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NUREG-2249

GENERIC ENVIRONMENTAL IMPACT STATEMENT FOR ADVANCED NUCLEAR REACTORS

Draft Report for Comment

Office of Nuclear Material Safety and Safeguards

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Office of Nuclear Material Safety and Safeguards

ABSTRACT

The U.S. Nuclear Regulatory Commission (NRC) staff prepared this draft advanced nuclear reactor generic environmental impact statement (ANR GEIS) in accordance with the National Environmental Policy Act of 1969 (NEPA), as amended, to analyze the environmental impacts of licensing the building, operating, and decommissioning of advanced nuclear reactors in the United States. In the ANR GEIS, the NRC staff uses the values and assumptions of a technology-neutral plant parameter envelope (PPE) to evaluate the environmental impacts of building, operating, and decommissioning an advanced nuclear reactor. In addition, the ANR GEIS assumes that a new advanced nuclear reactor that meets the requirements of the NRC's siting regulations might be built anywhere in the United States. To accommodate this broad range of siting possibilities, the staff developed a site parameter envelope (SPE) that provides limiting values and assumptions related to the site.

The purpose and need for the ANR GEIS is to present analyses of potential environmental impacts that are common to many or most advanced nuclear reactors that can be addressed generically, thereby eliminating the need to repeatedly reproduce the same analyses each time a licensing application is submitted and allowing applicants and NRC staff to focus future environmental review efforts on issues that can be resolved only once a site is identified. The generic impact findings in this ANR GEIS will be codified in Part 51 of Title 10 of the *Code of Federal Regulations*. In preparing the environmental report that is submitted along with its application, an applicant may rely upon the generic findings for a given issue, and provide no further project-specific analysis regarding that issue, if the applicant can demonstrate that its proposed project meets or is bounded by the issue's PPE and SPE values. Likewise, in preparing the project-specific supplemental environmental impact statement (SEIS), the NRC staff may rely upon the generic findings for a given issue if the staff determines that the applicant demonstrated that its proposed project meets or is bounded by the issue's PPE and SPE values. This approach is intended to help both applicants and the NRC staff focus on project-specific issues rather than revisiting issues that can appropriately be considered generically. By developing the ANR GEIS, the NRC staff expects to streamline the time and effort needed to complete environmental reviews under NEPA for most advanced nuclear reactors.

The ANR GEIS evaluates the potential environmental impacts of 121 issues relevant to building, operating, and decommissioning of an advanced nuclear reactor. It identifies 100 issues as Category 1 issues. Category 1 issues are those that the NRC staff has preliminarily determined that a generic conclusion regarding the potential environmental impacts of issuing a permit or license for an advanced nuclear reactor can be reached, provided that the project is bounded by relevant PPE and SPE values and assumptions. Additionally, Category 1 issues are those that the NRC staff has preliminarily determined will result in no more than a small adverse impact or significance level (in relation to a small, moderate, or large impact or significance level scale) or will have a beneficial impact. The ANR GEIS identifies 19 issues as Category 2 issues, which are those that the NRC staff has preliminarily determined cannot be resolved generically and for which both the applicant, in its environmental report, and the NRC staff, in its draft SEIS, must analyze in detail. Finally, as discussed in Section 1.4.3.3, there are two issues that are designated as N/A (i.e., impacts are Uncertain), which are neither Category 1 nor Category 2.

In general, an application for an advanced nuclear reactor can refer to the generic analysis in this GEIS for any Category 1 issue without further analysis if it demonstrates that it meets or is bounded by the relevant values and assumptions in the PPE and SPE and there is no new and

significant information to change the conclusions in the ANR GEIS. If the relevant parameters and assumptions for a Category 1 issue are not met, the applicant would have to provide the requisite information and analysis necessary for the NRC staff to perform a site-specific analysis. Applicants addressing Category 2 issues would have to provide all of the information typically needed to perform a site-specific analysis.

The NRC staff also addresses a no-action alternative where the staff would not issue the ANR GEIS and would continue to require both applicants and the NRC staff to analyze all issues, including those for which generic conclusions are available, in their respective environmental reports and in the environmental impact statements. The NRC staff concluded that this alternative was not environmentally preferable to the proposed action (development of the ANR GEIS).

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EXECUTIVE SUMMARY

In recent years, interest in developing and licensing advanced nuclear reactors (ANRs) in the United States using new technologies has increased. The increased interest is demonstrated by the recently enacted Nuclear Energy Innovation Capabilities Act of 2017 (Public Law 115-248) and Nuclear Energy Innovation and Modernization Act of 2019 (Public Law 115-439). On November 15, 2019, the U.S. Nuclear Regulatory Commission (NRC) staff issued a *Federal Register* notice (84 FR 62559) announcing an exploratory process and soliciting comments to determine the possible utility of developing a generic environmental impact statement (GEIS) for licensing ANRs.

In a GEIS, the NRC staff evaluates environmental impacts common to a group of related future licensing actions, thereby allowing the staff to focus on impacts requiring consideration of project-specific and site-specific factors once applications are received. As part of the exploratory process, the staff considered its experience with previous GEIS documents developed by NRC staff for power reactor license renewals, in situ uranium recovery facilities, and decommissioning. After considering the comments received from interested stakeholders and the public during the scoping process, the staff decided to develop the ANR GEIS. The NRC issued a notice of intent to prepare this GEIS on April 30, 2020 (85 FR 24040), carried out a scoping process, and held a scoping meeting to receive public comments on this GEIS on May 28, 2020.

This GEIS uses the definition of an ANR provided in the Nuclear Energy Innovation and Modernization Act of 2019. NEIMA states:

> The term advanced nuclear reactor means a nuclear fission or fusion reactor, including a prototype plant (as defined in Sections 50.2 and 52.1 of Title 10 of the *Code of Federal Regulations* [as in effect on the date of enactment of this Act]), with significant improvements compared to commercial nuclear reactors under construction as of the date of enactment of this Act, including improvements such as the following:
>
> (A) additional inherent safety features;
> (B) significantly lower levelized cost of electricity;
> (C) lower waste yields;
> (D) greater fuel utilization;
> (E) enhanced reliability;
> (F) increased proliferation resistance;
> (G) increased thermal efficiency; or
> (H) ability to integrate into electric and nonelectric applications.

ANRs are not defined on the basis of specific technologies, purposes, or sizes. Multiple technologies are under development that vary with respect to the fuel used, neutron moderators employed, cooling processes, and other factors. ANRs might serve various possible purposes, such as generating power for sale on a public electric grid, generating power for a specific facility or installation such as a military base, or generating power for a specific purpose such as desalinating water. Some ANRs may be small modular reactors, which are recognized by the U.S. Department of Energy as reactors generating between 20 and 300 MW of electricity (20–300 MWe). Some ANRs may be microreactors recognized by U.S. Department of Energy as generating less than 20 MWe. But other ANRs may be larger reactors generating more than 300 MWe.

S.1 Purpose and Need for this GEIS

The purpose and need for this GEIS is to present impact analyses for the environmental issues common to many or most ANRs that can be addressed generically, thereby eliminating the need to repeatedly reproduce the same analyses each time a licensing application is submitted and allowing applicants and NRC staff to focus future environmental review efforts on issues that can be resolved only once a site is identified. This GEIS is intended to improve the efficiency of licensing ANRs by (1) identifying the possible types of environmental impacts of building, operating, and decommissioning an ANR; (2) assessing impacts that are expected to be generic (the same or similar) for many or most ANRs; and (3) defining the environmental issues that will need to be addressed in project-specific supplemental EISs (SEISs) addressing specific projects.

S.2 Proposed Action

The proposed action is for the NRC staff to use a technology-neutral approach to issue a GEIS that identifies and analyzes environmental issues common to building, operating, and decommissioning an ANR for which a generic determination that impacts would not be environmentally significant is possible as long as it meets or is bounded by specific reasonable and practicable values and assumptions. Values and assumptions regarding the design of the plant are termed “plant parameter envelope” (PPE) and values and assumptions regarding site conditions are termed “site parameter envelope” (SPE). The results of this GEIS will be codified in Title 10 of the *Code of Federal Regulations* Part 51 (10 CFR Part 51).

