CHAPTER 3
PLANT DESCRIPTION

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ACRONYMS AND ABBREVIATIONS

°C	degree Celsius
°F	degree Fahrenheit
ac	alternating current
ac.	acre
ALARA	As Low As Reasonably Achievable
ALWR	advanced light water reactor
AM	amplitude modulation
ANSI/IEEE	American National Standards Institute/Institute of Electrical and Electronics Engineers
AP1000	Westinghouse Electric Company, LLC, AP1000 Reactor
AP600	Westinghouse Electric Company, LLC, AP600 Reactor
BBW	Brookridge Substation to Brooksville West Substation
BDS	blowdown system
BOD	biochemical oxygen demand
Btu/hr	British thermal unit per hour
BWG	Birmingham wire gauge
CAFEP	Corona and Field Effects Program
CB	CREC to Brookridge Substation
CCRE	proposed Citrus Substation to Crystal River East Substation
CCWS	component cooling water system
CDS	condensate system
CFBC	Cross Florida Barge Canal
CFR	Code of Federal Regulations
CFS	chemical feed system

ACRONYMS AND ABBREVIATIONS (CONTINUED)

Ci/yr	Curie per year
cm	centimeter
CMS	condenser air removal system
COLA	Combined License Application
CREC	Crystal River Energy Complex
CST	condensate storage tank
CVS	chemical and volume control system
CWA	Clean Water Act
CWIS	cooling water intake structure
CWS	circulating water system
DAW	dry active waste
dB	decibel
dBA	decibel (A-weighted scale)
dc	direct current
DCD	Westinghouse Electric Company, LLC, AP1000 Design Control Document for the certified design as amended
DG	diesel generator
DOE	U.S. Department of Energy
DSN	discharge serial number
DTS	demineralized water treatment system
DWS	demineralized water transfer and storage system
DWST	demineralized water storage tank

ACRONYMS AND ABBREVIATIONS (CONTINUED)

ECL	effluent concentration limit
EDI	electrodeionization
EIS	Environmental Impact Statement
EMF	electromagnetic field
EPRI	Electric Power Research Institute
ER	Environmental Report
ESF	engineered safety feature
ESP	Early Site Permit
ESRP	Environmental Standard Review Plan
F.A.C.	Florida Administrative Code
F.S.	Florida Statute
FCC	Federal Communications Commission
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FM	frequency modulation
FPS	fire protection system
FSAR	Final Safety Analysis Report
ft.	foot
$ft.^2$	square foot
$ft.^3$	cubic foot
ft/sec	foot per second
ft^3/min	cubic foot per minute

ACRONYMS AND ABBREVIATIONS (CONTINUED)

ft^3/yr	cubic foot per year
FWS	feedwater system
gal.	gallon
gpd	gallon per day
gph	gallon per hour
gpm	gallon per minute
ha	hectare
HEPA	high efficiency particulate air
hr/yr	hour per year
HUT	holdup tank
HVAC	heating, ventilation, and air conditioning
in.	inch
in. Hg	inch of mercury
in. HgA	inch of mercury absolute
kg	kilogram
km	kilometer
km^2	square kilometer
kV	kilovolt
kV/m	kilovolt per meter
kVA	kilovolt ampere
kW	kilowatt
l	liter

ACRONYMS AND ABBREVIATIONS (CONTINUED)

l/hr	liter per hour
lb.	pound
lb/gal	pound per gallon
lb/hr	pound per hour
lb/yr	pound per year
LCFS	LNP to proposed Central Florida South Substation
LCR	LNP to CREC 500-kV switchyard
LNP	proposed Levy Nuclear Plant Units 1 and 2
LNP 1	proposed Levy Nuclear Plant Unit 1
LNP 2	proposed Levy Nuclear Plant Unit 2
LPC	LNP to proposed Citrus Substation
lpm	liter per minute
LSB	last-stage blades
LWR	light water reactor
m	meter
m/s	meter per second
m^3/yr	cubic meter per year
µCi/cc	microCurie per cubic centimeter
MCR	main control room
mG	milliGauss
mg/l	milligram per liter
mi.	mile
min.	minute

ACRONYMS AND ABBREVIATIONS (CONTINUED)

ml	milliliter
mph	mile per hour
mrem	milliRoentgen equivalent man
mSv	milliSievert
MSR	moisture separator/reheater
MTU	metric ton of uranium
MVA	megavolt ampere
MW	megawatt
MWd/MTU	megawatt day per metric ton of uranium
MWe	megawatt electric
MWt	megawatt thermal
N/A	not applicable
NAVD88	North American Vertical Datum of 1988
NESC	National Electrical Safety Code
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NSSS	nuclear steam supply system
O.D.	outside diameter
PCCAWST	passive containment cooling auxiliary water storage tank
PCCWST	passive containment cooling water storage tank
PCS	passive containment cooling system
PEF	Florida Power Corporation doing business as Progress Energy Florida, Inc.

ACRONYMS AND ABBREVIATIONS (CONTINUED)

person-rem	person-roentgen equivalent man
person-Sv	person-Sievert
pH	hydrogen ion concentration
PHP	Polk to Hillsborough to Pinellas
PF	power factor
ppb	part per billion
ppm	part per million
PPSA	Power Plant Siting Act
psig	pound per square inch gauge
PSS	primary sampling system
PWR	pressurized water reactor
PWR-GALE code	calculation of releases of radioactive materials in gaseous and liquid effluents from pressurized water reactors
PWS	potable water system
PWST	potable water storage tank
PXS	passive core cooling system
RADTRAN 5	radioactive material transportation
RAT	reserve auxiliary transformer
RCA	radiologically controlled area
RCS	reactor coolant system
rem	roentgen equivalent man
RI	radio interference
RMS	radiation monitoring system
RNS	residual heat removal system

ACRONYMS AND ABBREVIATIONS (CONTINUED)

RO	reverse osmosis
ROW	right-of-way
rpm	revolution per minute
RRY	reference reactor year
RWS	raw water system
S&L	Sargent & Lundy, LLC
SDS	sanitary drainage system
SFS	spent fuel pool cooling system
SFW	startup feedwater
SG	steam generator
SGS	steam generator system
SRST	spent resin storage tank
SWFWMD	Southwest Florida Water Management District
SWS	service water system
TC6F	tandem-compound, six-flow
TCS	turbine building closed cooling water system
TRAGIS	Transportation Routing Analysis Geographic Information System
TVI	television interference
U-235	uranium-235
UO_2	uranium dioxide
USEPA	U.S. Environmental Protection Agency

ACRONYMS AND ABBREVIATIONS (CONTINUED)

VWS	chilled water system
VYS	hot water heating system
Westinghouse	Westinghouse Electric Company, LLC
WGS	gaseous radwaste system
WHUT	waste holdup tank
WLS	liquid radwaste system
WM&PPP	Waste Minimization and Pollution Prevention Plan
WMA	waste minimization assessment
WRS	radioactive waste drain system
WSS	solid radwaste system
WWRB	wastewater retention basin
WWS	wastewater system
ZIRLO™	Zirconium Alloy

3.0 PLANT DESCRIPTION

This chapter has been prepared in accordance with the requirements specified in NUREG-1555, Environmental Standard Review Plans (ESRPs) 3.0 through 3.8. This chapter provides site-specific information about the proposed Levy Nuclear Plant Units 1 and 2 (LNP) to be constructed by Florida Power Corporation doing business as Progress Energy Florida, Inc. (PEF) at the proposed site in Levy County, Florida. The following information is discussed in the Environmental Report (ER) sections that follow:

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

3.1 EXTERNAL APPEARANCE AND PLANT LAYOUT

The LNP site is located in Levy County, Florida (Figure 1.1-1). This is a large, primarily rural site located southwest of Gainesville and west of Ocala, and approximately 15.5 kilometers (km) (9.6 miles [mi.]) northeast of the Crystal River Energy Complex (CREC), an energy facility owned by PEF (Figure 1.1-1).

The LNP site is approximately 1257 hectares (ha) (3105 acres [ac.]) in size. The two reactors and ancillary power production support facilities will be located near the center of the site.

The LNP will consist of two pressurized water reactors (PWRs), Units 1 and 2. These units are based on the Westinghouse Electric Company, LLC (Westinghouse), AP1000 Reactor (AP1000) standard design. The major structures of the LNP that will contain radioactive materials are the containment buildings, annex buildings, radwaste buildings, and auxiliary buildings.

Figure 2.3-1 provides an illustration of the LNP site in relation to the region and state. Figure 2.3-2 presents a depiction of the LNP site in relation to the local area. Figure 2.1-2 presents a depiction of the proposed reactors superimposed on a map of the LNP site area, the makeup and blowdown piping routes, proposed transmission corridors, cooling towers, switchyard, and intake location

on the Cross Florida Barge Canal (CFBC). Figure 2.3-3 provides an illustration of the LNP, which is superimposed onto a topographic map of the site. Figure 3.1-1 is an architect's rendition of an AP1000 reactor plant when built. Figure 3.1-2 illustrates the AP1000 plant layout. A conceptual view of major station components on the LNP site is presented in Figure 3.1-3.

3.1.1 STATION LAYOUT AND APPEARANCE

The LNP site will be a large industrial facility similar in general appearance to most nuclear power generating facilities. As noted in ER Section 3.1, the LNP site is approximately 1257 ha (3105 ac.) in size. The primary location for the two reactors and ancillary power production support facilities comprises approximately 121 ha (300 ac.) near the center of the site.

The Westinghouse Electric Company, LLC, AP1000 Design Control Document for the certified design as amended (DCD) indicates that the plant arrangement (for each AP1000 unit) is comprised of the following five principal building structures: nuclear island, turbine building, annex building, diesel generator building, and 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 associated cooling towers are not considered part of the plant arrangement.

3.1.1.1 Nuclear Island

The DCD provides the following information about the nuclear island for each unit:

> 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.

3.1.1.1.1 Containment Building

The DCD provides the following information about the containment building:

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

The containment building, a seismic Category I structure, 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.

3.1.1.1.2 Shield Building

The DCD provides the following information about the shield building:

The 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 reactor coolant system 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. The shield building protects the containment vessel and the reactor coolant system from the effects of tornadoes and tornado produced missiles.

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.

3.1.1.1.3 Auxiliary Building

The auxiliary building is a reinforced concrete structure. The DCD states, “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.”

3.1.1.2 Turbine Building

The turbine building is a steel column and beam structure. The DCD provides the following information about the turbine building:

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.

3.1.1.3 Annex Building

The DCD provides the following information about the annex building:

The annex building is a combination of reinforced concrete structure and steel framed structure with insulated metal siding.

The annex building ([DCD] Figures 1.2-17, 1.2-18, 1.2-19, and 1.2-20) provides the main personnel entrance to the power generation complex. It includes accessways 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 non-1E [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 annex building includes the health physics facilities and provides personnel and equipment accessways to and from the containment building and the rest of the radiological control area via the auxiliary building. Provided are large, direct accessways to the upper and lower equipment hatches of the containment building for personnel access during outages and for large equipment entry and exit. The building 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.

3.1.1.4 Diesel Generator Building

The following information about the diesel generator building is based on information in the DCD:

The diesel generator building is a single-story, steel-framed structure with insulated metal siding which houses the two identical, side-by-side diesel generators and their associated heating, ventilation, and air conditioning (HVAC) 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.

3.1.1.5 Radwaste Building

The DCD states, “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.”

3.1.1.6 Cooling Water Intake Structure

Operations at the LNP will require makeup water from the CFBC. The construction of an LNP makeup water system intake structure and LNP makeup water system pumphouse on the CFBC is proposed. The intake structure will be located approximately 11.1 km (6.9 mi.) from the Gulf of Mexico on the berm that forms the north side of the canal and is within 0.8 km (0.5 mi.) of the Inglis Lock. The cooling water intake structure (CWIS) consists of the intake structure, vertical bar screens, traveling screens, pumps, and pumphouse.

3.1.1.7 Blowdown Pipelines

Cooling tower blowdown from a series of on-site mechanical draft cooling towers, including residual waste heat, will be transported in two pipelines (one for each unit) from the LNP. The blowdown lines will run south to the CFBC and then west along the northern edge of the Inglis Lock Bypass Channel. They will then cross the bypass channel just north of CREC, run south, and will discharge into the CREC discharge canal and ultimately into the Gulf of Mexico. Figure 2.1-2 presents an illustration of the pipelines.

3.1.1.8 Cooling System

Waste heat will be dissipated by a series of mechanical draft cooling towers, which will draw cooling water makeup from the CFBC. This canal extends about 11.9 km (7.4 mi.) from the Inglis Lock at Lake Rousseau to the Gulf (Figure 1.1-1).

The waters in the CFBC downstream of the lock vary in salinity seasonally and with tidal influences; however, when the intake is operational, it is anticipated that the makeup water to the cooling towers will be seawater drawn from shallow, nearshore Gulf waters.

3.1.2 TRANSMISSION SYSTEM

Four major 500-kilovolt (kV) transmission lines will leave the station switchyard and connect with three high-voltage substations. Additional system upgrades will be constructed by PEF to accommodate demand in the central and south Florida areas primarily served by the LNP. Detailed descriptions of the transmission line system and associated environmental impacts are described in ER Section 3.7 and ER Chapters 4 and 5.

3.1.3 TRANSFORMERS

The DCD provides the following information about the transformer area:

> The transformer area is typically 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.

At the LNP site, the transformer area will be located adjacent to the turbine building.

3.1.4 AESTHETIC APPEARANCE

3.1.4.1 Containment Building

The reactor containment structure will have the appearance of a vertical cylinder with an upper conical section tapering to a smaller diameter cylinder. It will be 140 m (225 ft.) high and 81 m (130 ft.) in diameter.

The containment building is illustrated in Figure 3.1-2.

3.1.4.2 Heat Dissipation System

The heat dissipation system (a series of mechanical draft cooling towers) will typically have a height of up to 22.3 meters (m) (75 feet [ft.]), and each of the two trains (two trains for each unit) will have an approximate length of 304.8 m (1000 ft.). The mechanical draft cooling towers for the LNP have an actual height of 17.1 m (56 ft.).

Any visual effects from the visible plumes from the cooling towers will be similar to those associated with other nuclear power generating facilities and that of the present cooling towers for the nearby CREC.

3.1.4.3 Viewshed of the Facility

The structures at the LNP site will not be high enough to be visible from public areas at ground level, and only the cooling tower plumes are likely to be visible to a few residences and recreational users in the vicinity.

The effects, if any, of seasonal changes on the vegetation that would affect the viewshed surrounding the LNP are considered minor. The site is heavily forested and vegetated and is secluded from public areas. Plans to screen the LNP will not be required.

3.2 REACTOR POWER CONVERSION SYSTEM

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

3.2.1 CERTIFICATION STATUS

Westinghouse's AP1000 is a certified design in accordance with 10 Code of Federal Regulations (CFR) 52, Appendix D.

3.2.2 AP1000 DESIGN

The DCD provides the following information about the AP1000 design:

> Westinghouse Electric Company, LLC (Westinghouse), is responsible for the overall design and design certification of the AP1000 nuclear power plant. A significant portion of the AP1000 design is the same as the design of [Westinghouse Electric Company, LLC, AP600 Reactor] AP600. Westinghouse Electric Company was also responsible for the overall design and design certification of AP600.

Additionally, the DCD states, "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 included 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 AP1000 units are proposed for the LNP site. The architect-engineer for the LNP project is Shaw-Stone & Webster (The Shaw Group).

Table 3.2-1 (based on DCD Table 10.1-1) presents the requirements regarding core thermal power, gross electrical output, and net electrical output.

3.2.3 FUEL ASSEMBLY, FUEL ROD, AND FUEL PELLET DESCRIPTION

3.2.3.1 Fuel Assemblies

The following information about fuel assemblies is based on information in the DCD:

The reactor contains a matrix of fuel rods assembled into 157 mechanically identical fuel assemblies along with control and structural elements. 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 for in-core instrumentation, and the remaining 24 positions are guide thimbles. 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.

3.2.3.2 Fuel Rods

The following information about fuel rods is based on information provided in the DCD:

The fuel rods consist of enriched uranium, in the form of cylindrical pellets of sintered uranium dioxide (UO_2), contained in Zirconium Alloy (ZIRLO™) tubing. The core contains 95,975 kilograms (kg) (211,588 pounds [lb.]) of enriched UO_2 fuel. There are 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.

3.2.3.3 Fuel Pellets

The following information about fuel pellets is based on DCD Table 4.1-1:

The fuel pellets are comprised of sintered UO_2 with a density of 95.5 (percent of theoretical) and a diameter of 0.8192 centimeters (cm) (0.3225 inches [in.]). They are 0.983 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 lb.).

3.2.3.4 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. Extended burnup to 62,000 MWd/MTU is addressed in DCD Subsection 4.3.1.1.1.

3.2.4 STEAM AND POWER CONVERSION

The power conversion system used by the AP1000 is a water-cooled reactor plant, which uses two steam turbines. 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 steam generated in the two steam generators [SG] 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 steam generator feedwater booster pump and is discharged to the suction of the main feedwater pump. The steam generator feedwater pumps discharge the feedwater through two stages of high-pressure feedwater heating to the two steam generators.
>
> The turbine-generator has an output of approximately 1,199,500 [kilowatts] kW for the Westinghouse nuclear steam supply system (NSSS) thermal output of 3,415 [megawatts thermal] MWt.

The DCD provides the following information specific to the turbine-generator:

> The turbine is a 1800-[revolutions per minute] rpm, tandem-compound, six-flow, reheat unit with 52-inch last-stage blades (TC6F 52-inch 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 moisture separator/reheaters (MSRs) with two stages of reheating. The single direct-driven generator is hydrogen gas and de-ionized water cooled and rated at 1375 [megavolt amperes] MVA at 0.90 [power factor] PF.

Table 3.2-2 (based on DCD Table 10.2-1) contains information on the turbine-generator and auxiliaries design parameters.

