and is provided with fill, vent and drain connections.
>
> One chemical mixing tank is provided and is a small vertical, cylindrical tank sized to provide sufficient capacity for injecting an oxygen scavenger solution necessary to provide a concentration of 10 parts per million (ppm) in the cold RCS for oxygen scavenging. A variety of chemicals to be added to the primary system are mixed in the tank. The solution to be injected is placed into the mixing tank and then flushed to the suction of the makeup pumps with demineralized water. The tank is constructed of austenitic stainless steel and is provided with fill, vent, and drain connections.

3.3.3.2.1.4 Chemical and Volume Control System Demineralizers

The DCD provides the following information about the CVS demineralizers:

> One cation resin bed demineralizer is located downstream of the mixed bed demineralizers and is used intermittently to control the concentration of lithium-7 (pH control) in the RCS. The demineralizer is sized to accommodate maximum purification flow when in service, which is adequate to control the lithium-7 and/or cesium concentration in the reactor coolant.

> The demineralizer vessel is designed for RCS pressure and is constructed of austenitic stainless steel, with connections for resin addition, replacement, flushing, and draining.
>
> The vessel incorporates a retention screen, an inflow screen, and mesh screens on the drain connections. The screens are designed to retain the resin with minimum pressure drop. The inflow screen prevents inadvertent flushing of the resin into the purification loop through the demineralizer inlet and also deflects the incoming flow to preserve a smooth resin bed.
>
> Two mixed bed demineralizers are provided in the purification loop to maintain reactor coolant purity. A mixture of lithiated cation and anion resin is used in the demineralizer. Both forms of resin remove fission and corrosion products. Each demineralizer is sized to accept the full purification flow during normal plant operation and to have a minimum design life of one core cycle. The construction of the mixed bed demineralizers is identical to that of the cation bed demineralizer.

3.3.3.2.1.5 Chemical and Volume Control System Filters

The DCD provides the following information about the CVS filters:

> One makeup filter is provided to collect particulates in the makeup stream, such as boric acid tank sediment. The filter is designed to accept maximum makeup flow. The unit is constructed of austenitic stainless steel with a disposable synthetic cartridge and is designed for RCS hydrostatic test pressure.
>
> Two reactor coolant filters are provided. The filters are designed to collect resin fines and particulate matter from the purification stream. Each filter is designed to accept maximum purification flow. The units are constructed of austenitic stainless steel with disposable synthetic cartridges and are designed for RCS pressure.

3.3.3.2.1.6 Chemical and Volume Control System Letdown Orifice

The DCD provides the following information about the CVS letdown orifice:

> One letdown orifice is provided in the letdown line, where fluid leaves the high-pressure purification loop before it exits containment. The orifice limits the letdown flow to a rate compatible with the CVS equipment and also plant heatup and dilution requirements. The orifice consists of an assembly that provides for permanent pressure loss without recovery and is made of austenitic stainless steel. A manual bypass line is provided around the orifice to allow shutdown purification and degassing when the RCS pressure is low.

3.3.3.2.1.7 Chemical and Volume Control System Valves

The DCD provides the following information about the CVS valves:

> The CVS valves are stainless steel for compatibility with the borated reactor coolant. Isolation valves are provided at connections to the RCS. They include the following:
>
> - Purification Stop Valves.
> - Letdown Flow Inside Containment Isolation Valve.
> - Letdown Flow Outside Containment Isolation Valve.
> - Makeup Stop Valve.
> - Auxiliary Spray Line Isolation Valve.
> - Makeup Line Containment Isolation Valves.
> - Hydrogen Addition Containment Isolation Valve.
> - Demineralized Water System Isolation Valves.
> - Makeup Pump Suction Header Valve.
> - Makeup Pump Suction Relief Valves.
> - Letdown Line Relief Valve.
> - Resin Sluice Line Relief Valve.

3.3.3.2.1.8 Piping Requirements

The DCD provides the following information about the CVS piping requirements:

> The CVS piping that handles radioactive liquid is made of austenitic stainless steel. The piping joints and connections are welded, except where flanged connections are required for equipment removal for maintenance and hydrostatic testing.

3.3.3.2.2 Plant Startup

The DCD provides the following information about plant startup:

> Plant startup is the operation that brings the reactor plant from a cold shutdown condition to no-load operating temperature and pressure, and subsequently to power operation.
>
> Criticality is achieved as follows:
>
> - The RCS boron concentration is reduced to the calculated level by dilution, routing effluent from the CVS purification loop to the liquid radwaste system, and by providing unborated makeup with the makeup pumps taking suction from the demineralized water storage tank.

- Chemical analysis is used to measure water quality, boron concentration, and hydrogen concentration.
- Appropriate control rods are withdrawn.
- Further adjustments in boron concentration are made to establish preferred control group rod positions.

3.3.3.2.3 Normal Operation

The DCD provides the following information about normal operation:

> Normal operation consists of operation at steady power (base load) level, load follow operation, and hot standby.

3.3.3.2.3.1 Base Load Operation

The DCD provides the following information about base load operation:

> At a constant power level, the CVS purification loop operates continuously as a closed loop around a reactor coolant pump. The purification flow is approximately 100 gpm with one mixed bed demineralizer and one reactor coolant filter in service. The CVS makeup pumps and the letdown line to the liquid radwaste system are not normally operating. The makeup pumps are normally available and are set to start automatically on low pressurizer level. The boric acid blending valve in the pump suction permits the operator to preset the blend of boric acid and demineralized water to achieve the desired makeup concentration. The letdown control valve opens automatically, if the pressurizer level reaches its high (relative to programmed level) setpoint. Reactor coolant samples are taken to check boron and H_2 concentration, water quality, pH, and activity level.
>
> Variations in power demand are accommodated automatically by control rod and gray rod movement. The only adjustments in boron concentration necessary are those to compensate for core burnup. These adjustments are made to maintain the rod control groups within their allowable limits by setting the makeup pumps to provide the required amount of demineralized water as makeup. If necessary, effluent is automatically routed to the liquid radwaste system to maintain the required pressurizer level.

3.3.3.2.3.2 Load Follow Operation

The DCD provides the following information about load follow operation:

> Load follow power changes and the resulting xenon changes are accommodated by the control rods and gray rods, with no changes

> required to the RCS boron concentration. The CVS does not have load follow functions.

3.3.3.2.4 Plant Shutdown

3.3.3.2.4.1 Hot Shutdown

The DCD provides the following information about hot shutdown:

> If required for periods of maintenance or following spurious reactor trips, the reactor is maintained subcritical, with the capability to return to full power within the period of time required to withdraw the control rods. During hot standby operation, the average temperature is maintained at no-load T_{avg} by initially dumping steam to the condenser to provide residual heat removal, or at later stages by running the reactor coolant pumps to maintain system temperature.

3.3.3.2.4.2 Cold Shutdown

The DCD provides the following information about cold shutdown:

> Cold shutdown is the operation that brings the reactor plant from normal operating temperature and pressure to a cold shutdown temperature and pressure for maintenance or refueling.

3.3.3.2.4.3 Ion Exchange Media Replacement

The DCD provides the following information about ion exchange media replacement:

> The initial and subsequent fill of ion exchange media is made through a resin fill nozzle on the top of the ion exchange vessel. When the media is spent and ready to be transferred to the solid radwaste system (WSS), the vessel is isolated from the process flow. The flush water line is opened to the sluice piping and demineralized water is pumped into the vessel through the normal process outlet connection upward through the media retention screen. The media fluidizes in the upward, reverse flow. When the bed has been fluidized, the sluice connection is opened and the bed is sluiced to the spent resin tanks in the solid radwaste system. Demineralized water flow continues until the bed has been removed and the sluice lines are flushed clean of spent resin.

3.3.3.3 Turbine Island Chemical Feed System

The DCD provides the following information about the turbine island CFS:

> The turbine island chemical feed system (CFS) injects required chemicals into the condensate (CDS), feedwater (FWS), auxiliary steam (ASS),

> circulating water (CWS), service water (SWS), demineralized water treatment (DTS) and PWS systems. CFS components are located in the turbine building.

3.3.3.4 Demineralized Water Treatment System

Note: Subsection 3.3.1.3 also discusses the DTS.

The DCD provides the following information about the DTS:

> After receiving water from the RWS, the filtered water is pumped to the DTS. The DTS is a water purification system consisting of filters, pumps, RO units, an electrodeionization unit, and associated piping, valves, and instrumentation.
>
> A pH adjustment chemical is added upstream of the cartridge filters to adjust the pH of the RO influent. The pH is maintained within the operating range of the RO membranes to inhibit scaling and corrosion.
>
> A dilute antiscalant, which is chemically compatible with the pH adjustment chemical feed, is metered into the RO influent water to increase the solubility of the salts (decrease scale formation on the membranes).

Table 3.3-5 provides guidelines for demineralized water measured at the outlet of the DTS.

3.3.3.5 Potable Water

Potable water used throughout the plant will typically be processed through an RO filtration system and, if necessary, be treated with an anti-bacterial inhibitor (such as chlorine).

3.3.4 REFERENCES

3.3-001 Carolina Power & Light Company, “Shearon Harris Nuclear Power Plant Final Safety Analysis Report,” Amendments 15, 27, 48, and 51, 1983.

3.3-002 Worley Parsons, "Final Plant Water Usage Data, HAR New Units (based on two AP1000 units)," Revision 3, WorleyParsons Design Information Transmittal No. WP-009, April 30, 2007.

Table 3.3-1
Nominal Service Water Flows and Heat Loads at Different Operating Modes

Operation Mode	CCS Pumps and Heat Exchangers	SWS Pumps and Cooling Tower Cells (Number Normally in Service	Flow (gpm)	Heat Transferred (Btu/hr)
Normal Operation (Full Load)	1	1	10,500	1.03E+08
Cooldown	2	2	21,000	3.46E+08 (1.73E+08 per cell)
Refueling (Full Core Offload)	1	1	10,500	7.49E+07
Plant Startup	2	2	21,000	7.58E+07
Minimum to Support Shutdown Cooling and Spent Fuel Cooling	1	1	10,000	1.70E+08

Notes:

Btu/hr = British thermal units per hour
CCS = component cooling water system
gpm = gallon per minute
SWS = service water system

Table 3.3-2
Required Raw Water Supply for Cooling Towers Used for Turbine Cycle and Other Related Raw Water Usage (Based on Two AP1000s)

Service	Normal	Maximum
Cooling Tower Makeup (Evaporation and Drift + Blowdown)	40,220 gpm	----
Service Water (SW) Tower (Evaporation and Drift)	326 gpm	1304 gpm
Service Water (SW) Tower Makeup	644 gpm	1600 gpm
Raw Water to Makeup Demineralizers	1080 gpm (main and SW RW pumps)	----
Raw Water Use	130 gpm (main and SW RW pumps)	----
Fire Protection	----	625 gpm
Main Raw Water Pump Strainer Backwash	1800 gpm	----
Service Water RW Pump Strainer	800 gpm	-----
Media Filter Backwash	1000 gpm	-----

Source: Reference 3.3-002

Table 3.3-3
Water Returned to Harris Reservoir from the Operation of the HAR Facility (Based on Two AP1000s)

Service	Normal	Maximum
Cooling Tower Blowdown	13,200 gpm	26,400 gpm
Service Water Tower Blowdown	317 gpm	500 gpm
Sanitary Waste Discharge (This is the discharge from the potable/sanitary water system.)	75 gpm	210 gpm
Demineralizer Water Discharge to Waste	360 gpm	----
Main Raw Water Pump Strainer Backwash	1800 gpm	----
Service Water RW Pump Strainer	800 gpm	-----
Media Filter Backwash	1000 gpm	-----

Source: Reference 3.3-002

Table 3.3-4 (Sheet 1 of 2) Chemicals Added to Liquid Effluent Streams for Each Unit

System	Chemical-Type/Specific	Amount Used/yr	Frequency of Use	Waste Stream Concentrations
CWS	Biocide/sodium hypochlorite (NaClO)	1,020,928 l (269,730 gal)	Continuous	0.2 ppm residual chlorine or 0.36 ppm sodium hypochlorite
CWS	Algaecide/quarternary amine (ammonium chloride, [NH_4Cl])	1,026,037.8 l (271,080 gal)	Continuous	0.2 ppm residual chlorine or 0.303 ppm ammonium chloride
CWS	pH adjustment/ sulphuric acid (H_2SO_4)	35,225 l (9,306.5 gal)	Continuous	2.237 ppm H_2SO_4
CWS	Corrosion Inhibitor/ ortho-polyphosphate	624,684 l (165,042 gal)	Continuous	30 ppm orthopolyphosphate
CWS	Silt Dispersant/ polyacrylate	473,125 l (125,000 gal)	Continuous	150 ppm polyacrylate
SWS	Biocide/sodium hypochlorite (NaClO)	1362.6 l (360 gal)	~1 hour per day (hr/day)	0.2 ppm residual chlorine or 0.36 ppm sodium hypochlorite
SWS	Algaecide/ quarternary amine (ammoniumchloride, NH_4Cl)	1366.4 l (361 gal)	~1 hr/day	0.2 ppm residual chlorine or 0.303 ppm ammonium chloride
SWS	pH adjustment/sulphuric acid (H_2SO_4)	23.47 l (6.2 gal)	~1 min/ 24 hr day	2.237 ppm H_2SO_4
SWS	Corrosion Inhibitor ortho-polyphosphate	416.35 l (110 gal)	~1.3% of the time	30 ppm orthopolyphosphate
SWS	Silt Dispersant/ polyacrylate	2838.8 l (750 gal)	~9% of the time	150 ppm polyacrylate
SWS	Antiscalant/ phosphonate	303 l (80 gal)	~0.91% of the time	20 ppm phosphonate
DTS	pH adjustment/sulphuric acid (H_2SO_4)	70.97 l (18.75 gal)	Intermittent	2.254-6.762 ppm H_2SO_4
DTS	Coagulant/ polyaluminum Chloride	450.4 l (119 gal)	Intermittent	5-15 mg/l (4.2E-05 - 1.3E-04 pounds per gallon [lb/gal])
DTS	Anti-scalant/polyacrylate	8516 l (2250 gal)	Intermittent	150-450 ppm polyacrylate
BDS	Oxygen scavenging/ Hydrazine(N_2H_4)	200.6 l (53 gal)	37.85 l/hr (10 gph) for 2.5 hrs/yr or 1.25 hrs/shutdown	200 ppm hydrazine (if steam generator is drained to the WWS)

**Table 3.3-4 (Sheet 2 of 2)
Chemicals Added to Liquid Effluent Streams for Each Unit**

System	Chemical-Type/Specific	Amount Used/yr	Frequency of Use	Waste Stream Concentrations
BDS	pH adjustment/ ammonium hydroxide (NH_4OH)	783.5 l (207 gal)	37.85 l/hr (10 gph), 20.7 hrs/yr or 10.4 hrs/shutdown	100 ppm ammonia (if steam generator is drained to WWS)

Table 3.3-5
Guidelines for Demineralized Water
(Measured at the Outlet of the Demineralized Water Treatment System)

Parameters	Normal Value	Initiate Action
Specific conductivity, μS/cm at 77°F	≤ 0.1	≤ 0.2
Active silica, ppb	≤ 10	≤ 20
Total silica, ppb	≤ 50	
Suspended solids, ppb	≤ 50	
Aluminum, ppb	≤ 20	
Calcium, ppb	≤ 5	
Magnesium, ppb	≤ 5	
Chloride, ppb	≤ 1	
Sulfate, ppb	≤ 1	
Total organic carbon, ppb	≤ 100	

Notes:

μS/cm = microSiemens per centimeter
gal = gallon
ppb = parts per billion

3.4 COOLING SYSTEM

Subsection 3.4.1 describes the HAR cooling systems and their anticipated modes of operation. Subsection 3.4.2 presents design data and performance characteristics for these cooling system components. The parameters provided are used to evaluate the effects to the environment from cooling system operations. These design parameters help determine the environmental effects on the site and the suitability of the site for a nuclear facility.

NUREG-1555 requires that this section address the following topical areas:

- Intake Flow Rates (Table 3.3-2 and Figure 3.3-3).
- Discharge Flow Rates (Table 3.3-3 and Figure 3.3-3).
- Circulating Water Flow Rates (Figures 3.3-1 and 3.3-2).
- Other Major Plant System Flow Rates (Figures 3.3-1 and 3.3-2).
- Temperature Rise across the Condenser (Table 3.2-3).
- Temperature Rise across Heat Exchangers in the Service Water System (Note: the heat exchangers served by the SWS are part of the component cooling water system).
- Heat Dissipation System Discharge Temperatures (discharge to Harris Reservoir will be dictated by NCDENR NPDES permit requirements).
- Chemical Concentration Factors for Major Cooling System Components (Table 3.3-4).
- Frequency and Duration of Operation for Each Mode.
- Average Discharge Temperatures for Each Month of the Year (Subsection 3.2.6.3).

As noted above, this section, as well as other sections of Chapter 3, contain a discussion of these parameters.

3.4.1 DESCRIPTION AND OPERATIONAL MODES

3.4.1.1 Cooling Water Source

The HAR will be located between Tom Jack Creek and Thomas Creek. These creeks are two of the tributaries of White Oak Creek; White Oak Creek is a tributary of Buckhorn Creek (Reference 3.4-001).

The principle source of water for the HAR will be the expanded Harris Reservoir. A 1460 hectares (ha) (3610 acres [ac.] or 5.6 square miles [$mi.^2$]) Harris Reservoir was constructed on Buckhorn Creek (a tributary of the Cape Fear River) to serve as the source of cooling tower makeup for the HNP. A smaller 146 ha (360 ac. or 0.6 $mi.^2$) Auxiliary Reservoir was built to serve as the primary source for the Emergency Cooling Water System for HNP. (Reference 3.4-002) The Auxiliary Reservoir will not be used by the HAR.

The Main Reservoir, situated on Buckhorn Creek, is impounded by an earthen dam located just below the confluence of White Oak Creek and Buckhorn Creek. The Auxiliary Reservoir, located on Tom Jack Creek, is formed by an earthen dam situated to the west of the plant island. There are two creeks adjacent to the HAR–Tom Jack Creek to the west and Thomas Creek to the east (Reference 3.4-001).

Operations at HAR will require additional makeup water from Harris Reservoir. The construction of a Harris Lake makeup water system intake structure and Harris Lake makeup water system pumphouse on the Cape Fear River is proposed (Figure 3.3-4). A new makeup water pipeline will be constructed that will provide makeup water from the Cape Fear River to Harris Reservoir to support HAR operations. The pipeline will be constructed in an existing ROW (Figures 4.0-1, 4.0-4, and 4.0-10).

A new outfall structure will be constructed on Harris Reservoir (Figure 3.3-4). Water from the Cape Fear River will be used to maintain the level of Harris Reservoir to provide adequate cooling tower makeup water to support the new units (Figure 4.0-1).

HAR 2 and HAR 3 will collect cooling tower makeup water at the proposed raw water pumphouse located on the Thomas Creek arm of the Main Reservoir east of the site and approximately 975.4 m (3200 ft.) north of the HNP cooling tower makeup water intake channel (Figure 4.0-1). An illustration of the intake structure is provided as Figure 3.3-5.

Makeup water will be obtained from the Cape Fear River to maintain the proposed operating level of the Main Reservoir. The Harris Lake makeup water system has been designed to maintain the required reservoir level. This system includes the Intake Channel in the Cape Fear River, the Harris Lake makeup water system pumphouse on the Cape Fear River, the Harris Lake makeup water system pipeline from the Cape Fear River to the Main Reservoir, and the Harris Lake makeup water system Discharge structure on the Main Reservoir (Figures 4.0-1, 4.0-5, and 3.3-3).

A new Harris Lake makeup water system intake structure, Harris Lake makeup water system pumphouse, and Harris Lake makeup water system pipeline will be required to move water from the Cape Fear River to Harris Reservoir (Figures 4.0-1 and 4.0-5). The Harris Lake makeup water system intake structure will be constructed immediately upstream of the Buckhorn Dam within a dredged intake channel to the Cape Fear River main channel. The Harris Lake makeup water system pumphouse will be on the eastern bank of the Cape Fear River north of the Buckhorn Dam adjacent to the existing Cape Fear Steam Plant's discharge canal. The proposed Harris Lake makeup water system pipeline will extend along existing ROWs to the shore of Harris Reservoir.

The Harris Lake makeup water system pumphouse is proposed to be located in a small cove on the east side of the Cape Fear River, just north of Buckhorn Dam (Figure 4.0-5). An intake channel, with a width of approximately 10.7 m (35 ft.), will be dredged into the cove. The channel will consist of reinforced concrete slab with sloped riprap sides. The Harris Lake makeup water system intake structure and Harris Lake makeup water system pumphouse will encompass approximately 1.4 ha (3.4 ac. or 0.0053 mi.^{2}) (Figure 4.0-5).

3.4.1.2 Service Water Cooling System

Westinghouse's DCD provides the following information about the SWS:

> The SWS (for each unit) is arranged in two trains of components and piping. Each train includes one service water pump and one strainer. Each train provides 100-percent capacity cooling for normal power operation. Cross connections between the trains upstream and downstream of the component cooling water system heat exchangers allows either service water pump to supply either heat exchanger, and allows either heat exchanger to discharge to the basin.

The DCD provides the following information about the service water cooling system:

> The service water cooling system (normal heat sink) will provide cooling water to the component cooling water system heat exchangers located in the turbine building.
>
> The heated water from the components will be returned to the cooling towers for rejection of the heat to the atmosphere. Blowdown, from the circulating water and SWS pumps, will be used to control the concentration of impurities in the water due to evaporation in the cooling towers.

The DCD provides the following additional information about the SWS:

> A small portion of the service water flow is normally diverted to the circulating water system. This blowdown is used to control levels of solids concentration in the SWS. An alternate blowdown flow path is provided to the WWS.
>
> Temperatures in the system are moderate and the pressure of the SWS fluid is kept above saturation at all locations. This, along with other design

> features of the system arrangement and control of valves, minimizes the potential for thermodynamic or transient water hammer.
>
> Service water system materials are compatible with the cooling water chemistry and the chemicals used for the control of long-term corrosion and organic fouling. Water chemistry is controlled by the turbine island CFS.