To develop this GEIS, the NRC established an interdisciplinary team of environmental subject matter experts (SMEs) from the NRC and from contractor, Pacific Northwest National Laboratory and AJK NEPATech, LLC—all of whom have extensive experience in evaluating the environmental impacts of new reactors. The SMEs included individuals who have expertise in nuclear technology, radiation protection, land use, aquatic and terrestrial ecology, hydrology and water use, socioeconomics, environmental justice, meteorology and air quality, and human health. In this GEIS, the interdisciplinary team is collectively referred to as the NRC staff.

Because ANRs are not specific to one reactor design and could be sited anywhere in the United States that meets NRC siting requirements, the NRC pursued a technology-neutral approach using assumptions contained in the PPE and SPE (Appendix G). The PPE consists of bounding values or parameters for reactor design features regardless of the site. In addition, the staff developed an SPE table of site conditions and assumptions. The table includes the site size, size of water bodies supplying water to the reactor, and demographics of the region surrounding the site. The table also includes specific assumptions related to the condition of the affected environment, such as the extent and occurrence of wetlands and floodplains, site position relative to aquatic features, and site proximity to sensitive noise receptors. This GEIS presents generic analyses that evaluate the possible impacts of a reactor that fits within the bounds of the PPE on a site that fits within the bounds of the SPE for those issues for which a generic conclusion was possible (referred to as Category 1 issues).

The environmental issues are organized into 16 environmental resources. Each issue corresponds to a specific type of environmental impact determined by the interdisciplinary team of SMEs to potentially result from building, operating, or decommissioning an ANR. This GEIS will allow licensing applications for ANRs to reference the generic analysis for each Category 1 environmental issue for which it can demonstrate that the project is bounded by the applicable assumptions in the PPE and SPE and for which there is no new and significant information affecting the evaluation. The NRC staff would have to prepare a SEIS or other supplemental National Environmental Policy Act of 1969, as amended (NEPA) documentation for the licensing of an ANR. The SEIS would briefly describe how the project meets the PPE and SPE values and assumptions for the appropriate Category 1 issues. The SEIS would also evaluate the environmental impacts of any issues for which an application cannot demonstrate that the relevant assumptions in the PPE and SPE are met, as well as issues that the staff could not address generically in this GEIS.

S.3 Impact Significance Levels and Categorization of Issues

For each issue, the SMEs identified each value or assumption in the PPE and SPE that could effectively bound a meaningful generic analysis. The SMEs performed and described generic analyses for each issue for a hypothetical reactor that falls within the bounding values of the PPE on a site that falls within the bounding values of the SPE. The SMEs drew conclusions about each analysis using one of the three significance levels that the NRC staff typically uses in EISs for new reactors:

- SMALL – Environmental effects that are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission’s regulations are considered SMALL.
- MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
- LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

These significance levels follow the definitions presented in the footnotes to Table B–1 in Appendix B to Subpart A of 10 CFR Part 51.

The SMEs assigned each issue to one of three categories depending on the potential utility of the generic analysis to applicants preparing specific ANR licensing applications and to the NRC staff when completing environmental reviews of those applications. The categories are as follows:

- Category 1 issues – Environmental issues for which the NRC has been able to make a generic finding of SMALL adverse environmental impacts, or beneficial impacts, provided that the applicant’s proposed reactor facility and site meet or are bounded by the relevant values and assumptions in the PPE and SPE that support the generic finding for that Category 1 issue.[1]
- Category 2 issues – Environmental issues for which a generic finding regarding the environmental impacts cannot be reached because the issue requires the consideration of project-specific information that can only be evaluated once the proposed site is identified.

[1] Beneficial impacts may include increased tax revenues associated with the increased assessed value of new reactor projects, and other economic activity such as increases in local employment, labor income, and economic output.

The impact significance (i.e., SMALL, MODERATE, or LARGE) for these issues will be determined in a project-specific evaluation.

- Not Applicable (N/A). Environmental issues for which the state of the science is currently inadequate, and no generic conclusion on human health impacts is possible.

An applicant addressing a Category 1 issue in its Environmental Report (ER) that accompanies an application may refer to the generic analysis in this GEIS for that issue without further analysis, provided that it demonstrates that the relevant assumptions in the PPE and SPE are met and that there is no new and significant information that changes the issue's generic analysis or finding, as determined by the NRC. If the relevant parameters and assumptions for a Category 1 issue are not met, the applicant would have to supply the requisite information necessary for the staff to perform a site-specific analysis. All applicants would have to individually address each Category 2 issue without reference to this GEIS.

This GEIS also identifies other elements of environmental documentation that must be addressed individually, including sections addressing the purpose and need, need for power (or project), and alternatives to the proposed action.

S.4 Alternatives

In addition to the proposed action of preparing a GEIS for ANRs, the NRC staff analyzed a no-action alternative in which the NRC does not issue this GEIS. Without the availability of this GEIS, applicants for ANR licensing actions would have to address all relevant environmental issues individually in their ERs and staff would have to prepare individual EISs for each application received that address all relevant environmental issues (including all Category 1 and Category 2 issues). The processes for an applicant to prepare an ER and for the NRC staff to prepare an EIS would remain the same as those used in the past for new reactor licensing applications. Conclusions in this GEIS regarding potential environmental impacts could not be referenced. However, the No-Action Alternative would accomplish none of the benefits intended by the preparation of this GEIS, which include (1) reducing the time and resources for the applicant's preparation of the Environmental Report, (2) reducing the time and resources for the NRC staff's preparation of the EIS, and (3) focusing the resources of the applicant, NRC staff, and decision-makers on issues where there is truly a potential for significant environmental impacts. The NRC staff therefore concludes that the No-Action Alternative is not preferable to the proposed action.

Prior to scoping, the NRC staff contemplated preparing a GEIS that would analyze the potential environmental impacts of a hypothetical reactor that would have a power level of approximately 30 MWt or less on a hypothetical site. The analytical approach to developing this GEIS would have been similar to that used under the proposed action, but the PPE/SPE would have been developed based on a typical reactor of 30 MWt, limiting the range of reactors for which this GEIS would have been useful. Use of the power-level–based GEIS by applicants for small reactors and NRC staff would have been the same as for the environmental performance-based GEIS called for in the proposed action. Multiple commenters suggested that the parameters used in the generic analyses should be tied to the potential for environmental impacts rather than to an arbitrary power level. After reviewing the comments, the staff agreed that a GEIS developed using technology-neutral performance-based values and assumptions tied to environmental impacts might help streamline environmental reviews even for some larger ANRs that have a low potential for significant environmental impacts with respect to some environmental issues. Because of the limited utility of a GEIS based on a limited power level, the staff decided not to evaluate this alternative approach in detail.

The staff also considered whether it would be possible to develop a GEIS that could serve as the sole technical documentation of potential environmental impacts for any ANR. However, the staff concluded that it is not technically possible to develop generic analyses addressing all potentially significant environmental impacts from any ANR without consideration of project-specific conditions. It is also unrealistic to assume that a GEIS would be able to fully comply with the requirements of other environmental laws, such as the Endangered Species Act (16 U.S.C. §§ 1531 *et seq*.) or the National Historic Preservation Act (54 U.S.C. §§ 300101 *et seq*.). Therefore, the staff decided not to evaluate this alternative approach in detail.

S.5 Affected Environment and Environmental Consequences

The baseline condition described as the "affected environment" in this GEIS is the environment that exists at a site proposed for building and operating an ANR. The site could be anywhere in the United States that meets the NRC reactor siting criteria in 10 CFR Part 100. The affected environment reflects the existing condition of environmental resources as influenced by natural physical conditions and by past human activities such as agriculture, forestry, mining, urbanization, and industrial and non-industrial development. The range of existing environmental conditions that might possibly occur at a proposed site located anywhere in the United States is too broad to characterize. To address this, the NRC staff developed the PPE, SPE, and related assumptions presented in Appendix G. The PPE and SPE contain assumptions regarding the absence of, or limited presence of, sensitive environmental resources such as sensitive habitats, wetlands, floodplains, and residences on or near the site. The PPE and SPE also contain assumptions regarding the size and condition of resources near the site, including water sources and air.

The NRC staff evaluated the potential environmental impacts from 121 issues in 16 environmental resource categories in this GEIS. Of these, the staff identified 100 issues as Category 1 issues and 19 issues as Category 2 issues (Table 4-1). In addition, as discussed in Section 1.4.3.3, there are two issues that are designated as N/A (i.e., impacts are Uncertain), which are neither Category 1 nor Category 2. The NRC staff determined that the potential environmental impacts for each Category 1 issue would be of SMALL significance, as long as the applicable assumptions in the PPE and SPE are met. The basis for identifying an issue as a Category 1 issue is whether a generic analysis of the issue is sufficient for decision-makers and the public when licensing an ANR that meets the assumptions bound by the PPE and SPE.