3.2.4.1 Condensate and Feedwater System

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

> The condensate and feedwater system provides feedwater at the required temperature, pressure, and flow rate to the steam generators. 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 steam generators.
>
> The condensate and feedwater system is composed of components from the condensate system (CDS), main and startup feedwater system (FWS), and steam generator system (SGS).

3.2.4.2 Steam Generators

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

The AP1000 steam generator (SG) is a vertical shell and U-tube evaporator with integral moisture separating equipment. The basic steam generator design and features have been proven in tests and in previous steam generators including replacement steam generator 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 steam generator employs tube supports utilizing a broached hole support plate design. All tubes in the steam generator are accessible for sleeving, if necessary. The design enhancements are based on proven technology.

The basic function of the AP1000 steam generator 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 steam generator. The steam generator 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 feedwater system replenishes the steam generator water inventory by entering the steam generator through a feedwater inlet nozzle and feedring.

As noted in DCD Table 5.4-4, the AP1000 SG has a heat transfer area of 123,538 square feet (ft.^{2}).

Table 3.2-2 (based on DCD Table 10.2-1) presents significant design features and performance characteristics for the SGs and turbines.

3.2.4.3 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.

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 condenser hotwell is designed to store at the normal operating water level an amount of condensate equivalent to at least three minutes of full load condensate system operating flow.
>
> 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 DCD notes that the main condenser is a three-shell, single-pass, multipressure, spring-supported unit, with each shell located beneath its respective low-pressure turbine. The LNP main condenser will be equipped with titanium tubes. The titanium material provides good corrosion and erosion resisting properties.

Table 3.2-3 (based on DCD Table 10.4.1-1) presents the main condenser design data. The main condenser is part of the AP1000 CDS, and is described in the DCD as follows:

> The condensate system 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.

3.2.4.4 Circulating Water System

Each AP1000 unit's CWS will consist of three 33-$^{1}/_{3}$-percent-capacity circulating water pumps, a series of mechanical draft cooling towers, and associated piping, valves, and instrumentation. Makeup water to the CWS will be provided by the raw water system (RWS). In addition, water chemistry will be controlled by the turbine island chemical feed system (CFS).

3.2.5 ENGINEERED SAFETY FEATURES

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

> Engineered safety features (ESF[s]) protect the public in the event of an accidental release of radioactive fission products from the reactor coolant system. The engineered safety features function 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.

ER Subsections 3.2.5.1, 3.2.5.2, 3.2.5.3, 3.2.5.4, 3.2.5.5, and 3.2.5.6 include definitions of ESFs.

3.2.5.1 Containment

The DCD provides the following information about the containment vessel:

The containment vessel, discussed in [DCD] Subsection 6.2.1, is a free standing cylindrical steel vessel with ellipsoidal upper and lower heads. It is surrounded by a Seismic Category I reinforced concrete shield building. 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 ultimate heat sink by transferring the heat associated with accident sources to the surrounding environment.

3.2.5.2 Passive Containment Cooling System

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

The function of the passive containment cooling system, discussed in [DCD] Subsection 6.2.2, 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 ultimate heat sink 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.

3.2.5.3 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, discussed in [DCD] Subsection 6.2.3, 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.

3.2.5.4 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, discussed in [DCD] Section 6.3, is to provide emergency core cooling following

postulated design-basis events. The passive core cooling system provides reactor coolant system makeup and boration during transients or accidents where the normal reactor coolant system makeup supply from the chemical and volume control system [CVS] is lost or is insufficient. The passive core cooling system provides safety injection to the reactor coolant system 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 reactor coolant system piping. The passive core cooling system provides core decay heat removal during transients, accidents, or whenever the normal heat removal paths are lost.

3.2.5.5 Main Control Room Emergency Habitability System

The DCD provides the following information about the main control room (MCR) emergency habitability system:

> The main control room emergency habitability system, discussed in [DCD] Section 6.4, is designed so that the main control room 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.

3.2.5.6 Fission Product Control

The DCD provides the following information about fission product control:

> Post-accident safety-related fission product control for the AP1000, discussed in [DCD] Section 6.5, 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)	greater than or equal to 1000
Steam Generator Outlet Pressure (psig)	823
Steam Generator Inlet Feedwater Temperature (°F)	440
Maximum Steam Generator Outlet Steam Moisture (%)	0.25
Steam Generator Outlet Steam Temperature (°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	TC6F 52-in. LSB
Turbine Elements	1 high pressure and 3 low pressure
Operating speed (rpm)	1800

Notes:

°F = degrees Fahrenheit
in. = inch
kW = kilowatt
lb/hr = pounds per hour
LSB = last-stage blades
MWe = megawatt electric
MWt = megawatt thermal
psig = pounds per square inch gauge
rpm = revolutions per minute
TC6F = tandem-compound, six-flow

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:

in. = inch
in. HgA = inches of mercury absolute
kW = kilowatt
kVA = kilovolt ampere
LSB = last-stage blades
psig = pounds per square inch gauge
rpm = revolutions per minute
TC6F = tandem-compound, six-flow

Table 3.2-3
Main Condenser Design Data

Condenser Data	Characteristic
Condenser type	Multipressure, Single pass
Hotwell storage capacity	3 min.
Heat transfer	7.54E+09 Btu/hr
Design operating pressure (average of all shells)	2.9 in. Hg
Shell pressure (design)	0 in. Hg 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.

°F = degrees Fahrenheit
Btu/hr = British thermal units per hour
BWG = Birmingham wire gauge
in. = inch
in. Hg = inches of mercury
min. = minute
O.D. = outside diameter
psig = pounds per square inch gauge
rpm = revolutions per minute

3.3 PLANT WATER USE

This section provides information about the anticipated plant water use for the LNP. The LNP will require water for both plant cooling and operational uses. The plant will use two independent cooling water systems with seawater used for the CWS, that cools the turbine-generator, and freshwater used for the service water system (SWS). The waters in the CFBC downstream of Inglis Lock vary in salinity, seasonally and with tidal influences; however, when the intake is operational, it is anticipated that the makeup water to the cooling towers will be seawater drawn from shallow, nearshore Gulf waters. Freshwater from the RWS will also be used for the other water services required for operation. The other water services supplied from the RWS will consist of potable water, demineralized water treatment, and the fire protection system (FPS). Potable water is required for human consumption, sanitary, and other domestic purposes. The RWS supply will be from supply wells installed into the freshwater aquifer at the site. Makeup water for the CWS will be supplied from the intake structure located on the CFBC.

Table 3.3-1 and Figure 3.3-1 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 and Figure 3.3-2 present the anticipated plant water usage and discharges for the two new AP1000 units at the LNP site.

The CWIS will be located on the berm that forms the north side of the CFBC and is in close proximity to the Inglis Lock. NUREG-1555 also requires a discussion regarding periods of maximum water consumption, minimum water availability, and average operation by month. Tables 3.3-1 and 3.3-2 provide the average and maximum water consumption values for the AP1000 (the values are assumed to remain constant and consistent throughout the year). The LNP will withdraw cooling water from the CFBC, which is fed by the Gulf of Mexico. In this case, the availability of minimum water is not applicable to the LNP site because there is an unlimited supply of water for cooling water needs. Figure 3.3-3 presents an illustration of the LNP CWIS that will be located on the CFBC. Figure 3.3-4 shows a sectional view of the CWIS. The discharge structure is likely to be an open pipe discharge into the existing CREC discharge canal.

Cooling tower blowdown from a series of mechanical draft cooling towers, including residual waste heat, will be transported in two pipelines (one for each unit) from the LNP. The pipelines will run south to the CFBC and then west along the northern edge of the bypass channel. They will then cross the bypass channel just north of CREC, run south, and will discharge into the CREC discharge canal and ultimately into the Gulf of Mexico.

Waste heat will be dissipated by a series of on-site mechanical draft cooling towers, which will draw cooling water makeup from the CFBC. This canal extends from the Inglis Lock at Lake Rousseau to the Gulf of Mexico (Figure 1.1-1).

It is expected that normal releases of contaminants into the environment from the LNP 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 Florida Department of Environmental Protection (FDEP). ER Subsection 3.6.1 discusses the FDEP requirements for applying for an NPDES permit. This permit will ensure that discharges are controlled from systems such as discharge lines, sewage treatment facilities, radwaste treatment systems, activated carbon treatment systems, water treatment waste systems, and facility service water. The effect on water quality due to the operation of the LNP will be monitored to ensure compliance with the issued NPDES permits for construction and operation.

ER Subsection 2.3.3 discusses water quality effects, ER Subsection 3.3.1 discusses water consumption, and ER Subsection 3.3.2 discusses water treatment.

3.3.1 WATER CONSUMPTION

3.3.1.1 Circulating Water System (Normal Plant Heat Sink)

Waste heat will be transferred from the main condenser to the atmosphere through the CWS. Makeup water from the CFBC will be used to replenish water losses due to evaporation, drift, and blowdown. Flow rates are shown on Figure 3.3-2 and are tabulated in Table 3.3-2. The blowdown flow from the CWS will ultimately be directed back to the Gulf of Mexico.

The CWS will consist of three 33-$^{1}/_{3}$-percent-capacity circulating water pumps, one set of mechanical draft cooling towers, and associated piping, valves, and instrumentation.

A more detailed description of the CWS is presented in ER Section 3.4.

3.3.1.2 Service Water System

The SWS will supply cooling water to remove heat from the nonsafety-related component cooling water system (CCWS) heat exchangers in the turbine building.

Cooling will be supplied through a closed-cycle system using heat exchangers and a mechanical draft cooling tower. The cooling tower will require makeup water from the RWS to replace losses due to evaporation, drift, and blowdown. Flow rates are shown on Figure 3.3-2 and are tabulated in Table 3.3-2.

The DCD provides the following information about the SWS:

> The system consists of two 100-percent-capacity service water pumps, automatic backwash strainers, a two-cell cooling tower with a divided 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 waste water system (WWS).

A more detailed discussion of the SWS is presented in ER Section 3.4.

3.3.1.3 Demineralized Water Treatment System

The DCD provides the following information about the demineralized water treatment system (DTS):

> The demineralized water treatment system (DTS) receives water from the raw water system (RWS), processes this water to remove ionic impurities, and provides demineralized water to the demineralized water transfer and storage system (DWS).

The DCD provides the following information about the DWS:

> The demineralized water transfer and storage system receives water from the demineralized water treatment system, 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 demineralized water transfer and storage system 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 chemical and volume control system (as described in [DCD] Subsection 9.3.6), the spent fuel pool cooling system (as described in [DCD] Subsection 9.1.3), and the liquid radwaste system [WLS] (as described in [DCD] Section 11.2) to the solid radwaste system.

Flow rates are shown on Figure 3.3-2 and tabulated in Table 3.3-2.

3.3.1.4 Potable Water System

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

The potable water system (PWS) is designed to furnish water for domestic use and human consumption. It complies with the following standards:

- Bacteriological and chemical quality requirements as referenced in [U.S. Environmental Protection Agency] [USEPA] "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 3.3-2 provide information about the PWS.

3.3.1.5 Potable Water System Operation

The DCD provides the following information about PWS 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 potable water system is protected by a reduced pressure zone type backflow prevention device.

No interconnections exist between the potable water system and any system using water for purposes other than domestic water service including any potentially radioactive system. The common supply from the onsite raw water system is designed to use an air gap to prevent contamination of the potable water system from other systems supplied by the raw water system.

The LNP water source will be an aquifer.

3.3.1.6 Fire Protection System

The FPS will provide water to points throughout the plant where wet system-type fire suppression (for example, a sprinkler or deluge) may be required.

As stated in the DCD, the FPS is designed to "supply fire suppression water at a flow rate and pressure sufficient to satisfy the demand of any automatic sprinkler system plus 500 [gallons per minute] gpm for fire hoses, for a minimum of 2 hours."

Makeup water for the FPS will be provided by the RWS.

3.3.2 WATER TREATMENT

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 (that is, there is no difference in how the systems operate during full power plant operations, plant shutdown/refueling, and plant startup).

Each unit of the LNP will have a CWS, SWS, PWS, DTS, and an FPS. The description of the chemicals that will be injected into these systems and the concentration of the effluents that will be discharged to the Gulf of Mexico are presented in Table 3.3-3. Chemicals that will be added to cooling water for treatment will be effective at low concentrations and will be mostly consumed or broken down in application.

For wastes discharged to surface waters, LNP will provide compliance with an NPDES permit issued by the FDEP. 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 the Gulf through one NPDES-permitted outfall.

3.3.2.1 Circulating Water System

The DCD provides the following information about the CWS:

> Circulating water chemistry is maintained by the turbine island chemical feed system. 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 and therefore will be provided as discussed in [DCD] Subsection 10.4.12. The chemicals can be divided into six categories based upon function: biocide, algaecide, [hydrogen ion concentration] 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 will 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.

The specific chemicals that will be used within the system are presented in Table 3.3-3.

The chemicals that will be used will be subject to review and approval for use by the FDEP. The total residual chemical concentrations in the discharges to the Gulf will be subject to discharge permit limits established by the FDEP in an approved NPDES permit.

3.3.2.2 Service Water System

The DCD provides the following information about the SWS:

> The turbine island chemical feed system equipment injects the required chemicals into the service water system. 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 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 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.

The chemicals that will be used will be subject to review and approval for use by the FDEP. The total residual chemical concentrations in the discharges to the Gulf will be subject to discharge permit limits established by the FDEP in an approved NPDES permit.

Table 3.3-1 (Sheet 1 of 8)
AP1000 Water Balance Flow Rates and Volumes by Path

Flow Path No.	Path Description	Annualized Cycle Average Gallons [(a)] gpm [(a)]	Maximum Gallons [(a)] gpm [(a)]
1	Makeup Source to DTS RO Unit Filter	11,722,395 22.30288	 540
2	DTS RO Unit Filter to RO Unit	11,722,395 22.303	 540
3	RO Unit to EDI Unit	8,249,093 15.6946	 380
4	EDI Unit to DWST	7,814,930 14.8686	 360
5	RO Unit Reject Water to WWS	3,473,302 6.60826	 160
6	EDI Unit Reject Water to WWS	434,163 0.82603	 20
7	RO and EDI Reject Water to WWS	3,907,465 7.4343	 180
8	DWST Supply to Demineralized Water Header and CST	7,814,930 14.8686	 360
9	DWST Supply to CST	2,886,630 5.492066	 200
10	DWST Supply to Demineralized Water Header	4,928,300 9.37652	 150
11	CST Makeup to Condenser	2,880,269 5.47996	
12	SG Blowdown from SGS to SG BDS	11,762,214 22.3786	 280
13	Recycled Blowdown to Condenser	9,287,352 17.67	 176.7
14	SG Blowdown to Wastewater System (Includes Draining)	2,474,862 4.70864	 80
15	Radioactive Blowdown Discharged to WLS	 0	 186
16	Wastewater to Turbine Building Drain Trench Sump	2,443,165 4.64834	
17	Turbine Building Drain Sump to Oil/Water Separator	9,131,853 17.37415	 200
18	Oil/Water Separator to Wastewater Disposition	9,131,853 17.37415	 200
19	Secondary Drain and Wastewater to Wastewater Retention	9,537,260 18.14547	 200
20	CST to Auxiliary Steam and Startup Fire Water Pumps	6,361 0.0121	
21	CST Supply to Auxiliary Steam System	6,361 0.0121	 285

Table 3.3-1 (Sheet 2 of 8)
AP1000 Water Balance Flow Rates and Volumes by Path

Flow Path No.	Path Description	Annualized Cycle Average Gallons [(a)] gpm [(a)]	Maximum Gallons [(a)] gpm [(a)]
22	Auxiliary Steam Boiler Blowdown / Drain to WWS	6,361 0.0121	
23	CST to Startup Feed for Def In-Depth	0	760
24	SFW Pump to SG for Defense-in-Depth	0	760
25	Secondary Equipment Drains / Losses	405,407 0.77132	
26	SG to Main Steam	INTERNAL	
27	Steam Vented to Atmosphere – Consumption Loss	0	0
28	Main Steam to Turbine Generator and Turbine Bypass	INTERNAL	
29	Turbine Generator Flow	INTERNAL	
30	Turbine Bypass	INTERNAL	
31	Turbine Generator Exhaust to Main Condenser	INTERNAL	
32	Return Rinse to Condenser from Condensate Polisher	INTERNAL	
33	Rinse from CDS to Condensate Polisher	INTERNAL	
34	Makeup Source to PWST	19,833,333 37.735	105
35	Potable Water Supply from PWST	19,833,333 37.735	105
36	Potable Water to Sink, Showers, Toilets, Fountains	19,760,333 37.596	105
37	Potable Water to Decontamination Rooms	73,000 0.13889	
38	Potable Water Discharge to SDS and Consumption	19,760,333 37.596	105
39	Potable Water Consumption / Evaporation	0	0
40	Potable Water to SDS	19,760,333 37.596	105
41	Decontamination Room Sinks / Showers to Chemical Waste Tank	73,000 0.13889	
42	SDS Discharge to Sanitary Waste Treatment	19,760,333 37.596	105