3.4.1.2.1 Service Water System Operational Modes

The DCD provides the following information about system operation:

> The SWS operates during normal modes of plant operation, including startup, power operation (full and partial loads), cooldown, shutdown, and refueling. The SWS is also available during loss of normal ac power conditions.

3.4.1.2.1.1 Service Water System Startup

The DCD provides the following information about SWS startup:

> For initial system startup, service water piping and equipment can be filled with raw water. Thereafter, at least one train normally remains in service. An inactive train is started by starting the associated pump and realigning valves as required.

3.4.1.2.1.2 Plant Startup

The DCD provides the following information about plant startup:

> During plant startup, the SWS normally provides service to both component cooling water system heat exchangers. This requires that both service water pumps, strainers, and cooling tower basin be in service. At the end of this phase of operation, when one of the component cooling water system heat exchangers is removed from service, one of the service water pumps, strainers and cooling tower basin may also be removed from service.

3.4.1.2.1.3 Power Operation

The DCD provides the following information about power operation:

> The SWS, during normal power operation, provides cooling water at a maximum temperature of 93.5°F to the component cooling water heat exchanger in service.

Table 3.4-1 presents the flow rate and heat load.

The DCD provides the following additional information about power operation:

> The standby service water pump is automatically started if the operating pump should fail, thereby providing a reliable source of cooling water. The system is designed so either pump can serve as the operating or standby pump.

3.4.1.2.1.4 Plant Cooldown/Shutdown

The DCD provides the following information about plant cooldown/shutdown:

> During the plant cooldown phase in which the RNS has been placed in service and is providing shutdown cooling, the service water cooling tower provides cooling water at a temperature of 88.5°F or less when operating at design heat load. Two service water pumps and the cooling tower basin are normally used for plant cooldown, and the cross-connection valves between trains are normally closed. During these modes of operation the RNS and the component cooling water system remove sensible and decay heat from the RCS. In the event of failure of a SWS pump, the cooldown time is extended.

3.4.1.2.1.5 Refueling

The DCD provides the following information about refueling:

> During refueling, the SWS normally provides cooling water flow to both component cooling water system heat exchangers. Two service water pumps normally provide flow through the system for refueling modes.

3.4.1.2.1.6 Loss of Normal AC Power Operation

The DCD provides the following information about loss of normal ac power operation:

> In the event of loss of normal ac power, the service water pumps, along with the associated motor operated valves, are automatically loaded onto their associated diesel bus. This includes isolation of cooling tower blowdown, which minimizes drain down of the system while both pumps are off. What drainage of system fluid that does occur is replaced by air without vapor cavities. The potential for water hammer on pump restart is minimized. Pumps automatically start after power from the diesel generator is available. Following automatic start, the operator may return the system to the appropriate configuration.

3.4.1.3 Component Cooling Water System

The DCD provides the following information about the component cooling water system:

> The component cooling water system is a non-safety-related, closed loop cooling system that transfers heat from various plant components to the SWS during normal phases of operation. It removes heat from various components needed for plant operation and removes core decay heat and sensible heat for normal reactor shutdown and cooldown.
>
> Westinghouse's AP1000 Reactor component cooling water system provides a barrier to the release of radioactivity between the plant components being cooled that handle radioactive fluid and the environment. The component cooling water system also provides a barrier against leakage of service water into primary containment and reactor systems.

Circulating water and service water pumps take suction from the cooling tower basin and supply water to the components for cooling. The heated water from the components is returned to the cooling towers for rejection of the heat to the atmosphere. The makeup water supply for the cooling towers is taken from Harris Reservoir. Pumps for the makeup water are located in a new Harris Lake makeup water system intake structure. The intake water for the facility passes through bar racks or similar devices to remove large debris. In addition, it passes through traveling screens to remove smaller debris before entering the pump suction chamber. The approach velocity to the intake is limited to a maximum velocity of 0.2 meters per second (m/s) (0.5 feet per second [fps]) (Reference 3.4-003). Trash collection baskets are provided to collect trash from the screen washwater for approved disposal, before the washwater is discharged to Harris Reservoir. Strainers are provided on the makeup pump discharges and when the strainer backwash water is returned to Harris Reservoir.

3.4.1.3.1 Component Cooling Water System Operational Modes

The following subsections provide information about three operational aspects of the component cooling water system:

- Subsection 3.4.1.3.1.1 — Normal Operation
- Subsection 3.4.1.3.1.2 — Normal Plant Cooldown
- Subsection 3.4.1.3.1.3 — Refueling

3.4.1.3.1.1 Normal Operation

The DCD provides the following information about normal operation:

> The component cooling water system transfers heat from various plant components needed to support normal power operation with a single active component failure. The component cooling water system is designed for normal operation in accordance with the following criteria:

- The component cooling water supply temperature to plant components is not more than 99°F for service water cooling at normal operations.

- The minimum component cooling water supply temperature to plant components is 60°F.

- The component cooling water system provides sufficient surge capacity to accept 50 gpm leakages into or out of the system for 30 minutes before any operator action is required.

3.4.1.3.1.2 Normal Plant Cooldown

The DCD provides the following information about normal plant cooldown:

> The first phase of plant cooldown is accomplished by transferring heat from the RCS via the SGs to the main steam systems. The component cooling water system, in conjunction with the RNS removes both residual and sensible heat from the core and the RCS and reduces the temperature of the RCS during the second phase of cooldown.
>
> The component cooling water system reduces the temperature of the RCS from 350°F at approximately 4 hours after reactor shutdown to 125°F within 96 hours after shutdown by providing cooling to the RNS heat exchangers. In addition to the cooldown time requirements, other system design criteria during cooldown are as follows:

- Operation is consistent with the established RCS cooldown rates while maintaining the component cooling water supply below 110°F.

- The system design prevents boiling in the component cooling water system during plant cooldown.

- A single failure of an active component during normal cooldown will not cause an increase in RCS temperature above 350°F. Such a single failure also will not cause the RCS to boil once the reactor vessel head has been removed and the refueling cavity flooded. The component cooling system continues to provide cooling water to the RNS throughout the shutdown after cooldown is complete.

3.4.1.3.1.3 Refueling

The DCD provides the following information about refueling:

> During fuel shuffling (partial core off-load) or a full core off-load, cooling water flow is provided to spent fuel pool heat exchangers to cool the

spent fuel pool. For a full core off-load cooling water is also supplied to a normal residual heat removal heat exchanger as part of spent fuel pool cooling. The system design criteria during refueling are as follows:

- System operation is with both component cooling water system mechanical trains available.

- The component cooling water system maintains the spent fuel pool water temperature below 120°F for service water cooling.

3.4.2 COMPONENT AND SYSTEM DESCRIPTIONS

3.4.2.1 Service Water Cooling System Description

The DCD provides the following information about the service water cooling system component description:

> The SWS supplies cooling water to remove heat from the non-safety-related component cooling water system (CCS) heat exchangers in the turbine building. The SWS provides cooling water to the component cooling water system heat exchangers located in the turbine building.
>
> During normal power operation, the SWS supplies cooling water at a maximum temperature of 93.5°F to one component cooling water heat exchanger. During plant cooldown and refueling, the SWS supplies cooling water to both component cooling water heat exchangers to support the cooling requirements for the component cooling water system.
>
> The system consists of two 100-percent capacity service water pumps, automatic backwash strainers, a cooling tower basin, and associated piping, valves, controls, and instrumentation.
>
> The service water pumps, located in the turbine building, take suction from piping which connects to the basin of the service water cooling tower. Service water is pumped through strainers to the component cooling water heat exchangers for removal of heat. Heated service water from the heat exchangers then returns through piping to a hyperbolic natural draft cooling tower where the system heat is rejected to the atmosphere. Cool water, collected in the tower basin, flows through fixed screens to the pump suction piping for recirculation through the system.
>
> A small portion of the service water flow is normally diverted to the circulating water system. This blowdown is used to control levels of solids concentration in the SWS. An alternate blowdown flow path is provided to the WWS.

> The SWS is arranged into two trains of components and piping. Each train includes one service water pump, and one strainer. Each train provides 100-percent capacity cooling for normal power operation. Cross connections between the trains upstream and downstream of the component cooling water system heat exchangers allows either service water pump to supply either heat exchanger, and allows either heat exchanger to discharge to the cooling tower basin.
>
> Temperatures in the system are moderate and the pressure of the SWS fluid is kept above saturation at all locations. This, along with other design features of the system arrangement and control of valves, minimizes the potential for thermodynamic or transient water hammer.
>
> Service water system materials are compatible with the cooling water chemistry and the chemicals used for the control of long-term corrosion and organic fouling. Water chemistry is controlled by the turbine island CFS.

3.4.2.1.1 Component Description

The next subsections provide information related to the following components:

- Subsection 3.4.2.1.1.1 — Service Water Chemical Injection System
- Subsection 3.4.2.1.1.2 — Service Water Towers
- Subsection 3.4.2.1.1.3 — Service Water Strainers
- Subsection 3.4.2.1.1.4 — Service Water Pumps
- Subsection 3.4.2.1.1.5 — Service Water System Valves
- Subsection 3.4.2.1.1.6 — Facility Intake Structure
- Subsection 3.4.2.1.1.7 — Discharge Line

3.4.2.1.1.1 Service Water Chemical Injection System

The DCD provides the following information about the service water chemical injection system:

> The turbine island CFS equipment injects the required chemicals into the SWS. This injection maintains a noncorrosive, nonscale forming condition and limits biological film formation. Chemicals are injected into service water pump discharge piping located in the turbine building.

3.4.2.1.1.2 Service Water Towers

The service water tower makeup water, evaporation, and drift rate is estimated at 3,672 liter per minute (l/min) (970 gpm) with an associated blowdown rate of 1,200 l/min. (317 gpm) during normal operations and a maximum estimated usage of 10,993 l/min. (2,904 gpm) with an associated blowdown rate of 1,893 l/min. (500 gpm). Normal net consumptive water usage from Harris Reservoir for the SWS is estimated at 4,172 l/min. (1,102 gpm) (Figure 3.3-3) (Reference 3.4-004).

After usage, the service water tower blowdown water will be discharged into Harris Reservoir through a new discharge line installed parallel to the current discharge pipe for the HNP (Figures 4.0-1 and 4.0-10).

3.4.2.1.1.3 Service Water Strainers

The DCD provides the following information about service water strainers:

> An automatic self-cleaning strainer will be located in the service water supply piping to each component cooling water heat exchanger. The strainer is sized for a capacity compatible with the flow through the heat exchanger. When in service, each strainer will periodically backwash on a timed cycle, or will backwash if the differential pressure across the strainer exceeds a setpoint. The backwash cleaning features of the strainer can also be manually actuated. Backwash flow from the strainers will be discharged to waste at the wastewater retention basins.

The DCD provides the following additional information about service water strainers:

> The service water strainers are provided with air-operated backwash valves which open during a backwash cycle. These valves fail closed upon loss of control air or electrical power.

3.4.2.1.1.4 Service Water Pumps

The DCD provides the following information about service water pumps:

> The service water pumps are vertical, centrifugal, constant speed, electric motor-driven pumps. The pumping elements of each pump are enclosed within a suction barrel which connects to supply piping from the cooling tower basin. The suction barrel of each pump is located in the circulating water pipe trench area of the turbine building. The pumps are powered from the normal ac power system and are backed by the standby power source for occurrences of loss of normal ac power. Each pump provides 100 percent of the normal power operation flow requirements and is therefore capable of supporting normal power operation with one pump out of service for maintenance.

> The starting logic for the service water pumps requires at least one of the cooling tower valves to be open prior to pump start to provide a flow path through the cooling tower or tower bypass. The pump starting logic also interlocks with the motor operated valve at the discharge of each pump. The pump starts with the discharge valve closed and the valve then opens at a controlled rate to slowly admit water to the system while maintaining pump minimum flow. This feature results in reduced fluid velocities during system start to minimize transient effects that may occur as the system sweeps out air that may be present and obtains a water solid condition.

3.4.2.1.1.5 Service Water System Valves

The DCD provides the following information about SWS valves:

> Manual isolation valves upstream and downstream of each component cooling water system heat exchanger can be used to isolate the heat exchanger and associated strainer from the SWS. The upstream valves are also normally used during power operation to align the SWS to the component cooling water heat exchanger in use by blocking flow to the inactive heat exchanger. Manual valves in the cross-connection lines between the two service water trains are normally open during power operation to allow the standby pump to quickly be placed in service if needed. The cross-connection valves are closed as necessary to isolate portions of the system for maintenance, and are normally closed when the system is configured for plant shutdown cooling with both trains in operation.
>
> A motor-operated isolation valve downstream of each pump automatically closes when the associated pump stops and automatically opens when the pump starts.
>
> An air-operated control valve will be provided in the cooling tower blowdown line. This valve allows the plant operator to set the blowdown flowrate. The valve also provides automatic isolation of blowdown flow upon loss of off-site power. The valve fails closed upon loss of control air or electrical power.

3.4.2.1.1.6 Facility Intake Structure

Operations at HAR will require additional makeup water from Harris Reservoir. The construction of the Harris Lake makeup water system intake structure and Harris Lake makeup water system pumphouse on the Cape Fear River is proposed (Figure 3.3-4). A new makeup water pipeline will be constructed that will provide makeup water from the Cape Fear River to Harris Reservoir to support HAR operations. The pipeline will be constructed in an existing ROW (Figures 4.0-1, 4.0-4, and 4.0-10).

A new outfall structure will be constructed on Harris Reservoir (Figure 3.3-4). Water from the Cape Fear River will be used to maintain the level of Harris Reservoir to provide adequate cooling tower makeup water to support the new units (Figure 4.0-1).

HAR 2 and HAR 3 will collect cooling tower makeup water at the proposed raw water pumphouse located on the Thomas Creek arm of the Main Reservoir east of the site and approximately 975.4 m (3200 ft.) north of the HNP cooling tower makeup water intake channel (Figure 4.0-1). An illustration of the intake structure is provided as Figure 3.3-5.

Makeup water will be obtained from the Cape Fear River to maintain the proposed operating level of the Main Reservoir. The Harris Lake makeup water system has been designed to maintain the required reservoir level. This system includes the intake channel in the Cape Fear River, the Harris Lake makeup water system pumphouse on the Cape Fear River, the Harris Lake makeup water system pipeline from the Cape Fear River to the Main Reservoir, and the Harris Lake makeup water system discharge structure on the Main Reservoir (Figures 4.0-1, 4.0-5, and 3.3-3).

A new Harris Lake makeup water system intake structure, Harris Lake makeup water system pumphouse, and Harris Lake makeup water system pipeline will be required to move water from the Cape Fear River to Harris Reservoir (Figures 4.0-1 and 4.0-5). The Harris Lake makeup water system intake structure will be constructed immediately upstream of the Buckhorn Dam within a dredged intake channel to the Cape Fear River main channel. The Harris Lake makeup water system pumphouse will be on the eastern bank of the Cape Fear River north of the Buckhorn Dam adjacent to the existing Cape Fear Steam Plant's discharge canal. The proposed Harris Lake makeup water system pipeline will extend along existing ROWs to the shore of Harris Reservoir.

The Harris Lake makeup water system pumphouse is proposed to be located in a small cove on the east side of the Cape Fear River, just north of Buckhorn Dam (Figure 4.0-5). An intake channel, with a width of approximately 10.7 m (35 ft.), will be dredged into the cove. The channel will consist of reinforced concrete slab with sloped riprap sides. The Harris Lake makeup water system intake structure and Harris Lake makeup water system pumphouse will encompass approximately 1.4 ha (3.4 ac. or 0.0053 $mi.^2$) (Figure 4.0-5).

Both the CWIS and the Harris Lake makeup water system intake structure for the HAR will be designed to meet CWA 316 (b) Phase I standards.

3.4.2.1.1.7 Discharge Line

A new discharge line will be constructed to accommodate cooling tower blowdown discharges from the new units (Figures 4.0-1 and 4.0-10).

3.4.2.1.2 Component Cooling Water System Component Description

The following subsections provide general descriptions of the component cooling water system components:

- Subsection 3.4.2.1.2.1 — Component Cooling Water Pumps
- Subsection 3.4.2.1.2.2 — Component Cooling Water Heat Exchangers
- Subsection 3.4.2.1.2.3 — Component Cooling Water Surge Tank
- Subsection 3.4.2.1.2.4 — Component Cooling Water System Valves
- Subsection 3.4.2.1.2.5 — Piping Requirements

3.4.2.1.2.1 Component Cooling Water Pumps

The DCD provides the following information about component cooling water pumps:

> The two component cooling water pumps are horizontal, centrifugal pumps. They have a coupled pump shaft driven by an ac powered induction motor. Each pump provides the flow required by its respective heat exchanger for removal of its heat load. The pumps are redundant for normal operation heat loads. Both pumps are required for the cooldown; however, an extended cooldown can be achieved with only one pump in operation. One pump can be out of service during normal plant operation.

3.4.2.1.2.2 Component Cooling Water Heat Exchangers

The DCD provides the following information about component cooling water heat exchangers:

> Two component cooling water heat exchangers provide redundant cooling for normal operation heat loads. Both heat exchangers are required to achieve the design cooldown rate; however, an extended cooldown can be achieved with one heat exchanger in operation. Either heat exchanger can be aligned with either component cooling water pump allowing one heat exchanger to be out of service during normal plant operation.
>
> The component cooling water heat exchangers are plate type heat exchangers. Component cooling water circulates through one side of the heat exchanger while service water circulates through the other side. Component cooling water in the heat exchanger is maintained at a higher pressure than the service water to prevent leakage of service water into the system.

3.4.2.1.2.3 Component Cooling Water Surge Tank

The DCD provides the following information about the component cooling water surge tank:

> The component cooling water system has a single surge tank. The surge tank accommodates changes in component cooling water volume due to changes in operating temperature. The tank is designed to accommodate a 50-gpm leakage into or out of the system for 30 minutes before any operator action is required. The tank is a cylindrical, vertical unit constructed of carbon steel.

3.4.2.1.2.4 Component Cooling Water System Valves

The DCD provides the following information about component cooling water system valves:

> Most of the valves in the component cooling water system are manual valves used to isolate cooling flow from components for which cooling is not required in a given plant operating mode.
>
> Three motor-operated isolation valves and a check valve provide containment isolation for the supply and return component cooling water system lines that penetrate the containment barrier. The motor-operated valves are normally open and are closed upon receipt of a safety injection signal. They are controlled from the MCR and fail as-is.
>
> A motor-operated isolation valve is located in the component cooling water discharge line from each reactor coolant pump. These valves, which are normally open, are closed on a high component cooling water flow signal. High flow in the component cooling water discharge line indicates significant reactor coolant leakage from the pump cooling coils or thermal barrier into the component cooling water system. Closing these valves prevents radioactive reactor coolant flow through the component cooling water system.
>
> Relief valves are provided in the cooling water outlet line from each reactor coolant pump. These valves are sized to protect the pump motor cooling jacket (design pressure 200 psig) and the component cooling water piping in the event of a tube rupture in the pump motor cooling coil or thermal barrier. A relief valve in the cooling water outlet line from the letdown heat exchanger also protects the component cooling water piping in the event of a tube rupture in the heat exchanger. Small relief valves are included in the cooling water outlet line from the other components to relieve the volumetric expansion which occurs if the cooling water lines to the component are isolated and the water temperature rises.

3.4.2.1.2.5 Piping Requirements

The DCD provides the following information about piping requirements:

> Component cooling water system piping is made of carbon steel.

3.4.2.2 Instrumentation

3.4.2.2.1 Service Water System Instrumentation

The DCD provides the following information about instrumentation for the SWS:

> Pressure indication, with low and high alarms, is provided for the discharge of each service water pump. A low pressure signal automatically starts the standby pump. Flow indication, with low and high alarms, is also provided for each service water pump. Due to the system configuration, pump flow indication can also normally be used to monitor flow through the heat exchanger or heat exchangers in service.
>
> Temperature indication is provided for the service water supply to each component cooling water heat exchanger and for the discharge from each heat exchanger to determine the temperature differential across the heat exchanger. Heat exchanger inlet temperature indication also is used for performance monitoring of the service water cooling tower. Low and high heat exchanger inlet temperature alarms are provided. A high alarm is provided for the outlet temperature from each heat exchanger.
>
> Differential pressure measurement across each service water strainer is provided and will initiate backwash of the strainer on high differential. A high-high differential pressure alarm across the strainer is provided.
>
> Power actuated valves in the SWS are provided with valve position indication instrumentation. In addition, the tower bypass valves are provided with position indication instrumentation.
>
> Level indication is provided for the cooling tower basin along with high and low level alarms. The basin level signal is also used to control the normal makeup water supply valve to maintain the proper level in the cooling tower basin.
>
> A radiation monitor with a high alarm is provided to monitor the service water blowdown flow for detection of potentially radioactive leakage into the SWS from the component cooling water heat exchangers. Provisions are also available for taking local fluid samples.

3.4.2.2.2 Component Cooling Water System Instrumentation

The DCD provides the following information about instrumentation for the component cooling water system:

> Instruments are provided for monitoring system parameters. Essential system parameters are monitored in the MCR. Low flow in the discharge header automatically starts the backup component cooling water pump. A radiation monitor alarms in the MCR if reactor coolant leaks into the component cooling water system.
>
> Level instrumentation on the surge tank provides both high- and low-level alarms in the MCR. Also, at a low-tank level, a valve in the makeup water line is automatically actuated to provide makeup flow from the DWS into the component cooling water system.
>
> High flow from a leak from the reactor coolant pump motor cooling coil or thermal barrier into the component cooling water system is alarmed in the MCR.
>
> The signal also actuates a motor-operated valve which prevents reactor coolant flow from the pump with the high-flow signal into the component cooling water system.

3.4.3 REFERENCES

3.4-001 Carolina Power & Light Company, “Shearon Harris Nuclear Power Plant Final Safety Analysis Report,” Amendments 15, 27, 40, 48, 52, and 53, 1983.