The NRC staff determined that it is not possible to evaluate the significance of environmental impacts from the Category 2 issues without application-specific evaluation after receiving a licensing application that identifies specific design parameters and site conditions that depart from the PPE and the SPE. The staff identified certain issues as Category 2 issues because they require project-specific consultation with outside agencies to comply with statutes other than NEPA. Examples include issues related to threatened or endangered species regulated under the Endangered Species Act, essential fish habitat regulated under the Magnuson-Stevens Fishery Conservation and Management Act, and historic properties regulated under the National Historic Preservation Act. The staff is unable to evaluate the significance of impacts on those resources without receiving technical input from the consultations. The staff identified certain other issues as Category 2 issues because it was not possible to set realistic assumptions that could underlie a conclusion that the impacts would necessarily be SMALL at any hypothetical site in the United States. However, the fact that an individualized analysis is necessary does not mean that the supplemental NEPA documentation will enable the NRC staff to conclude that impacts pertaining to the issue will be greater than SMALL; it only means that more than a generic analysis is necessary to reach a conclusion. Although it would theoretically be possible to constrain the assumptions to the extent that impacts on almost any environmental impact would be SMALL, the staff intends for this GEIS to be a practicable, usable document for most ANR projects.

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ABBREVIATIONS AND ACRONYMS

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
^{235}U	uranium-235
ac	acre(s)
ABC	American Bird Conservancy
ACHP	Advisory Council on Historic Preservation
ADAMS	Agencywide Documents Access and Management System
ADU	ammonium diuranate
ALARA	as low as is reasonably achievable
AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AEGL	Acute Exposure Guideline Level
ALI	Annual Limit on Intake
ANA	aquatic natural area
ANR	advanced nuclear reactor
APE	area of potential effect
APLIC	Avian Power Line Interaction Committee
ARE	Aircraft Reactor Experiment
ARIS	Advanced Reactors Information System
ASLB	Atomic Safety and Licensing Board
BLM	Bureau of Land Management
BMP	best management practice
Bq	becquerel(s)
BTSP	Bulk Tritium Shipping Package
BWR	boiling water reactor
BWXT	BWX Technologies, Inc.
CAA	Clean Air Act
CANDU	Canada Deuterium Uranium
CDF	core damage frequency
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
CH_4	methane
Ci	curie(s)

CISF	Consolidated Interim Storage Facility
CMP	coastal management program
CO	carbon monoxide
CO_2	carbon dioxide
CO_2(e)	CO_2 equivalent
CoC	Certificate of Compliance
COL	combined construction permit and operating license or combined license
COLEX	column exchange
CP	construction permit
CWA	Clean Water Act (aka Federal Water Pollution Control Act)
CZM	coastal zone management
CZMA	Coastal Zone Management Act
d	day(s)
DAC	Derived Air Concentration
dB	decibel(s)
dBA	decibel(s) on the A-weighted scale
DBA	design basis accident
DCP	dry conversion process
D-D	deuterium-deuterium
DEIS	draft environmental impact statement
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
D-T	deuterium-tritium
DTS	dry transfer system
EA	environmental assessment
EBR-II	Experimental Breeder Reactor-II
EHS	extremely hazardous substance
EIS	environmental impact statement
EJ	environmental justice
EMF	electromagnetic field
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPRI	Electric Power Research Institute
ER	Environmental Report
ESA	Endangered Species Act of 1973, as amended
ESP	early site permit
ESRP	Environmental Standard Review Plan (NUREG–1555)
FAA	Federal Aviation Administration

FAST	Fixing America's Surface Transportation Act
FE	finite element
FEIS	final environmental impact statement
FPPA	Farmland Protection Policy Act
FR	*Federal Register*
FRN	*Federal Register* Notice
FSAR	Final Safety Analysis Report
FSER	Final Safety Evaluation Report
ft	foot or feet
ft^2	square foot or feet
ft^3	cubic foot or feet
FWS	U.S. Fish and Wildlife Service
g	gram(s)
gal	gallon(s)
GEIS	generic environmental impact statement
GHG	greenhouse gas
gpd	gallon(s) per day
gpm	gallon(s) per minute
GTCC	greater than Class C
GWd	gigawatt day(s)
Gy	gray(s)
ha	hectare(s)
HALEU	high-assay low- enriched uranium
HAP	hazardous air pollutant
HEDP	hydroxyethylidine diphosphonic acid
HEU	highly enriched uranium
HFC	hydrofluorocarbon
HGM	hydrogeomorphic
HLRW	high-level radioactive waste
HLW	high-level waste
H_2O	water vapor
hr	hour(s)
Hz	hertz
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
in.	inch(es)
INL	Idaho National Laboratory
IPCC	Intergovernmental Panel on Climate Change

IPPP	Integrated Pollution Prevention Plan
ISFSI	independent spent fuel storage installation
ISG	Interim Staff Guidance
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km^2	square kilometer(s)
kV	kilovolt(s)
kWh	kilowatt-hour(s)
L	liter(s)
lb	pound(s)
LEPC	Local Emergency Planning Committee
LEU	low-enriched uranium
LLC	Limited Liability Company
LLRW	low-level radioactive waste
LOS	level of service
LWR	light-water reactor
m	meter(s)
m^3	cubic meter(s)
MEI	maximally exposed individual
mGy	milligray(s)
mi	mile(s)
mi^2	square mile(s)
MIMS	Manifest Information Management System
MIT	Massachusetts Institute of Technology
MITR	MIT reactor
M	million
MMPA	Marine Mammal Protection Act
MMT	million metric tons
mo	month(s)
MOA	Memorandum of Agreement
mrad	millirad(s)
mrem	millirem(s)
mSv	millisievert(s)
MSR	molten-salt reactor
MSRE	Molten-Salt Reactor Experiment
MT	metric ton(nes)
MTU	metric ton(nes) uranium

MW	megawatt(s)
MWe	megawatt(s) electrical
MWt	megawatt(s) thermal
MWd	megawatt-day(s)
MWd/MTU	megawatt-day(s) per metric ton of uranium
MWh	megawatt-hour(s)
N_2O	nitrous oxide
N/A	not applicable
NAAQS	National Ambient Air Quality Standard
NAC	NAC International Inc.
NAC-LWT	NAC International Inc. - Legal Weight Truck
NAGPRA	Native American Graves Protection and Repatriation Act
NAVD	North American Vertical Datum (sea level reference point used in surveying)
NaOCl	sodium hypochlorite
NaOH	sodium hydroxide
NAVD88	North American Vertical Datum of 1988
NCRP	National Council on Radiation Protection and Measurements
NEI	Nuclear Electric Institute
NEIMA	Nuclear Energy Innovation and Modernization Act of 2019
NEPA	National Environmental Policy Act of 1969, as amended
NFS	Nuclear Fuel Services
NHPA	National Historic Preservation Act
NIOSH	National Institute for Occupational Safety and Health
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulations
NRC	U.S. Nuclear Regulatory Commission
NRCS	Natural Resource Conservation Service
NRHP	National Register of Historic Places
NRIC	National Reactor Innovation Center
NUREG	U.S. Nuclear Regulatory Commission technical document
NWP	Nation Wide Permit
O_3	ozone
OSHA	Occupational Safety and Health Administration
PA	Programmatic Agreement

PAC	Protective Action Criteria for Chemicals
Pb	lead
PER	pyrochemical/electrochemical reprocessing
PFC	perfluorocarbons
PFSF	Private Fuel Storage Facility
PILT	payments in lieu of taxes
PM	particulate matter
PM_{10}	particulate matter with a mean aerodynamic diameter of 10 μm or less
$PM_{2.5}$	particulate matter with a mean aerodynamic diameter of 2.5 μm or less
PNNL	Pacific Northwest National Laboratory
PPE	plant parameter envelope
ppt	part(s) per thousand
PRA	probabilistic risk assessment
PSAR	Preliminary Safety Analysis Report
PSDAR	post-shutdown decommissioning activity report
PSEG	Public Service Enterprise Group
PSWS	potable and sanitary water system
PUREX	plutonium uranium extraction
PWR	pressurized water reactor
RAMPAC	Radioactive Material Packaging (DOE website)
RCRA	Resource Conservation and Recovery Act of 1976, as amended
REMP	Radiological Environmental Monitoring Program
RG	Regulatory Guide
RMP	Risk Management Plan
ROW	right-of-way
RRY	reference reactor-year
RV	recreational vehicle
Ryr	reactor-year(s)
s or sec	second(s)
SAAQS	State Ambient Air Quality Standards
SAFSTOR	SAFe STORage
SAMA	severe accident mitigation alternative
SAMDA	severe accident mitigation design alternative
scf	standard cubic feet
SDWA	Safe Drinking Water Act
SEIS	supplemental environmental impact statement
SF_6	sulfur hexafluoride
SFR	sodium fast reactor
SHPO	State Historic Preservation Office