Table 3.3-1 (Sheet 3 of 8)
AP1000 Water Balance Flow Rates and Volumes by Path

Flow Path No.	Path Description	Annualized Cycle Average Gallons [(a)] gpm [(a)]	Maximum Gallons [(a)] gpm [(a)]
43	Makeup Supply to Fire Water Storage Tank	300,000 0.5708	650
44	Non-Radioactive Fire Testing Drains to WWS	300,000 0.5708	
45	Fire Water Backup Supply to Spent Fuel Pit	INTERMITTENT	
46	Fire Water Backup Supply to PCS	INTERMITTENT	
47	Radioactive Fire Testing Drains to WRS	INTERMITTENT	
48	Makeup to Service Water Cooling Tower Basin	169,246,720 322.01	800
49	Steam Water Circulating Water Flow	INTERNAL	
50	Net Circulating Water Flow	INTERNAL	
51	Service Water Blowdown to Disposition	83,224,320 158.34	250
52	Steam Water Cooling Tower Evaporation	85,198,080 162.096	650
53	Steam Water Cooling Tower Drift – Consumption Loss	529,920 1.1008	2
54	Makeup to Circulating Water Cooling Tower Basin	12,066,987,600 22,958.5	12,066,987,600 22,958.5
55	CWS Circulating Water Flow Rate	INTERNAL	
56	CWS Circulating Water Blowdown to Disposition	6,000,249,600 11,416	6,000,249,600 11,416
57	New CWS Circulating Water Flow Rate	INTERNAL	
58	CWS Cooling Tower Evaporation – Consumption	6,049,656,000 11,510	6,049,656,000 11,510
59	CWS Cooling Tower Drift – Consumption	16,819,200 32	16,819,200 32
60	Circulating Water Discharge to TCS Heat Exchangers	9,565,920,000 18,200	18,200
61	From TCS Heat Exchanger to Condenser Outlet	9,565,920,00 18,200	18,200
62	Condensate Flow	INTERNAL	
63	Feedwater Flow	INTERNAL	

Table 3.3-1 (Sheet 4 of 8)
AP1000 Water Balance Flow Rates and Volumes by Path

Flow Path No.	Path Description	Annualized Cycle Average Gallons [a] gpm [a]	Maximum Gallons [a] gpm [a]
64	Demineralized Water Supply to Component Cooling Surge Tank	4,000 0.00761	150
65	Component Cooling System Drains to Wastewater	4,000 0.00761	
66	Demineralized Water to Turbine Island CFS for Batching Mass Chemicals	240 0.0004566	
67	CFS Drains to Wastewater	240 0.0004566	
68	Demineralized Water To Fill CMS Vacuum Breaker Water Seals	18,250 0.03472	5
69	CMS Vacuum Breaker Water Seal Overflow to Wastewater	18,250 0.03472	5
70	Demineralized Water to Fill / Makeup PCCWST/ PCCAWST	31,867 0.06063	
71	PCS Testing and Drains to Wastewater	0	
72	Demineralized Water for TCS Surge Tank Fill / Makeup	800 0.001522	75
73	Turbine Island Closed Cooling Drains to Wastewater	800 0.001522	
74	Demineralized Water for VWS (Chiller) Fill / Makeup	1020 0.0019406	
75	Chilled Water Drains to Wastewater	1020 0.0019406	
76	Demineralized Water for VYS (Hot Water) Surge Tank Fill / Makeup	855 0.001627	25
77	Hot Water Heating Drains, etc. to Wastewater	855 0.001627	
78	Demineralized Water for Condensate Polisher Flush, etc.	2,418,000 4.6005	310
79	Condensate Polisher Drains to Wastewater	2,418,000 4.6005	310
80	Demineralized Water to PSS Eductor Water Storage Tank	133,225 0.25347	10
81	PSS Effluent to WLS	133,225 0.25347	10
82	Demineralized Water to Flush RMS Radiation Monitors	1,051,200 2.0	2
83	RMS Effluent to WLS	1,051,200 2.0	2
84	Demineralized Water to Washdown RNS Pump Cubicle	400 0.000761	10

Table 3.3-1 (Sheet 5 of 8)
AP1000 Water Balance Flow Rates and Volumes by Path

Flow Path No.	Path Description	Annualized Cycle Average Gallons [a] gpm [a]	Maximum Gallons [a] gpm [a]
85	RNS Pump Washdown to Liquid Radwaste	400 0.000761	 10
86	Demineralized Water Makeup for Spent Fuel Pit	42.692 0.081225	 100
87	SFS Effluent to WLS	33,925 0.064545	 20
88	SP Fuel Resin Sluice to Solid Radwaste	4,800 0.0091324	 75
89	SP Fuel Pit Evaporation – Consumption	3,967 0.007548	
90	Demineralized Water for HVAC Humidification	474,100 0.90202	 2.5
91	Radioactive HVAC Condensation to Drains	182,500 0.34722	 0.3472
92	Humidification – Consumption Loss to Atmosphere	291,600 0.5548	291,600 0.5548
93	Demineralized Water for CVS Operations	230,432 0.4384	 135
94	CVS Effluents to WLS	225,921 0.42983	 100
95	CVS Effluents To Radioactive Drains WRS	INTERMITTENT	
96	CVS Resin Sluice to Solid Radwaste System	4,511 0.00858	
97	Charging / Letdown Between RCS and CVS	INTERNAL	
98	Reactor Cooling Drain Tank to CVS Letdown Path	INTERNAL	
99	RCS Effluent to Reactor Cooling Drain Tank WLS	INTERNAL	
100	Combined Liquid Radwaste Stream to WHUT	1,499,084 2.85214	 75
101	Combined Radioactive Drain to Auxiliary Building Sump	182,500 0.3472	
102	Combined Solid Radwaste to SRST (WSS)	9,311 0.017715	
103	Auxiliary Building RCA Sump to WLS	443,475 0.84375	
104	WLS Discharge to Wastewater, etc.	2,156,971 4.1038	 75
105	WLS Resin Slurry to WSS	1,795 0.003415	 70

Table 3.3-1 (Sheet 6 of 8)
AP1000 Water Balance Flow Rates and Volumes by Path

Flow Path No.	Path Description	Annualized Cycle Average Gallons [a] gpm [a]	Maximum Gallons [a] gpm [a]
106	Excess Water Solid Radwaste to WLS	12,706 0.024174	
107	Off-site Resin Disposal	0	0
108	Off-site Chemical Disposal	73,730 0.14028	75
109	Demineralized Water to Users Discharging to Wastewater	2,475,032 4.70896	
110	Demineralized Water to Users Aligned to WLS, WSS, WRS	2,453,268 4.667557	
111	Demineralized Water to Users Aligned to WLS, WSS, WRS	1,987,192 3.7808	
112	Not Used		
113	Demineralized Water to SRST	1,600 0.003044	120
114	Demineralized Water to WLS HUT	203,501 0.38718	70
115	RO Unit Filter Drain	INTERMITTENT	
116	Oil / Water Separator Drain to Waste Waster Disposition	9,131,853 17.37415	200
117	Auxiliary Building Sump to Turbine Building Sump	INTERMITTENT	
118	Annex Building Sump to Turbine Building Sump	INTERMITTENT	
119	Diesel Generator Building Sump to Turbine Building Sump	INTERMITTENT	
120	Bypass Around Oil / Water Separator	0	0
121	Diesel Fuel Sump to Oil / Water Separator	INTERMITTENT	
122	Turbine Building and Diesel Fuel Sumps to Oil / Water Separator	9,131,853 17.37415	200
123	Turbine Building and Diesel Fuel Sumps to Oil / Water Separator and Bypass	9,131,853 17.37415	200
124	Wastewater Retention Basin to On-site Disposal	9,831,660 18.70559	400
125	Oil Water Separator to Oil Storage / Disposal	INTERMITTENT	
126	Radioactive Chemical Lab to Chemical Waste Tank	730 0.0013889	
127	Service Water Strainer Backwash to Wastewater Retention Basin	294,400 0.56012	800

Table 3.3-1 (Sheet 7 of 8)
AP1000 Water Balance Flow Rates and Volumes by Path

Flow Path No.	Path Description	Annualized Cycle Average Gallons [a] gpm [a]	Maximum Gallons [a] gpm [a]
128	PCS Evaporative Losses	15,934 0.0303	
129	PCS Losses to Storm Drains	15,933 0.0303	
130	Equipment/Area Decontamination Drains to WLS	14,600 0.02778	100
131	Equipment/Floor Drains Washdown	246,375 0.46875	100
132	Demineralized Water Makeup to PXS	54,413 0.10353	40
133	PXS Drains to WLS	54,413 0.10353	
134	Demineralized Water Makeup to WLS and WSS	205,101 0.39022	
135	Demineralized Water to WLS, WSS, Equipment and Drain Washdown	451,476 0.85897	
136	Demineralized Water to WLS, WSS, Equipment and Area Decontamination and Floor Drain Washdown	466,076 0.88675	
137	Combined SG Blowdown and Auxiliary Boiler Blowdown / Drain	2,481,223 4.72074	
138	CWS Leakage	262,800 0.5	

Notes:

Data in this table were obtained from Westinghouse's Standard Plant Water Balance Calculation APP-RWS-M3C-001, Revision A.

a) Where two values appear in the table, the top value is in annualized gallons and the bottom value is in average gpm. Where only one value appears, the value is in gpm.

BDS = blowdown system
CDS = condensate system
CFS = chemical feed system
CMS = condenser air removal system
CST = condensate storage tank
CVS = chemical and volume control system
CWS = circulating water system
DTS = demineralized water treatment system
DWST = demineralized water storage tank
EDI = electrodeionization
gpm = gallons per minute
HUT = holdup tank
HVAC = heating, ventilation, and air conditioning
INTERNAL = within the system
INTERMITTENT = not constant
PCCAWST = passive containment cooling auxiliary water storage tank
PCCWST = passive containment cooling water storage tank

Table 3.3-1 (Sheet 8 of 8)
AP1000 Water Balance Flow Rates and Volumes by Path

Notes (continued):

PCS = passive containment cooling system
PSS = primary sampling system
PWST = potable water storage tank
PXS = passive core cooling system
RCA = radiologically controlled area
RCS = reactor coolant system
RO = reverse osmosis
RMS = radiation monitoring system
RNS = residual heat removal system
SDS = sanitary drainage system
SFS = spent fuel pool cooling system
SFW = startup feedwater
SG = steam generator
SGS = steam generator system
SRST = spent resin storage tank
TCS = turbine building closed cooling water system
VWS = chilled water system
VYS = hot water heating system
WHUT = waste holdup tank
WLS = liquid radwaste system
WRS = radioactive waste drain system
WSS = solid radwaste system
WWS = wastewater system

Table 3.3-2
Anticipated Water Use (Two AP1000 Units)

Service	Normal (gpm)	Maximum (gpm)
Circulating Water System		
Evaporation Rate	28,255	28,255 [(a)]
Drift Rate	5.32	5.32 [(a)]
Blowdown Rate	57,923	61,065 [(a)]
CWS Makeup Flow	84,780	84,780 [(a)]
Service Water System		
Evaporation rate	368	1248
Drift Rate	0.05	0.1
Blowdown rate [(b)]	128	410
SWS Makeup Flow	496	1662
Demineralized Water Makeup Rate	350	1080
Fire Protection Makeup Rate	0.8	1250
Potable Water	35	69

Notes:

Values in this table were based on site-specific conditions and will differ from those reported in Table 3.3-1.

a) Typically, the plant is at 100-percent power; therefore, maximum and normal values are approximately equal.

b) SWS cooling tower blowdown is discharged to CWS cooling tower basin and will reduce the CWS makeup flow required from the intake on the canal when blowdown is in operation.

gpm = gallons per minute

Table 3.3-3 (Sheet 1 of 2)
Chemicals Added to Liquid Effluent Streams for Each Unit

System	Chemical-Type/Specific	Amount Used per Year	Frequency of Use	Dosing Concentrations
CWS	Biocide/sodium hypochlorite	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)	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	35,225 l (9306.5 gal.)	Continuous	2.237 ppm sulphuric acid
CWS	Corrosion Inhibitor ortho-polyphosphate	624,684 l (165,042 gal.)	Continuous	30 ppm ortho-polyphosphate
CWS	Silt Dispersant/polyacrylate	473,125 l (125,000 gal.)	Continuous	150 ppm polyacrylate
SWS	Biocide/sodium hypochlorite	1362.6 l (360 gal.)	~1 hour per day	0.2 ppm residual chlorine or 0.36 ppm sodium hypochlorite
SWS	Algaecide/quarternary amine (ammonium chloride)	1366.4 l (361 gal.)	~1 hour per day	0.2 ppm residual chlorine or 0.303 ppm ammonium chloride
SWS	pH adjustment/sulphuric acid	23.47 l (6.2 gal.)	~1 min/ 24-hour day	2.237 ppm sulphuric acid
SWS	Corrosion Inhibitor ortho-polyphosphate	416.35 l (110 gal.)	~1.3% of the time	30 ppm ortho-polyphosphate
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

Table 3.3-3 (Sheet 2 of 2)
Chemicals Added to Liquid Effluent Streams for Each Unit

System	Chemical-Type/Specific	Amount Used per Year	Frequency of Use	Waste Stream Concentrations
DTS	pH adjustment/sulphuric acid	70.97 l (18.75 gal.)	Intermittent	2.254-6.762 ppm sulphuric acid
DTS	Coagulant/Polyaluminum Chloride	450.4 l (119 gal.)	Intermittent	5-15 mg/l (4.2E-05 -1.3E-04 lb/gal)
DTS	Anti-scalant/polyacrylate	8516 l (2,250 gal.)	Intermittent	150-450 ppm polyacrylate
BDS	Oxygen scavenging/Hydrazine	200.6 l (53 gal.)	37.85 l/hr (10 gph) for 2.5 hr/yr or 1.25 hr/shutdown	200 ppm hydrazine (if steam generator is drained to the WWS)
BDS	pH adjustment/ammonium hydroxide	783.5 l (207 gal.)	37.85 l/hr (10 gph), 20.7 hr/yr or 10.4 hr/shutdown	100 ppm ammonia (if steam generator is drained to WWS)

Notes:

BDS = blowdown system
CWS = circulating water system
DTS = demineralized water treatment system
gal. = gallon
gph = gallons per hour
hr/yr = hours per year
l = liter
l/hr = liters per hour
lb/gal = pounds per gallon
ppm = parts per million
SWS = service water system
WWS = wastewater system

3.4 COOLING SYSTEM

ER Subsection 3.4.1 describes the LNP cooling systems and their anticipated modes of operation. ER 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 power generating facility.

NUREG-1555 requires that this section address the following topical areas; however, some of the topics are discussed in other sections of this chapter and will not be repeated in this section.

- Intake Flow Rates (Table 3.3-2 and Figure 3.3-2).
- Discharge Flow Rates (Table 3.3-2 and Figure 3.3-2).
- Circulating Water Flow Rates (Table 3.3-1 and Figure 3.3-1).
- Other Major Plant System Flow Rates (Table 3.3-1 and Figure 3.3-1).
- Temperature Rise across the Condenser (Table 3.2-3).
- Temperature Rise across Heat Exchangers in the SWS (Note: the heat exchangers served by the SWS are part of the CCWS) (ER Section 3.4).
- Heat Dissipation System Discharge Temperatures (discharge to Gulf of Mexico will be dictated by the FDEP NPDES permit requirements).
- Chemical Concentration Factors for Major Cooling System Components (ER Section 3.4).
- Frequency and Duration of Operation for Each Mode (ER Section 3.4).
- Typical performance curves for the CWS cooling towers are illustrated in Figure 3.4-1.

As previously noted, this section, as well as other sections of this chapter, contains a discussion of these parameters.

3.4.1 DESCRIPTION AND OPERATIONAL MODES

Each LNP unit will be equipped with two cooling systems that transfer heat to the environment during normal modes of plant operations. These systems are the SWS and the CWS. There are four operational modes:

- Normal Operation (Full Load).

- Cooldown.
- Refueling (Full Core Offload).
- Plant Startup.

Heat generated from each operational mode will be released to the atmosphere from cooling towers and from cooling tower blowdown to the Gulf of Mexico via the CREC discharge canal. The amount of heat released to the atmosphere and the Gulf of Mexico for each mode of operation is documented in Table 3.4-1 (based on DCD Tables 9.2.1-1 and 10.4.5-1).

The CWS will be supplied with seawater from the makeup intake structure located on the CFBC. The SWS will be supplied with freshwater pumped from the aquifer by the RWS.

3.4.1.1 System Description

3.4.1.1.1 Circulating Water System

The DCD provides the following information about the CWS:

> The circulating water system supplies cooling water to remove heat from the main condensers. The CWS and/or makeup water from the raw water system supplies cooling water to the turbine building closed cooling water system (TCS) heat exchangers and the condenser vacuum pump seal water heat exchangers under varying conditions of power plant loading and design weather conditions.

Circulating water from the cooling tower basin will be pumped by three 33-$^{1}/_{3}$-percent-capacity vertical turbine pumps which will provide a flow rate of 670,018 liters per minute (lpm) (177,000 gpm) each, into the main condenser and heat exchangers, then to the mechanical draft cooling towers.

Once in the cooling towers, the water will be cooled by forced convection and evaporation. The removed heat will be rejected to the atmosphere, and the cooled water will be returned to the cooling tower basin. The system will be provided with a blowdown capability to maintain the system performance by elimination of contaminants that build up as a result of the evaporation process.

Blowdown flow from the cooling tower basin will be discharged to the Gulf of Mexico via the CREC discharge canal. The blowdown temperature at the cooling tower design wet bulb temperature of 28.3 degrees Celsius (°C) (83 degrees Fahrenheit [°F]) is 31.7°C (89.1°F).

The cooling tower makeup water system will supply water to the CWS cooling tower to make up for water consumed as a result of evaporation, drift, and blowdown. The chemical concentration factor for the CWS cooling tower will vary

between 1.5 to 2 cycles of concentration. PEF will ensure that these cycles of concentration are appropriate for discharge to the CREC discharge canal.

As previously noted, the CWS cooling tower makeup system will consist of three 33-$^{1}/_{3}$-percent-capacity pumps. Two of these pumps will be in operation whenever the CWS requires makeup water. The third pump will be in standby and will start in the event that one of the operating pumps trips off-line. At the intake on the CFBC, the water will first be strained by trash racks, and then it will pass through traveling screens before entering the makeup water pumps. The discharge from the makeup pumps will be strained by an automatic strainer before discharging to the cooling tower. A backwashing feature of the strainers will remove debris and send it back to the CFBC.