3.4-002 Progress Energy Carolinas, Inc., “Applicant’s Environmental Report – Operating License Renewal Stage Shearon Harris Nuclear Plant Progress Energy, Unit 1,” Docket No. 50-400, License No. NPF-63, Final, November 2006.

3.4-003 U.S. Environmental Protection Agency, “National Pollutant Discharge Elimination System: Regulations Addressing Cooling Water Intake Structures for New Facilities; Final Rule”, *Federal Register* Vol. 66, No. 243, December 18, 2001.

3.4-004 WorleyParsons, "Final Plant Water Usage Data, HAR New Units (based on two AP1000 units)," Revision 3, WorleyParsons Design Information Transmittal No. WP-009, April 30, 2007.

Table 3.4-1
Nominal Service Water Flows and Heat Loads at Different Operating Modes

Operation Mode	CCS Pumps and Heat Exchangers	SWS Pumps and Cooling Tower Cells (Number Normally in Service	Flow (gpm)	Heat Transferred (Btu/hr)
Normal Operation (Full Load)	1	1	10,500	1.03E+08
Cooldown	2	2	21,000	3.46E+08 (1.73E+08 per cell)
Refueling (Full Core Offload)	1	1	10,500	7.49E+07
Plant Startup	2	2	21,000	7.58E+07
Minimum to Support Shutdown Cooling and Spent Fuel Cooling	1	1	10,000	1.70E+08

Notes:
Btu/hr = British thermal units per hour
CCS = component cooling water system
gpm = gallon per minute
SWS = service water system

3.5 RADIOACTIVE WASTE MANAGEMENT SYSTEMS

Westinghouse's DCD provides the following information about radioactive waste management source terms:

This section addresses the sources of radioactivity that are treated by the liquid and WGSs. Per DCD Section 11.1.1, radioactive materials are primarily generated within the core (fission products) and have the potential for leaking into the RCS by way of defects in the fuel cladding. Corrosion products are produced from activation of materials in the RCS. Tritium is produced in the fuel and can leak to the RCS and also can be produced by neutron activation of soluble Boron in the reactor coolant. The core radiation field also results in activation of the coolant to form N-16 from oxygen.

The DCD presents two source terms for the primary and secondary coolant. The first is a conservative, or design basis, source term that assumes the design basis fuel defect level. This source term serves as a basis for system design and shielding requirements.

The second source term is a (more) realistic (but less conservative) source term. This source term represents the expected average concentrations of radionuclides in the primary and the secondary coolant. The realistic source term model reflects the industry experience at a large number of operating PWRs and is the source term selected for use in this ER.

This radioactive waste management systems section provides a list of the bounding quantities of radioactive wastes that are projected to be generated, processed, and stored or released annually in liquid and gaseous effluents, and in the form of solid waste from HAR 2 and HAR 3. Table 3.5-9 presents data needed for radioactive source term calculations for PWRs. Radioactive waste management and effluent control systems will be designed to minimize releases from active reactor operations to values as low as reasonably achievable (ALARA). The HAR facility radioactive waste systems have been evaluated against the requirements of 10 CFR 20, Appendix B and 10 CFR 50, Appendix I. The systems are capable of meeting the design objectives of 10 CFR 20 and 10 CFR 50, Appendix I. They will be maintained in accordance with ALARA principles, be protective of the environment, and will minimize radiological doses to the public. Section 5.4 provides maximum individual and population doses during normal plant operations.

3.5.1 LIQUID RADIOACTIVE WASTE MANAGEMENT SYSTEM

Process flow diagrams for the AP1000 liquid pathway are illustrated on Figures 3.3-1 and 3.3-2.

The DCD provides the following information about liquid waste management systems:

> The liquid radwaste system includes tanks, pumps, ion exchangers, and filters. The liquid radwaste system is designed to process, or store for processing by mobile equipment, radioactively contaminated wastes in four major categories:
>
> - *Borated, Reactor-grade, Wastewater* – This input is collected from the RCS effluents received through the CVS, primary sampling system sink drains and equipment leakoffs and drains.
> - *Floor Drains and Other Wastes with Potentially High Suspended Solids Content* – This input is collected from various building floor drains and sumps.
> - *Detergent Wastes* – This input comes from the plant hot sinks and showers, and some cleanup and decontamination processes. It generally has low concentrations of radioactivity.
> - *Chemical Waste* – This input comes from the laboratory and other relatively small volume sources. It may be mixed hazardous and radioactive wastes or other radioactive wastes with high dissolved solids content.
>
> Radioactivity can enter the secondary systems from SG tube leakage. If significant radioactivity is detected in secondary-side systems, blowdown is diverted to the liquid radwaste system for processing and disposal.
>
> The liquid radwaste system (includes the SG blowdown processing system, radioactive waste drain system, and the liquid radwaste system) is designed to control, collect, process, handle, store, and dispose of liquid radioactive waste generated as the result of normal operation, including anticipated operational occurrences. The system provides the capability to reduce the amounts of radioactive nuclides released in the liquid wastes through the use of demineralization and time delay for decay of short-lived radionuclides.
>
> Radioactive isotopes are produced as a normal by-product of reactor operations.

The DCD provides the following information about fission products:

> For the design basis source term, it is assumed that there is a significant fuel defect level, well above that anticipated during normal operation. It is assumed that small cladding defects are present in the fuel rods producing 0.25 percent fuel defects. The defects are assumed to be uniformly distributed throughout the core.

It is expected that the HAR will run without fuel failures but for the determination of the source term it is assumed that a small quantity of these radionuclides can contribute to the normal radioactive liquid effluents released from the plant. The liquid radioactive waste management system is designed to control, collect, process, store, and dispose of potentially radioactive liquids during the phases of plant operation. This includes startup, normal operation, shutdown, refueling, and anticipated operational occurrences.

Radioactive liquid effluents can be released from the plant to the environment via waste liquid processing systems. The process systems will be designed to minimize the releases to, and impact on, the aquatic environment.

The DCD provides the following information about radioactive liquid effluent:

> Before radioactive liquid waste is discharged, it is pumped to a monitor tank. A sample of the monitor tank contents is analyzed and the results are recorded prior to discharge. If within acceptable limits the liquid waste is discharged from the monitor tank in a batch operation, and the discharge flow rate is restricted as necessary to maintain an acceptable concentration when diluted by the circulating water discharge flow. In addition, the discharge line contains a radiation monitor with diverse methods of stopping the discharge. The first method closes an isolation valve in the discharge line, which prevents any further discharge from the liquid radwaste system. The valve automatically closes and an alarm is actuated if the activity in the discharge stream reaches the monitor setpoint. The second method stops the monitor tank pumps.

Discharges from HAR to Harris Reservoir will be through a new discharge line installed parallel to the current discharge line used for the HNP (Figure 4.0-1 and Figure 4.0-10).

The release of radioactive liquid effluents from the plant will be controlled in such a manner as to not exceed the average annual effluent concentration limits (ECLs) specified in 10 CFR 20. The HAR will be operated such that releases of radioactive liquid effluent to the Harris Reservoir are expected to be negligible. To provide for a bounding assessment, the maximum quantities in Table 3.5-1 for releases of radioactive liquid wastes to the discharge line were used in the evaluation of the facility. The discharge quantity is taken from the bounding isotopic releases presented in DCD T-2 Table 11.2-7 for all isotopes. The liquid waste effluent concentrations are determined based on the highest activity content of the individual isotopes from AP1000. The discharge concentration is conservatively estimated based on an average daily discharge for 292 days per year with a 0.57 m^3/s (20 ft3/s) dilution flow. To provide for operating flexibility, a bounding assessment was performed to demonstrate the capability of complying with the 10 CFR 20 and 10 CFR 50, Appendix I, regulatory requirements at the HAR site. Compliance with the 10 CFR 20 criteria is based on demonstrating that average annual concentrations of radioactive material released in the liquid effluents at the boundary of the restricted area do not exceed the values specified in 10 CFR 20.

The fraction of ECL is determined by performing a ratio of the resulting concentrations by the 10 CFR 20 ECL limits. Table 3.5-2 was derived from the DCD T-2 Table 11.2-8, which compares the releases for those radionuclides identified in the table with the 10 CFR 20 ECLs and shows compliance to 10 CFR 20 requirements.

ER Section 5.4 discusses in detail tritium releases from the existing HNP site, as well as tritium releases from the HAR, and how they will be managed by PEC.

3.5.1.1 Sources of Radioactive Liquid Waste

The DCD provides the following information about sources of liquid radioactive waste within the plant:

Reactor Coolant System Effluents

The effluent subsystem receives borated and hydrogen-bearing liquid from two sources: the reactor coolant drain tank and the CVS. The reactor coolant drain tank collects leakage and drainage from various primary systems and components inside containment. Effluent from the CVS is produced mainly as a result of RCS heatup, boron concentration changes, and CS level reduction for refueling.

Floor Drains and Other Wastes with Potentially High Suspended Solid Contents

Potentially contaminated floor drain sumps and other sources that tend to be high in particulate loading are collected in the waste holdup tank. Additives may be introduced to the tank to improve filtration and ion exchange processes. Tank contents may be recirculated for mixing and sampling. The tanks have sufficient holdup capacity to allow time for realignment and maintenance of the process equipment.

Steam Generator Blowdown

If SG tube leakage results in significant levels of radioactivity in the SG blowdown stream, this stream is redirected to the liquid radwaste system for treatment before release. In this event, one of the waste holdup tanks is drained to prepare it for blowdown processing. The blowdown stream is brought into that holdup tank, and continuously or in batches, pumped through the waste ion exchangers. The number of ion exchangers in service is determined by the operator to provide adequate purification without excessive resin usage. The blowdown is then collected in a monitor tank, sampled, and discharged in a monitored fashion.

3.5.2 GASEOUS RADIOACTIVE WASTE MANAGEMENT SYSTEM

Process flow diagrams for the AP1000 gaseous pathway are illustrated on Figures 11.3-1 and 11.3-2 of the DCD.

The DCD provides the following information about the gaseous waste management system:

> During reactor operation, radioactive isotopes of xenon, krypton, and iodine are created as fission products. A portion of these radionuclides is released to the reactor coolant because of a small number of fuel cladding defects. Leakage of reactor coolant thus results in a release to the containment atmosphere of the noble gases.
>
> The AP1000 gaseous radwaste system is designed to perform the following major functions:
>
> - Collect gaseous wastes that are radioactive or hydrogen bearing.
> - Process and discharge the waste gas, keeping off-site releases of radioactivity within acceptable limits.

The DCD provides the following information about the gaseous radwaste system:

> The AP1000 gaseous radwaste system is a once through, ambient-temperature, activated carbon delay system. The system includes a gas cooler, a moisture separator, an activated carbon-filled guard bed, two activated carbon-filled delay beds, an oxygen analyzer subsystem, and a gas sampling subsystem. Releases from the gaseous radwaste system are continuously monitored by a radiation detector in the discharge line. In addition, the system includes provisions for taking grab samples of the discharge flow stream for analysis.

The release of radioactive gaseous effluents from the plant will be controlled and monitored so that the regulatory limits specified in 10 CFR 20 and 10 CFR 50, Appendix I, are maintained.

The DCD provides the following information about radioactive releases:

> Releases of radioactive effluent by way of the atmospheric pathway occur due to the following:
>
> - Venting of the containment which contains activity as a result of leakage of reactor coolant.
> - Ventilation discharges from the auxiliary building which contains activity as a result of leakage from process streams.

- Ventilation discharges from the turbine building.
- Condenser air removal system (gaseous activity entering the secondary coolant as a result of primary to secondary leakage is released via this pathway).
- Gaseous radwaste system discharges.

> These releases are ongoing throughout normal plant operations. There is no gaseous waste holdup capability in the gaseous waste management system and thus no criteria are required for determining the timing of releases or the release rates to be used.

The DCD provides the following information about release points:

> Airborne effluents are normally released through the plant vent or the turbine building vent. The plant vent provides the release path for containment venting releases, auxiliary building ventilation releases, annex building releases, radwaste building releases, and gaseous radwaste system discharge. The turbine building vents provide the release path for the condenser air removal system, gland seal condenser exhaust, and the turbine building ventilation releases.

The DCD does not currently provide estimates for stack heights for the various release points from the AP1000. All modeling performed for the ER assumed ground level releases.

Table 3.5-3 presents the annual average quantity of radioactive gases released from the gaseous waste processing systems and the building ventilation systems used in the evaluation of the HAR facility. Discharge quantities are taken from the bounding isotopic releases given in DCD T-2 Table 11.3-3. The gaseous effluent concentrations were determined based on the annual average release of the individual isotopes in combination with the highest sector average annual site dispersion factor at the effluent control boundary (Reference 3.5-001).

Compliance with the isotopic limits of 10 CFR 20 was based on demonstrating that the annual average concentrations of radioactive material, which would be released in the gaseous effluents at the boundary of the restricted area, would not exceed the values specified in 10 CFR 20.

Table 3.5-4, which compares the releases identified in Table 3.5-3 with the 10 CFR 20 ECLs, shows compliance with the 10 CFR 20 requirements.

3.5.2.1 Sources of Gaseous Radioactive Waste

The DCD provides the following information about normal operation of the gaseous waste management system:

The largest input to the gaseous radwaste system is from the liquid radwaste system degasifier, which processes the CVS letdown flow when diverted to the liquid radwaste system and the liquid effluent from the liquid radwaste system reactor coolant drain tank.

The liquid radwaste system degasifier is also used to degas liquid pumped out of the reactor coolant drain tank. The amount of fluid pumped out, and therefore, the gas sent to the gaseous radwaste system, is dependent upon the input into the reactor coolant drain tank. This is smaller than the input from the CVS letdown line.

The final input to the gaseous radwaste system is from the reactor coolant drain tank vent. A nitrogen cover gas is maintained in the reactor coolant drain tank. This input consists of nitrogen, hydrogen, and radioactive gases. The tank operates at nearly constant level, with its vent line normally closed, so this input is minimal. Venting is required only after enough gas has evolved from the input fluid to increase the reactor coolant drain tank pressure.

3.5.3 SOLID WASTE MANAGEMENT SYSTEM

The DCD provides the following information about solid waste management:

The solid waste management system provides temporary on-site storage for wastes prior to processing and for the packaged wastes. The system has a 60-year design objective and is designed for maximum reliability, minimum maintenance, and minimum radiation exposure to operating and maintenance personnel. The system has sufficient temporary waste accumulation capacity based on maximum waste generation rates so that maintenance, repair, or replacement of the solid waste management system equipment does not impact power generation.

The solid waste management system is designed to collect and accumulate spent ion exchange resins and deep bed filtration media, spent filter cartridges, dry active wastes, and mixed wastes generated as a result of normal plant operation, including anticipated operational occurrences. The system is located in the auxiliary and radwaste buildings. Processing and packaging of wastes are by mobile systems in the auxiliary building rail car bay and in the mobile systems facility part of the radwaste building. The packaged waste is stored in the auxiliary and radwaste buildings until it is shipped off-site to a licensed disposal facility.

The solid waste management system is designed to meet the following objectives:

- Provide for the transfer and retention of spent radioactive ion exchange resins and deep bed filtration media from the various ion exchangers and filters in the liquid waste processing, chemical and volume control, and spent fuel cooling systems.

- Provide the means to mix, sample, and transfer spent resins and filtration media to high integrity containers or liners for dewatering or solidification as required.
- Provide the means to change out, transport, sample, and accumulate filter cartridges from liquid systems in a manner that minimizes radiation exposure of personnel and the spread of contamination from RCAs.
- Provide the means to accumulate spent filters from the plant heating, ventilation, and air-conditioning systems.
- Provide the means to segregate solid wastes (trash) by radioactivity level and to temporarily store the wastes.
- Provide the means to accumulate hazardous (mixed) wastes.
- Provide the means to segregate clean wastes originating in the RCA.
- Provide the means to store packaged wastes for at least 6 months in the event of delay or disruption of off-site shipping.
- Provide the space and support services required for mobile processing systems that will reduce the volume of and package radioactive solid wastes for off-site shipment and disposal according to applicable State and federal regulations.
- Provide the means to return liquid radwaste to the liquid radwaste system for subsequent processing and monitored discharge.

In addition, to minimize radiation exposure and maintain doses ALARA, the solid waste management system should meet the following two objectives:

- Minimize exposure to solid radioactive waste materials that could conceivably be hazardous to either operating personnel or the public, in accordance with 10 CFR 20 and 10 CFR 50.
- Take due account (through equipment selection, arrangement, remote handling, and shielding) of the necessity to keep radiation exposure of in-station personnel ALARA.

Table 3.5-5 presents information about the estimated annual solid radwaste volumes that would be treated and shipped from the HAR (two units). The total annual expected and maximum volumes of solid radioactive wastes treated and shipped within and from the system are projected to be 326 m^3/yr (11,518 cubic feet per year [ft^3/yr]) (expected-generated), 624 m^3/yr (22,040 ft^3/yr) (maximum-generated), 111 m^3/yr (3,928 ft^3/yr) (expected-shipped), 324 m^3/yr (11,434 ft^3/yr) (maximum-shipped). Tables 3.5-6, 3.5-7, and 3.5-8 present the expected and maximum anticipated annual activity generated and shipped is projected not to exceed 4.66E+03 Curies per year (Ci/yr) (expected-generated), 8.30E+04 Ci/yr (maximum-generated), 3.52E+03 Ci/yr (expected-shipped), 7.40E+04 Ci/yr (maximum-shipped), as well as the bounding list of the principle radionuclides.

3.5.4 DIRECT RADIATION SOURCES

The DCD provides the following information about direct radiation sources:

> The direct radiation from the containment and other plant buildings is negligible. The AP1000 design also provides storage of refueling water inside the containment instead of in an outside storage tank that eliminates it as a radiation source.

3.5.5 REFERENCES

3.5-001 Progress Energy Carolinas, Inc., “Long Term X/Q Modeling Request,” JVT – Request for Information (RFI) # 129, January 12, 2007.

Table 3.5-1
Normal Radioactive Liquid Effluent Releases (Two AP1000 Units)

Isotope	Maximum Release Ci/yr	Isotope	Maximum Release Ci/yr
Corrosion and Activation Products		**Fission Products (cont.)**	
Na-24	3.26E-03	Rh-106	1.47E-01
Cr-51	3.70E-03	Ag-110m	2.10E-03
Mn-54	2.60E-03	Ag-110	2.80E-04
Fe-55	2.00E-03	Te-129rn	2.40E-04
Fe-59	4.00E-04	Te-129	3.00E-04
Co-58	6.72E-03	Te-131m	1.80E-04
Co-60	8.80E-04	Te-131	6.00E-05
Zn-65	8.20E-04	I-131	2.82E-02
W-187	2.60E-04	Te-132	4.80E-04
Np-239	4.80E-04	I-132	3.28E-03
Fission Products		I-133	1.34E-03
Br-84	4.00E-05	I-134	1.62E-03
Rb-88	5.40E-04	Cs-134	1.99E-02
Sr-89	2.00E-04	I-135	9.94E-03
Sr-90	2.00E-05	Cs-136	1.26E-03
Sr-91	4.00E-05	Cs-137	2.66E-02
Y-91m	2.00E-05	Ba-137m	2.50E-02
Y-93	1.80E-04	Ba-140	1.10E-02
Zr-95	4.60E-04	La-140	1.49E-02
Nb-95	4.20E-04	Ce-141	1.80E-04
Mo-99	1.14E-03	Ce-143	3.80E-04
Tc-99m	1.10E-03	Pr-143	2.60E-04
Ru-103	9.86E-03	Ce-144	6.32E-03
Rh-103m	9.86E-03	Pr-144	6.32E-03
Ru-106	1.47E-01	All others	4.00E-05
		Total (except Tritium)	**5.11E-01**

Tritium Release = 2.02E+03 Ci/yr

Notes:
Ci/yr = Curies per year

Table 3.5-2 (Sheet 1 of 2)
Comparison of Annual Average Liquid Release Concentrations to 10 CFR 20 Effluent Concentration Limits (ECLs) for Expected Releases (Two AP1000 Units)

Isotope	Discharge Concentration (μCi/cc)[(a)]	ECL (μCi/cc)[(b)]	Fraction of ECL
Na-24	2.27E-10	5.00E-05	4.56E-06
Cr-51	2.57E-10	5.00E-04	5.18E-07
Mn-54	1.81E-10	3.00E-05	6.07E-06
Fe-55	1.39E-10	1.00E-04	1.40E-06
Fe-59	2.78E-11	1.00E-05	2.80E-06
Co-58	4.67E-10	2.00E-05	2.35E-05
Co-60	6.12E-11	3.00E-06	2.05E-05
Zn-65	5.70E-11	5.00E-06	1.15E-05
W-187	1.81E-11	3.00E-05	6.07E-07
Np-239	3.34E-11	2.00E-05	1.68E-06
Br-84	2.78E-12	4.00E-04	7.00E-09
Rb-88	3.76E-11	4.00E-04	9.45E-08
Sr-89	1.39E-11	8.00E-06	1.75E-06
Sr-90	1.39E-12	5.00E-07	2.80E-06
Sr-91	2.78E-12	2.00E-05	1.40E-07
Y-91m	1.39E-12	2.00E-03	7.00E-10
Y-93	1.25E-11	2.00E-05	6.30E-07
Zr-95	3.20E-11	2.00E-05	1.61E-06
Nb-95	2.92E-11	3.00E-05	9.80E-07
Mo-99	7.93E-11	2.00E-05	3.99E-06
Tc-99m	7.65E-11	1.00E-03	7.70E-08
Ru-103	6.86E-10	3.00E-05	2.30E-05
Rh-103m	6.86E-10	6.00E-03	1.15E-07
Ru-106	1.02E-08	3.00E-06	3.43E-03
Ag-110m	1.46E-10	6.00E-06	2.45E-05
Te-129m	1.67E-11	7.00E-06	2.40E-06
Te-129	2.09E-11	4.00E-04	5.25E-08
Te-131m	1.25E-11	8.00E-06	1.58E-06

**Table 3.5-2 (Sheet 2 of 2)
Comparison of Annual Average Liquid Release Concentrations to
10 CFR 20 Effluent Concentration Limits (ECLs) for Expected Releases
(Two AP1000 Units)**