SIP	state implementation plan
SME	subject matter expert
SMR	small modular reactor
SNF	spent nuclear fuel
SNM	special nuclear material
SO_2	sulfur dioxide
SO_x	oxides of sulfur
SPE	site parameter envelope
SRM	Staff Requirements Memorandum
SRP	standard review plan
SSA	Sole Source Aquifer
SSC	structure, system, or component
Sv	sievert
SWU	separative work unit
T	ton(s)
TCP	traditional cultural properties
TDS	total dissolved solids
TEDE	total effective dose equivalent
TEEL	Temporary Emergency Exposure Limit
Th-232	thorium-232
THPO	Tribal Historic Preservation Office
TN	Transnuclear (also tracking number)
TPQ	Threshold Planning Quantity
TQ	threshold quantity
TRAGIS	Transportation Routing Analysis Geographic Information System
TRISO	TRi-structural ISOtropic
TRU	transuranic
TSCA	Toxic Substances Control Act
U_3O_8	triuranium octaoxide (also called yellow cake)
U-235	uranium-235
U-238	uranium-238
UF_6	uranium hexafluoride
U.S.	United States
UO_2	uranium dioxide
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
U.S.C.	United States Code
USDA	U.S. Department of Agriculture

VOC	volatile organic compound
WCS	Waste Control Specialists, LLC
WIPP	Waste Isolation Pilot Plant
WNA	World Nuclear Association
Y-12	Y-12 National Security Complex
yd^3	cubic yard(s)
yr	year(s)
ZIRCEX	zirconium extraction (process)

1.0 INTRODUCTION

In recent years, interest in developing and licensing advanced nuclear reactors (ANRs) in the United States using new technologies has increased. The increased interest is demonstrated by the recently enacted Nuclear Energy Innovation Capabilities Act of 2017 (Public Law 115-248; TN6468) and Nuclear Energy Innovation and Modernization Act of 2019 (NEIMA, Public Law 115-439; TN6469). One purpose of NEIMA is to provide a program for developing "the expertise and regulatory processes necessary to allow innovation and commercialization of advanced nuclear reactors." A strategic nonprofit organization dedicated to advancing nuclear development in the United States, ClearPath, sent a letter dated February 19, 2019, to the U.S. Nuclear Regulatory Commission (NRC) recommending that it develop a generic environmental impact statement (GEIS) for construction and operation of ANRs (ClearPath 2019-TN6466). Multiple representatives of Congress also expressed interest in having the NRC develop such a GEIS. On June 25, 2019, Senators Barrasso and Braun sent a letter to the Chairman of the NRC requesting that the NRC initiate a process to develop a GEIS for ANRs (Barrasso and Braun 2019-TN6465). The Chairman responded on July 29, 2019 (NRC 2019-TN6467) that the NRC would explore whether development of a GEIS would beneficially streamline environmental reviews for ANRs while still fulfilling NRC's responsibilities to protect the environment and comply with the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. §§ 4321 *et seq*.; TN661).

On November 15, 2019, the NRC staff issued a *Federal Register* notice (84 FR 62559-TN6470) announcing an exploratory process and soliciting comments to determine the possible utility of developing a GEIS for licensing ANRs. The exploratory process included two public meetings, a comprehensive public workshop attended by multiple stakeholders, and a site visit to the Idaho National Laboratory, which is one location that is being contemplated for a future ANR site. As part of the exploratory process, the staff considered its experience with previous NRC GEIS documents that support power reactor license renewals, in situ uranium recovery facilities, and decommissioning. The staff gathered information to determine whether a GEIS for building, operating, and decommissioning ANRs might be viable. The exploratory process concluded with an information paper to the Commission concluding that the staff decided to pursue a GEIS using a technology-neutral approach, and that a GEIS would generically resolve many environmental issues, save resources, and provide predictability for potential applicants.

After considering the comments received from various sources during the scoping process, the staff has developed this ANR GEIS. This GEIS was developed using a technology-neutral, performance-based approach to allow its use by a wide range of future applicants. In Staff Requirements Memorandum 20-0020, dated September 21, 2020, (NRC 2020-TN6492), the Commission approved the development of a GEIS for the construction and operation of ANRs using a technology-neutral, performance-based approach, and directed staff to codify results in the *Code of Federal Regulations*. Details of this approach are discussed in Section 1.4.

1.1 Definition of Advanced Nuclear Reactor

This GEIS uses the definition of an ANR provided in NEIMA. NEIMA states:

> The term advanced nuclear reactor means a nuclear fission or fusion reactor, including a prototype plant (as defined in Sections 50.2 (TN249) and 52.1 (TN251) of Title 10 of the *Code of Federal Regulations* [as in effect on the date of enactment of this Act]), with significant improvements compared to commercial

nuclear reactors under construction as of the date of enactment of this Act, including improvements such as the following:

(A) additional inherent safety features;
(B) significantly lower levelized cost of electricity;
(C) lower waste yields;
(D) greater fuel utilization;
(E) enhanced reliability;
(F) increased proliferation resistance;
(G) increased thermal efficiency; or
(H) ability to integrate into electric and nonelectric applications.

ANRs are not defined on the basis of specific technologies, purposes, or sizes. Multiple technologies under development vary with respect to fuel used, neutron moderators employed, cooling processes, and other factors. ANRs might serve various possible purposes, such as generating power for (1) sale on a public electric grid, (2) a specific facility or installation such as a military base, or (3) a specific purpose, such as desalinating water. Some ANRs may be small modular reactors (SMRs), which are recognized by the U.S. Department of Energy (DOE) as reactors generating between 20 and 300 MW of electricity (20–300 MWe). Some ANRs may be microreactors recognized by DOE as generating less than 20 MWe. But other ANRs may be larger reactors generating more than 300 MWe. This GEIS is intended to assist in the environmental review for any proposed ANR meeting the NEIMA definition noted above and the values and assumptions outlined in the generic analyses presented herein.

1.2 Purpose and Need for this GEIS

The purpose and need for this GEIS is to present impact analyses for the environmental issues common to many or most ANRs that can be addressed generically, thereby eliminating the need to repeatedly reproduce the same analyses each time a licensing application is submitted and allowing applicants and NRC staff to focus future environmental review efforts on issues that can be resolved only once a site is identified. This GEIS is intended to improve the efficiency of licensing ANRs by (1) identifying the types of potential environmental impacts[2] of building, operating, and decommissioning an ANR, (2) assessing impacts that are expected to be generic (the same or similar) for many or most ANRs, and (3) defining the environmental issues that will need to be addressed in project-specific supplemental EISs (SEISs) addressing specific projects.

1.3 NEPA Process

After completing the exploratory process, the NRC established an interdisciplinary team of environmental subject matter experts (SMEs) to develop this GEIS. The team comprised experts from the NRC staff and from contractors, including Pacific Northwest National Laboratory, possessing extensive experience in evaluating the environmental impacts of new reactors. The SMEs included individuals who have expertise in nuclear technology, radiation protection, land use, aquatic and terrestrial ecology, hydrology and water use, socioeconomics, environmental justice, meteorology and air quality, and human health. A complete list of SMEs, their credentials, and their roles in preparing this GEIS is provided in Appendix A of this GEIS.

[2] The ANR GEIS documents the potential impacts of building, operating, and decommissioning ANRs and henceforth when discussing impacts, they are potential impacts.

On April 30, 2020, the NRC issued a *Federal Register* notice informing the public of its intent to develop an ANR GEIS and to conduct a scoping process to gather the information necessary to prepare an ANR GEIS for small-scale ANRs (85 FR 24040-TN6458). The NRC held a webinar on May 28, 2020, to receive comments from the public on the scope of this GEIS (NRC 2020-TN6459).