3.4.1.1.2 Service Water System

The SWS will supply cooling water to remove heat from the nonsafety-related CCWS heat exchangers located in the turbine building.

The SWS is illustrated in DCD Figure 9.2.1-1.

The DCD provides the following information about the SWS:

> The system consists of two 100-percent-capacity service water pumps, automatic backwash strainers, a two-cell cooling tower with a divided 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.

The temperature rise across the heat exchangers will vary with each mode of operation. For each mode of operation, the temperature rise can be calculated by dividing the values listed in DCD Table 9.2.1-1 by the SWS flow rate for each mode of operation. For normal and refueling operations, the SWS flow rate used to calculate the temperature rise is 39,747 lpm (10,500 gpm). For cooldown and startup, the SWS flow rate is 79,494 lpm (21,000 gpm). During normal operations, the temperature rise is approximately 10.9°C (19.7°F), 18.4°C (33.1°F) during cooldown, 7.9°C (14.3°F) during refueling, 4.1°C (7.3°F) during plant startup, and 18.9°C (34.1°F) to support safe shutdown cooling and spent fuel cooling.

The DCD provides the following additional information about the SWS:

> 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 cooling 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 concentrations in the SWS. An alternate blowdown flow path is provided to the waste water system (WWS).

The service water system [for each unit] is arranged in two trains of components and piping. Each train includes one service water pump, one strainer, and one cooling tower cell. 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 either cooling tower cell.

The RWS will supply water to the SWS cooling tower to make up for water consumed as a result of evaporation, drift, and blowdown. The chemical concentration factor for the SWS cooling tower will be two cycles of concentration during full power operation and four cycles of concentration during cooldown. PEF will ensure that these cycles of concentration are appropriate for discharge to the CREC discharge canal.

The RWS will provide makeup water to the SWS from wells placed into a freshwater aquifer. Two 100-percent-capacity raw water pumping systems will be provided for each unit. The discharge of the raw water pumps will pass through automatic, self-cleaning strainers and media filters before being discharged to the SWS cooling tower basin and other raw water uses. Backwash water from the self-cleaning strainers and media filters will be discharged to the Gulf of Mexico through the discharge line.

3.4.1.2 Operational Modes

3.4.1.2.1 Circulating Water System

The CWS will provide cooling during the power operation mode. The power operation mode will reject heat as the CWS removes heat rejected from the turbine by way of the condenser. The LNP is estimated to be in the power operation mode for 97.2 percent of the operating cycle (approximately 17.5 months). During startup, a smaller amount of heat will be rejected by way of the condenser. The LNP is estimated to be in the startup mode for less than 0.1 percent of the operating cycle (6 hours). The power operation mode is paramount, operating for 17.5 months out of an 18-month cycle and consuming the most flow. Therefore, all other modes are bounded by the power operation mode.

3.4.1.2.2 Service Water System

The SWS will provide heat removal from the CCWS during all modes of normal operation, power operation, cooldown, refueling, and plant startup. During

refueling, the SWS will also support a full core offload. The LNP is estimated to be in the startup mode for less than 0.1 percent of the operating cycle (6 hours), refueling mode for 1.4 percent of the operating cycle (46 hours), and cooldown modes for 1.2 percent of the operating cycle (153 hours). These times do not include forced outages, as they cannot be predicted. The power operation mode is paramount, operating for 17.5 months out of an 18-month cycle and consuming the most flow. Therefore, all other modes are bounded by the power operation mode.

3.4.1.3 Heat Generated, Dissipated to the Atmosphere, and Released in Liquid Discharges

3.4.1.3.1 Circulating Water System

In the power operation mode, heat will be generated, dissipated to the atmosphere, and released in liquid discharges from the CWS. The CWS will release heat to the atmosphere via the CWS cooling tower and to the Gulf of Mexico as liquid discharges in the cooling tower blowdown. The quantities of heat released are summarized in Table 3.4-1.

3.4.1.3.2 Service Water System

The SWS will be operating in all modes of operation and will release heat to the atmosphere via the SWS cooling tower and in liquid discharges to the CWS cooling tower basin in the form of blowdown from the SWS cooling tower. The amount of heat released during the operation modes in the CWS and the SWS is presented in Table 3.4-1.

3.4.2 COMPONENT DESCRIPTIONS

3.4.2.1 Water Supply

3.4.2.1.1 Circulating Water

Makeup water to the CWS cooling tower and water to initially fill the CWS will be provided from the intake structure on the CFBC and will be seawater. An intake structure will be located on the side of the canal. The intake structure will have trash racks, traveling screens, three makeup pumps, and self-cleaning strainers for the makeup pump discharges. Screen wash pumps for the traveling screens will also be located in the intake structure. The screen wash flow and strainer backwash water flows will be returned to the canal. Debris collected from the screen wash will be disposed of in local landfills. The normal operating capacity of each CWS cooling tower makeup pump is 81,935 lpm (21,645 gpm). The pump flow may be throttled by operating personnel for control of the cooling tower basin level. The traveling screens in the intake structure have 0.94-cm ($^3/_8$-in.) mesh openings and the through flow water velocity at the screen is less than 0.15 meters per second (m/s) (0.5 feet per second [ft/sec]).

3.4.2.1.2 Service Water

The RWS will supply makeup water to the SWS cooling tower and to other plant systems that require freshwater. The RWS will pump water from the two supply wells per unit installed into the aquifer using 100-percent-capacity vertical well water pump systems. The number of pumps in each pumping system will be based on the sustained capacity of an individual well pump and the required RWS supply capacity. The discharge from the well pumps will pass through a self-cleaning strainer and a media filter before entering the raw water distribution system. Backwash water from the strainers and media filters will be discharged to the CWS cooling tower blowdown line to the Gulf of Mexico via the CREC discharge canal. The RWS will supply water to the DTS, PWS, and fire water tanks, in addition to the SWS makeup flow.

3.4.2.2 Heat Dissipation

3.4.2.2.1 Circulating Water

The CWS uses two 22-cell mechanical draft towers for each unit. The two towers utilize a common basin. The design heat dissipation capacity for the towers is 7628 x 10^6 British thermal units per hour (Btu/hr). At design conditions, water enters the tower at 47.7°C (117.8°F) and discharges at 31.7°C (89.1°F). At design conditions, the evaporation from the cooling tower is 115,177 lpm (30,427 gpm for two operating units), and the normal operating blowdown rate at 1.5 concentrations is 213,952 lpm (56,520 gpm for two units), resulting in a required makeup flow of 320,094 lpm (84,780 gpm for two units) for the pair of CWS towers used for each of the two units. The drift rate for the plume exiting the tower is 0.0005 percent of the rated flow, which corresponds to 20.1 lpm (5.32 gpm) of drift leaving the tower during normal operation.

Typical performance curves representative of the type and size of cooling towers selected for the LNP site are illustrated in Figure 3.4-1.

3.4.2.2.2 Service Water

The SWS has one mechanical draft cooling tower per unit, which blows down to the CWS tower basin. The rated heat dissipation capacity of the SWS tower is 346 x 10^6 Btu/hr.

The maximum SWS cooling tower evaporation and blowdown rates occur during cooldown and are 4724 lpm (1248 gpm) evaporation, 1552 lpm (410 gpm) blowdown, and 15 lpm (4 gpm) drift, which results in a maximum required makeup flow of 6291 lpm (1662 gpm) to the SWS cooling tower. During normal power operation, the SWS tower evaporation is 1393 lpm (368 gpm), and the blowdown is 485 (128 gpm), with 0.19 lpm (0.05 gpm) drift, resulting in a makeup requirement of only 1922 lpm (496 gpm). During normal operation, the SWS tower provides cooling water at a maximum temperature of 34.1°C (93.5°F). The water use, evaporation rate, and drift losses associated with the operation of the

SWS cooling towers represent only approximately 1 percent of the those parameters for the CWS cooling towers.

Table 3.4-1
Heat Transferred to the Atmosphere and Released in Liquid Discharges (One AP1000 Unit)

Operation Mode	Heat Dissipated to Atmosphere by the SWS (Btu/hr)	Heat Released in Liquid Discharges by the SWS (Btu/hr) [a]	Heat Dissipated to Atmosphere by the CWS (Btu/hr)	Heat Released in Liquid Discharges by the CWS (Btu/hr) [c]
Normal Operation (Full Load)	103×10^6	1.19×10^6	7628×10^6	123×10^6
Cooldown	346×10^6	1.33×10^6	0	0
Refueling (Full Core Offload)	74.9×10^6	1.19×10^6	0	0
Plant Startup	75.8×10^6	1.19×10^6	3050×10^6 [b]	49.2×10^6

Notes:

a) Assumes 80ºF makeup water and blowdown at 93.5ºF with the normal blowdown flow rate of 183 gpm. Cooldown uses 205 gpm blowdown.

b) Heat load based on 40 percent steam dump and normal operation.

c) Assumes 80ºF makeup water and blowdown at 89.1ºF with the normal blowdown flow rate of 28,260 gpm, assuming 40 percent blowdown flow for startup.

Btu/hr = British thermal units per hour
CWS = circulating water system
gpm = gallons per minute
SWS = service water system

3.5 RADIOACTIVE WASTE MANAGEMENT SYSTEMS

The 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 gaseous radwaste systems. Radioactive materials are generated within the core (fission products) and have the potential for leaking into the reactor coolant system by way of defects in the fuel cladding. The core radiation field also results in activation of the coolant to form N-16 from oxygen and the activation of corrosion products in the reactor coolant system.

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 the LNP. The annual average liquid and gaseous releases of radionuclides from the plant are determined using the calculation of releases of radioactive materials in gaseous and liquid effluents from pressurized water reactors (PWR-GALE code). The PWR-GALE code models releases using realistic source terms derived from data obtained from the experience of operating PWRs.

Table 3.5-1 (based on DCD Table 11.2-6) presents the code input data needed for radioactive source term calculations for PWRs. Radioactive waste management and effluent control systems are designed to minimize releases from active reactor operations to values As Low As Reasonably Achievable (ALARA). The LNP 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.

3.5.1 LIQUID RADIOACTIVE WASTE MANAGEMENT SYSTEM

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

> The liquid waste management systems include the systems that may be used to process and dispose of liquids containing radioactive material. These include the following:
>
> - Steam generator blowdown processing system ([DCD] Subsection 10.4.8);
> - Radioactive waste drain system ([DCD] Subsection 9.3.5);
> - Liquid radwaste system (WLS) ([DCD] Section 11.2).

> 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 DCD provides the following information about the controlled release of radioactivity:

> The liquid radwaste 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 nuclides.

The DCD provides the following WLS description:

> The liquid radwaste system, shown in [DCD] Figure 11.2-1, 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, waste water -- this input is collected from the reactor coolant system (RCS) effluents received through the chemical and volume control system (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 a high dissolved-solids content.
>
> Nonradioactive secondary-system waste is not processed by the liquid radwaste system. Secondary-system effluent is normally handled by the steam generator blowdown processing system, as described in [DCD] Subsection 10.4.8, and by the turbine building drain system.
>
> Radioactivity can enter the secondary systems from steam generator tube leakage. If significant radioactivity is detected in secondary-side systems, blowdown is diverted to the liquid radwaste system for processing and disposal.

Radioactive isotopes are produced as a normal by-product of reactor operations. A small quantity of these radionuclides can contribute to the normal radioactive

liquid effluents released from the plant. The process systems will be designed to minimize releases to the aquatic environment.

The DCD provides the following information:

> 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. In this way, a record is kept of planned releases of radioactive liquid waste.
>
> 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. These provisions preclude uncontrolled releases of radioactivity.
>
> 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 the LNP will be transported in two blowdown pipelines (one for each unit) from the LNP south to the CFBC and then run west along the northern edge of the bypass channel. The pipelines will then cross the bypass channel due north of the CREC, then run south and discharge to the CREC discharge canal, which will ultimately discharge to the Gulf of Mexico.

The release of radioactive liquid effluents from the LNP will be controlled in such a manner as to not exceed the average annual effluent concentration limits (ECLs) specified in 10 CFR 20. The LNP will be operated such that releases of radioactive liquid effluent to the Gulf of Mexico, via the CREC discharge canal, are expected to be negligible. To provide for a bounding assessment, the maximum quantities in Table 3.5-2 for releases of radioactive liquid wastes to the discharge lines for the LNP were used in the evaluation. The discharge quantity is taken from the bounding isotopic releases presented in DCD 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 the AP1000.

The discharge concentration is conservatively estimated based on an average daily discharge for 292 days per year with a 6000-gpm-per-unit dilution flow, as specified in DCD Table 11.2-8.

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 LNP 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 ECLs. Table 3.5-3 (based on DCD Table 11.2-8) compares the releases for two AP1000 units for those radionuclides identified in the table with the 10 CFR 20 ECLs and shows compliance with the 10 CFR 20 requirements.

3.5.1.1 Sources of Radioactive Liquid Waste

3.5.1.1.1 Reactor Coolant System Effluents

The DCD provides the following information about RCS effluents:

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

> Floor Drains and Other Wastes with Potentially High Suspended Solid Contents

The DCD provides the following information about 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.

3.5.1.1.2 Steam Generator Blowdown

The DCD provides the following information about SG blowdown:

> If steam generator tube leakage results in significant levels of radioactivity in the steam generator 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.

The LNP blowdown discharge lines are discussed in ER Subsection 3.1.1.7.

3.5.1.1.3 Doses

ER Section 5.4 provides maximum individual and population doses from the liquid effluents during normal plant operations of LNP.

3.5.1.1.4 Cost Benefit Analysis of Population Doses

The site-specific cost-benefit analysis regarding population doses due to liquid effluents during normal plant operation is addressed in Final Safety Analysis Report (FSAR) Subsection 11.2. This FSAR subsection applies to the cost-benefit analysis for each unit.

3.5.2 GASEOUS RADIOACTIVE WASTE MANAGEMENT SYSTEM

Process flow diagrams for the AP1000 gaseous radwaste system (WGS) are shown in Figures 11.3-1 and 11.3-2 of the DCD. The DCD provides the following information:

> 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 (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.

The DCD provides the following general description of the WGS:

> The AP1000 gaseous radwaste system, as shown on [DCD] Figure 11.3-1, 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, and two activated carbon-filled delay beds. Also included in the system are an oxygen analyzer subsystem and a gas sampling subsystem.

Further, the DCD notes that, “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 LNP will be controlled and monitored so that the regulatory limits specified in 10 CFR 20 and 10 CFR 50, Appendix I, are not exceeded.

The DCD provides the following information about radioactive releases:

> Releases of radioactive effluent by way of the atmospheric pathway occur due to:
>
> - Venting of the containment which contains activity as a result of leakage of reactor coolant and as a result of activation of naturally occurring Ar-40 in the atmosphere to form radioactive Ar-41
> - 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 on-going 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.

Table 3.5-4 presents the expected annual average quantity of radioactive gases released from the gaseous waste processing systems and the building ventilation systems for two units used in the evaluation of the LNP. Discharge quantities are taken from the bounding isotopic releases provided in DCD 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.

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 3.5-5, which compares the releases identified in Table 3.5-4 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:

> The largest input to the gaseous radwaste system is from the liquid radwaste system degasifier, which processes the chemical and volume control system 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 chemical and volume control 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.

3.5.2.1.1 Doses

ER Subsection 5.4.2.2 provides maximum individual and population doses from the gaseous effluents during normal plant operations for the LNP.

3.5.2.1.2 Cost Benefit Analysis of Population Doses

The site-specific cost-benefit analysis regarding population doses due to gaseous effluents during normal plant operation is addressed in FSAR Subsection 11.3. This FSAR subsection applies to the cost-benefit analysis for each unit.

3.5.3 SOLID WASTE MANAGEMENT SYSTEM

The DCD provides the following information about the solid waste management system power generation design basis:

> The solid waste management system [not including new or spent fuel] provides temporary onsite 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 DCD provides the following information about solid waste management:

> The solid waste management system (WSS) is designed to collect and accumulate spent ion exchange resins and deep bed filtration media, spent filter cartridges, dry active wastes [DAW], 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 offsite to a licensed disposal facility.

The DCD provides the following information about the functional design basis for the WSS:

> 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
>
> - 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 radiologically controlled area (RCA)
- Provide the means to store packaged wastes for at least 6 months in the event of delay or disruption of offsite shipping
- Provide the space and support services required for mobile processing systems that will reduce the volume of and package radioactive solid wastes for offsite shipment and disposal according to applicable [state and federal] regulations
- Provide the means to return liquid radwaste to the liquid radwaste system (WLS) for subsequent processing and monitored discharge

In addition, to minimize radiation exposure and maintain doses ALARA, the WSS 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.

Radioactive waste will be disposed in radioactive landfills in accordance with regulations governing radioactive waste. Final disposition of hazardous waste will be managed in accordance with regulatory requirements governing permitted radioactive waste facilities.

Table 3.5-6 (based on DCD Table 11.4-1) presents information about the estimated annual solid radwaste volumes that would be treated and shipped from the LNP (two units). The following values are summed from the individual contributing tables. The total annual expected and maximum volumes of solid radioactive wastes treated and shipped within and from the system are projected to be 326.2 cubic meters per year (m^3/yr) (11,518 cubic feet per year [ft^3/yr]) (expected generation), 624.1 m^3/yr (22,040 ft^3/yr) (maximum generation), 111.2 m^3/yr (3928 ft^3/yr) (expected shipped), and 323.8 m^3/yr (11,434 ft^3/yr) (maximum shipped). Tables 3.5-7 (based on DCD Tables 11.4-2 and 11.4-3), 3.5-8 (based on DCD Tables 11.4-4 and 11.4-5), and 3.5-9 (based on DCD Tables 11.4-6, 11.4-7, 11.4-8, and 11.4-9) present the expected and maximum anticipated annual activity for waste generated and shipped for two units, as well as the bounding list of the principle radionuclides. The total activity for waste are 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).

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.