Isotope	Discharge Concentration ($\mu Ci/cm^3$)[(a)]	ECL ($\mu Ci/cm^3$) [(b)]	Fraction of ECL
Te-131	4.17E-12	8.00E-05	5.25E-08
I-131	1.96E-09	1.00E-06	1.97E-03
Te-132	3.34E-11	9.00E-06	3.73E-06
I-132	2.28E-10	1.00E-04	2.30E-06
I-133	9.32E-10	7.00E-06	1.34E-04
I-134	1.13E-10	4.00E-04	2.83E-07
Cs-134	1.38E-09	9.00E-07	1.54E-03
I-135	6.91E-10	3.00E-05	2.32E-05
Cs-136	8.76E-11	6.00E-06	1.47E-05
Cs-137	1.85E-09	1.00E-06	1.86E-03
Ba-140	7.65E-10	8.00E-06	2.10E-04
La-140	1.04E-09	9.00E-06	1.16E-04
Ce-141	1.25E-11	3.00E-05	4.20E-07
Ce-143	2.64E-11	2.00E-05	1.33E-06
Pr-143	1.81E-11	7.00E-05	2.60E-07
Ce-144	4.39E-10	3.00E-06	1.47E-04
Pr-144	4.39E-10	2.00E-05	2.21E-05
H-3	1.40E-04	1.00E-03	1.41E-01
			Total = 1.51E-01

Notes:
a) Annual average discharge concentration based on release of average daily discharge for 292 days per year with 0.57 m^3/min. (20 ft^3/min) dilution flow.

b) Effluent concentration limits are from 10 CFR 20, Appendix B

$\mu Ci/cm^3$ = microCuries per cubic centimeter
ECL = effluent concentration limit
m^3/min = cubic meters per minute
ft^3/min = cubic feet per minute

Table 3.5-3
Expected Annual Average Release of Airborne Radionuclides (Two AP1000 Units)

Isotope	Average Annual Release Ci/yr	Isotope	Annual Average Release Ci/yr
Kr-85m	7.20E+01	Co-58	4.60E-02
Kr-85	8.20E+03	Co-60	1.74E-02
Kr-87	3.00E+01	Fe-59	1.58E-04
Kr-88	9.20E+01	Sr-89	6.00E-03
Xe-131m	3.60E+03	Sr-90	2.40E-03
Xe-133m	1.74E+02	Zr-95	2.00E-03
Xe-133	9.20E+03	Nb-95	5.00E-03
Xe-135m	1.40E+01	Ru-103	1.60E-04
Xe-135	6.60E+02	Ru-106	1.56E-04
Xe-138	1.20E+01	Sb-125	1.22E-04
I-131	2.40E-01	Cs-134	4.60E-03
I-133	8.00E-01	Cs-136	1.70E-04
C-14	1.46E+01	Cs-137	7.20E-03
Ar-41	6.80E+01	Ba-140	8.40E-04
Cr-51	1.22E-03	Ce-141	8.40E-05
Mn-54	8.60E-04	H-3	7.00E+02
Co-57	1.64E-05	**Total**	**2.28E+04**

Notes:
Ci/yr = Curies per year

Sources: Reference 3.5-001

Table 3.5-4 (Sheet 1 of 2)
Comparison of Gaseous Releases to 10 CFR 20 Effluent Concentration Limits (ECLs) (Two AP1000 Units)

Isotope	Release Ci/yr	Boundary Concentration μCi/cc[(a)]	10 CFR 20 ECL μCi/cc[(b)]	Fraction of ECL
Kr-85m	7.20E+01	2.51E-11	1.0E-07	2.51E-04
Kr-85	8.20E+03	2.86E-09	7.0E-07	4.09E-03
Kr-87	3.00E+01	1.05E-11	2.0E-08	5.23E-04
Kr-88	9.20E+01	3.21E-11	9.0E-09	3.57E-03
Xe-131m	3.60E+03	1.26E-09	2.0E-06	6.28E-04
Xe-133m	1.74E+02	6.07E-11	6.0E-07	1.01E-04
Xe-133	9.20E+03	3.21E-09	5.0E-07	6.42E-03
Xe-135m	1.40E+01	4.88E-12	4.0E-08	1.22E-04
Xe-135	6.60E+02	2.30E-10	7.0E-08	3.29E-03
Xe-138	1.20E+01	4.19E-12	2.0E-08	2.09E-04
I-131	2.40E-01	8.37E-14	2.0E-10	4.19E-04
I-133	8.00E-01	2.79E-13	1.0E-09	2.79E-04
C-14	1.46E+01	5.09E-12	3.0E-09	1.70E-03
Ar-41	6.80E+01	2.37E-11	1.0E-08	2.37E-03
Cr-51	1.22E-03	4.26E-16	3.0E-08	1.42E-08
Mn-54	8.60E-04	3.00E-16	1.0E-09	3.00E-07
Co-57	1.64E-05	5.72E-18	9.0E-10	6.36E-09
Co-58	4.60E-02	1.60E-14	1.0E-09	1.60E-05
Co-60	1.74E-02	6.07E-15	5.0E-11	1.21E-04
Fe-59	1.58E-04	5.51E-17	5.0E-10	1.10E-07
Sr-89	6.00E-03	2.09E-15	2.0E-10	1.05E-05
Sr-90	2.40E-03	8.37E-16	6.0E-12	1.40E-04
Zr-95	2.00E-03	6.98E-16	4.0E-10	1.74E-06
Nb-95	5.00E-03	1.74E-15	2.0E-09	8.72E-07
Ru-103	1.60E-04	5.58E-17	9.0E-10	6.20E-08
Ru-106	1.56E-04	5.44E-17	2.0E-11	2.72E-06
Sb-125	1.22E-04	4.26E-17	7.0E-10	6.08E-08

Table 3.5-4 (Sheet 2 of 2)
Comparison of Gaseous Releases to 10 CFR 20 Effluent Concentration Limits (ECLs) (Two AP1000 Units)

Isotope	Release Ci/yr	Boundary Concentration μCi/cm³ (a)	10 CFR 20 ECL μCi/cm³ (b)	Fraction of ECL
Cs-134	4.60E-03	1.60E-15	2.0E-10	8.02E-06
Cs-136	1.70E-04	5.93E-17	9.0E-10	6.59E-08
Cs-137	7.20E-03	2.51E-15	2.0E-10	1.26E-05
Ba-140	8.40E-04	2.93E-16	2.0E-09	1.46E-07
Ce-141	8.40E-05	2.93E-17	8.0E-10	3.66E-08
H-3	7.00E+02	2.44E-10	1.0E-07	2.44E-03
Total	**2.28E+04**			**2.67E-02**

Notes:

a) Annual average discharge concentration based on release of average daily discharge for 292 days per year. Boundary concentration values based on an average annual X/Q at the boundary of the restricted area (taken as the site exclusion area distance of 1,245 meters) in the sector with the highest value (SSW) = 8.8E-06 sec /m^3

b) Effluent concentration limits are from 10 CFR 20, Appendix B

Ci/yr = Curies per year
μCi/cm^3 = microCuries per cubic centimeter
ECL = effluent concentration limit

Sources: Reference 3.5-001

Table 3.5-5
Estimated Annual Solid Radwaste Volumes (Two AP1000 Units)

Source	Expected Generation m^3/yr (ft^3/yr)	Expected Shipped Solid m^3/yr (ft^3/yr)	Maximum Generation m^3/yr (ft^3/yr)	Maximum Shipped Solid m^3/yr (ft^3/yr)
WET WASTES				
Primary Resins (includes spent resins and wet activated carbon)	22.7 (800)	28.9 (1,020)	96.3 (3,400)	122.3 (4,320)
Chemical	19.8 (700)	1.1 (40)	39.6 (1,400)	2.3 (80)
Mixed Liquid	0.8 (30)	1.0 (34)	1.7 (60)	1.9 (68)
Condensate Polishing Resin[(a)]	0	0	11.7 (412)	14.7 (518)
Steam Generator Blowdown Material (Resin and Membrane)[(a)(b)]	0	0	33.6 (1,080)	38.5 (1,360)
Wet Waste Subtotals	**43.3 (1,530)**	**31 (1,094)**	**179.9 (6,352)**	**179.7 (6,346)**
DRY WASTES				
Compactable Dry Wastes	269 (9,500)	57.2 (2,020)	411.2 (14,520)	87.8 (3,100)
Non-Compactable Dry Wastes	13.3 (468)	21.1 (746)	32.1 (1,134)	51.5 (1,820)
Mixed Solid	0.3 (10)	0.4 (15)	0.6 (20)	0.8 (30)
Primary Filters (includes high activity and low activity cartridges)	0.3 (10)	1.5 (52)	0.5 (19)	3.9 (138)
Dry Waste Subtotals	**282.8 (9,988)**	**80.2 (2,834)**	**444.3 (15,692)**	**144.1 (5,088)**
TOTAL WET AND DRY WASTES	**326.1 (11,518)**	**111.2 (3,928)**	**624.1 (22,040)**	**323.8 (11,434)**

Notes:
a) Radioactive secondary resins and membranes result from primary to secondary systems leakage (e.g., SG tube leak).

b) Estimated volume and activity used for conservatism. Resin and membrane will be removed with the electrodeionization units and not stored as wet waste.

ft^3/yr = cubic feet per year
m^3/yr = cubic meters per year

Table 3.5-6 (Sheet 1 of 2)
Expected and Maximum Annual Curie Content of Generated Primary Effluents (Two AP1000 Units)

Isotope	Primary Resin Expected (Ci/yr)	Primary Resin Maximum (Ci/yr)	Primary Filter Expected (Ci/yr)	Primary Filter Maximum (Ci/yr)
Br-83	---	1.41E+01	---	1.41E+00
Br-84	3.96E-01	6.84E-01	3.96E-02	6.84E-02
Br-85	---	7.48E-03	---	7.48E-04
I-129	---	6.88E-03	---	6.88E-04
I-130	---	1.80E+01	---	1.80E+00
I-131	2.84E+02	1.09E+04	2.84E+01	1.09E+03
I-132	2.08E+01	3.94E+02	2.08E+00	3.94E+01
I-133	1.06E+02	3.32E+03	1.06E+01	3.32E+02
I-134	1.38E+01	1.46E+01	1.38E+00	1.46E+00
I-135	6.98E+01	7.62E+02	6.98E+00	7.62E+01
Rb-86	---	5.94E+01	---	5.94E+00
Rb-88	1.94E+00	5.04E+01	1.94E-01	5.04E+00
Rb-89	---	1.97E+00	---	1.97E-01
Cs-134	6.12E+02	1.91E+04	6.12E+01	1.91E+03
Cs-136	6.32E+00	3.44E+03	6.32E-01	3.44E+02
Cs-137	9.28E+02	1.83E+04	9.28E+01	1.83E+03
Cs-138	---	2.12E+01	---	2.12E+00
Ba-137m	8.88E+02	1.73E+04	8.88E+01	1.73E+03
Cr-51	6.42E+01	7.90E+01	6.42E+00	7.90E+00
Mn-54	2.08E+02	2.36E+02	2.08E+01	2.36E+01
Mn-56	---	9.50E+01	---	9.50E+00
Fe-55	2.08E+02	2.28E+02	2.08E+01	2.28E+01
Fe-59	1.00E+01	1.17E+01	1.00E+00	1.17E+00
Co-58	4.10E+02	6.06E+02	4.10E+01	6.06E+01
Co-60	1.92E+02	4.90E+02	1.92E+01	4.90E+01
Zn-65	6.04E+01	---	6.04E+00	---
Sr-89	5.34E+00	9.12E+01	5.34E-01	9.12E+00
Sr-90	2.26E+00	2.18E+01	2.26E-01	2.18E+00
Sr-91	3.44E-01	2.32E+00	3.44E-02	2.32E-01
Sr-92	---	1.99E-01	---	1.99E-02
Ba-140	1.26E+02	2.38E+01	1.26E+01	2.38E+00
Y-90	---	2.14E+01	---	2.14E+00
Y-91m	---	6.96E-01	---	6.96E-02
Y-91	7.48E-06	1.10E+00	7.48E-07	1.10E-01
Y-92	---	8.38E-02	---	8.38E-03
Y-93	---	1.81E-04	---	1.81E-05

Table 3.5-6 (Sheet 2 of 2)
Expected and Maximum Annual Curie Content of Generated Primary Effluents (Two AP1000 Unit)

Isotope	Primary Resin Expected (Ci/yr)	Primary Resin Maximum (Ci/yr)	Primary Filter Expected (Ci/yr)	Primary Filter Maximum (Ci/yr)
La-140	---	2.14E+01	---	2.14E+00
Zr-95	5.60E-04	---	5.60E-05	---
Ru-103	1.07E-02	---	1.07E-03	---
Ru-106	1.27E-01	---	1.27E-02	---
Te-129m	2.72E-04	---	2.72E-05	---
Total	**4.22E+03**	**7.57E+04**	**4.22E+02**	**7.57E+03**

Notes:
Ci/yr = Curies per year

Table 3.5-7
Expected and Maximum Annual Curie Content of Shipped Primary Wastes (Two AP1000 Units)

Isotope	Primary Resin Expected (Ci/yr)	Primary Resin Maximum (Ci/yr)	Primary Filter Expected (Ci/yr)	Primary Filter Maximum (Ci/yr)
I-129	---	6.88E-03	---	6.88E-04
I-131	1.21E-01	8.20E+02	1.21E-02	8.20E+01
I-133	---	1.25E-07	---	1.25E-08
Rb-86	---	1.95E+01	---	1.95E+00
Cs-134	5.62E+02	1.86E+04	5.62E+01	1.86E+03
Cs-136	5.22E-02	6.94E+02	5.22E-03	6.94E+01
Cs-137	9.22E+02	1.83E+04	9.22E+01	1.83E+03
Ba-137m	9.22E+02	1.83E+04	9.22E+01	1.83E+03
Cr-51	6.74E+00	3.72E+01	6.74E-01	3.72E+00
Mn-54	1.70E+02	2.20E+02	1.70E+01	2.20E+01
Fe-55	1.95E+02	2.24E+02	1.95E+01	2.24E+01
Fe-59	2.46E+00	7.32E+00	2.46E-01	7.32E-01
Co-58	1.70E+02	4.52E+02	1.70E+01	4.52E+01
Co-60	1.86E+02	4.84E+02	1.86E+01	4.84E+01
Zn-65	4.68E+01	---	4.68E+00	---
Sr-89	1.61E+00	6.12E+01	1.61E-01	6.12E+00
Sr-90	2.26E+00	2.18E+01	2.26E-01	2.18E+00
Ba-140	9.60E-01	4.70E+00	9.60E-02	4.70E-01
Y-90	2.26E+00	2.18E+01	2.26E-01	2.18E+00
Y-91	8.06E-04	7.80E-01	8.06E-05	7.80E-02
La-140	1.10E+00	5.40E+00	1.10E-01	5.40E-01
Zr-95	2.18E-04	---	2.18E-05	---
Nb-95	2.62E-04	---	2.62E-05	---
Ru-103	2.20E-03	---	2.20E-04	---
Ru-106	1.08E-01	---	1.08E-02	---
Rh-103m	2.22E-03	---	2.22E-04	---
Rh-106	1.08E-01	---	1.08E-02	---
Te-129m	4.20E-05	---	4.20E-06	---
Te-129	2.74E-05	---	2.74E-06	---
Total	**3.20E+03**	**5.82E+04**	**3.20E+02**	**5.82E+03**

Notes:
Ci/yr = Curies per year

Table 3.5-8 (Sheet 1 of 3)
Expected and Maximum Annual Curie Content of Generated and Shipped Secondary Wastes (Two AP1000 Units)

Isotope	Generated Secondary Resins Expected (Ci/yr)	Generated Secondary Resins Maximum (Ci/yr)	Shipped Secondary Resins Expected (Ci/yr)	Shipped Secondary Resins Maximum (Ci/yr)
Na-24	3.66E-02	9.24E-04	---	---
Cr-51	8.58E-02	1.03E+00	9.10E-03	1.09E-01
Mn-54	5.90E-02	7.10E-01	4.80E-02	5.78E-01
Mn-56	---	4.48E-01	---	---
Fe-55	4.70E-02	5.56E-01	4.38E-02	5.20E-01
Fe-59	8.98E-03	1.18E-01	2.28E-03	3.00E-02
Co-58	1.56E-01	1.85E+00	6.50E-02	7.74E-01
Co-60	2.06E-02	2.46E-01	1.99E-02	2.38E-01
Zn-65	1.91E-02	---	1.48E-02	---
Br-83	---	7.46E-02	---	---
Br-84	4.44E-05	2.82E-03	---	---
Br-85	---	3.28E-06	---	---
Rb-88	1.80E-04	9.12E-02	---	---
Rb-89	---	3.06E-03	---	---
Sr-89	4.48E-03	1.82E+00	1.37E-03	5.58E-01
Sr-90	4.74E-04	1.00E-01	4.72E-04	9.92E-02
Sr-91	4.22E-04	4.26E-02	---	---
Sr-92	---	1.45E-03	---	---
Y-90	4.12E-04	9.20E-02	4.62E-04	1.02E-01
Y-91	5.06E-04	8.86E-02	1.34E-08	2.24E-06
Y-91m	3.64E-04	4.22E-02	---	---
Y-92	---	5.32E-03	---	---
Y-93	1.96E-03	2.08E-03	---	---
Zr-95	1.31E-02	1.55E-01	5.04E-03	5.96E-02
Nb-95	1.04E-02	1.65E-01	8.12E-03	1.04E-01
Nb-95m	9.48E-03	1.10E-01	4.64E-03	5.40E-02
Mo-99	3.04E-02	3.04E+01	---	5.44E-09
Tc-99m	2.82E-02	3.36E+01	---	6.08E-09

Table 3.5-8 (Sheet 2 of 3)
Expected and Maximum Annual Curie Content of Generated and Shipped Secondary Wastes (Two AP1000 Units)

Isotope	Generated Secondary Resins Expected (Ci/yr)	Generated Secondary Resins Maximum (Ci/yr)	Shipped Secondary Resins Expected (Ci/yr)	Shipped Secondary Resins Maximum (Ci/yr)
Ru-103	2.26E-01	1.26E-01	4.68E-02	2.60E-02
Ru-103m	---	7.74E-02	---	6.54E-02
Ru-106	3.30E+00	---	2.76E+00	---
Rh-103m	2.78E-01	1.26E-01	5.74E-02	2.60E-02
Rh-106	4.22E+00	1.19E-01	3.54E+00	1.01E-01
Ag-110	4.24E-02	2.68E-02	3.32E-02	2.10E-02
Ag-110m	4.90E-02	4.48E-01	3.84E-02	3.52E-01
Te-129	4.58E-03	2.38E+00	6.88E-04	3.84E-01
Te-129m	5.58E-03	2.20E+00	8.96E-04	3.54E-01
Te-131	2.28E-03	4.70E+00	---	---
Te-131m	2.84E-03	4.02E-01	---	---
Te-132	9.48E-04	1.35E+01	---	---
Te-134	---	2.98E-03	---	---
I-130	---	2.38E-01	---	---
I-131	3.40E-01	2.74E+02	1.46E-04	1.19E-01
I-132	1.59E-02	1.35E+01	---	4.72E-08
I-133	1.05E-01	5.02E+01	---	---
I-134	2.36E-03	9.98E-02	---	---
I-135	5.12E-02	7.98E+00	---	---
Cs-134	5.00E-01	1.38E+03	4.62E-01	1.27E+03
Cs-135	9.40E-10	1.23E-07	9.72E-10	1.27E-07
Cs-136	2.96E-02	1.03E+03	3.12E-04	1.08E+01
Cs-137	6.78E-01	1.00E+03	6.72E-01	9.96E+02
Cs-138	---	6.82E-02	---	---
Ba-136m	2.78E-02	1.27E+03	2.94E-04	1.34E+01
Ba-137m	6.84E-01	1.03E+03	6.80E-01	1.02E+03
Ba-140	2.34E-01	5.66E-01	1.79E-03	4.36E-03
La-140	2.94E-01	6.62E-01	2.10E-03	5.74E-03

Table 3.5-8 (Sheet 3 of 3)
Expected and Maximum Annual Curie Content of Generated and Shipped Secondary Wastes (Two AP1000 Units)

Isotope	Generated Secondary Resins Expected (Ci/yr)	Generated Secondary Resins Maximum (Ci/yr)	Shipped Secondary Resins Expected (Ci/yr)	Shipped Secondary Resins Maximum (Ci/yr)
Ce-141	4.26E-03	1.28E-01	6.26E-04	1.88E-02
Ce-143	5.82E-03	9.88E-03	---	---
Ce-144	1.47E-01	1.27E-01	1.18E-01	1.02E-01
Pr-143	4.08E-03	9.26E-02	4.76E-05	9.50E-04
Pr-144	1.27E-01	1.27E-01	1.02E-01	1.02E-01
Total	**1.19E+01**	**6.16E+03**	**8.76E+00**	**3.32E+03**

Notes:
Values shown as "---" Ci/yr are those calculated to be lower than 1.0E-10 Ci/yr, and thus considered to have insignificant contributions to total.