The *Federal Register* notice stated that the NRC intended to develop a GEIS for ANRs that have a small generating output and correspondingly small environmental footprint in order to streamline the environmental review process for future small-scale ANR environmental reviews (85 FR 24040-TN6458). At the time of scoping, the NRC staff considered a "small-scale" ANR to be one that has the potential to generate up to approximately 30 MWt per unit and has a correspondingly small environmental footprint. The staff indicated that the actual bounding thermal power level and environmental footprint used in this GEIS were topics to be determined during the scoping process.

The NRC received a number of comments about the scope of this GEIS during the May 28, 2020 webinar and throughout the scoping comment period. A summary of the scoping comments was issued on September 25, 2020 (NRC 2020-TN6593). A number of commenters questioned the utility of a GEIS for ANRs, given that the NRC did not know the type of reactor or the site where the reactor would be located. Others agreed with the technology-neutral approach but recommended a performance-based approach without limiting this GEIS to small-scale reactors. Based on the comments received during scoping, the NRC decided to use a technology-neutral, performance-based approach with specified values and assumptions. "Performance" reflects the ability of an applicant to design an ANR that minimizes environmental impacts while still meeting the reactor's objectives. The approach outlined above constitutes a technology-neutral, performance-based approach whereby the efficiencies gained through use of this GEIS increase as the potential for environmental impacts decreases.

1.4 Analytical Approach Used in this GEIS

1.4.1 Methodology

This section discusses the methodology the NRC staff used to develop this GEIS. This GEIS evaluates the impacts of building, operating, and decommissioning an ANR sited within the United States that is bounded by the values and assumptions in Appendix G and the analyses in this GEIS. In addition, this GEIS considered fuel cycle impacts and the impacts from continued storage of spent fuel after operations. The term "building," as used in this GEIS, includes the full range of preconstruction (building activities not within the NRC's regulatory authority), and construction and installation activities (building activities within the NRC's regulatory authority). The term "construction worker" includes any worker engaged in building activities and the term "construction equipment" includes any equipment used for building activities. For the ANR GEIS, the NRC staff assumed that the U.S. Army Corps of Engineers would be a cooperating agency for all advanced nuclear reactor applications, in accordance with the Memorandum of Understanding (MOU) between the two agencies dated September 19, 2008 (USACE and NRC 2008-TN637). In this regard, the U.S. Army Corps of Engineers has been a cooperating agency on new reactor reviews since the MOU was signed in 2008. Because the USACE is assumed to be a cooperating agency on SEISs that would rely on this GEIS, preconstruction activities are addressed in Chapter 3 along with the impacts of NRC-authorized construction.

Because ANRs are not specific to only one reactor design and could be sited anywhere in the United States that meets NRC siting requirements as set forth in Title 10 of the *Code of Federal Regulations* Part 100 (10 CFR Part 100; TN282), the NRC decided to pursue a technology-neutral, performance-based approach using a plant parameter envelope (PPE). The PPE consists of parameters for specific reactor design features regardless of the site. Examples of parameters include the footprint of disturbance, building height, water use, air emissions, employment levels, and noise generation levels. For each PPE parameter, the staff developed a set of bounding values and assumptions.

In addition, the staff developed a set of site-related parameters termed the "site parameter envelope" (SPE). Examples of parameters include site size, size of water bodies supplying water to the reactor, and demographics of the region surrounding the site. For each SPE parameter, the staff developed a set of bounding values and assumptions related to the condition of the affected environment, such as the extent and occurrence of wetlands and floodplains, position near aquatic features, and proximity to sensitive noise receptors. This GEIS presents generic analyses that evaluate the possible impacts of a reactor that fits within the bounds of the PPE on a site that fits within the bounds of the SPE.

The PPE and SPE are presented in Appendix G. The PPE and SPE values and assumptions were developed by the interdisciplinary team of SMEs assigned to prepare this GEIS. The SMEs developed the values and assumptions based on one or more of the following:

- regulatory limits and permitting requirements relevant to the resource as established by Federal, State, or local agencies;
- relevant information obtained from other NRC GEISs, including the License Renewal GEIS (NRC 2013-TN2654) and the Continued Storage GEIS (NRC 2014-TN4117);
- empirical knowledge gained from conducting evaluations and analyses for past new reactor EISs;
- values and assumptions derived from other documents applying a PPE/SPE approach (such as the National Reactor Innovation Center [NRIC] PPE Report; NRIC 2021-TN6940); and
- subject matter expertise and/or development of calculations and formulas based upon education and experience with the resource.

The SMEs strove to ensure that the PPE and SPE were set broadly enough to make this GEIS a useful licensing tool, while still ensuring that enough project-specific analyses would be completed upon receipt of an application to document significant environmental impacts for the public and decision-makers.

The NRC staff presented preliminary tables outlining the PPE and SPE at the March 28, 2020 scoping meeting. The PPE and SPE presented in Appendix G reflect the staff's consideration of comments received during the scoping process and subsequent research conducted by the SMEs to prepare the draft GEIS.

The SMEs started their analysis by identifying specific types of impacts relevant to each of 16 environmental resource areas. Each type of impact is termed an "issue." Each issue corresponds to a specific type of environmental impact determined by the interdisciplinary team of SMEs that could potentially result from building, operating, or decommissioning an ANR. The SMEs identified 121 specific issues. For each issue, the SMEs then determined whether it would be possible to identify values and assumptions in the PPE and SPE that could effectively bound a meaningful generic analysis and provided the basis for each value and assumption. The SMEs then performed and described their generic analyses for each issue for a hypothetical reactor/site that meets the PPE and SPE values and assumptions. For this GEIS, the values and assumptions were set such that the SMEs could reach a generic conclusion of SMALL adverse impacts, which are designated as Category 1 issues (i.e., issues for which a generic analysis was possible). Issues for which the impacts are beneficial are also designated as Category 1.

After considering potential values and assumptions for the PPE and SPE for some environmental impact issues, the staff could not reach a generic conclusion. In some cases, this was due to requirements of other statutes, such as the National Historic Preservation Act (54 U.S.C. §§ 300101 *et seq*.; TN4157) and the Endangered Species Act (ESA; 16 U.S.C. §§ 1531 *et seq.*; TN1010). In other cases, the wide range of potential reactor designs and potential site locations made it impossible for the staff to reach a generic conclusion. These issues are designated as Category 2 issues, which require site- or project-specific analysis in an NRC EIS.

The SMEs drew conclusions about each analysis using one of the three significance levels that the NRC staff typically uses in EISs for new reactors, including the following:

- SMALL –The environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small as the term is used in this definition.
- MODERATE – The environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
- LARGE – The environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

These significance levels follow the definitions presented in the footnotes in Table B–1 in Appendix B of Subpart A of 10 CFR Part 51 (TN250). These are the same environmental significance levels and definitions used in the License Renewal GEIS (NRC 2013-TN2654) and in recent EISs prepared by the NRC staff for combined licenses and early site permits for new light-water reactors (LWRs). The discussion of each Category 1 environmental impact issue in this GEIS includes an explanation of how the significance category of SMALL was determined. For issues for which the probability of occurrence is a key consideration (i.e., postulated accidents), the probability of occurrence has been factored into the determination of significance. Possible mitigation measures that could be used to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse impacts are discussed where appropriate.

The SMEs assigned each issue to one of the two categories depending on the potential utility of the generic analysis to applicants preparing specific ANR licensing applications and to the NRC staff when completing environmental reviews of those applications. In summary, the categories are as follows:

- Category 1 issues – environmental issues for which a generic analysis concluding SMALL adverse environmental impacts is possible, provided that relevant values and assumptions in the PPE and SPE are met, or beneficial impacts;

- Category 2 issues – environmental issues for which a meaningful generic analysis of environmental impacts is not possible because the issue requires consideration of project-specific information.

In addition, as discussed in Section 1.4.3.3, there are two issues that are designated as N/A (i.e., impacts are Uncertain), which are neither Category 1 nor 2.

Category 1 issues include one or more PPE/SPE parameters with associated values and assumptions; these values and assumptions are set to define a SMALL impact. This GEIS provides generic analyses for these Category 1 environmental issues, organized under the 16 environmental resources described in Chapter 3 of this GEIS.