Table 3.5-1 (Sheet 1 of 3)
Input Parameters for the PWR-GALE Computer Code for Radioactive Source Term Calculations for Pressurized Water Reactors

Parameter	Value
Thermal Power Level (MWt)	3400
Mass of Primary Coolant (lb.)	4.35E+05
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)	14.97E+06
Mass of Liquid in Each Steam Generator (lb.)	1.75E+05
Total Blowdown Rate (lb/hr)	4.2E+04
Blowdown Treatment Method	0 [(a)]
Condensate Demineralizer Regeneration Time	N/A
Condensate Demineralizer Flow Fraction	0.33
Primary Coolant Bleed for Boron Control	
Bleed Flow Rate (gpd)	435
Decontamination Factor for Iodine	10^3
Decontamination Factor for Cesium and Rubidium	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 Iodine	10^3
Decontamination Factor for Cesium and Rubidium	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 Iodine	10^3
Decontamination Factor for Cesium and Rubidium	10^3
Decontamination Factor for Others	10^3
Collection Time (day)	10
Process and Discharge Time (day)	0
Fraction Discharged	1.0

Table 3.5-1 (Sheet 2 of 3)
Input Parameters for the PWR-GALE Computer Code for Radioactive Source Term Calculations for Pressurized Water Reactors

Parameter	Value
Blowdown Waste	
Blowdown Fraction Processed	1
Decontamination Factor for Iodine	100
Decontamination Factor for Cesium and Rubidium	10
Decontamination Factor for Others	100
Collection Time (day)	N/A
Process and Discharge Time (day)	N/A
Fraction Discharged	0
Regenerant Waste	N/A
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	N/A
Gas Waste System: HEPA Filter	None
Auxiliary Building: Charcoal Filter	None
Auxiliary Building: HEPA Filter	None
Containment Volume ($ft.^3$)	2.1E+06
Containment Atmosphere Internal Cleanup Rate (ft^3/min)	N/A
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 hours/week at 4000 ft^3/min)	500
Charcoal Filter Efficiency (%)	90
HEPA Filter Efficiency (%)	99
Fraction of Iodine Released from Blowdown Tank Vent	N/A
Fraction of Iodine Removed from Main Condenser Air Ejector Release	0.0
Detergent Waste Decontamination Factor	0.0 (b)

Notes:

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

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

Table 3.5-1 (Sheet 3 of 3)
Input Parameters for the PWR-GALE Computer Code for Radioactive Source Term Calculations for Pressurized Water Reactors

Notes (continued):

ft. = foot
$ft.^3$ = cubic feet
ft^3/min = cubic feet per minute
PWR-GALE code = calculation of releases of radioactive materials in gaseous and liquid effluents from pressurized water reactors
gpd = gallons per day
HEPA = high efficiency particulate air
lb. = pound
lb/hr = pounds per hour
MWt = megawatt thermal
N/A = not applicable

Table 3.5-2
Normal Radioactive Liquid Effluent Releases Calculated by the PWR-GALE Code (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-129m	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:

The “m” next to an isotope indicates a metastable state.

Ci/yr = Curies per year
PWR-GALE code = calculation of releases of radioactive materials in gaseous and liquid effluents from pressurized water reactors

Table 3.5-3 (Sheet 1 of 2)
Comparison of Annual Average Liquid Release Concentrations to 10 CFR 20 Effluent Concentration Limits for Expected Releases (Two AP1000 Units)

Isotope	Discharge Concentration (µCi/cc) [(a)]	ECL (µCi/cc) [(b)]	Discharge as Fraction of ECL
Na-24	3.4E-10	5.00E-05	6.8E-06
Cr-51	3.8E-10	5.00E-04	7.8E-07
Mn-54	2.8E-10	3.00E-05	9.0E-06
Fe-55	2.0E-10	1.00E-04	2.0E-06
Fe-59	4.2E-11	1.00E-05	4.2E-06
Co-58	7.0E-10	2.00E-05	3.6E-05
Co-60	9.2E-11	3.00E-06	3.0E-05
Zn-65	8.6E-11	5.00E-06	1.7E-05
W-187	2.8E-11	3.00E-05	9.0E-07
Np-239	5.0E-11	2.00E-05	2.6E-06
Br-84	4.2E-12	4.00E-04	1.0E-08
Rb-88	5.6E-11	4.00E-04	1.4E-07
Sr-89	2.0E-11	8.00E-06	2.6E-06
Sr-91	4.2E-12	2.00E-05	1.0E-07
Y-91m	2.0E-12	2.00E-03	1.0E-09
Y-93	2.4E-11	2.00E-05	1.2E-06
Zr-95	5.8E-11	2.00E-05	3.0E-06
Nb-95	5.2E-11	3.00E-05	1.7E-06
Mo-99	1.7E-10	2.00E-05	8.4E-06
Tc-99m	1.6E-10	1.00E-03	1.6E-07
Ru-103	1.0E-09	3.00E-05	3.4E-05
Rh-103m	1.0E-09	6.00E-03	1.7E-07
Ru-106	1.5E-08	3.00E-06	5.2E-03
Ag-110m	2.2E-10	6.00E-06	3.6E-05
Te-129m	2.6E-11	7.00E-06	3.6E-06
Te-129	3.2E-11	4.00E-04	7.8E-08
Te-131m	1.9E-11	8.00E-06	2.4E-06

Table 3.5-3 (Sheet 2 of 2)
Comparison of Annual Average Liquid Release Concentrations to 10 CFR 20 Effluent Concentration Limits for Expected Releases (Two AP1000 Units)

Isotope	Discharge Concentration (µCi/cc) [a]	ECL (µCi/cc) [b]	Discharge as Fraction of ECL
Te-131	6.2E-12	8.00E-05	7.8E-08
I-131	3.0E-09	1.00E-06	3.0E-03
Te-132	5.0E-11	9.00E-06	5.6E-06
I-132	3.4E-10	1.00E-04	3.4E-06
I-133	1.4E-09	7.00E-06	2.0E-04
I-134	1.7E-10	4.00E-04	4.2E-07
Cs-134	2.0E-09	9.00E-07	2.4E-03
I-135	1.0E-09	3.00E-05	3.4E-05
Cs-136	1.3E-10	6.00E-06	2.2E-05
Cs-137	2.8E-09	1.00E-06	2.8E-03
Ba-140	1.2E-09	8.00E-06	1.4E-04
La-140	1.6E-09	9.00E-06	1.7E-04
Ce-141	1.9E-11	3.00E-05	6.2E-07
Ce-143	4.0E-11	2.00E-05	2.0E-06
Pr-143	2.8E-11	2.50E-05	1.1E-06
Ce-144	6.6E-10	3.00E-06	2.2E-04
Pr-144	6.6E-10	6.00E-04	1.1E-06
H-3	2.2E-04	1.00E-03	2.2E-01
		Total	**2.2E-01**

Notes:

The “m” next to an isotope indicates a metastable state.

a) The annual average discharge concentration release is based on an average daily discharge for 292 days per year with 6000 gpm/unit dilution flow.

b) ECLs are from 10 CFR 20, Appendix B.

CFR = Code of Federal Regulations
ECL = effluent concentration limit
gpm = gallons per minute
µCi/cc = microCuries per cubic centimeter

Table 3.5-4
Expected Annual Average Release of Airborne Radionuclides as Determined by PWR-GALE Code (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**	**2.20E+04**

Notes:

The “m” next to an isotope indicates a metastable state.

Ci/yr = Curies per year
PWR-GALE code = calculation of releases of radioactive materials in gaseous and liquid effluents from pressurized water reactors

Table 3.5-5 (Sheet 1 of 2)
Comparison of Calculated Gaseous Releases to 10 CFR 20 Effluent Concentration Limits (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	5.71E-11	1.0E-07	5.71E-04
Kr-85	8.20E+03	6.50E-09	7.0E-07	9.29E-03
Kr-87	3.00E+01	2.38E-11	2.0E-08	1.19E-03
Kr-88	9.20E+01	7.29E-11	9.0E-09	8.10E-03
Xe-131m	3.60E+03	2.85E-09	2.0E-06	1.43E-03
Xe-133m	1.74E+02	1.38E-10	6.0E-07	2.30E-04
Xe-133	9.20E+03	7.29E-09	5.0E-07	1.46E-02
Xe-135m	1.40E+01	1.11E-11	4.0E-08	2.77E-04
Xe-135	6.60E+02	5.23E-10	7.0E-08	7.47E-03
Xe-138	1.20E+01	9.51E-12	2.0E-08	4.76E-04
I-131	2.40E-01	1.90E-13	2.0E-10	9.51E-04
I-133	8.00E-01	6.34E-13	1.0E-09	6.34E-04
C-14	1.46E+01	1.16E-11	3.0E-09	3.86E-03
Ar-41	6.80E+01	5.39E-11	1.0E-08	5.39E-03
Cr-51	1.22E-03	9.67E-16	3.0E-08	3.22E-08
Mn-54	8.60E-04	6.82E-16	1.0E-09	6.82E-07
Co-57	1.64E-05	1.30E-17	9.0E-10	1.44E-08
Co-58	4.60E-02	3.65E-14	1.0E-09	3.65E-05
Co-60	1.74E-02	1.38E-14	5.0E-11	2.76E-04
Fe-59	1.58E-04	1.25E-16	5.0E-10	2.51E-07
Sr-89	6.00E-03	4.76E-15	2.0E-10	2.38E-05
Sr-90	2.40E-03	1.90E-15	6.0E-12	3.17E-04
Zr-95	2.00E-03	1.59E-15	4.0E-10	3.96E-06
Nb-95	5.00E-03	3.96E-15	2.0E-09	1.98E-06
Ru-103	1.60E-04	1.27E-16	9.0E-10	1.41E-07
Ru-106	1.56E-04	1.24E-16	2.0E-11	6.18E-06
Sb-125	1.22E-04	9.67E-17	7.0E-10	1.38E-07

Table 3.5-5 (Sheet 2 of 2)
Comparison of Calculated Gaseous Releases to 10 CFR 20 Effluent Concentration Limits (Two AP1000 Units)

Isotope	Release Ci/yr	Boundary Concentration µCi/cc [(a)]	10 CFR 20 ECL µCi/cc [(b)]	Fraction of ECL
Cs-134	4.60E-03	3.65E-15	2.0E-10	1.82E-05
Cs-136	1.70E-04	1.35E-16	9.0E-10	1.50E-07
Cs-137	7.20E-03	5.71E-15	2.0E-10	2.85E-05
Ba-140	8.40E-04	6.66E-16	2.0E-09	3.33E-07
Ce-141	8.40E-05	6.66E-17	8.0E-10	8.32E-08
H-3	7.00E+02	5.55E-10	1.0E-07	5.55E-03
Total	**2.20E+04**			**6.07E-02**

Notes:

The “m” next to an isotope indicates a metastable state.

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 χ/Q at the boundary of the restricted area (taken as the site exclusion area distance of 1340 meters) in the sector with the highest value (WSW) = 2.0E-05 sec /m^3

b) ECLs are from 10 CFR 20, Appendix B.

Ci/yr = Curies per year
ECL = effluent concentration limit
µCi/cc = microCuries per cubic centimeter

Table 3.5-6
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 (1020)	96.3 (3400)	122.3 (4320)
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 (1080)	38.5 (1360)
Wet Waste Subtotals	**44.3 (1530)**	**31 (1094)**	**179.9 (6352)**	**179.7 (6346)**
Dry Wastes				
Compactable Dry Wastes	269 (9500)	57.2 (2020)	411.2 (14,520)	87.8 (3100)
Non-Compactable Dry Wastes	13.3 (468)	21.1 (746)	32.1 (1134)	51.5 (1820)
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 (9988)**	**80.2 (2834)**	**444.3 (15692)**	**144.1 (5088)**
Total Wet and Dry Wastes	**326.2 (11,518)**	**111.2 (3928)**	**624.1 (22,040)**	**323.8 (11,434)**

Notes:

a) Radioactive secondary resins and membranes result from primary to secondary systems leakage (for example, 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 3.5-7 (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

Table 3.5-7 (Sheet 2 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)
Y-93	---	1.81E-04	---	1.81E-05
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:

The “m” next to an isotope indicates a metastable state.

Ci/yr = Curies per year

Table 3.5-8
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:

The “m” next to an isotope indicates a metastable state.

Ci/yr = Curies per year

Table 3.5-9 (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 3.5-9 (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	---	5.80E-08
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 3.5-9 (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:

The “m” next to an isotope indicates a metastable state.

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

Ci/yr = Curies per year

3.6 NONRADIOACTIVE WASTE MANAGEMENT SYSTEMS

This section describes non-radioactive waste management systems that are expected at the LNP, including cooling water and auxiliary boiler blowdown that may contain water-treatment chemicals or biocides, water-treatment wastes, floor and equipment drains, stormwater runoff, laboratory wastes, trash, hazardous waste, effluents from the sanitary sewage treatment system, and miscellaneous gaseous, liquid, and solid effluents. Petroleum and other hazardous materials may include fuels, such as gasoline and diesel oil, paints, solvents, and herbicides. These materials will be stored and used on-site in accordance with federal, state, and local regulations.

The section is divided into three subsections that evaluate these non-radioactive waste systems, as follows:

- ER Subsection 3.6.1 — Effluents Containing Biocides or Chemicals
- ER Subsection 3.6.2 — Sanitary System Effluents
- ER Subsection 3.6.3 — Other Effluents

Treated wastes from the LNP will ultimately be disposed of into the Gulf of Mexico. It is anticipated that discharges from the LNP will consist of the following effluents:

- Cooling tower blowdown for the CWS.
- Strainer and filter backwash water.
- Nonradioactive WWS discharges.
- Sanitary drain system (SDS) discharge.

The FDEP requires that an applicant develop and implement a plan for utilizing practices incorporating pollution prevention measures. From this point forward, the plan will be referred to as the LNP Waste Minimization and Pollution Prevention Plan (WM&PPP).

The LNP WM&PPP will address all activities that could contribute to the discharge of pollutants to the Gulf of Mexico from LNP operations.

For purposes of permitting, wastewater facilities or activities are categorized as either industrial or domestic based on the type of wastewater the facility handles. Domestic wastewater is wastewater from dwellings, business buildings, institutions, and the like, commonly referred to as sanitary wastewater or sewage. Domestic wastewater facilities include domestic wastewater sewers, pipelines, conduits, pumping stations, and force mains that transmit wastewater

to the plant; the wastewater treatment plant; or residuals or septage management facilities.

All wastewater that is not defined as domestic wastewater is considered industrial wastewater. Sources of industrial wastewater include large and small facilities and activities such as manufacturing, commercial businesses, mining, agricultural production and processing, and wastewater discharge from cleanup of petroleum- and chemical-contaminated sites.

Industrial wastewater discharged under the NPDES permits may be subject to federal Effluent Limitations Guidelines. In addition, all industrial wastewater discharges in Florida must provide reasonable assurance of meeting Florida's Water Quality Standards for surface water or groundwater in order to receive a discharge permit.

The FDEP is authorized by the U.S. Environmental Protection Agency (USEPA) to issue permits for discharge to surface waters under NPDES. Permits for discharge to groundwater are issued by the FDEP under state statutes and rules. Industrial wastewater permits are issued by the district offices, with two exceptions. NPDES permits for steam electric power plants are issued by the Industrial Wastewater Section in the Tallahassee, Florida, office. Industrial wastewater permitting for the phosphate industry is handled by the Phosphogypsum Management Section, which is located in Tampa, Florida.

PEF's Industrial Wastewater Facility Permit (Number FL0000159) for Crystal River Units 1, 2, and 3, issued by the State of Florida on May 9, 2005, provides the following definitions:

(1) The term "pollutants" refers to conventional, non-conventional and toxic pollutants.

(2) Conventional pollutants are: biochemical oxygen demand (BOD), suspended solids, pH, fecal coliform bacteria, and oil & grease.

(3) Non-conventional pollutants are those which are not defined as conventional or toxic.

(4) Toxic pollutants include, but are not limited to: (a) any toxic substance listed in Section 307(a)(1) of the [Clean Water Act] CWA, any hazardous substance listed in Section 311 of the CWA, or chemical listed in Section 313(c) of the Superfund Amendments and Reauthorization Act of 1986; and (b) any substance (that is not also a conventional or non-conventional pollutant except ammonia) for which [USEPA] has published an acute or chronic toxicity criterion.

(5) "Pollution prevention" and "waste minimization" refer to the first two categories of [USEPA's] preferred hazardous waste management strategy: first, source reduction and then, recycling. [PEF will utilize to the greatest extent possible both concepts.]

(6) “Recycle/Reuse” is defined as the minimization of waste generation by recovering and reprocessing usable products that might otherwise become waste; or the reuse or reprocessing of usable waste products in place of the original stock, or for other purposes such as material recovery, material regeneration or energy production.

(7) “Source reduction" means any practice which: (a) reduces the amount of any pollutant entering a waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment or disposal; and (b) reduces the hazards to public health and the environment associated with the release of such pollutant. The term includes equipment or technology modifications, process or procedure modifications, reformulation or redesign of products, substitution of raw materials, and improvements in housekeeping, maintenance, training, or inventory control. It does not include any practice which alters the physical, chemical, or biological characteristics or the volume of a pollutant through a process or activity which itself is not integral to, or previously considered necessary for, the production of a product or the providing of a service.

The LNP WM&PPP will be written by LNP operations personnel and approved by the FDEP to allow PEF to discharge wastewater from the LNP. The LNP WM&PPP will be directed toward reducing those pollutants of concern, which discharge to surface waters and will be prepared in accordance with good engineering and good housekeeping practices. The LNP WM&PPP will address all activities that could discharge pollutants to the surface water discharge, including process, treatment, and ancillary activities. The LNP WM&PPP will contain the following components when written:

- Signatory Authority and Management Responsibilities.
- WM&PPP Requirements.
- Waste Minimization Assessment (WMA).
- Best Management Practices and Pollution Prevention Committee.
- Employee Training.
- Plan Development and Implementation.
- Submission of Plan Summary and Progress/Update Reports to the FDEP.
- Plan Review and Modification.