Ci/yr = Curies per year

Table 3.5-9 (Sheet 1 of 3)
Data Needed for Radioactive Source Term Calculations for Pressurized-Water Reactors

Parameter	Value
Thermal Power Level (MWt)	3400
Mass of Primary Coolant (lb)	4.35×10^5
Primary System Letdown Rate (gpm)	100
Letdown Cation Demineralizer Flow Rate, Annual Average (gpm)	10
Number of Steam Generators	2
Total Steam Flow (lb/hr)	14.97×10^6
Mass of Liquid in Each Steam Generator (lb)	1.75×10^5
Total Blowdown Rate (lb/hr)	4.2×10^4
Blowdown Treatment Method	0[a]
Condensate Demineralizer Regeneration Time	Not Applicable
Condensate Demineralizer Flow Fraction	0.33
Primary Coolant Bleed for Boron Control	
Bleed Flow Rate (gpd)	435
Decontamination Factor for I	10^3
Decontamination Factor for Cs and Rb	10^3
Decontamination Factor for Others	10^3
Collection Time (day)	30
Process and Discharge Time (day)	0
Fraction Discharged	1.0
Equipment Drains and Clean Waste	
Equipment Drains Flow Rate (gpd)	290
Fraction of Reactor Coolant Activity	1.023
Decontamination Factor for I	10^3
Decontamination Factor for Cs and Rb	10^3
Decontamination Factor for Others	10^3
Collection Time (day)	30
Process and Discharge Time (day)	0
Fraction Discharged	1.0
Dirty Waste	
Dirty Waste Input Rate (gpd)	1200
Fraction of Reactor Coolant Activity	0.001
Decontamination Factor for I	10^3
Decontamination Factor for Cs and Rb	10^3
Decontamination Factor for Others	10^3
Collection Time (day)	10
Process and Discharge Time (day)	0
Fraction Discharged	1.0

Table 3.5-9 (Sheet 2 of 3)
Data Needed for Radioactive Source Term Calculations for Pressurized-Water Reactors

Parameter	Value
Blowdown Waste	
Blowdown Fraction Processed	1
Decontamination Factor for I	100
Decontamination Factor for Cs and Rb	10
Decontamination Factor for Others	100
Collection Time (day)	Not Applicable
Process and Discharge Time (day)	Not Applicable
Fraction Discharged	0
Regenerant Waste	Not Applicable
Gaseous Waste System	
Continuous Gas Stripping of Full Letdown Purification Flow	None
Holdup Time for Xenon (days)	38
Holdup Time for Krypton (days)	2
Full Time of Decay Tanks for Gas Stripper	Not Applicable
Gas Waste System: HEPA Filter	None
Auxiliary Building: Charcoal Filter	None
Auxiliary Building: HEPA Filter	None
Containment Volume (ft^3)	2.1×10^6
Containment Atmosphere Internal Cleanup Rate (ft^3/min)	Not Applicable
Containment High Volume Purge	
Number of Purges per Year (in addition to two shutdown purges)	0
Charcoal Filter Efficiency (%)	90
HEPA Filter Efficiency (%)	99
Containment Normal Continuous Purge Rate (ft^3/min) (based on 20 hrs/week at 4,000 ft^3/min)	500
Charcoal Filter Efficiency (%)	90
HEPA Filter Efficiency (%)	99
Fraction of Iodine Released from Blowdown Tank Vent	Not Applicable
Fraction of Iodine Removed from Main Condenser Air Ejector Release	0.0
Detergent Waste Decontamination Factor	0.0[(b)]

**Table 3.5-9 (Sheet 3 of 3)
Data Needed for Radioactive Source Term Calculations for
Pressurized-Water Reactors**

Parameter	Value

Notes:
a) A “0” is input to indicate that the blowdown is recycled to the condensate system (CDS) after treatment in the blowdown system.

b) A “0.0” is input to indicate that the plant does not have an on-site laundry.

ft^3 = cubic feet
ft^3/min = cubic feet per minute
gpd = gallon per day
gpm = gallon per minute
lb/hr = pounds per hour
MWt = megawatt thermal

3.6 NONRADIOACTIVE WASTE MANAGEMENT SYSTEMS

This section generically describes the nonradioactive waste management systems and the chemical and biocidal characteristics of each nonradioactive waste stream that will be discharged from the HAR. These units will be Westinghouse's AP1000s.

Within this section, the effects from the effluents from these nonradioactive waste systems have been evaluated against applicable and appropriate federal, state, regional, local, and any affected Native American tribal agencies.

Nonradioactive wastes from nuclear power plants typically include, but are not limited to, cooling tower blowdown, condensate demineralizer regeneration wastes, sanitary waste, metal cleaning wastes, low-volume wastes, and stormwater runoff. These streams are monitored for multiple constituents typically temperature, flow, pH, fecal coliform, free available chlorine, total residual chlorine, total suspended solids, hydrazine, oil and grease, total nickel, total manganese, total chromium, total zinc, total copper, total nitrogen, total phosphorus and total iron.

If applicable, nonradioactive wastes will be collected in the wastewater treatment system. The system will be designed to stop the discharge of wastewater upon detection of high radiation in the stream to the discharge line.

The following discharges and waste treatment operations are currently permitted for operation at the HNP (this is provided for background information only). Treated wastes are ultimately disposed of from various outfalls into the Harris Reservoir (Reference 3.6-001).

- Discharge of cooling tower blowdown.
- Operation of a 0.05 million gallons per day (mgd) extended aeration wastewater treatment plant consisting of dual package plants with the following components:
  - Equalization tanks.
  - Aeration tanks.
  - Sludge holding tanks.
  - Clarifiers.
  - Chlorine contact tanks.
- Operation of a metal cleaning waste treatment system consisting of dual neutralization basins.

- Operation of a low-volume waste treatment system consisting of the following:
  - Waste neutralization basin (also used for metal cleaning waste treatment).
  - Settling basin.
- Operation of a radwaste treatment system consisting of a Modular Fluidized Transfer Demineralization System.
- Operation of a 0.02-mgd wastewater treatment facility consisting of the following:
  - Holding tanks
  - Comminutor
  - Bar screen
  - Influent pump station
  - Aerated pond
  - Stabilization pond
  - Polishing pond
  - Sand filter
  - Chlorination and dechlorination
- Discharge of stormwater, normal service water, emergency service water, circulating water, potable water, demineralized water, and hydrostatic flushing of system piping and wash water.
- Discharge of treatment works.

Figure 3.6-1 presents the current HNP NPDES permit outfall information and Figure 3.6-2 shows the stormwater outfalls related to these systems.

Aqueous discharges for HAR are regulated through the NPDES program both for stormwater and wastewater.

Stormwater runoff from the HAR will be collected and controlled by a stormwater drainage system, which will most probably discharge into Harris Reservoir. Site grading and drainage during site preparation activities would be designed to mitigate erosion and comply with a comprehensive Erosion and Sedimentation

Control Plan (E&SCP) and a Stormwater Pollution Prevention Plan (SWPPP), which are required by the NCDENR. HNP has an approved E&SCP and SWPPP. These plans have not yet been written and approved for the HAR but will be prior to the start of site grading and construction activities.

The NCDENR is authorized to oversee the NPDES program in North Carolina, and incorporates chemical monitoring requirements for wastewater and stormwater in NPDES discharge permits. Within the permit, point-source discharge outfalls are assigned a discharge serial number (DSN), constituents to be monitored or sampled, and associated limits. This permit is amended as new wastewater streams are identified. Table 3.3-4 presents the chemicals added to each system, the amount used per year (not by season), the frequency of use, and the concentration in the waste stream discharged from each unit to Harris Reservoir. ER Section 2.3 provides a discussion regarding past and present water quality conditions in Harris Reservoir that may potentially affect or be affected by the construction or operation of the HAR facility, specifically temperature, dissolved oxygen, specific conductance, pH, total alkalinity, water clarity, nitrogen, phosphorus, ions/hardness, and metals. ER Chapter 5 considers the effects from chemical discharges to Harris Reservoir.

It is anticipated that the number of permitted outfalls will be reduced because the AP1000 design consolidates several facility liquid-waste streams from facility operations into a single discharge point that will discharge to Harris Reservoir through one NPDES permitted outfall. Chemicals that are added to cooling water for treatment are effective at low concentrations and are mostly consumed or broken down in application.

The current NPDES permit for HNP will either be revised to include HAR or a new permit will be applied for that specifically encompasses HAR discharges.

3.6.1 EFFLUENTS CONTAINING BIOCIDES OR CHEMICALS

3.6.1.1 Sources

When in operation, the HAR will have many processes that may result in the intermittent discharge of low volumes of chemical contaminants to Harris Reservoir. Table 3.3-4 presents information about the types of chemicals that may be added to liquid effluent waste streams, systems where chemicals will be added, amount used, frequency of use, and waste stream concentrations.

Typically, wastes will be treated in an oil waste separator and neutralization basin, as required, prior to routing to a sedimentation basin, which ultimately will discharge to the common outfall line. Chemicals present in these systems typically include corrosion products (such as copper and iron), corrosion inhibitors (such as nitrates, molybdates, ammonia, hydrazine, carbohydrazide, and ethanolamine), acids and bases from water treatment processes, wastewater from ion exchange processes, and ammonium bisulfate from dechlorinination. Low-volume waste sources typically include the following (Reference 3.6-001):

- Water treatment system wastes from processing of demineralized and potable water (The water treatment system typically includes coagulation, filtration, disinfection, and ion exchange. Wastes from treatment may include filter backwash and demineralizer regeneration wastes.).

- Nonradioactive oily waste, floor drains, and chemical tank containment drains (Turbine building wastes that could contain oil are typically routed to an oil waste separator for treatment prior to routing to a neutralization basin. Used oil is usually collected by a contractor for reclamation.).

- Steam generator and auxiliary boiler draining following wet layup.

- Nonradioactive secondary waste from condensate polishers.

- Miscellaneous drains/leaks from the condenser, SG, and secondary components.

- Auxiliary boiler system blowdown.

- Miscellaneous waste streams.

Other small volumes of wastewater will be discharged from sources such as the service water and auxiliary cooling systems, water treatment, laboratory and sampling wastes, floor drains, stormwater runoff, and metal treatment wastes. These waste streams will be discharged as separate point sources or will be combined with the cooling water discharges (Reference 3.6-001).

3.6.1.1.1 Nonradioactive and Potentially Radioactive Waste Drains

Westinghouse's DCD provides the following information about nonradioactive and potentially radioactive waste drains:

> The WWS collects nonradioactive waste from floor and equipment drains in auxiliary, annex, turbine, and diesel generator building sumps or tanks. Selected normally nonradioactive liquid waste sumps and tanks are monitored for radioactivity to determine whether the liquid wastes have been inadvertently contaminated. If contaminated, the wastes are diverted to the liquid radwaste system for processing and ultimate disposal. Drainage lines from the positive pressure boundary areas of the auxiliary building do not terminate outside the positive pressure boundary without a closed valve, plugged drain, or water seal to maintain the integrity of the positive pressure boundary.

3.6.1.1.2 Chemical Waste Drains

The DCD provides the following information about chemical waste drains:

> The radioactive waste drain system collects chemical wastes from the auxiliary building chemical laboratory and decontamination solution drains from the annex building and directs these wastes to the chemical waste tank of the liquid radwaste system.

3.6.1.1.3 Detergent Waste Drains

The DCD provides the following information about detergent waste drains:

> The laundry and respirator cleaning functions that generate detergent wastes are performed off-site. Detergent wastes from hot sinks and showers are routed to the chemical waste tank.

3.6.1.1.4 Oily Waste Drains

The DCD provides the following information about oily waste drains:

> The WWS collects nonradioactive, oily, liquid waste in drain tanks and sumps. Drain tank and sump liquid wastes are pumped through an oil separator prior to further processing. The oil is collected in a tank for disposal.
>
> Sampling for oil in the waste holdup tank of the liquid radwaste system is provided to detect oil contamination before the ion exchanger resins are damaged. Oily water is pumped from the tank through an oil adsorbing bag filter before further processing.

3.6.1.2 Service Water Chemical Injection System

The DCD provides the following information about the service water chemical injection system:

> The turbine island CFS equipment injects the required chemicals into the SWS. This injection maintains a noncorrosive, nonscale forming condition and limits biological film formation. Chemicals are injected into service water pump discharge piping located in the turbine building.
>
> The chemicals can be divided into six categories based upon function: biocide, algicide, pH adjustor, corrosion inhibitor, scale inhibitor, and, silt dispersant. Specific chemicals used within the system, other than the biocide, are determined by the site water conditions. The pH adjustor, corrosion inhibitor, scale inhibitor, and dispersant are metered into the system continuously or as required to maintain proper concentrations. A sodium hypochlorite treatment system is provided for use as the biocide

and controls microorganisms that cause fouling. The biocide application frequency may vary with seasons. Algicide is applied, as necessary, to control algae formation on the cooling tower.

Chemical concentrations are measured through analysis of grab samples. Chlorine residual is measured to monitor the effectiveness of the biocide treatment. Addition of water treatment chemicals is performed by CFS injection metering pumps and is adjusted as required.

Chemical injections are interlocked with each service water pump to prevent injection into a train when the associated service water pump is not running.

3.6.1.3 Metal Cleaning Wastes

Infrequently, cleaning of the heat exchanger equipment by chemical solutions may be necessary. Cleaning solutions would be routed to a waste neutralization basin for pH adjustment or other chemical neutralization prior to discharge to a settling basin. In the settling basin, further treatment by sedimentation would typically occur. If new systems were added in the future, pre-operational flushing would be necessary. Chemical solutions that may be used may include phosphates, organic cleaners, citric acid, or oxalic acid (Reference 3.6-001).

The chemicals used will be subject to review and approval for use by the NCDENR. Chemical releases will be in strict compliance with an approved NPDES permit. The total residual chemical concentrations in the discharges to Harris Reservoir will be subject to limits that will be established by the NCDENR.

3.6.2 SANITARY SYSTEM EFFLUENTS

3.6.2.1 Portable Sanitary Systems (Pre-Construction/Construction)

Sanitary systems installed for pre-construction and construction activities include portable toilets, which will be supplied and serviced by an off-site vendor. During operation of the HAR, sanitary system wastes that are anticipated to be discharged to Harris Reservoir include discharges from the potable/sanitary water treatment system.

3.6.2.2 Plant Sewage Treatment Systems

The SDS collects sanitary waste from plant restrooms and locker room facilities in the turbine building, auxiliary building, and annex building. The system carries this waste to the treatment plant where it is processed. The SDS does not service facilities in RCAs. Although this SDS transports sanitary waste to the waste treatment plant, the waste treatment plant is site specific. HNP has an existing sewage treatment plant that will have to be expanded to accommodate HAR or a new facility will have to be constructed to accommodate HAR sanitary wastes.

The DCD provides the following information about the SDS:

> The SDS within the scope of the plant covered by Design Certification is designed to accommodate 25 gallons/person/day for up to 500 persons during a 24-hour period. Section 3.3 provides a detailed water balance table for the discharges from the sanitary sewage treatment system for the HAR facility.

A 0.025-mgd extended sewage treatment facility serves the existing HNP. The facility consists of an equalization basin, an aeration basin, sludge holding tanks, raw sewage holding tank, clarifiers, and chlorine contact tanks. Disinfected effluent is pumped to a common outfall pipe. Currently, sludge is land applied off-site by a contract disposal firm (Reference 3.6-001).

It is anticipated that a new sanitary sewage treatment plant will be constructed. Alternatively, and more likely, the sewage treatment facilities will be shared and, if necessary, upgraded to accommodate the additional sanitary waste discharged by the HAR facility. These discharges will be controlled in compliance with an approved NPDES permit for the HAR facility, to be issued by NCDENR. Section 3.3 provides information about the volume of sanitary waste that the HAR facility will discharge to Harris Reservoir.

3.6.3 OTHER EFFLUENTS

This section presents a description of typical effluents that may be released for the AP1000. The information presented in the following sections was obtained from the current NPDES permit for HNP operations. It is anticipated that HAR will also have similar effluent discharges. Any discharges to Harris Reservoir will be subject to review and approval for use by the NCDENR. Releases will be in strict compliance with an approved NPDES permit. The total residual chemical concentrations in the discharges to Harris Reservoir will be subject to limits that will be established by the NCDENR.

3.6.3.1 Liquid Effluents

The runoff from parking lots, outside storage areas, and roof drains discharge to storm drains and then to Harris Reservoir (Reference 3.6-001).

3.6.3.1.1 Upflow Filter Clearwell Drains

The upflow clearwell tank stores filtered reservoir water used in the potable water treatment system. Periodically, some of the water from this clearwell tank is discharged through upflow filter clearwell drains to storm drains that discharge to Harris Reservoir. The discharged water may contain low concentrations of chlorine because sodium hypochlorite is added to control biological growth in the clearwell tank prior to treatment through the upflow filter (Reference 3.6-001).

3.6.3.1.2 Heat Exchanger on the Demineralizer Feedwater

The source water to the DTS is heated to achieve optimum degasification. To accomplish this, steam heats the feedwater. The condensed steam is discharged to the storm drains that flow to Harris Reservoir. This steam could contain trace amounts of hydrazine and ammonia used for chemistry control in the auxiliary boiler steam system (Reference 3.6-001).

3.6.3.1.3 Condenser Waste Box Drains

Prior to condenser maintenance or repairs, it is sometimes necessary to drain circulating water to the storm drains that discharge to Harris Reservoir (Reference 3.6-001).

3.6.3.1.4 Filtered Water Storage Tank

Water from the upflow filter clearwell is treated using a micro-filtration unit for turbidity control and then stored in a tank prior to subsequent filtration and disinfection. Occasionally, some of this water may be drained to the storms drains that discharge to Harris Reservoir. The water may contain trace amounts of chlorine (Reference 3.6-001).

3.6.3.1.5 Fire Protection System

It is anticipated that approximately 5000 gallons of water from Harris Reservoir used for the annual testing of the fire protection system will be routed to most of the existing or newly constructed storm drains. These storm drains are either presently connected to, or will soon be connected to, lines that discharge to Harris Reservoir (Reference 3.6-001).

3.6.3.1.6 Condenser Hotwell

During outages, it is sometimes necessary to drain the condenser hotwell for condenser maintenance and inspection. Approximately 70,000 gallons of this water resulting from condensed steam may be drained to storm drains that discharge to Harris Reservoir. The water may contain trace amounts of ethanolamine, boron, or ammonia (Reference 3.6-001).

3.6.3.1.7 Condensate Storage Tank

Infrequently, it is necessary to drain the condensate storage tank for maintenance. Approximately 400,000 gallons per event are drained to the storm drains that drain to Harris Reservoir. The condensate water may contain trace amounts of boron, ammonia, and hydrazine (Reference 3.6-001).

3.6.3.1.8 Air Conditioning System Condensate

The condensate from the various building air conditioning systems is drained to the storm drains that drain to Harris Reservoir (Reference 3.6-001).

3.6.3.1.9 Service Water System Strainers

Infrequently, service water strainers located at the makeup pumps from the cooling tower basin must be backwashed to remove biofouling organisms or debris. At those times, it is expected that a small volume of service water will overflow the basin. This service water would run to an adjacent storm drain that discharges to Harris Reservoir (Reference 3.6-001).

3.6.3.1.10 Maintenance Activities

During scheduled maintenance activities at the HAR, it may become necessary to drain all or some portion of the following plant systems (Reference 3.6-001):

- Normal service water.
- Emergency service water.
- Circulating water.
- Potable water.
- Demineralizer water.

Maintenance activities at the HAR may also require the hydrostatic flushing of system piping with the discharge entering the storm drain system. In addition, it may sometimes be necessary to wash down equipment with demineralized water that would discharge to Harris Reservoir (Reference 3.6-001).

3.6.3.1.11 Erosion and Sedimentation

ER Section 4.6 discusses erosion, sedimentation, and other controls for pre-construction and construction activities.

3.6.3.2 Gaseous Effluents

Each AP1000 unit typically contains one electric auxiliary boiler, two standby diesel generators, two ancillary diesel generators, and one diesel-driven fire pump. There is no treatment of the gaseous emissions from this equipment.

3.6.3.2.1 Auxiliary Boiler

The DCD provides the following information about the auxiliary boiler:

> The auxiliary boiler is located in the turbine building with an estimated emissions release point at a typical elevation of 76 m (250 ft.). The system consists of steam generation equipment and distribution headers.
>
> Condensate from the condensate storage tank is chemically treated and pumped to the auxiliary boiler deaerator where oxygen and non-condensables are removed using auxiliary steam. The auxiliary boiler feedwater pumps deliver condensate from the auxiliary boiler deaerator to the auxiliary boiler. A feedwater control valve, located in the feedwater piping, regulates water level in the auxiliary boiler. Feedwater flow is proportional to auxiliary boiler steaming rate. Steam generated by the auxiliary boiler is supplied to the plant auxiliary steam distribution piping.
>
> Boiler water quality is maintained by controlling boiler blowdown flow to an atmospheric blowdown tank and by feeding oxygen scavenging and pH control chemicals to the boiler makeup water system. Water level in the auxiliary boiler deaerator is maintained by an automatic control valve in the condensate supply and deaerator overflow piping. Makeup water is supplied from the DWS.
>
> When in operation, the ASS provides the following services:
>
> - Steam to the plant hot water heating system heat exchangers where water is heated and pumped to the heating system ventilation coils.
> - Steam for the CDS deaerator when condensate heating occurs during preoperational cleanup of the condensate and FWS.
> - Sealing steam to the glands of the main turbine prior to the availability of main steam.
> - Steam for maintaining pressure in the CDS deaerator after a turbine trip when extraction steam is lost.
> - Steam for blanketing of the MSR and feedwater heaters when main steam is not available.
>
> Operational safety features are provided within the system for the protection of plant personnel and equipment. The ASS does not interface directly with nuclear process systems.

3.6.3.2.1.1 Component Description

3.6.3.2.1.1.1 Auxiliary Steam System and Boiler

The DCD provides the following information about the ASS and boiler:

> The auxiliary steam boiler is an electric package boiler with a nominal net output capacity of approximately 100,000 pounds per hour (lbs/hr) of saturated steam at 195 psig. The system is protected from overpressure by safety valves located on the boiler, boiler deaerator, and auxiliary steam header.

3.6.3.2.1.1.2 Pumps

The DCD provides the following information about the auxiliary boiler pumps:

> Two 100-percent capacity auxiliary boiler feedwater pumps are provided to feed the auxiliary steam boiler. Two 100-percent capacity auxiliary boiler makeup pumps maintain level in the boiler deaerator.

3.6.3.2.1.1.3 Auxiliary Boiler Deaerator

The DCD provides the following information about the auxiliary boiler:

> The auxiliary boiler deaerator is a 100-percent capacity deaerator which uses steam supplied by the auxiliary steam header. The auxiliary boiler deaerator steam blanket is controlled for preheating and deaerating boiler makeup water. The auxiliary boiler deaerator removes oxygen and non-condensables from auxiliary boiler feedwater.