An applicant addressing a Category 1 issue in its Environmental Report (ER) may refer to the generic analysis in this GEIS for that issue without further analysis, provided that it demonstrates that the relevant values and assumptions of the PPE and SPE used in the resource analysis are met and there is no new and significant information that would require project-specific analysis.[3] The applicant will have to document how the values and assumptions are met, unless this is made clear in other information provided in the application package. The extent of the information necessary to demonstrate that a value or assumption is met will vary. In some cases, the demonstration may only require showing that the project falls within a parameter value or assumption (e.g., building height). But in other cases, analysis may be required to demonstrate that a value or assumption has been met (e.g., noise levels).

If the relevant values and assumptions for a Category 1 issue are not met, the applicant would have to supply the requisite information necessary for the staff to perform a project-specific analysis. One place for guidance for applicants providing information to the staff in an ER is available in the latest version of Regulatory Guide (RG) 4.2[4] (NRC 2022-TN7081). The applicant may, however, be able to incorporate by reference all or part of the generic analysis provided in this GEIS and focus on providing the additional project-specific information needed. Applicants addressing Category 2 issues in an ER would have to provide all the information typically needed by the staff to perform a project-specific analysis and may rely on guidance available in RG 4.2 (NRC 2022-TN7081). The staff expects that applicants may be able to rely on the generic conclusions for certain Category 1 issues, but not all Category 1 issues.

When addressing Category 1 issues in SEISs, the NRC staff may likewise refer to the generic analysis in this GEIS for that issue without further analysis, provided that the relevant values and assumptions in the PPE and SPE are met and there is no new and significant information that changes the conclusions in this GEIS. Staff may also have to briefly document how the values and assumptions are met. If the relevant values and assumptions are not met, staff would have to complete a project-specific analysis in accordance with the latest version of the Environmental Standard Review Plan or related guidance (such as any relevant Interim Staff Guidance). Staff may however be able to streamline the effort by incorporating all or a portion of the generic analysis in this GEIS and expanding it to account for project-specific information.

This GEIS included the assumption that the USACE would be a cooperating agency for any ANR SEIS. This GEIS does not, therefore, distinguish between the impacts of NRC-authorized

[3] As used in this document, when the staff states that the project meets a value or assumption of the PPE or SPE, it should be read as to mean that the project meets or is bounded by the value or assumption.
[4] Unless stated otherwise, references to RG 4.2 in this document refer to DG-4032 (NRC 2022-TN7081), the draft revision to RG 4.2.

construction, and preconstruction. The values and assumptions in the PPE and SPE also include, and do not differentiate between, the impacts of NRC-authorized construction and preconstruction. If, for a particular ANR review, the USACE is not a cooperating agency, then the impacts of preconstruction would be considered to be cumulative impacts. However, the applicant and the NRC staff must still include both NRC-authorized construction and preconstruction when it is evaluating whether the values and assumptions in the PPE and SPE have been met.

It is possible that applicants for certain ANRs carefully designed to minimize environmental impacts may be able to demonstrate that their projects fall within all or most of the values and assumptions and may be able to reference generic analyses in this GEIS for all or most of the Category 1 environmental issues. In such a case, the NRC staff's SEIS would likely be shorter than an EIS has been in the past for a typical new reactor application. Also, as has always been the case, if the design of a project is such that an environmental issue (or group of environmental issues) is not applicable, then the applicant need not analyze the issue(s). For example, if the ANR design does not use cooling water then the impact issues associated with the use of cooling water do not need to be analyzed. However, the applicant must briefly describe its basis for concluding that the issue(s) is/are not applicable.

The NRC cannot rely on this GEIS alone to analyze the environmental impacts of building, operating, or decommissioning any ANRs. For example, the staff would still have to conduct the consultations required by Section 106 of the National Historic Preservation Act (54 U.S.C. §§ 300101 *et seq*.; TN4157) and Section 7 of the ESA (16 U.S.C. §§ 1531 *et seq.*; TN1010), and include the documentation in the SEIS for each application. Therefore, these consultations will not be part of this GEIS. The NRC staff will still have to complete other project-specific analyses upon receiving an ANR application.

The NRC staff has evaluated fuel cycle impacts for LWRs, as documented in 10 CFR 51.51 (10 CFR Part 51-TN250), Table S-3, Table of Uranium Fuel Cycle Environmental Data. However, in accordance with 10 CFR 51.51, only an ER for LWRs can rely on the bases in Table S–3 to evaluate the environmental impacts of the uranium fuel cycle. For reactors other than LWRs, the application must contain the basis for evaluating the contribution of the environmental effects of fuel cycle activities for the reactor (10 CFR 51.50(b)(3) and 10 CFR 51.50(c)). Section 3.14 of this GEIS evaluated the fuel cycle impacts for ANRs and determined that data from Table S–3 could bound the impacts of the fuel cycle for certain advanced non-LWRs. An applicant for an advanced non-LWR license could meet the requirements of 10 CFR 51.50(b)(3) and 10 CFR 51.50(c) by demonstrating that their fuel falls within the fuel cycle analysis in this GEIS. If the fuel cycle or parts of the fuel cycle do not fall within the analysis in this GEIS, then the applicant would need to provide the analysis of the parts of the fuel cycle that are not bounded.

The ANR GEIS incorporates by reference NUREG-2157, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel* (NRC 2014-TN4117), in which the NRC evaluated the environmental impacts of the continued storage of spent nuclear fuel beyond the licensed life for the operation of LWRs. In 10 CFR 51.23 (TN250), "Environmental impacts of continued storage of spent nuclear fuel beyond the licensed life for operation of a reactor," the NRC specifies that NUREG-2157 is deemed to be incorporated into the EIS for certain licensing applications. However, NUREG-2157 did not evaluate the storage of spent nuclear fuel from non-LWRs. The staff expects that many ANRs will not be LWRs. Section 3.14.2.6 of this GEIS therefore evaluates the applicability of NUREG-2157 to ANRs and determines that the findings are applicable to non-LWR fuel, provided that the non-LWR fuel is stored in a manner that meets the regulatory requirements for spent fuel storage cask approval and fabrication in accordance with 10 CFR Part 72 (TN4884), Subpart L – "Approval of Spent Fuel Storage Casks," as was the LWR spent fuel evaluated in NUREG-2157 (NRC 2014-TN4117).

The NRC has generically evaluated the environmental impacts of the transportation of fuel and waste in 10 CFR 51.52 (TN250), "Environmental effects of transportation of fuel and waste – Table S4," Table S-4, Environmental Impact of Transportation of Fuel and Waste to and from One Light Water Cooled Nuclear Power Reactor, for LWR fuel that meets certain entry conditions specified in 10 CFR 51.52(a). The staff evaluated the impacts of transportation of non-LWR fuel and waste in Section 3.15 of this GEIS and determined that the shipment of unirradiated and irradiated ANR fuel and radioactive waste would be a Category 1 issue. The applicant can rely on the generic analysis as long as the PPE values and assumptions in this GEIS are met.

The ANR GEIS incorporates by reference NUREG-0586, Supplement 1 (NRC 2002-TN665), in which the NRC evaluated the environmental impacts of the decommissioning of nuclear power reactors as residual radioactivity at the site is reduced to levels that allow for termination of the NRC license. The NRC staff's evaluation of the environmental impacts of decommissioning presented in NUREG-0586, Supplement 1, considered environmental issues for LWRs and three permanently shutdown facilities that included a fast breeder reactor and two high-temperature gas-cooled reactors (NRC 2002-TN665). Therefore, in Section 3.16.2 of this GEIS, the NRC staff evaluated the applicability of NUREG-0586, Supplement 1, and determined that the findings are expected to be applicable to any ANR, provided that the impacts from decommissioning can be shown to be within the bounds described in the Decommissioning GEIS, and that regulatory requirements for decommissioning in 10 CFR 50.82 (TN249) or 10 CFR 52.110 (TN251) are met.

In summary, the general analytical approach used by the NRC staff in this GEIS to evaluate environmental impacts was to (1) describe each environmental issue relevant to each of the 16 environmental resources considered; (2) categorize each issue as Category 1 or Category 2; (3) identify for each Category 1 issue the relevant values and assumptions in the PPE and SPE; and (4) assess the significance of the environmental impact on the Category 1 issue.