3.6.1 EFFLUENTS CONTAINING BIOCIDES OR CHEMICALS

The FDEP is responsible for issuing NPDES permits. The permit is issued under the provisions of Chapter 403, Florida Statutes (F.S.), and applicable rules of the Florida Administrative Code (F.A.C.), and it constitutes authorization to discharge to waters of the state under the NPDES. The NPDES program in Florida incorporates chemical monitoring requirements for wastewater 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 3.3-3 presents information about the types of chemicals and systems where chemicals will be added. ER Chapter 5 considers the effects from chemical and thermal discharges to the Gulf of Mexico.

The LNP discharges will typically include, but are not limited to, cooling tower blowdown, liquid waste, and treated sanitary waste. These discharge streams are typically monitored for multiple constituents, such as temperature, flow, pH, fecal coliform, free available chlorine, oxidants, total residual chlorine, total suspended solids, hydrazine, oil and grease, total nickel, total manganese, total chromium, total zinc, total copper, total nitrogen, total phosphorus, total mercury, total selenium, and total iron.

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 the Gulf of Mexico through one NPDES-permitted outfall. Chemicals that will be added to cooling water for treatment will be effective at low concentrations and will be mostly consumed or broken down in application.

Any deminimus radioactive component of the discharge will be regulated by the U.S. Nuclear Regulatory Commission (NRC) under the Atomic Energy Act and not by the USEPA under the CWA.

3.6.1.1 Circulating Water, Service Water, Potable Water, and Demineralized Water

When in operation, the LNP will have many processes that may result in the intermittent discharge of low volumes of chemical contaminants to the Gulf of Mexico. Table 3.3-3 presents information about the types of chemicals and systems where chemicals will be added.

The average, maximum, and seasonal variations of principle constituents of intake and receiving waters and any trace materials that may be of environmental relevance are discussed in ER Subsection 2.3.3.

3.6.1.1.1 Circulating Water System

Water from the CFBC will be used in the CWS cooling tower. The operation of the CWS is described in ER Sections 3.3 and 3.4. The CWS will operate with

between 1.5 and 2 cycles of concentration of the impurities in the makeup water from the CFBC. Blowdown water will be discharged from the cooling tower to the Gulf of Mexico, via the CREC discharge canal, to control the cycles of concentration. The chemicals that are needed to maintain proper operation in the system will be injected by the turbine island CFS. Table 3.3-3 presents information about the types of chemicals that may be added to the CWS.

3.6.1.1.2 Service Water System

Water from a freshwater aquifer will be used in the SWS cooling tower. The operation of the SWS is described in ER Sections 3.3 and 3.4. The SWS will operate with between two and four cycles of concentration of the impurities in the makeup water from the aquifer. Blowdown water will be discharged from the cooling tower to the CWS cooling tower basin to control the cycles of concentration. The chemicals that are needed to maintain proper operation in the system will be injected by the turbine island CFS. Table 3.3-3 presents information about the types of chemicals that may be added to the SWS. Backwash water from the SWS strainer will be discharged to the wastewater retention basin (WWRB). This basin will be discharged to the CREC discharge canal and then to the Gulf of Mexico.

The DCD provides the following information:

> The turbine island chemical feed system equipment injects the required chemicals into the service water system. 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. The impact of toxic material on main control room habitability is addressed in [DCD] Section 6.4.
>
> 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 system 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.

3.6.1.1.3 Potable Water System

The operation of the PWS is designed to continuously furnish water for domestic use and human consumption. The operation of the system is not dependent on the mode of operation of the plant. The source of the potable water is the RWS that will withdraw freshwater from supply wells tapping the underlying aquifer. The raw water is typically filtered by media filters to remove suspended solids and is then treated with sodium hypochlorite before entering the potable water storage tank. Used potable water will be discharged to the SDS.

3.6.1.1.4 Demineralized Water Treatment System

The operation of the DTS is described in ER Subsection 3.3.1.3. The capacity of the DTS will be sufficient to supply the plant makeup demand during startup, shutdown, and power operation. The operation of the DTS will be on an as-needed basis. The chemicals that will be injected into the DTS are shown on Table 3.3-3. The effluent processed by the DTS will be discharged into the WWRB.

3.6.1.2 Steam Generator Blowdown System

Each unit will have an SG blowdown system (BDS). The DCD provides the following information about the BDS:

> The steam generator blowdown system (BDS) assists in maintaining acceptable secondary coolant water chemistry during normal operation and during anticipated operational occurrences of main condenser inleakage or primary to secondary steam generator tube leakage. It does this by removing impurities that are concentrated in the steam generator.

The BDS will consist of two blowdown trains, one for each steam generator. The DCD provides the following general description of the BDS:

> The blowdown water is extracted from each steam generator from a location just above the tube sheet. The blowdown from each steam generator is cooled by a regenerative heat exchanger, and flow is controlled and pressure reduced by a blowdown flow control valve. To recover the thermal energy, the condensate system provides cooling for the heat exchangers. To recover the blowdown fluid, each blowdown train has an electrodeionization (EDI) demineralizing unit which removes impurities from the blowdown flow.

The following information about BDS normal operation is based on information in the DCD:

The effectiveness of the BDS in controlling water chemistry depends upon the blowdown rate. The blowdown fluid is processed through the EDI units and discharged to the condensate system for reuse. In the event of main condenser tube leakage, when the concentration of impurities is high, the blowdown rate is increased. Normal operation is to recover the blowdown flow through the condensate system. However, blowdown with high levels of impurities can be discharged to the WWS.

The chemicals that are needed to maintain proper operation of the system will be injected by the CFS on an as-needed basis and are not dependant on the modes of operation of the plant.

Information about the types of chemicals and systems where chemicals will be added is presented in Table 3.3-3.

3.6.1.3 LNP Wastewater System

The LNP WWS is designed to collect and process effluents from process equipment, floor drains, laboratory and sample sinks from nonradiological areas. The DCD provides the following information about the WWS:

The power generation design basis is:

- 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 waste water system is capable of handling the anticipated flow of waste water during normal plant operation and during plant outages. The classification of components and equipment is given in [DCD] Section 3.2.

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 waste water 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 waste water. 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 waste water from either of the two sumps to the oil separator for removal of oily waste. The diesel fuel oil area sump pump also discharges waste water 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 offsite disposal.
>
> The waste water from the oil separator flows by gravity to the waste water retention basin for settling of suspended solids and treatment, if required, prior to discharge.

The wastewater collected in the WWRB will be discharged to the CREC discharge canal. The estimated amount of effluent that will be discharged to the CREC discharge canal is presented in Figure 3.3-2.

3.6.2 SANITARY SYSTEM EFFLUENTS

Sanitary systems installed for preconstruction activities include portable toilets, which will be supplied and serviced by an off-site vendor. During construction and operation of the LNP, sanitary system wastes will be treated by a waste treatment facility and will be discharged in accordance with agreements with the FDEP, as described in the following section.

The DCD provides the following information about the SDS:

> The sanitary drainage system 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 sanitary drainage system does not serve facilities in radiologically controlled areas (RCA[s]).

Two package sewage treatment plant units, each having a capacity of 40,000 gallons per day (gpd) extended aeration process, will be required to support LNP operations. Both units will be in operation during the construction phase using the contact stabilization process. One of the two units will be operated using the extended aeration process during permanent plant operations.

The following information is based on a sanitary waste treatment system conceptual design prepared by PEF and Sargent & Lundy, LLC (S&L):

The sewage plant will be designed for 800 people per day using the extended aeration process for the operational stage of the LNP and 3500 people per day using the contact stabilization process for the construction stage of the LNP. The extended aeration and contact stabilization processes are similar and use the same plant. The package plants will be required to meet the following capacity requirements, per unit, in order to support both the construction and operational phases of the LNP:

- Plant Capacity: 40,000 gallons (gal.) for extended aeration process and 35,000 gal. for contact stabilization process.
- Surge Tank: 17,000 gal. (one tank common for both unit).
- BOD Loading: 420 population equivalent for construction stage and 480 population equivalent for permanent operation.
- Sludge Storage: 30,000 gal. (one tank common for both units).
- Clarifier Tank: 12,000 gal. (surface area greater than 100 $ft.^2$ and minimum flow depth of 10 ft. including a 3-ft. water depth over sludge blanket).

In addition, the plants are required to meet the following state-required conditions:

- BOD5: 30 milligrams per liter (mg/l), 20°C average over 30 days with daily maximum not greater than 45 mg/l.
- Suspended Solids: 30 mg/l average over 30 days with daily maximum not greater than 45 mg/l.
- Fecal Coliform: 200 coliform/100 milliliters (ml) average over 30 days with daily maximum not greater than 400 coliform/100 ml.

The chlorination tank will be required to have a minimum retention time of 20 minutes along with the equipment to disinfect the effluent by controlled injection and mixing of hypochlorite.

Sanitary system discharges will be via the blowdown lines to the CREC discharge canal and then to the Gulf of Mexico. Discharges will be controlled in compliance with an approved NPDES permit for the LNP, which will be issued by FDEP. The estimated amount of effluent that will be discharged to the CREC discharge canal from the sanitary system is presented in Figure 3.3-2.

3.6.3 OTHER EFFLUENTS

This subsection includes the identification of other miscellaneous non-radioactive gaseous, liquid, and solid effluents that will be discharged to the environment.

3.6.3.1 Gaseous Effluents

3.6.3.1.1 Diesel Generators

The following information about diesel generators is based on information in the DCD for each AP1000 unit:

Two on-site standby diesel generator units and two auxiliary diesel generator units provide power to the selected plant nonsafety-related ac loads. The diesel generator building houses the four diesel generators and their associated HVAC 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 height of 42 m (140 ft.) above nominal plant grade. Each standby diesel generator is tested to verify the capability to provide 4000 kW and each auxiliary diesel generator is tested to verify the capability to provide 35 kW.

3.6.3.1.2 Fuel Storage Tanks

Two fuel oil storage tanks will be provided, one for each of the standby diesel generators.

The DCD notes that for each AP1000 unit, “The two fuel oil storage tanks are located on grade” and that “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 vent for each fuel oil storage tank will have an emissions release point at an approximate height of 10.5 m (35 ft.) above nominal plant grade.

3.6.3.1.3 Diesel-Driven Fire Pumps

Two 100-percent-capacity fire pumps will be provided. Each pump is rated for 7571 lpm (2000 gpm). The lead pump is electric motor-driven and the second pump is diesel engine-driven. The fuel tank for the diesel-driven pump holds enough fuel to operate the pump for at least 8 hours.

The exhaust for the diesel-driven fire pump is typically located at an approximate elevation of 30.5 m (100 ft.). The vent for the diesel-driven fire pump oil storage tank has a typical emissions release point at an approximate height of 10.5 m (35 ft.) above nominal plant grade.

3.6.3.1.4 Annual Emissions

Table 3.6-1 presents the estimated annual hydrocarbon emissions from the diesel generators and the diesel-driven fire pumps. Table 3.6-2 presents the estimated annual hydrocarbon emissions from the associated diesel fuel oil storage tanks.

No source of gaseous emissions other than the diesel generators and the diesel-driven fire pumps is expected for the LNP site. Because air emissions from non-radiological sources are relatively small and are already addressed in NUREG-1555, exceedance of any air emissions standards (such as federal, state, and tribal regional standards) is not anticipated.

3.6.3.2 Stormwater

Stormwater runoff from the LNP site will be collected and controlled by a stormwater drainage system. The existing ground elevation near the main reactors and the cooling towers is 12.8 m (42 ft.) North American Vertical Datum of 1988 (NAVD88), while the overall property elevation varies from 12.5 m to 14.9 m (41 ft. to 49 ft.) NAVD88. After grading, the land around the reactors and cooling towers will be raised to elevation 15.2 m (50 ft.) NAVD88, while the switchyard and construction laydown areas in the periphery around the main plant building will be raised to 14.3 m (47 ft.) NAVD88. Because the ground elevation at the main reactors and the cooling towers will be raised 2.4 m (8 ft.) above the existing grade, these structures will be above the 100-year floodplain.

After site grading, a series of stormwater drainage ditches will be constructed within the plant site to drain the stormwater to stormwater ponds located around the LNP site. Site drainage will be maintained through a series of pipes, open ditches, culverts and storm sewers. The stormwater ponds will be designed to fully retain the runoff from a 25-year, 24-hour rainfall event. The criteria for the design of a stormwater pond is given in the Southwest Florida Water Management District (SWFWMD), *Basis of Review*, *Part B*. To comply with the SWFWMD rules, these ponds will recover in no less than 5 days. The bottom of the storage zone of the ponds (pump off) will be at an elevation of 12.8 m (42 ft.) NAVD88, which is also the estimated high groundwater elevation. Although the ponds are designed to retain a 25-year, 24-hour rainfall event, larger storm events (100-year rainfall) will be drained out of the ponds through broad-crested weir emergency spillways provided in each of the ponds. A minimum freeboard of 0.6 m (2 ft.) will be provided for each pond above the spillway elevation. Water will be discharged from the spillways through long spreader swales to pass runoff to the surrounding wetland as sheet flow to prevent erosion.

Stormwater runoff will be diverted away from the roadways near the LNP site by constructing swales along the roads. These swales will be constructed on the sides of the roadway to provide essential drainage and water quality treatment. Roadways and swales will be designed using the Florida Department of Transportation (FDOT) design standards. Overflow from these swales will discharge to surrounding lands as sheet flow to reduce the potential for erosion.

Cross drains under roadways will be designed to equalize the property flood levels on both sides of the roads around the plant site.

A stormwater permit that is required by the state (Environmental Resource Permit) will be obtained from the FDEP prior to the start of any construction on the plant site. Federal stormwater construction site permitting will be obtained by using the Generic Permit for Stormwater Discharge from Large and Small Construction Activities, which is also administered by the FDEP. Site grading and drainage during site preparation activities will be designed to mitigate erosion and comply with a comprehensive Erosion and Sedimentation Control Plan and a Stormwater Pollution Prevention Plan, which are required by the FDEP to comply with the Generic Permit. These plans will be written and approved for the LNP prior to the start of site grading and construction activities.

3.6.3.3 Other Wastes

The debris from the intake screens and self-cleaning strainers at the circulating water cooling system makeup water pumphouse will be sluiced back to the CFBC.

Media filters will be used in the RWS to remove particulates from the freshwater. The media filters will periodically require backwashing, and the backwash water will be discharged to the CREC discharge canal using the CWS blowdown pipe.

3.6.3.4 Fire Protection System

It is anticipated that up to 1,135,624 l (300,000 gal) of water from the freshwater aquifer will be used for the annual testing of the FPS and will be discharged to the LNP site storm drains.

3.6.3.5 Solid Waste

Non-radioactive solid wastes will be disposed in a permitted off-site landfill. Waste that may be generated on-site and that will be disposed of in an off-site permitted landfill is described in ER Section 5.5.

Table 3.6-1
Typical Bounding Estimates for Annual Emissions from Diesel Generators and Diesel-Driven Fire Pumps (Two AP1000 Units)

Pollutants Discharged	Diesel Generators [a]		Two Diesel Driven Fire Pumps [a] (lb/yr)
	Four 4000-kW Standby DGs (lb/yr)	Four 35-kW Ancillary DGs (lb/yr)	
Particulates [b]	2168	33	136
Sulphur Oxides [b]	111	1.6	6.4
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 hours per month of operation for each generator and diesel-driven fire pump.

b) Assumes sulphur content of Number 2 diesel fuel burned is 0.05 percent.

DG = diesel generator
lb/yr = pounds per year

Table 3.6-2
Estimated Annual Hydrocarbon Emissions from Diesel Fuel Oil Storage Tanks (Two AP1000 Units)

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 (lb/yr)	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.

DG = diesel generator
lb/yr = pounds per year

3.7 POWER TRANSMISSION SYSTEM

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

The LNP site is located in the service territory of PEF, the northwest and central Florida regional electrical transmission system owner/operator. The LNP will require a new transmission system to be constructed within the central Florida area.

The LNP will be connected to a new common dual voltage 500-kV/230-kV switchyard. The 500-kV section of the switchyard is designed to connect the new 500-kV transmission lines to the main step-up transformer for each unit. The 230-kV section of the switchyard will feed reserve auxiliary transformers (RAT) for the LNP. Two 500-kV/230-kV step-down transformers will be located within the switchyard boundary to feed 230-kV buses. Proposed Levy Nuclear Plant Unit 1 (LNP 1) and proposed Levy Nuclear Plant Unit 2 (LNP 2) will each have a main step-up transformer consisting of three single-phase transformers and a wired single-phase transformer as a spare. The main step-up transformer for each unit will be connected to the 500-kV/230-kV switchyard by an overhead line. LNP 1 and LNP 2 will each have two RATs, which will be connected to the 500-kV/230-kV switchyard by individual overhead lines. Startup and shutdown ac power, as well as the capability to provide power to the grid, are provided by these switchyard connections.

The LNP's new transmission system will be comprised of four 500-kV transmission lines in order to connect the LNP to the Florida electrical grid system.

3.7.1 BACKGROUND

3.7.1.1 Utility Grid Description

PEF is an investor-owned utility serving a 51,800 square-kilometer (km^2) (20,000 square-mile [$mi.^2$]) area in central and north Florida, including metropolitan St. Petersburg, Clearwater, and the greater Orlando area. The PEF electrical grid consists of nuclear and fossil fuel power generating facilities and an extensive 500-kV/230-kV bulk power transmission system serving 1.5 million customers and a population of more than 5 million people. PEF maintains multiple direct interconnections with neighboring utilities. These interconnections with neighboring utilities serve to increase the reliability of the PEF electrical grid. PEF participates as a member of the Florida Reliability Coordinating Council and the Southeastern Electric Reliability Corporation.