3.6.3.2.2 Diesel Generators

Two on-site standby diesel generator units provide power to selected plant ac loads. The diesel generator building houses the two diesel generators and their associated heating, ventilation, and air conditioning equipment. Each engine exhaust gas circuit consists of the engine exhaust gas discharge pipes from the turbocharger outlets to a single vertically mounted outdoor silencer which discharges to the atmosphere at an approximate elevation of 42 m (140 ft.). Each standby diesel generator is tested to verify the capability to provide 4000 kW.

3.6.3.2.3 Fuel Storage Tanks

Two fuel oil storage tanks are provided, one for each of the standby diesel generators. The two fuel oil storage tanks are located on grade. Each tank is erected on a continuous concrete slab totally contained within a concrete dike to contain spills and prevent damage to the environment and seepage into the ground water. The system is designed to meet the following requirements:

- Provide a supply of fuel sufficient to operate each diesel generator at a continuous rate for 7 days.
- Provide a 4-day fuel supply for two auxiliary diesel generators.

The vent for each fuel oil storage tank has an estimated emissions release point at an approximate elevation of 10.5 m (35 ft.).

3.6.3.2.4 Diesel-Driven Fire Pumps

Two 100-percent capacity fire pumps are provided. Each pump is rated for 0.13 m^3/s (4.46 ft3/s) or 2000 gpm. The lead pump is electric motor-driven and the second pump is diesel engine-driven. The exhaust for the diesel-driven pump is typically located at an approximate elevation of 30.5 m (100 ft.). The fuel tank for the diesel-driven pump holds enough fuel to operate the pump for at least 8 hours. The vent for the diesel-driven fire pump oil storage tank has a typical emissions release point at an approximate elevation of 10.5 m (35 ft.).

3.6.3.2.5 Annual Emissions

Table 3.6-1 shows the annual emissions (lb/yr) from the diesel generators and the diesel-driven fire pumps. Table 3.6-2 shows the annual hydrocarbon emissions (lb/yr) from the associated diesel fuel oil storage tanks.
No source of gaseous emissions other than the diesel generators and the diesel fire pumps is planned for the site. According to information presented in NUREG-1555, these emissions constitute a small additional atmospheric loading in comparison with these emissions from the stationary fuel combustion and transportation sectors in the United States.

3.6.4 REFERENCES

3.6-001 Progress Energy Carolinas, Inc., "Carolina Power & Light Company, Harris Nuclear Plant and Harris Energy & Environmental Center National Pollutant Discharge Elimination System Permit Number NC0039586," January 30, 2006.

Table 3.6-1
Typical Bounding Estimates for Yearly Emissions from Diesel Generators and Diesel-Driven Fire Pumps Associated with Two Units

Diesel Generators[(a)]			
Pollutants Discharged	**Four 4000-KW Standby DC (lb/yr)**	**Four 35-kW Ancillary DGs (lb/yr)**	**Two Diesel-Driven Fire Pumps [(a)] (lb/yr)**
Particulates[(b)]	2168	33	136
Sulphur Oxides[(b)(c)]	2209	31	127
Carbon Monoxide[(b)]	6645	101	415
Hydrocarbons[(b)]	2518	38	157
Nitrogen Oxides[(b)]	30,848	467	1928
Carbon Dioxide[(b)]	1,147,171	17,381	71,698

Notes:

a) Based on 4 hrs/month of operation for each generator and diesel-driven fire pump.

b) Emission factors for diesel generators and diesel-driven fire pumps from AP-42 Chapter 3 - Stationary Internal Combustion Sources; Section 3.3 - Gasoline and Diesel Industrial Engines, Table 3.3-1.

c) Assumes sulphur content of Number 2 diesel fuel burned is 1 percent.

DC = direct current
DG = diesel generator
kW = kilowatt
lb/yr = pounds per year

Source: NUSTART

Table 3.6-2
Annual Hydrocarbon Emissions from Diesel Fuel Oil Storage Tanks Associated with Two Units (lb/yr)

Pollutant Discharged	Four 85,000-Gallon Vertical Standby DG and Fuel Oil Tanks[(a)]	Two 650-Gallon Horizontal Ancillary DG Fuel Oil Tanks[(b)]	Two 240-Gallon Diesel Driven Fire Pump Fuel Oil Tanks[(c)]
Hydrocarbons[(d)]	70	1	1

Notes:
a) Based on total fuel throughput of 402,366 gallons per year for each tank.

b) Based on total fuel throughput of 384 gallons per year for each tank.

c) Based on total fuel throughput of 1584 gallons per year for each tank.

d) Hydrocarbon emissions for fuel storage tanks calculated using the USEPA's TANKS Computer Program (Version: 4.0.9d; October 3, 2005).

DG = diesel generator
kW = kilowatt
lb/yr = pounds per year

Source: NUSTART

3.7 POWER TRANSMISSION SYSTEM

This section provides a general discussion related to construction of the electric transmission system that is required in conjunction with construction of the HAR. ER Subsection 4.1.2 presents detailed information regarding the effects from construction of the electric transmission system.

The HAR facility is located in the service territory of PEC, the regional electrical transmission system owner/operator.

HAR 2 will be connected to the existing 230-kilovolt (kV) switchyard that serves the HNP. This switchyard will be modified to provide the required connections to HAR 2. HAR 3 will be connected to a new 230-kV switchyard. Each HAR unit has one main step-up transformer and two reserve auxiliary transformers (RATs). The main step-up transformer and both RATs will be connected to each unit's respective switchyard by individual 230-kV lines. Startup and shutdown ac power as well as the capability to provide power to the grid are provided by these switchyard connections (Reference 3.7-001).

3.7.1 BACKGROUND

3.7.1.1 Utility Grid Description

PEC is an investor-owned electric utility serving a 77,700-square km (km^2) (30,000-square miles [$mi.^2$]) area of North Carolina and South Carolina. The PEC electrical grid consists of nuclear, fossil, and hydro generating facilities and an extensive 500/230/115-kV bulk power transmission system (Reference 3.7-002).

PEC maintains 33 direct interconnections with neighboring utilities. PEC participates as a member of the Virginia-Carolinas (VACAR) Reliability Subregion of the Southeastern Electric Reliability Council (SERC). These interconnections with neighboring utilities serve to increase the reliability of the PEC electrical grid (Reference 3.7-002).

Seven transmission lines presently connect the HNP to the PEC electrical grid through an existing switchyard. These seven transmission lines, along with an eighth line planned for 2011 (the new Research Triangle Park [RTP] Line will primarily support HNP operations but will also be available for HAR 2 operations if deemed necessary), will connect HAR 2 to the PEC transmission grid. HAR 2 will connect to the PEC grid utilizing the existing towers, lines, and ROWs that currently support HNP operations.

The seven transmission lines that are currently in service are connected to the Cape Fear Plant Switchyard (North and South lines), Fort Bragg Woodruff Street Substation, Siler City Substation, Erwin Substation, Wake Substation, and Apex-U.S. 1 Substation (Reference 3.7-003). The planned RTP line will terminate in 2011 at the future RTP 230-kV Substation. Table 3.7-1 provides the termination points, nominal voltage, power transmission capacity, and approximate lengths of these transmission lines.

Three transmission lines will connect the 230-kV HAR 3 switchyard to the PEC electrical grid. These transmission lines will be connected to the existing Fort Bragg Woodruff Street Substation, Erwin Substation, and Wake Substation (Reference 3.7-001). Table 3.7-2 provides the termination points, nominal voltage, power transmission capacity, and approximate lengths of these transmission lines. The proposed routing of the new lines for HAR 3 are being evaluated to be adjacent to or within the existing maintained transmission corridors for the HNP and only small environmental impacts are anticipated from the expansion efforts.

3.7.1.2 Transmission Line Corridors (Existing and Proposed)

Figures 3.7-1 and 3.7-2 (Reference 3.7-003) present the current configuration of the transmission system, with seven 230-kV transmission lines connecting HNP to the regional grid as well as a depiction of the planned RTP line. These lines generally run through 100-ft.-wide corridors with a 15.2-m (50-ft.) easement on either side. Some areas, such as the short segment of ROW immediately south of the switchyard that holds five lines, are as wide as 106.7 m (350 ft.) But these wide segments are exceptions to the rule, making up a small proportion of the approximately 244.9 km (152.2 mi.) of transmission corridor associated with HNP (Reference 3.7-003). These seven lines and the planned eighth line are described in more detail in the paragraphs that follow:

- **Siler City** – This line terminates at Siler City, 48.6 km (30.2 mi.) west of HNP. The new Siler City substation was completed in 2006.

- **Cape Fear North** – This line connects HNP with the Cape Fear Steam Plant at a point 11.9 km (7.4 mi.) southwest of HNP.

- **Cape Fear South** – This line connects the plant with the Cape Fear Steam Plant following a more southerly 10.5-km (6.5-mi.) route than the north line.

- **Apex-U.S. 1** – This line terminates approximately 8.0 km (5.0 mi.) northeast of HNP, but formerly extended another 11.3 km (7 mi.) to the Cary Regency Park substation.

- **Erwin** – This line is approximately 47.9 km (29.8 mi.) long, connecting HNP to southeastern Harnett County.

- **Fort Bragg – Woodruff Street** – This line terminates at the Woodruff Street substation on the Fort Bragg post, approximately 57.2 km (35.5 mi.) south of HNP.

- **Wake** – This 230-kV line was built, in part, along the same corridor that was created for the originally planned 500-kV line to Wake County, which is identified in the revised operating permit Final Environmental Statement (FES). This line is approximately 60.9 km (37.8 mi.) long, extending to the east past the City of Raleigh to terminate at Knightdale. (Reference 3.7-003).

- **Planned RTP Line** – The planned line is not included in the HAR-related activities, though it is planned to eventually extend from the HNP to terminate at the RTP Substation. A portion of the existing transmission system between Apex and Green Level will be upgraded from 115 kV to 230 kV. The ROW acquired initially for the 115-kV line will also accommodate the planned 230-kV line. Route selection has not been completed for this new line; however, it is anticipated that the route will start at the HNP and will parallel the Apex line to U.S. 1, where it will turn north. When the line is north of U.S. 64, it will turn east until it is parallel to the proposed I-540 outer loop around Raleigh. It will run parallel to I-540 until it reaches the RTP, where it will tie into an existing transmission line at the new RTP substation.

As stated previously, three new transmission lines will connect the new HAR 3 switchyard to the PEC grid. The proposed routing of the new lines for HAR 3 are being evaluated to be adjacent to or within the existing maintained transmission corridors for the HNP (Figure 3.7-3). The new corridors for HAR 3 are conservatively estimated to require an additional 100 ft. of width. The three new lines will originate at the HAR 3 switchyard and terminate at the following existing substations (Reference 3.7-003):

- **Erwin (New)** — This new line will terminate at the Erwin substation.

- **Fort Bragg – Woodruff Street (New)** — This new line will terminate at the Woodruff Street substation on the Fort Bragg post.

- **Wake (New)** — This new line will terminate at the Wake substation.

In total, for the specific purpose of connecting HNP to the transmission system, PEC has approximately 166.0 km (103 mi.) of transmission corridor that will be impacted by expansion within or adjacent to these existing lines.

The expanded corridors will impact an area totaling no more than 5.1 km^2 (1250.2 ac. or 2.0 $mi.^2$) within 50 feet immediately adjacent to either side of the existing lines. As discussed in ER Subsection 4.1.2.2, most of these corridors pass through land that is primarily agricultural and forest land. The areas are mostly remote, with low population densities. The longer lines cross numerous state and United States highways. The effect of these corridors on land usage is minimal; farmlands that have corridors passing through them generally continue to be used as farmland (Reference 3.7-003).

PEC designed and constructed all HNP transmission lines in accordance with industry guidance that was current when the lines were built. Ongoing surveillance and maintenance of HNP-related transmission facilities ensure continued conformance to design standards. These maintenance practices also examine the conformance of the lines with the National Electrical Safety Code requirements on line clearance to limit shock from induced currents (Reference 3.7-003).

As they enter the plant area, five circuits share a common ROW. In that common corridor, the lines are spaced sufficiently far apart to preclude the possibility of one line's failure causing the failure of more than one other line (Reference 3.7-002).

3.7.2 TRANSMISSION SYSTEM DESIGN PARAMETERS

The new 230-kV transmission lines connecting the HAR 3 switchyard to the PEC system will be constructed on PEC standard concrete or steel H-frame structures (Figure 3.7-4). Transmission tower designs will be per PEC's construction specifications and line design philosophy (e.g., tower foundations, stringing, location of access roads, span length, clearing of ROWs, color and finish of the towers). Past experience with similar 230-kV lines on the PEC system has shown availability of power to be in excess of 99 percent (Reference 3.7-002).

New lines will be built to PEC's construction specifications, line design philosophy, and applicable standards stipulated by the National Electrical Safety Code (NESC). The typical transmission tower design consists of concrete or steel H-frame support structures with steel or wood crossarms (Figure 3.7-4). Pole heights are typically 21 to 27 m (70 to 90 ft.) with 183- to 213-m (600- to 700-ft.) spans between poles. The poles are normally direct buried, with engineered foundations as needed. Single steel poles with concrete footings will be used, as appropriate, in areas where the ROW widths are constrained. The typical line clearances above ground level will be 8.2 m (27 ft.) at 212°F conductor temperature. Phase spacing will typically be 5.5 m (18 ft.). The transmission structures will normally carry a single circuit line consisting of three phases of two-bundled conductors of 1590 kilo circular mils (kcmil) aluminum conductor steel reinforced (ACSR) and two shield wires. One of the shield wires will be standard optical ground wire (fiber optic cable) and will be used for protection and control communications.

Transmission line structures and support systems will be designed for the following load cases (Reference 3.7-002):

- National Electrical Safety Code Medium Loading (0.64-cm [0.25-in.] radial ice and 64-km/h [40-mile-per-hour (mph)] wind and overload capacity factors).
- PEC High Wind Loading (145-km/h [90-mph] wind on bare wires and structures).

- PEC Heavy Ice Loading (3.81-cm [1.50-in.] radial ice and no wind).

Loadings are applied to all conductor spans and shield wires for all cases rather than incorporating a gust-and-span reduction factor (Reference 3.7-002).

The highest observed wind speed recorded at the Raleigh-Durham Weather Service was a 127-km/h (79-mph) wind in September 1996. A climatic review of the plant site area indicates the ice in Load Case 3 is more than twice the greatest radial thickness (1.88 cm [0.74 in.]) on utility wires observed during the nine winters between 1928 and 1937 (Reference 3.7-002).

The transmission line structures and support systems will be designed for tolerances above the maximum observed occurrences within the service area. Therefore, no significant problems are expected related to line icing or other heavy loading conditions (Reference 3.7-002).

Transmission system design, construction, and operation will comply with the relevant local, state, and industry standards, including the NESC and various American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE) standards. These include standards relating to ground clearances, electromagnetic fields (EMF), radio interference (RI), television interference (TVI), audible noise, aviation safety, and other factors, as appropriate.

3.7.3 RADIATED ELECTRICAL AND ACOUSTICAL NOISES

When an electric transmission line is energized, an electric field is created in the air surrounding the conductors. If this field is sufficiently intense, it may cause the breakdown of the air in the immediate vicinity of the conductor (corona). Corona can result in audible noise or RI and TVI. Audible noise levels are usually very low and not heard, except possibly directly below the line on a quiet day.

RI and TVI can occur from corona, electrical sparking, and arcing between two pieces of loosely fitting hardware or burrs or edges on hardware. This noise occurs at discrete points and can be minimized with good design and maintenance practices. Design practices for the proposed transmission lines include the use of extra high voltage (EHV) conductors, corona resistant line hardware, and grading rings at insulators. The effect of corona on radio and television reception depends on the radio/television signal strength, the distance from the transmission line, and the transmission line noise level.

3.7.4 ELECTRO MAGNETIC FIELDS

The EMF is produced by electrical devices, including transmission lines. Electric fields are produced by voltage and are typically measured in kilovolts per meter (kV/m), while magnetic fields are produced by current and are measured in gauss (G). Some epidemiological studies have suggested a link between power-frequency EMF and some types of cancer, while others have not. Although there is no scientific consensus on the topic, the presence of EMF, especially from transmission lines, has become a greater public concern in recent years. Due to the lack of evidence supporting a health risk from EMF, there are no federal health standards for EMF. The parameters having the greatest effect on EMF levels near the transmission line are operating voltage, current, conductor height, electrical phasing, and distance from the source. EMF reduction measures will be incorporated into the line and station designs to minimize the EMF strengths.

Presently, North Carolina regulations do not stipulate what the acceptable predicted electric-field strength(s) at 1 m above ground or the predicted electric field strength(s) at the edge of the ROW should be. As discussed above, there is really no scientific consensus as to whether or not errant EMF is a health risk to the public.

3.7.5 INDUCED OR CONDUCTED GROUND CURRENTS

Objects located near transmission lines can become electrically charged due to their immersion in the lines' electric field. This charge results in a current that flows through the object to the ground. The current is called "induced" because there is no direct connection between the line and the object. The induced current can also flow to the ground through the body of a person who touches the object. An object that is insulated from the ground can actually store an electrical charge, becoming what is called "capacitively charged." A person standing on the ground and touching a vehicle or a fence receives an electrical shock due to the sudden discharge of the capacitive charge through the person's body to the ground. After the initial discharge, a steady-state current can develop, the magnitude of which depends on several factors including the following:

- The strength of the electric field which, in turn, depends on the voltage of the transmission line as well as its height and geometry.
- The size of the object on the ground.
- The extent to which the object is grounded.

Touching the object at a point remote from an electrical ground can result in a shock. To minimize these induced ground currents and distribute ground fault currents, each tangent or in-line structure will be grounded. Each tangent structure will have an electrical connection between the shield wire and ground lead that will be connected to ground rods. Ground resistance tests will be made at each tangent structure before the shield wire is electrically connected to the ground lead. Sufficient ground rods will be installed to reduce the resistance to 10 ohms or less under normal atmospheric conditions. Angle or corner structures will have a low voltage insulator installed between the shield wire and down guys to avoid possible anchor corrosion problems.

PEC has existing surveillance and maintenance procedures that provide assurance that design ground clearances will not change. These procedures include routine aerial inspections, which include checking for encroachments, broken conductors, broken or leaning structures, and signs of trees burning, any of which would be evidence of clearance problems. Ground inspections include examination of clearance at questionable locations, integrity of structures, and surveillance for dead or diseased trees that might fall on the transmission lines. Problems noted during any inspection are brought to the attention of the appropriate organization(s) for corrective action.

3.7.6 REFERENCES

3.7-001 Sargent & Lundy, LLC, "230-kV Switchyard Conceptual Design Report, Harris Advanced Reactors Units 2 and 3, HAG-ZBS-GER-001 Rev. 3," August 8, 2007.

3.7-002 Carolina Power & Light Company, "Shearon Harris Nuclear Power Plant Final Safety Analysis Report," Amendments 46, 48, and 51, 1983.

3.7-003 Progress Energy Carolinas, Inc., "Applicant's Environmental Report – Operating License Renewal Stage Shearon Harris Nuclear Plant Progress Energy, Unit 1," Docket No. 50-400, License No. NPF-63, Final, November 2006.

Table 3.7-1
Existing and Proposed Transmission Lines That Connect HAR 2 to the PEC Transmission System

Termination	Nominal Voltage (kV)	Thermal Capacity	Approximate Length
Cape Fear (North Line)	230	793 MVA	11.9 km (7.4 mi.)
Cape Fear (South Line)	230	797 MVA	10.5 km (6.5 mi.)
Apex US 1	230	797 MVA	8.0 km (5.0 mi.)
Ft. Bragg Woodruff St.	230	1077 MVA	57.2 km (35.5 mi.)
Erwin	230	797 MVA	47.9 km (29.8 mi.)
Siler City	230	797 MVA	48.6 km (30.2 mi.)
Wake	230	637 MVA	60.9 km (37.8 mi.)
Future RTP Line[a]	230	1195 MVA	35.4 km (22 mi.)

Notes:
a) This line is planned to primarily support HNP operations but may be used by HAR 2 if deemed necessary by PEC to support HAR 2 operations. Routing studies are still being evaluated and the RTP line length may ultimately change.

kV = kilovolt
MVA = megavolt ampere
RTP = Research Triangle Park

Table 3.7-2
Proposed Transmission Lines That Will Connect HAR 3 to the PEC Transmission System

Termination	Nominal Voltage (kV)	Thermal Capacity	Approximate Length
Ft. Bragg Woodruff St. (New Line)	230	1,256 MVA	57.2 km (35.5 mi.)[a]
Wake (New Line)	230	1,256 MVA	60.9 km (37.8 mi.)[a]
Erwin (New Line)	230	1,256 MVA	47.9 km (29.8 mi.)[a]

Notes:
a) Routing studies are still being evaluated and line lengths may vary depending on the outcome of the studies.

kV = kilovolt
MVA = megavolt ampere

3.8 TRANSPORTATION OF RADIOACTIVE MATERIALS

This section addresses issues associated with the transportation of radioactive materials from the HAR and alternative sites (Brunswick Nuclear Power Plant [BNP], H.B. Robinson Nuclear Power Plant [RNP], and Marion County [refer to ER Subsection 9.3.2]). Postulated accidents due to transportation of radioactive materials are discussed in ER Section 7.4.

3.8.1 TRANSPORTATION ASSESSMENT

The U.S. Nuclear Regulatory Commission (NRC) regulations in 10 CFR 51.52 state that:

> "Every environmental report prepared for the construction permit stage [or early site permit stage, or combined license stage] of a light-water-cooled nuclear power reactor, and submitted after February 4, 1975, shall contain a statement concerning transportation of fuel and radioactive wastes to and from the reactor. That statement shall indicate that the reactor and this transportation either meet all of the conditions in paragraph (a) of this section or all of the conditions in paragraph (b) of this section."