1.4.2 Primary Documents Used to Develop this GEIS

The NRC staff drew information from a broad range of sources while developing this GEIS, including the following more prominent written sources:

- *Results of Exploratory Process for Developing a Generic Environmental Impact Statement for the Construction and Operation of Advanced Nuclear Reactors* (SECY-20-0020, NRC 2020-TN6493)
- Staff Requirements – SECY-20-0020 – *Results of Exploratory Process for Developing a Generic Environmental Impact Statement for the Construction and Operation of Advanced Nuclear Reactors* (SRM-SECY-20-0020, NRC 2020-TN6492)
- *Standard Review Plans for Environmental Reviews for Nuclear Power Plants* (NUREG-1555, NRC 2000-TN614)
- *Preparation of Environmental Reports for Nuclear Power Stations* (RG 4.2, NRC 2018-TN6006)

- *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (NUREG-1437, NRC 2013-TN2654)
- *Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities* (NUREG-1910, NRC 2009-TN2559)
- *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel: Final Report, Volumes 1 and 2* (NUREG-2157, NRC 2014-TN4117)
- *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors* (NUREG–0586, Supplement 1, NRC 2002-TN665)
- *Environmental Considerations Associated with Micro-Reactors* (COL-ISG-029, NRC 2019-TN6523)
- *Final Environmental Assessment for the Use of Department of Energy-Owned High-Assay Low-Enriched Uranium Stored at Idaho National Laboratory* (DOE/EA-2087; DOE 2019-TN6757)
- *Advanced Nuclear Reactor Plant Parameter Envelope and Guidance* (NRIC-21-ENG-0001; PNNL-30992, NRIC 2021-TN6940)
- *Advances in Small Modular Reactor Technology Developments; A Supplement to IAEA Advanced Reactors Information System (ARIS)*, 2020 Edition (IAEA 2020-TN6953)
- *Manifest Information Management System* (DOE 2020-TN6669).

1.4.3 Issue Categories

1.4.3.1 Category 1 Issues – Generic Analysis

This GEIS identifies 100 environmental issues as Category 1 issues. Chapter 3 of this GEIS provides generic analyses for each Category 1 issue and indicates the relevant values and assumptions in the PPE and SPE underlying the analyses. Applicants and NRC staff may rely on the generic analysis for each Category 1 issue provided that the relevant values and assumptions are met and there is no new and significant information that changes the conclusions in this GEIS.

These issues and a list of the sections where they are discussed in this GEIS are listed in Table 1-1 (in Section 1.4.3.3).

1.4.3.2 Category 2 Issues – Project-Specific Analysis

This GEIS identifies 19 environmental issues as Category 2 issues. These issues cannot be evaluated generically and must be evaluated in the ER and SEIS using project-specific information. For example, the ESA requires every Federal agency to document its consideration of the impacts of its actions on threatened and endangered species and critical habitats. This ESA Section 7 consultation requirement is required in addition to NEPA; however, the impacts on threatened and endangered species and critical habitat are considered in the NEPA documents.

These issues and a list of the sections where they are discussed in this GEIS are listed in Table 1-1.

1.4.3.2.1 Resource-Specific Category 2 Issues

Category 2 issues specific to a given environmental resource are described in the applicable section of Chapter 3.

1.4.3.2.2 Category 2 Issues Applying Across Resources

Certain Category 2 issues apply across all resources and are summarized below.

Climate Change

Climate change is a subject of national and international interest that causes changes to the affected environment. Commission Order CLI-09-21 (NRC 2009-TN6406) provides the current direction to the NRC staff to include the consideration of the impacts of the emissions of carbon dioxide and other greenhouse gases in its environmental reviews for major licensing actions. Climate change is an environmental trend that could result in changes to the affected environment independent of the ANR project. Climate-related changes include rising temperatures and sea levels; increased frequency and intensity of extreme weather (e.g., heavy downpours, floods, and droughts); earlier snowmelts and associated frequent wildfires; and reduced snow cover, glaciers, permafrost, and sea ice. Greenhouse gases are transparent to incoming short-wave radiation from the sun but opaque to outgoing long-wave (infrared) radiation from the Earth's surface. The net effect over time is a trapping of absorbed radiation and a tendency to warm the Earth's atmosphere, which together constitute the "greenhouse effect" (GCRP 2014-TN3472, GCRP 2018-TN5847).

The NRC staff has considered the impacts of climate change in its recent new reactor EISs. Climate change can lead to changes in the affected environment around a new reactor project, potentially influencing the level of impacts on resources affected by the project. However, the effects of climate change are location-specific and cannot, therefore, be evaluated generically. For example, while climate change may cause many areas to receive less average annual precipitation, other areas may see an increase in average annual precipitation. Therefore, applicants and staff will address the effects of climate change in the environmental documents for ANR licensing. For additional information, see RG 4.2 (NRC 2022-TN7081) and Interim Staff Guidance (ISG) COL/ESP-ISG-026 (NRC 2014-TN3767).

Cumulative Impacts

Cumulative impacts are the impacts on the environment that result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Evaluating cumulative impacts without knowing specific site locations or the timeframe for evaluating reasonably foreseeable future actions is not possible generically. The cumulative impacts of building, operating, and decommissioning an ANR must be considered on a project-specific basis. Impacts would depend on regional resource characteristics, the resource-specific impacts of the project, and the cumulative significance of other factors affecting the resource. This is a Category 2 issue.

1.4.3.2.3 Non-Resource Related Category 2 Issues

This GEIS addresses the environmental impact issues associated with building, operating, and decommissioning a new ANR. However, the ER and the staff's SEIS must also include other information, as required by the regulations and discussed in regulatory guidance. These are not resource-specific issues. Rather, they are project-specific issues, not tied to any specific environmental resource, that are necessary to support the NRC staff's completion of its environmental review in accordance with NEPA. These issues cannot be evaluated generically and must be addressed in the ER and SEIS using project-specific information. Because of their unique nature, some of these issues are discussed further below, and are summarized in Table 4-1 (in Chapter 4). This list is not all-inclusive. NRC regulations at 10 CFR Part 51 (TN250) and guidance such as RG 4.2 (NRC 2022-TN7081) describe information not included in this list that must be included as part of an application.

Purpose and Need

The applicant must describe in its ER the purpose and need for its proposed action, i.e., the reasons for developing the project (10 CFR 51.45(b); TN250). The NRC staff will use this information to inform its development of the NRC's purpose and need in the SEIS. Properly defining the purpose and need is a critical step in the development of an environmental document for the purposes of meeting NEPA requirements because it establishes the need for the project and the range of reasonable alternatives that must be considered. For additional information, see RG 4.2 (NRC 2022-TN7081, ISG COL/ESP-ISG-026 (NRC 2014-TN3767), and COL-ISG-029 (NRC 2019-TN6523).

Need for Power

The Atomic Energy Act requires the social and environmental consequences of the civilian use of nuclear materials be weighed against the benefits that their use would provide. Historically, the primary benefit of nuclear power generation projects has been to provide electrical power to the grid. Therefore, the NRC staff has evaluated the need for power in its new reactor EISs. ANRs may also provide power to the grid, and if so, may require the same type of need for power evaluation in both the ER and SEIS. However, some ANRs may be built for other purposes (e.g., to generate process heat, to desalinate water, or as a research and demonstration project). In such cases, the applicant will need to present, and the NRC staff will have to evaluate, the need for the project (10 CFR 51.45(b); TN250).

Alternatives

The applicant's ER must address alternatives to the proposed action (10 CFR 51.45(b)(3) and (c); TN250). Identification and evaluation of alternatives for any proposed action, including actions to construct and operate an ANR, are inherently project-specific. The NRC staff is unable to generically evaluate alternatives universally applicable to ANRs. This GEIS therefore does not consider any alternatives to the action of building and operating an ANR. Identification of a range of reasonable alternatives requires consideration of information about a specific project and site. The staff will have to individually consider the range of reasonable alternatives that meet the purpose and need behind each incoming ANR licensing application.

Most new reactor EISs prepared by the NRC staff have evaluated alternatives with respect to the proposed reactor site (site alternatives), with respect to fuel used to generate the requisite power (energy alternatives), and with respect to cooling-system use (system design alternatives). Each of these broad types of alternatives is briefly discussed in the sections below. The staff expects that the range of reasonable alternatives will differ for each incoming ANR licensing application and may include alternatives from one or more of these groupings of possible alternatives. Other types of alternatives might also be possible.