3.7.1.2 Transmission Line Corridors (Existing and Proposed)

The LNP will require a new transmission system in order to incorporate the additional power into the Florida electrical grid system. The LNP new transmission lines and certain transmission system upgrades are components in PEF's baseload generation plan for serving the increasing load and customer base in the Central Florida region. PEF is seeking certification of the corridors pursuant to the Florida Electrical Power Plant Siting Act (PPSA), Chapter 403, F.S. and Chapter 62-17, F.A.C. The certification provides for the centralized and coordinated permitting of the LNP, as well as the associated facilities, including the associated transmission lines included in this application. For linear facilities associated with an electrical power plant, such as the proposed transmission lines, the PPSA provides for the certification of "corridors," which is the area within which the associated linear facilities' right-of-ways (ROWs) must be located. Once the ROWs for the new transmission lines have been acquired, the boundaries of the corridors will be revised to those of the acquired ROWs. The remainder of the corridors will then have no further legal significance with relation to this project. Certification under the PPSA is the sole license of the state of Florida and provides non-federal agency approval of the location of the LNP, associated facilities, and transmission corridors. Certification under the PPSA also authorizes construction and maintenance of the transmission lines.

Figure 3.7-1 depicts the current PEF high-voltage transmission system within central Florida, and Figure 3.7-2 depicts the anticipated location of the proposed transmission line corridors needed to support the LNP.

Four new 500-kV transmission lines will connect the LNP to the Florida electrical grid system. Two of the four 500-kV transmission lines will connect to the proposed Citrus Substation, one will connect to the proposed Central Florida South Substation, and one will connect to the CREC 500-kV switchyard.

The proposed corridors will be approximately 304.8 to 804.7 m (1000 to 2640 ft.) wide to allow for maximum flexibility when determining the ROW. A total of approximately 146.5 km (91 mi.) of transmission lines will be needed to connect to the first substations in order to incorporate the power generated by the LNP into the electrical grid system.

Table 3.7-1 provides the origin points, termination points, nominal voltage, power transmission capacity, approximate lengths, approximate average ROW needs, and potential structure types that may be constructed for each of the proposed transmission lines.

Below is a summary of the proposed transmission line corridors that will connect the LNP to the first substation:

- 500-kV transmission lines from the LNP to proposed Citrus Substation (LPC):

The LPC corridor for two 500-kV transmission lines will originate at the LNP south site boundary in Levy County and traverse south for approximately 14.5 km (9 mi.) to the proposed Citrus Substation in Citrus County. The LPC corridor is also known as Citrus 1 and 2.

- 500-kV transmission line from the LNP to CREC 500-kV switchyard (LCR):

  The LCR corridor for one 500-kV transmission line will originate at the LNP south site boundary in Levy County, traverse south, turn west at the existing PEF 500-kV/230-kV transmission line, and will terminate at the CREC 500-kV switchyard in Citrus County. The LCR corridor is approximately 22.5 km (14 mi.) in length and is also known as Crystal River.

- 500-kV transmission line from the LNP to proposed Central Florida South Substation (LCFS):

  The LCFS corridor for one 500-kV transmission line will originate at the LNP south site boundary in Levy County, traverse south, turn east, and will terminate at the proposed Central Florida South Substation near the boundary between Sumter and Lake counties. The LCFS corridor is approximately 100 km (59 mi.) in length and is also known as Sumter.

3.7.1.3 Additional Corridors

Additional (and supplemental) transmission lines will be required beyond the first substations to connect the LNP to the Florida electrical grid system, as described below:

- 230-kV transmission lines from the proposed Citrus Substation to Crystal River East Substation (CCRE):

  The CCRE corridor for two 230-kV transmission lines will originate at the proposed Citrus Substation located in Citrus County and will terminate at the existing Crystal River East Substation, also located in Citrus County. The CCRE corridor is also known as Crystal River East.

- 230-kV transmission line from the CREC 500-kV switchyard to Brookridge Substation (CB):

  The CB corridor for one 230-kV transmission line will originate at the CREC 500-kV switchyard in Citrus County and will terminate at the existing Brookridge Substation in Hernando County. The CB corridor is also known as Brookridge.

- 230-kV transmission line from the Brookridge Substation to Brooksville West Substation (BBW):

The BBW corridor for one 230-kV transmission line will originate at the Brookridge Substation in Hernando County, and will terminate at the Brooksville West Substation, also located in Hernando County. The BBW corridor is also known as Brookridge.

- 230-kV transmission line from Polk to Hillsborough to Pinellas (PHP):

  The PHP corridor for one 230-kV transmission line will originate at the Kathleen Substation in Polk County, traverse south to the existing Griffin Substation in Hillsborough County, traverse west, and will terminate at the existing Lake Tarpon Substation in Pinellas County. The corridor will collocate with the existing PEF Kathleen-Griffin 230-kV transmission line and the existing Higgins-Griffin 115-kV transmission line. The PHP corridor is also known as Kathleen.

Two 69-kV transmission lines will be required to support construction and administration of the LNP, as described below:

- 69-kV transmission line from the LNP via the north LNP construction/administration corridor:

  The north LNP construction/administration corridor for one 69-kV transmission line will originate at the west site boundary line of the LNP and connect to an existing 69-kV transmission line near US Highway 19. This corridor is also known as Levy North.

- 69-kV transmission line from the LNP via the south LNP construction/administration corridor:

  The south LNP construction/administration corridor for one 69-kV transmission line will originate at the south site boundary of the LNP and connect to the existing 69-kV transmission line north of the Inglis Lock Bypass Channel. This corridor is also known as Levy South.

The transmission line corridors will traverse through a variety of land uses and land covers (Figures 3.7-3, 3.7-4, and 3.7-5). The transmission line corridors will utilize to the maximum extent practicable PEF's existing high-voltage transmission line ROWs and other existing linear corridors and major roads. A more detailed description is provided in ER Subsection 2.2.2.

PEF will design and construct the transmission lines in accordance with current industry standards and guidelines. The transmission lines will meet or exceed the current National Electrical Safety Code (NESC) requirements.

3.7.1.3.1 Proposed Substations

As discussed in ER Subsection 3.7.1.2, there are two new substations proposed for construction in order to support the LNP and provide power to the Florida electrical grid system. Figure 3.7-2 depicts the locations of the proposed substations, which are the first substations to which the transmission line corridors will connect. Following is a summary of the proposed substations:

- The proposed Citrus Substation is approximately 28 ha (70 ac.) in Citrus County and will be designed for 500-kV and 230-kV transmission lines.

- The proposed Central Florida South Substation is approximately 24 ha (60 ac.) in the area of the boundary between Sumter and Lake counties and will be designed for 500-kV and 230-kV transmission lines.

3.7.2 TRANSMISSION SYSTEM DESIGN PARAMETERS

Table 3.7-1 identifies the potential structure types that may be constructed for each of the proposed transmission lines. Figures 3.7-6, 3.7-7, 3.7-8, 3.7-9, 3.7-10, 3.7-11, 3.7-12, 3.7-13, 3.7-14, 3.7-15, 3.7-16, 3.7-17, 3.7-18, 3.7-19, 3.7-20, 3.7-21, and 3.7-22 depict the typical structure profiles (single steel pole or steel H-Frame). Transmission structure designs will be per PEF's construction specifications and line design philosophy. Past experience with similar transmission lines on the PEF transmission system has shown availability of power to be 99.95 percent.

New lines will be built according to PEF's construction specifications, line design philosophy, and applicable standards stipulated by the current NESC. Typical structure heights will range from approximately 33.5 to 59.4 m (110 to 195 ft.) with typical span lengths between structures of approximately 304.8 to 457.2 m (1000 to 1500 ft.), as illustrated on Figures 3.7-23 and 3.7-24. The structures will be supported with engineered foundations. The foundations will normally consist of either direct buried structures with concrete backfill or reinforced concrete drilled piers. Structures may also utilize guys and anchors at angle and corner structures to help support the load. The minimum line clearances above ground level will be 10.7 m (35 ft.) at 140°C (284°F) conductor temperature. Phase spacing will typically be 10.4 m (34 ft.) The transmission structures will normally carry a single circuit line consisting of three phases of triple-bundled aluminum conductors, steel reinforced, of 1590 thousand circular mils, and two shield wires. One or both of the shield wires will be standard optical ground wire (fiber optic cable) and may be used for protection, control, and other communications.

Transmission line structures and support systems will be designed for the following load cases:

- 2007 NESC Light Loading District: Combined ice and wind load (0-in. radial ice and 60-mile per hour [mph] wind [9 pounds per square foot] with appropriate overload capacity factors and strength factors) (Reference 3.7-001).

- 2007 NESC Extreme Wind Loading: 130-mph wind with appropriate velocity pressure exposure coefficient, force coefficient, gust response factor, overload capacity factors, and strength factors (Reference 3.7-001).

- PEF High Wind Loading: 145-mph wind with appropriate velocity pressure exposure coefficient, force coefficient, gust response factor, overload capacity factors, and strength factors. The PEF High Wind Loading utilizes a basic wind speed of 145-mph, which exceeds the basic wind loading of 130 mph required by the NESC and will provide additional design tolerance over and above the basic wind speeds predicted to occur in the region according to American Society of Civil Engineers 7-05, Minimum Design Loads for Buildings and Other Structures.

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 (EMFs), radio interference (RI), television interference (TVI), audible noise, aviation safety, and other factors as appropriate.

3.7.3 RADIATED ELECTRICAL AND ACOUSTICAL NOISES

The electric field at the surface of transmission line conductors can, under some conditions, result in localized ionization of the air near the conductors. This phenomenon is called “corona.” As explained in the following subsections, corona activity at the surface of transmission line conductors produces low levels of acoustic and radio frequency electric energy which, under some conditions, can result in audible noise and RI or TVI.

3.7.3.1 Audible Noise

The primary cause of audible noise on high-voltage transmission lines is corona resulting from an irregularity on the surface of the conductor, such as buildup during foul weather (for example, fog, water droplets, or significant particulate matter). Corona activity at the surface of the conductor produces a low-level audible noise that is a slight humming sound. Under wet conditions, higher noise levels are experienced than would occur under dry conditions. However, the background noise from various sources, such as falling rain, traffic, common industrial noises, or blowing leaves has the effect of masking transmission line noise. (Reference 3.7-002)

The random phase relationship of the pressure waves generated by the corona source along the line combined with the significant high-frequency content result in the crackling, frying, or hissing characteristic of the transmission line noise (Reference 3.7-002).

During fair weather conditions when the conductors are dry, the audible noise levels produced by the proposed 500-kV transmission lines will be less than normal outdoor ambient noise levels. When the conductors are wet from rainfall or heavy fog, the transmission line noise will increase. (Reference 3.7-002)

Table 3.7-2 presents the maximum calculated audible noise levels that could be produced by the proposed transmission lines at the edge of the ROW during rain or other wet weather conditions. Audible noise levels were calculated using the Corona and Field Effects Program (CAFEP) developed by Bonneville Power Administration.

The calculated audible noise levels anticipated to be produced by the proposed transmission lines at the edge of the ROW will comply with all applicable federal and local audible noise ordinances in Levy, Citrus, Marion, Sumter, and Lake counties.

3.7.3.2 Radio and Television Interference

Electrical noise in the radio frequency range can be produced by corona on transmission line conductors or possibly by gap-type discharges on transmission line hardware. Corona noise is most significant in the lower frequencies, such as those used for amplitude modulation (AM) radio broadcasting.

Because the proposed transmission lines will be constructed with new hardware, gap-type discharges are not anticipated to occur. Should a gap-type discharge develop on a damaged, defective, or improperly installed piece of hardware and lead to interference, the hardware causing the gap-type discharge will be located and repaired or replaced. Therefore, the following analysis focuses on interference from corona on the transmission line conductors.

RI and TVI levels were calculated using the CAFEP developed by Bonneville Power Administration. The results of the calculations are summarized in ER Subsections 3.7.3.2.1 and 3.7.3.2.2.

3.7.3.2.1 Radio

Communications systems using frequency modulation (FM), such as FM radio broadcast or business and public service communications, are not affected by transmission line noise because the corona discharge radio frequency amplitude decreases significantly when above 3 megahertz (which is below the FM frequency band). Systems using AM, such as AM radio and the video (picture) portion of television broadcasts can be affected if the broadcast signal strength is weak, the noise level is high, or both. The Federal Communications Commission (FCC) has characterized AM broadcast signals into categories based on the strength of signal received. Six categories (Type A, B, C, D, E, and F) have been identified, with Type A being the strongest signal. The FCC primarily protects the Type A and Type B signals from co-channel or adjacent channel interference.

AM radio station signals that are strong enough to be free of naturally occurring atmospheric interference (static) at least 90 percent of the time are classified as Type A signal service by the FCC. In general, stations with Type A signal service will not experience objectionable RI from the proposed transmission lines during fair weather if the receiver is located beyond the edge of the ROW.

Weaker AM radio station signals that are likely to experience naturally occurring atmospheric interference at least 50 percent of the time are defined as Type B signal service by the FCC. Weak stations minimally meeting the Type B criterion (signal strength equal to 54 decibels [dB]) could experience noticeable RI from transmission line corona during fair weather at receivers located at the edge of the ROW; however, these stations will not experience objectionable RI from the proposed transmission lines during fair weather if the receiver is located 45.7 m (150 ft.) or more beyond the outermost conductor (RI levels are below 32 dB, which results in an acceptable signal-to-noise ratio of 22 dB or higher).

During wet weather conditions, naturally occurring RI from atmospheric electricity (static) increases significantly, causing interference with all but the stronger local AM radio station signals, thereby masking any RI from transmission lines. The primary source from atmospheric noise is lightning activity. Lightning activity several thousand miles away can cause severe static to weak AM radio station signals. Thus, RI from transmission line corona during wet weather conditions is not a significant concern.

3.7.3.2.2 Television

The FCC has defined the grades of television service to be used for station authorization purposes as follows:

- Television Channels 2 through 6: Grade A signal strength = 68 dB, Grade B signal strength = 47 dB.
- Television Channels 7 through 13: Grade A signal strength = 71 dB, Grade B signal strength = 56 dB.
- Television Channels 14 through 83: Grade A signal strength = 74 dB, Grade B signal strength = 64 dB.

The proposed transmission lines are not likely to cause TVI with any Grade A television stations under normal or wet weather conditions, regardless of antenna location outside the ROW.

The proposed transmission lines may interfere with the reception of weaker stations minimally meeting the Grade B signal criterion and operating on Channels 2 through 6 (signal strength equal to 47 dB). Signal interference for these weaker stations may occur at the edge of the ROW under wet weather conditions; however, these signals will not experience objectionable TVI from the proposed transmission lines during wet weather conditions if the receiver is located 91.4 m (300 ft.) beyond the outermost conductor (TVI levels are

approximately 7 dB, which results in an acceptable signal-to-noise ratio of 40 dB or higher). Grade B television signals operating on Channels 7 through 13 (signal strength equal to 56 dB and above) will not likely experience TVI from the proposed transmission lines under any weather conditions if the receiver is located outside the ROW. Television receivers may experience TVI if the antenna happens to be pointed in a direction of maximum noise. This interference is usually correctable by reorienting the antenna to get more signal, less line noise, or both.

3.7.3.2.3 Summary

Should any homeowner or business experience abnormal RI or TVI as a result of these transmission lines, PEF will investigate complaints and provide appropriate mitigation for RI and TVI impacts caused by the proposed transmission lines.

3.7.4 ELECTRIC AND MAGNETIC FIELDS

The proposed 500-kV transmission lines will produce EMFs. 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. 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 could be incorporated into the line and station designs to minimize the EMF strengths.

The FDEP regulates EMFs from electrical transmission lines under the provisions of Sections 403.061(30) and 403.523(10), F.S. The proposed 500-kV transmission lines comply with the FDEP EMF regulations found in Rule 62-814.450(3), F.A.C. The FDEP EMF provides the following rules applicable to PEF's proposed 500-kV transmission line project [a]:

- The maximum electric field at the edge of the transmission line ROW and at the new substation property boundary shall not exceed 2 kV/m.
- The maximum electric field on the transmission line ROW shall not exceed 10 kV/m.
- The maximum magnetic field at the edge of the transmission line ROW and at the new substation property boundary shall not exceed 200 milliGauss (mG).

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a. Where calculations under this section indicate that operation of existing electrical facilities on an existing ROW produces electric or magnetic fields at levels higher than the limits specified for new facilities in Rule 62-814.450, F.A.C., a new electrical facility may be constructed and operated on that existing ROW provided that the new facility does not increase the electric or magnetic fields above the maximum field values created by the existing lines. (Rule 62-814.470[1][c], F.A.C.)

Table 3.7-3 presents the maximum calculated EMF that can be produced by the proposed transmission lines under maximum normal operating conditions consistent with Rule 62-814, F.A.C. These fields comply with FDEP rule requirements for new 500-kV lines. Because some of the proposed corridors contain existing transmission line ROWs that may be used for alignment of the new transmission lines, the existing lines were included in the calculations, where appropriate.

The detailed design of the transmission lines will start after the corridors are certified, during which a specific ROW within the corridors is selected. PEF will submit EMF calculations for all configurations used in the final detailed design to the FDEP at least 90 days prior to the start of construction, as required by the FDEP EMF rule.

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 store an electrical charge, becoming what is called "capacitively charged." 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 structure will be grounded. Each structure will have an electrical connection between the shield wire and ground lead that will be connected to ground rods. Ground resistance testing will be conducted at each 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. In addition, PEF standards require that fences and gates, either crossing or parallel to and within the transmission line ROW, be grounded to mitigate shock hazards.