The NRC evaluated the environmental effects of transportation of fuel and waste for light water reactors (LWRs) in the U.S. Atomic Energy Commission's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Plants" (WASH-1238) and the NRC's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants, Supplement 1" (NUREG-75/038) and found the impacts to be small. These NRC analyses provided the basis for Table S-4 in 10 CFR 51.52 (reproduced in this ER as Table 3.8-1), which summarizes the environmental impacts of transportation of fuel and radioactive wastes to and from a reference LWR. The table addresses two categories of environmental considerations: (1) normal conditions of transport and (2) accidents in transport.

To compare the impacts of transporting AP1000 fuel to the conditions in Table S-4, the fuel characteristics for the AP1000 were normalized to a reference reactor year (RRY). The reference LWR is an 1100-megawatt electric (MWe) reactor that has an 80-percent capacity factor, for an electrical output of 880 MWe per year. One AP1000 is assumed to operate at 1115 MWe, with an annual capacity factor of 93 percent.

The advanced light water reactor (ALWR) technology that is being considered for the HAR site and the alternative sites is the AP1000. The proposed configuration for this new plant is two units. The standard configuration (a single unit) for the AP1000 has been used to evaluate transportation impacts relative to the reference LWR.

Subparagraphs 10 CFR 51.52(a)(1) through (5) delineate specific conditions the reactor licensee must meet to use Table S-4 as part of its environmental report. For reactors not meeting all of the conditions in paragraph (a) of 10 CFR 51.52, paragraph (b) of 10 CFR 51.52 requires a further analysis of the transportation effects.

The conditions in paragraph (a) of 10 CFR 51.52, establishing the applicability of Table S-4, are reactor core thermal power, fuel form, fuel enrichment, fuel encapsulation, average fuel irradiation, time after discharge of irradiated fuel before shipment, mode of transport for unirradiated fuel, mode of transport for irradiated fuel, radioactive waste form and packaging, and mode of transport for radioactive waste other than irradiated fuel. The following subsections describe the characteristics of the AP1000 relative to the conditions of 10 CFR 51.52 for use of Table S-4. Information for the AP1000 fuel is taken from the DCD and supporting documentation prepared by the Idaho National Engineering and Environmental Laboratory (Reference 3.8-001).

3.8.1.1 Reactor Core Thermal Power

Subparagraph 10 CFR 51.52(a)(1) requires that the reactor have a core thermal power level not exceeding 3800 megawatts (MW).

As noted in DCD Table 4.1-1, the 3400-MWt reactor power level rating of the AP1000 (the AP1000 core thermal is rated at 3400 MWt and the RCP heat addition is 15 MWt, for a total thermal power output of 3415 MWt) meets this requirement.

The core power level was established as a condition because, for the LWRs being licensed when Table S-4 was promulgated, higher power levels typically indicated the need for more fuel and, therefore, more fuel shipments than were evaluated for Table S-4. This is not the case for the new LWR designs, due to the higher unit capacity and higher burnup for these reactors. The annual fuel reloading for the reference LWR analyzed in WASH-1238 was 30 metric tons of uranium (MTU), while the average annual fuel reloading for the AP1000 is approximately 24 MTU. When normalized to equivalent electric output, the annual fuel reloading for the AP1000 is approximately 20 MTU or two-thirds that of the reference LWR.

3.8.1.2 Fuel Form

Subparagraph 10 CFR 51.52(a)(2) requires that the reactor fuel be in the form of sintered UO_2 pellets.

As noted in DCD Table 4.1-1, the AP1000 has a sintered UO2 pellet fuel form.

3.8.1.3 Fuel Enrichment

Subparagraph 10 CFR 51.52(a)(2) requires that the reactor fuel have a uranium-235 (U-235) enrichment not exceeding 4 percent by weight. As noted in DCD Table 4.1-1, for the AP1000, the enrichment of the initial core varies by region from 2.35 to 4.45 percent, and the average for reloads is 4.51 percent. Because the AP1000 exceeds the U-235 condition in subparagraph 10 CFR 51.52(a)(2), further analysis of the transportation impacts is provided in ER Subsection 3.8.2 and ER Section 7.4.

3.8.1.4 Fuel Encapsulation

Subparagraph 10 CFR 51.52(a)(2) requires that the reactor fuel pellets be encapsulated in Zircaloy rods. Regulation 10 CFR 50.46 also allows use of ZIRLO™.

As noted in DCD Table 4.1-1, the AP1000 uses ZIRLO™ clad fuel rods, which are equivalent to the Zircaloy clad fuel rods evaluated in Table S-4.

3.8.1.5 Average Fuel Irradiation

Subparagraph 10 CFR 51.52(a)(3) requires that the average burnup not exceed 33,000 MWd/MTU.

According to the DCD, the AP1000 has an average maximum burnup of 60,000 MWd/MTU for the peak rod. The extended burnup is 62,000 MWd/MTU. Because the AP1000 exceeds the average burnup condition in subparagraph 10 CFR 51.52(a)(3), further analysis of the transportation impacts is provided in ER Subsection 3.8.2 and ER Section 7.4.

3.8.1.6 Time after Discharge of Irradiated Fuel Before Shipment

Subparagraph 10 CFR 51.52(a)(3) requires that no irradiated fuel assembly be shipped until at least 90 days after it is discharged from the reactor. The WASH-1238 for Table S-4 assumes 150 days of decay time prior to shipment of any irradiated fuel assemblies. NUREG/CR-6703 updated this analysis to extend Table S-4 to burnups of up to 62,000 MWd/MTU, assuming a minimum of 5 years between removal from the reactor and shipment.

Five years is the minimum decay time expected before shipment of irradiated fuel assemblies. The 5-year minimum time is supported additionally by the following three practices:

- Five years is the minimum cooling time specified in 10 CFR 961.11, within Appendix E of the standard U.S. Department of Energy (DOE) contract for spent fuel disposal with existing reactors.
- In NUREG-1437, the NRC specifies 5 years as the minimum cooling period when it issues certificates of compliance for casks used for shipment of power reactor fuel.
- The NRC has generically considered the environmental effects of spent nuclear fuel with U-235 enrichment levels up to 5 percent and irradiation levels up to 62,000 MWd/MTU, and found that the environmental effects of spent nuclear fuel transport are bounded by the effects listed in Table S-4 (see Table 3.8-1), provided that more than 5 years has elapsed between removal of the fuel from the reactor and shipment of the fuel off-site.

In addition to the minimum fuel storage time, NUREG-1555, Environmental Standard Review Plan 3.8 asks for the capacity of the on-site storage facilities to store irradiated fuel.

As noted in DCD Table 9.1-2, the new spent fuel storage facilities (one per unit) constructed to support the HAR will have enough storage capacity to store 889 total fuel assemblies for each unit. This will provide more than enough capacity for 5 years of spent fuel storage.

3.8.1.7 Transportation of Unirradiated Fuel

Subparagraph 10 CFR 51.52(a)(5) requires that unirradiated fuel be shipped to the reactor site by truck. PEC will receive fuel via truck shipments for the AP1000 units being considered for the HAR and alternative sites.

Table S-4 includes a condition that the truck shipments not exceed 73,000 pounds as governed by federal or state gross vehicle weight restrictions. The fuel shipments to the HAR and the alternative sites will comply with federal and state weight restrictions.

3.8.1.8 Transportation of Irradiated Fuel

Subparagraph 10 CFR 51.52(a)(5) allows for truck, rail, or barge transport of irradiated fuel.

This condition will be met for the AP1000. For the impacts analysis described in ER Subsection 3.8.2, it was assumed that all spent fuel shipments will be made using legal weight trucks. According to 10 CFR 961.1, the DOE is responsible for spent fuel transportation from reactor sites to the repository and will make the decision on the transport mode.

3.8.1.9 Radioactive Waste Form and Packaging

Subparagraph 10 CFR 51.52(a)(4) requires that, with the exception of spent fuel, radioactive waste shipped from the reactor is to be packaged and in a solid form.
PEC will solidify and package its radioactive waste. The DCD provides the following information regarding the treatment and packaging of radioactive wastes:

> Processing and packaging of wastes will most likely be by mobile systems in the auxiliary building rail car bay and in the mobile systems facility part of the radwaste building. The packaged waste is stored in the auxiliary and radwaste buildings until it is shipped offsite to a licensed disposal facility.
>
> The use of mobile systems for the processing functions permits the use of the latest technology and avoids the equipment obsolescence problems experienced with installed radwaste processing equipment. The most appropriate and efficient systems may be used as they become available.

The process technologies that are available through vendors for large quantities of radioactive liquid waste typically include ion exchange through resin columns, resin dewatering, and solidification. Vendor processed wastes are typically packaged in high integrity containers, liners, or drums as appropriate. Small quantities of liquid waste are usually absorbed and then allowed to dry and shipped as dry active waste (DAW).

DAW will be placed in an approved transport container, surveyed to ensure it meets all applicable U.S. Department of Transportation criteria, and shipped to an off-site facility for disposal. Radiological DAW will be disposed of at an approved permitted disposal facility.

3.8.1.10 Transportation of Radioactive Waste

Subparagraph 10 CFR 51.52(a)(5) requires that the mode of transport of low-level radioactive waste be either truck or rail. PEC will ship radioactive waste from the HAR and the alternative sites by truck.

Radioactive waste shipments are subject to a weight limitation of 73,000 pounds per truck and 100 tons per cask per rail car. Radioactive waste from the AP1000 will be shipped in compliance with federal and state weight restrictions.

3.8.1.11 Number of Truck Shipments

Table S-4 (see Table 3.8-1) limits traffic density to less than one truck shipment per day or three rail cars per month. The number of truck shipments that will be required, assuming that all radioactive materials (fuel and waste) are received at the site or transported off-site via truck, was estimated, and a discussion below is provided.

Table 3.8-2 summarizes the number of truck shipments of unirradiated fuel. The table also normalizes the number of shipments to the electrical output for the reference LWR analyzed in WASH-1238. When normalized for electrical output, the number of truck shipments of unirradiated fuel for the AP1000 is less than the number of truck shipments estimated for the reference LWR.

For the AP1000, the initial core load is estimated at 84.5 MTU per unit, and the annual reload requirements are estimated at 24 MTU per year per unit. This equates to approximately 157 fuel assemblies in the initial core (assuming 0.5383 MTU per fuel assembly) and 43 fuel assemblies per year for refueling. The vendor is designing a transportation container that will accommodate one 4.3-m (14-ft.) fuel bundle. Due to weight limitations, the number of such containers will be limited to seven to eight per truck shipment. For the initial core load, the trucks are assumed to carry seven containers to allow for shipment of core components and the fuel assemblies. Truck shipments will be able to accommodate eight containers per shipment for refueling. The number of new fuel truck shipments equates to 23 for the initial core loading and 5.3 for annual reloads.

The numbers of spent fuel shipments were estimated as follows: For the reference LWR analyzed in WASH-1238, the NRC assumed that 60 shipments per year will be made, each carrying 0.5 MTU of spent fuel. This amount is equivalent to the annual refueling requirement of 30 MTU per year for the reference LWR. For this transportation analysis, PEC assumed that the AP1000 will also ship spent fuel at a rate equal to the annual refueling requirement. The shipping cask capacities used to calculate annual spent fuel shipments were assumed to be the same as those for the reference LWR (0.5 MTU per legal weight truck shipment). This results in 46 shipments per year for one AP1000. After normalizing for electrical output, the number of spent fuel shipments is 39 per year for the AP1000. The normalized spent fuel shipments for the AP1000 will be less than the reference LWR that was the basis for Table S-4.

Table 3.8-3 presents estimates of annual waste volumes and numbers of truck shipments. The values are normalized to the reference LWR analyzed in WASH-1238. The normalized annual waste volumes and waste shipments for the AP1000 will be less than the reference LWR that was the basis for Table S-4.

The total number of truck shipments of fuel and radioactive waste to and from the reactor is estimated at 65 per year for the AP1000. These radioactive material transportation estimates are well below the one truck shipment per day condition given in 10 CFR 51.52, Table S-4.

Doubling the estimated number of truck shipments to account for empty return shipments still results in a number of shipments well below the one truck shipment per day condition.

3.8.1.12 Summary

Table 3.8-4 summarizes the reference conditions in paragraph (a) of 10 CFR 51.52 for use of Table S-4 and the values for the AP1000. The AP1000 does not meet the conditions for average fuel enrichment or average fuel irradiation. Therefore, ER Subsection 3.8.2 and ER Section 7.4 present additional analyses of fuel transportation effects for normal conditions and accidents, respectively. Transportation of radioactive waste met the applicable conditions in 10 CFR 51.52 and no further analysis is required.

3.8.2 INCIDENT-FREE TRANSPORTATION IMPACTS ANALYSIS

Environmental impacts of incident-free transportation of fuel are discussed in this section. Transportation accidents are discussed in ER Section 7.4.

In NUREG-1811, NUREG-1815, and NUREG-1817, the NRC analyzed the transportation of radioactive materials in its assessments of environmental impacts for the proposed ESP sites at North Anna, Clinton, and Grand Gulf, respectively. The NRC analyses were reviewed for guidance in assessing transportation impacts for the HAR site and alternative sites.

In many cases, the assumptions used by the NRC are “generic” (that is, independent of the reactor technology). For example, the radiation dose rate associated with fuel shipments is based on the regulatory limit rather than the fuel characteristics or packaging. PEC used these same generic assumptions in assessing transportation impacts for unirradiated fuel shipments to the HAR and alternative sites.

3.8.2.1 Transportation of Unirradiated Fuel

Table S-4 (see Table 3.8-1) includes conditions related to radiological doses to transport workers and members of the public along transport routes. These doses, based on calculations in WASH-1238, are a function of the radiation dose rate emitted from the unirradiated fuel shipments, the number of exposed individuals and their locations relative to the shipment, the time of transit (including travel and stop times), and the number of shipments to which the individuals are exposed. In its assessments of environmental impacts for proposed ESP sites, the NRC calculated the radiological dose impacts of unirradiated fuel transportation using the radioactive material transportation (RADTRAN) 5 computer code.

The RADTRAN 5 calculations estimated worker and public doses associated with annual shipments of unirradiated fuel. One of the key assumptions in WASH-1238 for the reference LWR unirradiated fuel shipments is that the radiation dose rate at 1 m (3.28 ft.) from the transport vehicle is approximately 1.0E-03 milliSeiverts (mSv) per hour (0.1 milliRoentgen equivalent man [mrem] per hour). This assumption was also used by the NRC to analyze ALWR unirradiated fuel shipments for proposed ESP sites. This assumption is reasonable for all of the ALWR types because the fuel materials will all be low-dose rate uranium radionuclides and will be packaged similarly (inside a metal container that provides little radiation shielding). The per-shipment dose estimates are "generic" (that is, independent of reactor technology) because they were calculated based on an assumed external radiation dose rate rather than the specific characteristics of the fuel or packaging. Thus, the results can be used to evaluate the impacts for any of the ALWR designs.

For shipments from fuel fabrication facility sites, highway routes were analyzed using the routing computer code Transportation Routing Analysis Geographic Information System (TRAGIS) (Reference 3.8-002) and 2000 U.S. Census data.

Routes were estimated by minimizing the total impedance of a route, which is a function of distance and driving time between the origin and destination. TRAGIS can also estimate routes that maximize the use of interstate highways. For unirradiated fuel, the commercial route setting was used to generate highway routes generally used by commercial trucks. However, the routes chosen may not be the actual routes used in the future. The population summary module of the TRAGIS computer code was used to determine the exposed populations within 800 m (2624 ft.) (that is, 0.8 km [0.5 mi.] on either side) of the route. Unirradiated fuel for the AP1000 could be manufactured at facilities located in Wilmington, North Carolina; Columbia, South Carolina; or Lynchburg, Virginia. Because it is currently unknown which of these facilities would be used, the Lynchburg facility was evaluated to bound the radiological impacts because the distances to that facility would be greater than the other facilities. In addition to the HAR site near New Hill, North Carolina, three alternate sites were evaluated. These sites and starting locations are shown in Table 3.8-5. Summary data for unirradiated fuel are provided in Table 3.8-6.

Other input parameters used in the radiation dose analysis for ALWR unirradiated fuel shipments are summarized in Table 3.8-6. The results for this "generic" fresh fuel shipment based on the RADTRAN 5 analyses are provided in Table 3.8-7.

These unit dose values were used to estimate the impacts of transporting unirradiated fuel to the HAR and alternative sites. Based on the parameters used in the analysis, these per-shipment doses are expected to conservatively estimate the impacts for fuel shipments to a site in PEC's region of interest. For example, the average shipping distance of 3139 km (2000 mi.) used in the NRC analyses exceeded the shipping distance for fuel deliveries to the HAR and alternative sites (306 km [190 mi.] to 526 km [327 mi.]).

The unit dose values were combined with the average number of annual shipments of unirradiated fuel to calculate annual doses to the public and workers that can be compared to Table S-4 conditions.

The number of unirradiated fuel shipments was normalized to the reference LWR analyzed in WASH-1238. The number of shipments per year was obtained from Table 3.8-2. The results are presented in Table 3.8-8. As shown, the calculated radiation doses for transporting unirradiated fuel to the HAR and alternative sites are within the conditions presented in Table S-4 (see Table 3.8-1).

Draft NUREG-1872 provides the following information:

> Although radiation may cause cancers at high doses and high dose rates, there are currently no data that unequivocally establish the occurrence of cancer following exposure to low doses below about 100 mSv (10,000 mrem) and at low dose rates. However, radiation protection experts conservatively assume that any amount of radiation may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response relationship is used to describe the relationship between radiation dose and detriments such as cancer induction. A recent report by the National Research Council (2006), the BEIR VII report, supports the linear, no-threshold dose response theory. Simply stated, any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably overestimates those risks.
> Based on this model, the staff estimates the risk to the public from radiation exposure using the nominal probability coefficient for total detriment (730 fatal cancers, nonfatal cancers, and severe hereditary effects per 10,000 [person-Sieverts] person-Sv [1,000,000 [person-roentgen equivalent man] person-rem) from [International Commission on Radiation Protection] ICRP Publication 60 (ICRP 1991).

All of the public doses presented in Table 3.8-8 are less than 1E-03 person-Sv (1E-01 person-rem) per year; therefore, the total detriment estimates associated with these doses will each be less than 1E-04 fatal cancers, nonfatal cancers, and severe hereditary effects per year. These risks are very small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that the same population will incur annually from exposure to natural sources of radiation.

3.8.2.2 Transportation of Spent Fuel

This subsection discusses the environmental impacts of transporting spent fuel from the HAR and alternative sites to a spent fuel disposal facility using Yucca Mountain, Nevada, as a possible location for a geologic repository. The impacts of the transportation of spent fuel to a possible repository in Nevada provides a reasonable bounding estimate of the transportation impacts to a monitored retrievable storage facility because of the distances involved and the representative exposure to members of the public in urban, suburban, and rural areas.

Draft NUREG-1872 provides the following information:

> Normal conditions, sometimes referred to as “incident-free” transportation, are transportation activities in which shipments reach their destination without an accident occurring enroute. Impacts from these shipments would be from the low levels of radiation that penetrate the heavily shielded spent fuel shipping cask. Radiation exposures would occur to (1) persons residing along the transportation corridors between the [HAR site and alternative sites] and the proposed repository location; (2) persons in vehicles traveling on the same route as a spent fuel shipment; (3) persons at vehicle stops for refueling, rest, and vehicle inspections; and (4) transportation crew workers.

This analysis is based on shipment of spent fuel by legal-weight trucks in casks with characteristics similar to casks currently available (that is, massive, heavily shielded, cylindrical metal pressure vessels). Each shipment is assumed to consist of a single shipping cask loaded on a modified trailer. These assumptions are consistent with assumptions made in the evaluation of environmental impacts of spent fuel transportation in Addendum 1 to NUREG-1437. As discussed in NUREG-1437, the assumption of using legal-weight trucks is a conservative assumption because the alternative, using heavy-haul trucks, would require fewer shipments.

In its assessments of proposed ESP sites, the NRC calculated the environmental impacts of spent fuel transportation using the RADTRAN 5 computer code (Reference 3.8-003). Routing and population data used in the RADTRAN 5 for truck shipments were obtained from the TRAGIS routing code (Reference 3.8-002). The population data in the TRAGIS code were based on 2000 U.S. Census data. For fresh fuel, the commercial routing option was used with the following constraints:

- Prohibit use of links prohibiting truck use.
- Prohibit use of ferry crossing.
- Prohibit low height clearance.
- Prohibit narrow width clearance.
- Prohibit use of roads with hazardous materials prohibition.
- Prohibit use of roads with radioactive materials prohibition.
- Prohibit use of roads with tunnels.

For spent fuel, the highway route controlled option was selected with the following constraints:

- Prohibit use of links prohibiting truck use.
- Prohibit use of ferry crossing.
- Prohibit low height clearance.
- Prohibit narrow width clearance.
- Prohibit use of roads with radioactive materials prohibition.
- Prohibit use of roads with tunnels.
- Las Vegas Beltway is considered a preferred route.

Although shipping casks have not been designed for the ALWR fuels, the ALWR fuel designs will not be significantly different from existing LWR designs. Current shipping cask designs were used for analysis.

Radiation doses are a function of many parameters, including vehicle speed, traffic count, dose rate at 1 m (3.3 ft) from the vehicle, packaging dimensions, number in the truck crew, stop time, and population density at stops. A listing of the values for the parameters used in the NRC analyses can be found in Appendices G and H of NUREG-1811, NUREG-1815, and NUREG-1817.

The transportation route selected for a shipment determines the total potentially exposed population and the expected frequency of transportation-related accidents. For truck transportation, the route characteristics most important to the risk assessment include the total shipping distance between each origin-destination pair of sites and the population density along the route.

Representative shipment routes for the HAR and alternative sites were identified using the TRAGIS (Version 4.6.2) routing model (Reference 3.8-002) for the truck shipments. The highway data network in Web-TRAGIS is a computerized road atlas that includes a complete description of the interstate highway system and of all U.S. highways. The population densities along a route are derived from 2000 U.S. Census data. This transportation route information is summarized in Table 3.8-9. Other input parameters used in the radiation dose analysis for ALWR spent nuclear fuel shipments are summarized in Table 3.8-10. The results for the incident-free spent fuel shipments are presented in Table 3.8-11.