The NESC addresses induced currents in Rule 232 C1c for lines with voltage exceeding 98 kV ac to ground. This rule is often referred to in the industry as the 5 milliamp rule and states that clearances shall be increased as required to limit the steady-state current due to electrostatic effects to 5 milliamps if the largest anticipated truck, vehicle, or equipment under the line were short-circuited to

ground. The size of the anticipated truck, vehicle, or equipment used to determine these clearances may be less than, but need not be greater than that limited by federal, state, or local regulations governing the area under the line. (Reference 3.7-001)

Short circuit calculations performed for the project are based upon Section 7.8 of Electric Power Research Institute's (EPRI) *EPRI AC Transmission Line Reference Book—200 kV and Above*, Third Edition (Reference 3.7-003).

PEF chose three different scenarios and specific vehicle sizes for each scenario to review. These scenarios are described as follows:

- Case 1: Residential driveways and areas accessible to pedestrians only. In these areas, the maximum size vehicle anticipated under the line is a pickup truck or similar size off-road vehicle (size limited to an assumed 1.7 m, by 2.0 m, by 5.2 m [5.6 ft., by 6.6 ft., by 17.0 ft.]).

- Case 2: Residential and secondary streets. On residential and secondary streets, the largest vehicle anticipated under the line is a large truck (size limited to 4.1 m, by 2.6 m, by 17.5 m [13.5 ft., by 8.5 ft., by 57.5 ft.] as noted by American Trucking Associations, Inc.) (Reference 3.7-004).

- Case 3: Interstate, federal, and state highways, and major arterials. On these highways and arterials, the largest vehicle anticipated under the line is a combination truck tractor-semi-trailer (size limited to 4.1 m, by 2.6 m, by 22.9 m [13.5 ft., by 8.5 ft., by 75.0 ft.] [with appropriate flagging], as noted in Section 316.515, F.S.).

Case 1 yielded minimum required clearances that are less than the project minimum design clearance of 10.7 m (35 ft.) planned for this 500-kV transmission line, and therefore, this scenario does not pose a conflict. Case 2 yielded minimum required clearances of 10.1 m (33 ft.) for the 500-kV monopole delta structure and 11.6 m (38 ft.) for the 500-kV H-frame structure. Case 3 yielded minimum required clearances of 10.4 m (34 ft.) for the 500-kV monopole delta structure and 12.5 m (41 ft.) for the 500-kV H-frame structure. The results of these calculations will be applied to the design of the project, and therefore will maintain the NESC requirements applicable to induced currents.

3.7.6 REFERENCES

3.7-001 Institute of Electrical and Electronics Engineers, *National Electrical Safety Code (NESC)*, ANSI/IEEE C2-2007, August 1, 2006.

3.7-002 Electric Power Research Institute, *Transmission Line Reference Book, 345 kV and Above*, EL-2500, Second Edition, Revised, 1975.

3.7-003 Electric Power Research Institute, *EPRI AC Transmission Line Reference Book—200 kV and Above*, EPRI Product 1011974, Third Edition, 2006.

3.7-004 American Trucking Associations, Inc., "Summary of U.S. Size & Weight Limits," Army Field Manual 55-30, Appendix E, Website, www.globalsecurity.org/military/library/policy/army/fm/55-30/appe.htm, accessed March 14, 2008.

Table 3.7-1
Proposed Transmission Lines to Connect the LNP to the PEF Transmission System

Origin	Termination	Nominal Voltage (kV)	Approximate Length (mi.) [a]	Approximate Average ROW Needed (ft.) [b]	Potential Structure Types [c]
LNP 500-kV Switchyard [d]	Proposed Citrus Substation	500	9	220	Single Steel Pole or H-Frame
LNP 500-kV Switchyard	Proposed Central Florida South Substation	500	59	220	Single Steel Pole or H-Frame
LNP 500-kV Switchyard	CREC 500-kV Switchyard	500	14	220	Single Steel Pole or H-Frame

Notes:

a) Distances are approximate. Actual length of transmission lines will be determined once route selection has been completed.

b) Distances are approximate. ROW will be determined once route selection has been completed.

c) Final structure type and design will be determined once the route selection has been completed

d) Although there are two 500-kV transmission lines that will need to connect the LNP to the proposed Citrus Substation, the values in this row represent one 500-kV transmission line.

ft = foot
kV = kilovolt
mi. = mile
ROW = right-of-way

Table 3.7-2
Maximum Calculated Audible Noise for Proposed LNP 500-kV Transmission Lines

ROW Configuration	L50 (dBA) [a]	Allowable Limit as Specified in 10 CFR 1910.95 (dBA) [b]
Typical Tangent Single Steel Monopole with delta configuration on 200-ft. ROW.	42	85
Typical Tangent Steel H-Frame with horizontal configuration on 220-ft. ROW.	43	85
Typical Tangent Single Steel Monopole with delta configuration. Four lines on 670- to 1000-ft. ROW.	46	85
Typical Tangent Steel H-Frame with horizontal configuration. Four lines on 670- to 1000-ft. ROW.	48	85
Typical Tangent Steel H-Frame with horizontal configuration on existing 1325-ft. ROW parallel to PEF existing 500-kV/230-kV lines.	48	85
Typical Tangent Single Steel Monopole with delta configuration on existing 1325-ft. ROW parallel to PEF existing 500-kV/230-kV lines.	48	85
Typical Tangent Steel H-Frame with horizontal configuration on 435-ft. ROW parallel to and including PEF existing 500-kV/230-kV 295-ft. ROW	49	85
Typical Tangent Single Steel Monopole with delta configuration on 405-ft. ROW parallel to and including PEF existing 500-kV/230-kV 295-ft. ROW.	49	85

Notes:

a) Maximum audible noise occurs during rain or other wet weather conditions. Noise levels will be lower during dry weather conditions. Calculated results have been rounded up to the nearest whole number.

b) This is an 8-hour Time Weighted Average mostly applicable to personal work zones. It is applied here for conservatism.

dBA = decibel (A-weighted scale)
kV = kilovolt
ROW = right-of way

Table 3.7-3 (Sheet 1 of 2)
Maximum Calculated EMF for Proposed LNP 500-kV Transmission Lines

ROW Configuration	Status	ROW Width (ft)	Electric Field (kV/m) Within ROW	Electric Field (kV/m) Left Edge [a] of ROW	Electric Field (kV/m) Right Edge [b] of ROW	Magnetic Field (mG) Left Edge [a] of ROW	Magnetic Field (mG) Right Edge [b] of ROW
Typical Tangent Single Steel Monopole with delta configuration on 200-ft. ROW.	New	200	8.3	0.91	1.13	63.29	57.98
Typical Tangent Steel H-Frame with horizontal configuration on 220-ft. ROW.	New	220	9.0	1.30	1.30	96.73	96.73
Typical Tangent Single Steel Monopole with delta configuration. Four lines on 670- to 1000-ft. ROW.	New	670 to 1000	8.3	0.84	0.98	92.47	98.73
Typical Tangent Steel H-Frame with horizontal configuration. Four lines on 670- to 1000-ft. ROW.	New	670 to 1000	9.0	1.36	1.36	122.68	122.60
Typical Tangent Steel H-Frame with horizontal configuration on existing 1325-ft. ROW parallel to PEF existing 500-kV/230-kV lines.	New	1325	9.0	0.04	0.15	19.87	48.11
Typical Tangent Single Steel Monopole with delta configuration on existing 1325-ft. ROW parallel to PEF existing 500-kV/230-kV lines.	New	1325	8.8	0.05	0.13	16.70	46.04
Typical Tangent Steel H-Frame with horizontal configuration on 435-ft. ROW parallel to, and including, PEF existing 500-kV/230-kV 295-ft. ROW. (New line on right side of ROW.)	Existing	295	8.9	3.71	0.42	351.22	109.69
	New	435	9.0	3.71	1.35	343.94	87.43
Typical Tangent Single Steel Monopole with delta configuration on 405-ft. ROW parallel to, and including, PEF existing 500-kV/230-kV 295-ft. ROW. (New line on right side of ROW.)	Existing	295	8.9	3.71	0.42	351.22	109.69
	New	405	8.9	3.68	0.94	346.37	49.83
Florida EMF Rule limit for new 500-kV transmission line.			10	2.00	2.00	200	200

Table 3.7-3 (Sheet 2 of 2)
Maximum Calculated EMF for Proposed LNP 500-kV Transmission Lines

Notes:

The magnetically controlled shunt reactor of the proposed 500-kV transmission line is 3000 amperes per phase.

Where calculations under this section indicate that operation of existing electrical facilities on an existing ROW produces electric or magnetic fields at levels higher than the limits specified for new facilities in Rule 62-814.450, F.A.C., a new electrical facility may be constructed and operated on that existing ROW provided that the new facility does not increase the electric or magnetic fields above the maximum field values created by the existing lines. (Rule 62-814.470[1][c], F.A.C.)

a) Left side of ROW looking toward the LNP.

b) Right side of ROW looking toward the LNP.

EMF = electromagnetic field
ft. = foot
kV = kilovolt
kV/m = kilovolts per meter
mG = milliGauss
ROW = right-of-way

3.8 TRANSPORTATION OF RADIOACTIVE MATERIALS

This section addresses issues associated with the transportation of radioactive materials from the LNP and alternative sites (CREC, Dixie, Highlands, and Putnam sites [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 NRC regulations in 10 CFR 51.52 state that:

> Every environmental report prepared for the construction permit 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 reactor. The table addresses two categories of environmental considerations: (1) normal conditions of transport and (2) accidents in transport.

To analyze the impacts of transporting AP1000 fuel to Table S-4, the fuel characteristics for the AP1000 were normalized to a reference reactor year (RRY). The reference reactor 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 LNP 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 will be used to evaluate transportation impacts relative to the reference reactor.

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 MW_t rating of the AP1000 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 was 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 reactor analyzed in WASH-1238 was 30 metric tons of uranium (MTU), while the average annual fuel loading for the AP1000 is approximately 24 MTU. When normalized to equivalent electric output, the annual fuel requirement 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 UO_2 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. 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. The AP1000 fuel exceeds the 4-percent U-235 condition. 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; this analysis is included 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. 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. Therefore, the AP1000 does not meet this subsequent evaluation condition. 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; this analysis is included 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 LNP 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. PEF will receive fuel via truck shipments for the AP1000 units being considered for the LNP 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 LNP and the alternative sites will comply with federal or 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. The DOE is responsible for spent fuel transportation from reactor sites to the repository and will make the decision on transport mode (10 CFR 961.1).

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.

PEF 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 would typically be 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 DAW.

DAW is 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. PEF will ship radioactive waste from the LNP and the alternative sites by truck.

Radioactive waste shipments are subject to a weight limitation of 73,000 pounds per truck. Radioactive waste from the AP1000 will be shipped in compliance with federal or 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 reactor 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 about 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, PEF assumed that for 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 reactor 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 reactor 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 LNP 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. PEF used these same generic assumptions in assessing transportation impacts for unirradiated fuel shipments to the LNP 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 about 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 LNP site near Inglis, Florida, four alternate sites were evaluated. These sites and starting locations are shown in Table 3.8-5. Summary data produced by TRAGIS are provided in Table 3.8-6 for unirradiated fuel.

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 LNP 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 PEF'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 LNP and alternative sites (900 km [560 mi.] to 1200 km [746 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 were normalized to the reference reactor analyzed in WASH-1238. The number of shipments per year were 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 LNP and alternative sites are within the conditions presented in Table S-4 (see Table 3.8-1).

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 exposures to low doses and dose rates, below approximately 1E+02 mSv (1E+04 mrem). 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. 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 may over-estimate those risks. A recent review by the National Academy of Sciences Committee to Assess Health Risks from Low Levels of Ionizing Radiation supports the linear no-threshold model.

Based on this model, the risk to the public from radiation exposure is estimated using the nominal probability coefficient for total detriment: 730 fatal cancers, nonfatal cancers, and severe hereditary effects per 1E+04 person-Sieverts (person-Sv) (1E+06 person-roentgen equivalent man [person-rem]) from International Commission on Radiation Protection Publication 60. 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 all 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 LNP 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 the shipments reach their destination without an accident occurring en route. 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 [LNP 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, these assumptions are conservative because the alternative

assumptions involve rail transportation or heavy-haul trucks, which will reduce the overall number of spent fuel 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 the 2000 U.S. Census. 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 LNP 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 LNP 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 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 LNP and the alternative sites.

- Thirty minutes was assumed as the average time at a truck stop in the calculations. 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

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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.

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[h]	.93	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, 1115 MWe
Reactor Power Level (MWt)	Not exceeding 3800 per reactor	3415
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 50.44	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	10 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)
Rail cars per month	Less than 3	Not analyzed

Table 3.8-4 (Sheet 2 of 2)
AP1000 Comparisons to Table S-4 Reference Conditions

Notes:

a) Table 3.8-2 provides the total numbers of truck shipments of fuel and waste for the AP1000. These values are then 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 LNP COLA

Site	Location	TRAGIS Origin Location
LNP [(a)]	Near Inglis, FL	CRYSTAL RIVER NP (FL)
CREC [(a)]	Near Crystal River, FL	CRYSTAL RIVER NP (FL)
Dixie Site	Proprietary	Proprietary
Highlands Site	Proprietary	Proprietary
Putnam Site	Proprietary	Proprietary

Notes:

a) For the purposes of this analysis, one bounding analysis was performed for the LNP and the CREC.

Table 3.8-6 (Sheet 1 of 2)
RADTRAN 5 Input Parameters for LNP 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	530 vehicles per hour	Reference 3.8-006
Suburban	760 vehicles per hour	Reference 3.8-006
Urban	2400 vehicles per hour	Reference 3.8-006
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 LNP Analysis of Unirradiated Fuel Shipments

Parameter	Parameter Value	Comments
Distances (km)/Population densities (persons per km^2)		
LNP		
Rural	728.5/14.5	Reference 3.8-002
Suburban	410.2/303.7	Reference 3.8-002
Urban	12.7/1991.4	Reference 3.8-002
Dixie		
Rural	761.8/13.9	Reference 3.8-002
Suburban	348.7/290.6	Reference 3.8-002
Urban	11.7/1986.6	Reference 3.8-002
Highlands		
Rural	817.1/13.6	Reference 3.8-002
Suburban	447.7/326.6	Reference 3.8-002
Urban	39.6/2259.3	Reference 3.8-002
Putnam		
Rural	614.5/14.6	Reference 3.8-002
Suburban	354.2/310.9	Reference 3.8-002
Urban	24.1/2167.5	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:

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 LNP and Alternative Sites by Truck (One AP1000 Unit)

Population Component	Dose (person-rem per shipment)			
	LNP/CREC	Dixie	Highlands	Putnam
Transport workers	6.26E-04	6.10E-04	7.09E-04	5.40E-04
General public (Onlookers – persons at stops and sharing the highway)	1.58E-03	1.55E-03	2.22E-03	1.53E-03
General public (Along Route – persons living near a highway)	5.47E-05	4.55E-05	6.41E-05	4.84E-05

Notes:

person-rem = person-roentgen equivalent man

Table 3.8-8
Radiological Impacts of Transporting Unirradiated Fuel to the LNP and Alternative Sites by Truck (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
AP1000-LNP/CREC	4.9	3.07E-03	7.74E-03	2.68E-04
AP1000-Dixie	4.9	2.99E-03	7.60E-03	2.23E-04
AP1000-Highlands	4.9	3.47E-03	1.09E-02	3.14E-04
AP1000-Putnam	4.9	2.65E-03	7.50E-03	2.37E-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 LNP 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 LNP and Alternative Sites to the Potential Yucca Mountain Disposal Facility

Reactor Site	One-Way Shipping Distance (km)				Population Densities (people/km^2)			Stop Time per Trip (hours)
	Total	Rural	Suburban	Urban	Rural	Suburban	Urban	
LNP/CREC	4469.3	3462.0	903.8	103.7	9.7	321.5	2272.1	5.0
Dixie Site	4362.7	3427.6	835.1	100.1	9.5	323.6	2268.9	5.0
Highlands Site	4786.8	3697.7	973.5	115.6	9.6	330.6	2243.8	5.0
Putnam Site	4466.5	3474.0	883.8	108.8	9.5	330.4	2259.5	5.0

Notes:

km = kilometer
km^2 = square kilometer

Table 3.8-10
RADTRAN 5 Input Parameters for LNP 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	530 vehicles per hour	Reference 3.8-006
Suburban	760 vehicles per hour	Reference 3.8-006
Urban	2400 vehicles per hour	Reference 3.8-006
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:

ft. = foot
m = meter
mrem = milliRoentgen equivalent man

Table 3.8-11
Radiological Impacts of Transporting Spent Fuel from the LNP and Alternative Sites by Truck to the Potential Yucca Mountain Disposal Facility (One AP1000 Unit)

Population Component	Dose (person-rem per shipment)			
	LNP/CREC	Dixie	Highlands	Putnam
Transport workers	2.04E-01	1.99E-01	2.18E-01	2.03E-01
General public (Onlookers – persons at stops and sharing the highway)	4.97E-01	4.56E-01	5.39E-01	5.32E-01
General public (Along Route – persons living near a highway)	8.50E-03	7.95E-03	9.37E-03	8.53E-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	Reactor Type: One AP1000 Unit
			Number of Spent Fuel Shipments per Year	
			60	39 [a]
			Environmental Effects (person-rem per RRY) [b]	
LNP/CREC	Crew	4	5.90E+00	7.96E+00
	Onlookers	3	2.10E+01	1.94E+01
	Along Route	3	6.00E-01	3.32E-01
Dixie	Crew	4	5.90E+00	7.76E+00
	Onlookers	3	2.10E+01	1.78E+01
	Along Route	3	6.00E-01	3.10E-01
Highlands	Crew	4	5.90E+00	8.50E+00
	Onlookers	3	2.10E+01	2.10E+01
	Along Route	3	6.00E-01	3.65E-01
Putnam	Crew	4	5.90E+00	7.92E+00
	Onlookers	3	2.10E+01	2.07E+01
	Along Route	3	6.00E-01	3.33E-01

Notes:

a) This value is normalized.

b) Table values for the LNP 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