These per-shipment dose estimates are independent of reactor technology because they were calculated based on an assumed external radiation dose rate emitted from the cask, which was fixed at the regulatory maximum of 10 mrem per hour at 2 m (6.6 ft.). For purpose of this analysis, the transportation crew consists of two drivers. Stop times were assumed to accrue at the rate of 30 minutes per 4-hour driving time.

The number of spent fuel shipments for the transportation impacts analysis was derived as described in ER Subsection 3.8.1. The normalized annual shipment values and corresponding population dose estimates per RRY are presented in Table 3.8-12. The population doses were calculated by multiplying the number of spent fuel shipments per year for the AP1000 by the per-shipment doses. For comparison to Table S-4, the population doses were normalized to the reference LWR analyzed in WASH-1238.

As shown in Table 3.8-12, population doses to the transport crew and the onlookers for both the AP1000 and the reference LWR exceed Table S-4 values. As noted in NUREG-1811, NUREG-1815, and NUREG-1817, two key reasons for these higher population doses relative to Table S-4 are the number of spent fuel shipments and the shipping distances assumed for these analyses relative to the assumptions used in WASH-1238:

- The analyses in WASH-1238 used a "typical" distance for a spent fuel shipment of 1609 km (1000 mi.) The shipping distances used in this assessment were between 4400 and 4900 km (2734 and 3045 mi.), as presented in Table 3.8-9.

- The number of spent fuel shipments are based on shipping casks designed to transport shorter-cooled fuel (that is, 150 days out of the reactor). This analysis assumed that the shipping cask capacities are 0.5 MTU per legal-weight truck shipment. Newer cask designs are based on longer-cooled spent fuel (that is, 5 years out of reactor) and have larger capacities. For example, spent fuel shipping cask capacities used in the analysis were approximately 1.8 MTU per legal-weight truck shipment.

Use of the newer shipping cask designs will reduce the number of spent fuel shipments and decrease the associated environmental impacts (because the dose rates used in the impacts analysis are fixed at the regulatory limit rather than actual dose rates based on the cask design and contents).

If the population doses in Table S-4 (see Table 3.8-1) were adjusted for the longer shipping distance and larger shipping cask capacity, the population doses from incident-free spent fuel transportation from the HAR and the alternative sites would probably fall within Table S-4 requirements.

Other conservative assumptions in the spent fuel transportation impacts calculation include:

- The shipping casks assumed in the Yucca Mountain Environmental Impact Statement (EIS) (Reference 3.8-004) transportation analyses were designed for spent fuel that has cooled for 5 years. In reality, most spent fuel will have cooled for much longer than 5 years before it is shipped to a possible geologic repository. The NRC developed a probabilistic distribution of dose rates based on fuel cooling times that indicates that approximately three-fourths of the spent fuel to be transported to a possible geologic repository will have dose rates less than half of the regulatory limit (NUREG/CR-6672, Volume 1). Consequently, the estimated doses in Table 3.8-12 could be divided in half if more realistic dose rate projections are used for spent fuel shipments from the HAR and the alternative sites.

- The average time at a truck stop was assumed to be 30 minutes. Many stops made for actual spent fuel shipments are short-duration stops (10 minutes) for brief visual inspections of the cargo (checking the cask tie-downs). These stops typically occur in minimally populated areas, such as an overpass or freeway ramp in an unpopulated area. Based on data for actual truck stops, the NRC concluded that the assumption of a 30-minute stop for every 4 hours of driving time used to evaluate other potential ESP sites will overestimate public doses at stops by at least a factor of two (NUREG-1811, NUREG-1815, and NUREG-1817).

Consequently, the doses to onlookers presented in Table 3.8-12 could be reduced by half to reflect more realistic truck shipping conditions.

The environmental impact of incident-free transportation of unirradiated and spent fuel is anticipated to be SMALL and does not warrant additional mitigation.

3.8.3 REFERENCES

3.8-001 Idaho National Engineering and Environmental Laboratory, “Early Site Permit ER Sections and Supporting Documentation,” Engineering Design File Number 3747, 2003.

3.8-002 Johnson, P. E. and R. D. Michelhaugh, *Transportation Routing Analysis Geographic Information System (TRAGIS) User’s Manual*, Oak Ridge National Laboratory, ORNL/NTRC-006, Revision 0, June 2003.

3.8-003 Neuhauser, K. S. and F. L. Kanipe, *RADTRAN 5 User Guide*, Sandia National Laboratories, SAND2003-2354, July 2003.

3.8-004 U.S. Department of Energy, *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, DOE/EIS-0250, February 2002.

3.8-005 Jason Technologies Corporation, “Transportation Health and Safety Calculation/Analysis Documentation in Support of the Final EIS for the Yucca Mountain Repository,” Prepared for U.S. Department of Energy, CAL-HSS-ND-000003, December 2001.

3.8-006 U.S. Department of Energy, *A Resource Handbook on DOE Transportation Risk Assessment*, DOE/EM/NTP/HB-01, July 2002.

3.8-007 Neuhauser, K.S. and F.L. Kanipe, *RADTRAN 5 User Guide*, Sandia National Laboratories, SAND2000-1257, May 2000.

3.8-008 Weiner, Ruth F., Douglas M. Osborn, Daniel Hinojosa, Terence J. Heames, Janelle Penisten, and David Orcutt, *RADCAT 2.3 User Guide*, SAND2006-6315, Sandia National Laboratories, December 2007 (includes RADTRAN 5.6).

Table 3.8-1 (Sheet 1 of 2)
Summary Table S-4 — Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor

Normal Conditions of Transport			
		Environmental Impact	
Heat (per irradiated fuel cask in transport)		250,000 Btu/hr	
Weight (governed by federal or state restrictions)		73,000 lb. per truck; 100 tons per cask per rail car	
Traffic density:			
Truck		Less than 1 per day	
Rail		Less than 3 per month	
Exposed Population	**Estimated Number of Persons Exposed**	**Range of Doses to Exposed Individuals (per reactor year)** [(a)]	**Cumulative Dose to Exposed Population (per reactor year)** [(b)]
Transportation workers	200	0.01 to 300 mrem	4 person-rem.
General public:			
Onlookers	1100	0.003 to 1.3 mrem	3 person-rem.
Along route	600,000	0.0001 to 0.06 mrem	
Accidents in Transport			
Types of Effects		**Environmental Risk**	
Radiological effects		Small[(c)]	
Common (nonradiological) causes		1 fatal injury in 100 reactor years 1 nonfatal injury in 10 reactor years	
		$475 property damage per reactor year	

Notes:

Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," WASH-1238, December 1972, and Supp. 1 NUREG-75/038 April 1975.

a) The Federal Radiation Council has recommended that the radiation doses from the sources of radiation other than natural background and medical exposures should be limited to 5000 mrem per year for individuals as a result of occupational exposure and should be limited to 500 mrem per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 mrem per year.

b) Person-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1000 people were to receive a dose of 0.001 rem (1 mrem), or if two people were to receive a dose of 0.5 rem (500 mrem) each, the total person-rem dose in each case would be 1 person-rem.

Table 3.8-1 (Sheet 2 of 2)
Summary Table S-4 — Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor

Notes (continued):

c) Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified since a specific reactor has not been selected, the risk remains small regardless of whether it is being applied to a single reactor or a multireactor site.

Btu/hr = British thermal units per hour
lb. = pound
mrem = milliRoentgen equivalent man
person-rem = person-roentgen equivalent man
rem = roentgen equivalent man

Table 3.8-2
Number of Truck Shipments of Unirradiated Fuel (One AP1000 Unit)

Reactor Type	Number of Shipments per Unit			Unit Electric Generation (MWe)(c)	Capacity Factor(c)	Normalized Shipments Total(d)	Normalized Shipments Annual(e)
	Initial Core(a)	Annual reload	Total(b)				
Reference LWR	18(f)	6.0	252	1100	0.8	252	6.3
AP1000	23(g)	5.3(g)	230	1115	0.93(h)	196	4.9

Notes:

a) Shipments of the initial core have been rounded up to the next highest whole number.

b) Total shipments of fresh fuel over 40-year plant lifetime (initial core load plus 39 years of average annual reload quantities).

c) Unit generating capacities from the DCD and an assumed capacity factor.

d) Normalized to electric output for WASH-1238 reference plant (1100-MWe plant at 80 percent or an electrical output of 880 MWe).

e) Annual average for 40-year plant lifetime.

f) The initial core load for the reference boiling water reactor in WASH-1238 was 150 metric tons of uranium (MTU). The initial core load for the reference pressurized water reactor was 100 MTU. Both types result in 18 truck shipments of fresh fuel per reactor.

g) Initial core load of 157 assemblies required and 43 per year for refueling. Assume 7 assemblies/shipments for initial loading and 8 assemblies/shipments for annual reload.

h) Capacity factor was assumed.

LWR = light water reactor
MWe = megawatt electric

Table 3.8-3
Number of Radioactive Waste Shipments (One AP1000 Unit)

Reactor Type	Waste Generation, ft^3/yr, per unit	Annual Waste Volume, ft^3/yr, per site	Electrical Output, MWe, per site	Capacity Factor	Normalized Waste Generation Rate, $ft.^3$ per reactor-year[(a)]	Normalized Shipments/ reactor-year[(b)]
Reference LWR	3800	3800	1100	0.80	3800	46
AP1000	1964	3928	2230[(c)]	0.93	1667	21

Notes:

a) Annual waste generation rates normalized to equivalent electrical output of 880 MWe for reference LWR (1100-MWe plant with an 80 percent capacity factor) analyzed in WASH-1238.

b) The number of shipments was calculated assuming the average waste shipment capacity of 83 $ft.^3$ per shipment (3800 ft^3/yr divided by 46 shipments per year) used in WASH-1238.

c) The AP1000 site includes two reactor units at a net of 1115 MWe per unit.

LWR = light water reactor
$ft.^3$ = cubic foot
ft^3/yr = cubic feet per year
MWe = megawatt electric

Table 3.8-4 (Sheet 1 of 2)
AP1000 Comparisons to Table S-4 Reference Conditions

Characteristic	Table S-4 Condition	AP1000 Single Unit
Reactor Power Level (MWt)	Not exceeding 3800 per reactor	3415 (AP1000 core thermal = 3400 MWt + RCP heat addition = 15 MWt for a total thermal power output of 3415 MWt)
Fuel Form	Sintered UO_2 pellets	Sintered UO_2 pellets
U-235 Enrichment (%)	Not exceeding 4	Initial Core Region 1: 2.35 Region 2: 3.40; Region 3: 4.45 Reload Average 4.51
Fuel Rod Cladding	Zircaloy rods; NRC has also accepted ZIRLO™ per 10 CFR 50.46	Zircaloy or ZIRLO™
Average burnup (MWd/MTU)	Not exceeding 33,000	Peak-62,000
Unirradiated Fuel		
Transport Mode	Truck	Truck
No. of shipments for initial core loading [(a)]	--	23
No. of reload shipments per year [(a)]	--	5.3
Irradiated Fuel		
Transport mode	Truck, rail, or barge	Truck, rail
Decay time prior to shipment	Not less than 90 days is a condition for use of Table S-4; 5 years is per contract with DOE	Minimum of 5 years
No. of spent fuel shipments by truck [(a)]	--	39 per year
No. of spent fuel shipments by rail	--	Not analyzed
Radioactive Waste		
Transport mode	Truck or rail	Truck
Waste form	Solid	Solid
Packaged	Yes	Yes
No. of waste shipments by truck [(a)]	--	21 per year
Traffic Density		
Trucks per day [(b)]	Less than 1	<1
(normalized total)	--	(65 per year)

Table 3.8-4 (Sheet 2 of 2)
AP1000 Comparisons to Table S-4 Reference Conditions

Characteristic	Table S-4 Condition	AP1000 Single Unit
Rail cars per month	Less than 3	Not analyzed

Notes:

a) Table 3.8-2 provides the total numbers of truck shipments of fuel and waste for the AP1000. The values presented are normalized based on electric output and summed for comparison to the traffic density condition in Table S-4 (see Table 3.8-1).

b) Total truck shipments per year calculated after normalization of estimated fuel and waste shipments for equivalent electrical output to the reference reactor analyzed in WASH-1238.

MWd/MTU = megawatt days per metric ton of uranium
MWe = megawatt electric
MWt = megawatt thermal
U-235 = uranium-235
UO_2 = uranium dioxide

Table 3.8-5
Primary and Alternative Sites for the HAR COLA

Site	Location	TRAGIS Origin Location
HAR	New Hill, NC	HARRIS NP (NC)
BNP	Southport, NC	SOUTHPORT (NC)
RNP	Hartsville, SC	HARTSVILLE (SC)
Marion County	Proprietary	Proprietary

Table 3.8-6 (Sheet 1 of 2)
RADTRAN 5 Input Parameters for HAR Analysis of Unirradiated Fuel Shipments

Parameter	Parameter Value	Comments and Reference
Package		
Package dimension	11.76 m	Approximate length of two LWR Traveller XLs at 226 inches each.
Dose rate at 1 m from vehicle	0.1 mrem per hour	WASH-1238
Fraction of emitted radiation that is gamma	0.5	Assumed the same as for spent nuclear fuel (Reference 3.8-005)
Fraction of emitted radiation that is neutrons	0.5	Assumed the same as for spent nuclear fuel (Reference 3.8-005)
Crew		
Number of crew	2	WASH-1238 and Reference 3.8-006
Distance from source to crew	3.1 m	Reference 3.8-007
Crew shielding factor	1.0	No shielding - Analytical assumption
Route-specific parameters		
Rural Suburban Urban	88.49 kilometers per hour	Average speed in rural areas (Reference 3.8-006). Conservative in-transit speed of 55 miles per hour assumed: predominately interstate highways used.
Number of people per vehicle sharing route	1.5	Reference 3.8-006
One-way traffic volumes		
Rural	Varies by State	Reference 3.8-008 [(a)]
Suburban	Varies by State	Reference 3.8-008 [(a)]
Urban	Varies by State	Reference 3.8-008 [(a)]
Minimum and maximum distances to exposed resident off-link population	10 to 800 m	NUREG/CR-6672

Table 3.8-6 (Sheet 2 of 2)
RADTRAN 5 Input Parameters for HAR Analysis of Unirradiated Fuel Shipments

Parameter	Parameter Value	Comments
Distances (km)/Population densities (persons per km^2)		
HAR		
Rural	15.7/184.7	Reference 3.8-002
Suburban	383.5/115.9	Reference 3.8-002
Urban	1895.4/5.4	Reference 3.8-002
BNP		
Rural	17.1/364.7	Reference 3.8-002
Suburban	321.4/152.6	Reference 3.8-002
Urban	2156.5/8.2	Reference 3.8-002
RNP		
Rural	17.8/243.8	Reference 3.8-002
Suburban	313.9/156.1	Reference 3.8-002
Urban	1916.7/8.3	Reference 3.8-002
Marion County		
Rural	18.1/251.2	Reference 3.8-002
Suburban	322.7/173.4	Reference 3.8-002
Urban	1897.1/9.5	Reference 3.8-002
Truck Stop Parameters		
Min/Max radii of annular area around vehicle at stops	1 to 10 m	NUREG/CR-6672
Population density at stops	30,000 persons/km^2	NUREG/CR-6672
Shielding factor applied to annular area around vehicle at stops	1.0	NUREG/CR-6672
Min/Max radii of annular area around truck stop	10 to 800 m	NUREG/CR-6672
Population density surrounding truck stops	340 persons/km^2	NUREG/CR-6672
Shielding factor applied to area around truck stop	0.2	NUREG/CR-6672
Stop time	30 minutes per 4 hour driving time	NUREG/CR-6672
Shipments per year	4.9 Normalized	See Table 3.8-2

Notes:
a) Appendix D, Table D-3 and D-7

km = kilometer
km^2 = square kilometer
LWR = light water reactor
m = meter
mrem = milliRoentgen equivalent man

Table 3.8-7
Radiological Impacts of Transporting Unirradiated Fuel to the HAR and Alternative Sites by Truck (One AP1000 Unit)

	Dose (person-rem per shipment)			
Population Component	**HAR**	**BNP**	**RNP**	**Marion Co.**
Transport workers	1.66E-04	2.86E-04	2.22E-04	2.36E-04
General public (Onlookers – persons at stops and sharing the highway)	1.26E-04	7.52E-04	7.21E-04	7.35E-04
General public (Along Route – persons living near a highway)	1.91E-05	2.26E-05	2.16E-05	2.45E-05

Notes:

person-rem = person-roentgen equivalent man

Table 3.8-8
Radiological Impacts of Transporting Unirradiated Fuel to the HAR and Alternative Sites by Truck as Compared to the Reference LWR (One AP1000 Unit)

Reactor Type	Normalized Average Annual Shipments	Cumulative Annual Dose (person-rem per RRY) [(a)]		
		Transport Workers	General Public-Onlookers	General Public-Along Route
Reference LWR	6.3	1.10E-02	4.20E-02	1.00E-03
HAR	4.9	8.13E-04	6.17E-04	9.36E-05
BNP	4.9	1.40E-03	3.68E-03	1.11E-04
RNP	4.9	1.09E-03	3.53E-03	1.06E-04
Marion County	4.9	1.16E-03	3.60E-03	1.20E-04
10 CFR 51.52	365	4.00E+00	3.00E+00	3.00E+00
Table S-4 Condition	< 1 per day	--	--	--

Notes:

a) Table values for the HAR were calculated by multiplying Table 3.8-7 values by the number of shipments.

LWR = light water reactor
person-rem = person-roentgen equivalent man
RRY = reference reactor year

Table 3.8-9
Transportation Route Information for Spent Fuel Shipments from the HAR and Alternative Sites to the Potential Yucca Mountain Disposal Facility

	One-Way Shipping Distance (km)				Population Densities (people/km^2)			
Reactor Site	Total	Rural	Suburban	Urban	Rural	Suburban	Urban	Stop Time per Trip (hours)
HAR	4294.0	3310.3	893.4	90.5	9.8	335.9	2174.5	5.0
BNP	4526.7	3480.9	950.8	95.3	10.1	332.6	2175.7	5.5
RNP	4234.3	3349.4	802.3	82.9	9.6	315.3	2209.2	5.0
Marion County	4272.2	3368.1	821.3	83.0	9.7	313.0	2208.6	5.0

Notes:

km = kilometer
km^2 = square kilometer

Table 3.8-10
RADTRAN 5 Input Parameters for HAR Analysis of Spent Nuclear Fuel Shipments

Parameter	Parameter Value	Comments and Reference
Package		
Package dimension	5.82 m	Plus 2 ft. (Reference 3.8-006)
Dose rate at 1 meter from vehicle	14 mrem per hour	Approximate dose at 1 m that is equal to the legal limit of 10 mrem per hour at 2 m (WASH-1238)
Fraction of emitted radiation that is gamma	0.5	Reference 3.8-005
Fraction of emitted radiation that is neutrons	0.5	Reference 3.8-005
Crew		
Number of crew	2	WASH-1238 and Reference 3.8-006
Distance from source to crew	3.1 m	Reference 3.8-007
Crew shielding factor	1.0	Analytical assumption. Results in dose rate to crew greater than legal limit. Crew dose rate reset by RADTRAN to 2 mrem per hour
Route-specific parameters		
Rural Suburban Urban	88.49 kilometers per hour	Average speed in rural areas given in Reference 3.8-006. Conservative in-transit speed of 55 miles per hour assumed: predominately interstate highways used.
Number of people per vehicle sharing route	1.5	Reference 3.8-006
One-way traffic volumes		
Rural	Varies by State	Reference 3.8-008 [(a)]
Suburban	Varies by State	Reference 3.8-008 [(a)]
Urban	Varies by State	Reference 3.8-008 [(a)]
Minimum and maximum distances to exposed resident off-link population	10 to 800 m	NUREG/CR-6672
Shipments per year per reactor	46 Average 39 normalized	See Table 3.8-2

Notes:

a) Appendix D, Table D-3 and D-7

ft. = foot
m = meter
mrem = milliRoentgen equivalent man

Table 3.8-11
Radiological Impacts of Transporting Spent Fuel from the HAR and Alternative Sites by Truck to the Potential Yucca Mountain Disposal Facility (One AP1000 Unit)

Population Component	Dose (person-rem per shipment)			
	HAR	BNP	RNP	Marion Co.
Transport workers	1.96E-01	2.06E-01	1.93E-01	1.95E-01
General public (Onlookers – persons at stops and sharing the highway)	4.53E-01	4.93E-01	4.49E-01	4.50E-01
General public (Along Route – persons living near a highway)	8.69E-03	9.19E-03	7.48E-03	7.60E-03

Notes:

person-rem = person-roentgen equivalent man

Table 3.8-12
Population Doses from Spent Fuel Transportation, Normalized to Reference LWR

Reactor Site	Exposed Population	Cumulative Dose Limit Specified in Table S-4 (person-rem per RRY)	Reactor Type: Reference LWR — Number of Spent Fuel Shipments per Year: 60 — Environmental Effects (person-rem per RRY) [b]	Reactor Type: One AP1000 Unit — Number of Spent Fuel Shipments per Year: 39 [a] — Environmental Effects (person-rem per RRY) [b]
HAR	Crew	4	5.90E+00	7.64E+00
	Onlookers	3	2.10E+01	1.77E+01
	Along Route	3	6.00E-01	3.39E-01
BNP	Crew	4	5.90E+00	8.03E+00
	Onlookers	3	2.10E+01	1.92E+01
	Along Route	3	6.00E-01	3.58E-01
RNP	Crew	4	5.90E+00	7.53E+00
	Onlookers	3	2.10E+01	1.75E+01
	Along Route	3	6.00E-01	2.92E-01
Marion County	Crew	4	5.90E+00	7.61E+00
	Onlookers	3	2.10E+01	1.76E+01
	Along Route	3	6.00E-01	2.96E-01

Notes:

a) This value is normalized.

b) Table values for the HAR were calculated by multiplying Table 3.8-11 values by the number of shipments, in this case 39.

LWR = light water reactor
person-rem = person-roentgen equivalent man
RRY = reference reactor year