Site Alternatives

New reactor EISs prepared by NRC staff have evaluated in detail situating the proposed reactor at three or four alternative sites as well as the proposed site (unless siting has been previously addressed, as in the case of a combined license referencing an early site permit). For any site to be a reasonable alternative, it must meet all of the NRC siting criteria established in 10 CFR Part 100 (TN282). Applicants typically consider many other factors as well when determining whether sites are reasonable alternatives—factors such as proximity to customers, proximity to existing transmission lines, availability of water sources, land ownership, avoidance of sensitive features such as wetlands and historic sites, accessibility to workers, and considerations of local residents and government officials. Applicants often favor sites on or adjacent to existing nuclear plant sites or sites containing other energy generation facilities. The advantages of such sites include the availability of existing transmission lines, pipelines, highways, and other facilities that do not have to be newly built, thereby reducing construction costs and disturbance to non-industrial landscapes and environmentally sensitive lands.

Applicants commonly follow systematic approaches to narrowing a field of potential sites such as that developed by the Electric Power Research Institute (EPRI 2015-TN5285). However, use of any specific siting guidance is not mandatory. The NRC offers additional guidance in RG 4.7 (NRC 2014-TN3550).

The geographical area that must be considered for site alternatives will be determined based on the purpose and need for the proposed action. ISG COL/ESP-027 (NRC 2014-TN3774) contains some insights regarding this aspect in its discussion of Chapter 9.

According to ISG-027, an applicant may request construction at a specific location to meet its purpose and need for a light-water SMR facility (NRC 2014-TN3774). For example, an applicant may propose to use excess heat for industrial processes or station heating. A proposed SMR may be used to provide a secure energy source for military, government, or critical industrial facilities. In these cases, the applicant must still submit, and the staff must review alternative sites. However, the region of interest used for the site selection process may be much smaller than is typical for large LWRs (e.g., within the confines of a military installation).

Although the ISG was written specifically for SMRs, the fundamental concept is informative for most other ANRs as well. The range of alternatives that must be considered is a direct product of the purpose and need for the proposed action. The proposed and alternative sites can be adjacent to each other.

This GEIS can be used for both the proposed and alternative sites for the evaluation of resource impacts. However, the application must compare the differences between the proposed and alternative sites, so that a determination can be made about whether an alternative site is environmentally preferable or obviously superior to the proposed site.

Energy Alternatives

A reasonable alternative must meet the purpose and need for the project. For example, new reactor EISs recently have evaluated alternatives that could meet the purpose and need for the project to supply baseload power. The EISs have evaluated alternatives such as coal, natural gas, and mixtures of natural gas and renewable energy sources that could supply baseload power. Energy sources such as wind and solar by themselves were not considered reasonable alternatives because they could not supply baseload power.

The range of alternative energy sources constituting reasonable alternatives for each proposed ANR project may differ. For example, if the purpose and need statement was "demonstrate a specific type of advance reactor technology to supply power," then coal, natural gas, wind, or solar would not be reasonable alternatives because they do not demonstrate the specific type of ANR technology and therefore the EIS would not evaluate them. Other potential purposes of new reactors include desalinating water, providing process heat, or aiding States in meeting carbon emission goals. Because the purpose and need for each project is likely to be different, applicants and the NRC staff would have to individually identify reasonable alternatives suited to each specific application.

<u>System Design Alternatives</u>

Because operation of water-based cooling systems to discharge waste heat from large nuclear reactors has the potential to significantly affect the water bodies from which water is taken, and into which it is discharged, new reactor EISs recently prepared by NRC staff have evaluated alternative system designs that use different cooling processes. Possible cooling systems considered have included (1) once-through cooling, in which water is withdrawn from a source such as a river or lake and run through the system once to absorb waste heat before being returned to the source; (2) recirculating cooling-water systems, in which water is withdrawn and recirculated through cooling towers multiple times (cycles of concentration) before being discharged; (3) air cooling that does not involve water; and (4) use of multiple cooling approaches. Different types of cooling towers are also possible, such as natural draft cooling towers comprising tall hyperbolic structures that direct air upward on a pressure gradient to cool water, or lower mechanical draft cooling towers that use electrically driven fans to cool water. Consideration of system design alternatives involving cooling systems may not be appropriate for ANRs designed for air cooling or for which smaller volumes of cooling water may be used. If the design of the project does not use cooling water, then an evaluation of alternative cooling systems is not required. Because of the wide range of possible ANR technologies, the NRC staff is not able to anticipate all possible alternative design approaches that might be reasonable.

1.4.3.3 Uncertain Issues

This GEIS identifies the impacts of two issues as Uncertain, and therefore the determination of Category 1 or Category 2 is not applicable (N/A). These issues relate to exposure to electromagnetic fields (EMFs). Studies of 60 Hz EMFs have not uncovered consistent evidence linking harmful effects with field exposures. Because the state of the science is currently inadequate, no generic conclusion on human health impacts is possible. If, in the future, the Commission finds that a general agreement has been reached by appropriate Federal health agencies that there are adverse health effects from EMFs, the Commission will require applicants to submit project-specific reviews of these health effects as part of their application. Until such time, applicants are not required to submit information on this issue.

Table 1-1 Issues Discussed in this GEIS

Issue	Section	Category
Land Use		
Construction		
Onsite Land Use	3.1.2.1.1	1
Offsite Land Use	3.1.2.1.2	1
Impacts to Prime and Unique Farmland	3.1.2.1.3	1
Coastal Zone and Compliance with the Coastal Zone Management Act	3.1.2.1.4	1
Operation		
Onsite Land Use	3.1.2.2.1	1
Offsite Land Use	3.1.2.2.2	1
Visual Resources		
Construction		
Visual Impacts in Site and Vicinity	3.2.2.1.1	1
Visual Impacts from Transmission Lines	3.2.2.1.2	1
Operation		
Visual Impacts During Operations	3.2.2.2.1	1
Meteorology and Air Quality		
Construction		
Emissions of Criteria Pollutants and Dust During Construction	3.3.2.1.1	1
Greenhouse Gas Emissions During Construction	3.3.2.1.2	1
Operation		
Emissions of Criteria and Hazardous Air Pollutants during Operation	3.3.2.2.1	1
Greenhouse Gas Emissions During Operation	3.3.2.2.2	1
Cooling-System Emissions	3.3.2.2.3	1
Emissions of Ozone and NOx during Transmission Line Operation	3.3.2.2.4	1
Water Resource		
Construction		
Surface Water Use Conflicts during Construction	3.4.2.1.1	1
Groundwater Use Conflicts due to Excavation Dewatering	3.4.2.1.2	1
Groundwater Use Conflicts due to Construction-Related Groundwater Withdrawals	3.4.2.1.3	1
Water Quality Degradation due to Construction-Related Discharges	3.4.2.1.4	1
Water Quality Degradation due to Inadvertent Spills during Construction	3.4.2.1.5	1
Water Quality Degradation due to Groundwater Withdrawal	3.4.2.1.6	1
Water Quality Degradation due to Offshore or In-Water Construction Activities	3.4.2.1.7	1
Water Use Conflict Due to Plant Municipal Water Demand	3.4.2.1.8	1
Degradation of Water Quality from Plant Effluent Discharges to Municipal Systems	3.4.2.1.9	1
Operation		
Surface Water Use Conflicts during Operation due to Water Withdrawal from Flowing Water Bodies	3.4.2.2.1	1

Issue	Section	Category
Surface Water Use Conflicts during Operation due to Water Withdrawal from Non-flowing Water Bodies	3.4.2.2.2	1
Groundwater Use Conflicts Due to Building Foundation Dewatering	3.4.2.2.3	1
Groundwater Use Conflicts Due to Groundwater Withdrawals for Plant Uses	3.4.2.2.4	1
Surface Water Quality Degradation Due to Physical Effects from Operation of Intake and Discharge Structures	3.4.2.2.5	1
Surface Water Quality Degradation Due to Changes in Salinity Gradients Resulting from Withdrawals	3.4.2.2.6	1
Surface Water Quality Degradation Due to Chemical and Thermal Discharges	3.4.2.2.7	2
Groundwater Quality Degradation Due to Plant Discharges	3.4.2.2.8	1
Water Quality Degradation due to Inadvertent Spills and Leaks during Operation	3.4.2.2.9	1
Water Quality Degradation due to Groundwater Withdrawals	3.4.2.2.10	1
Water Use Conflict from Plant Municipal Water Demand	3.4.2.2.11	1
Degradation of Water Quality from Plant Effluent Discharges to Municipal Systems	3.4.2.2.12	1
Terrestrial Ecology		
Construction		
Permanent and Temporary Loss, Conversion, Fragmentation, and Degradation of Habitats	3.5.2.1.1	1
Permanent and Temporary Loss and Degradation of Wetlands	3.5.2.1.2	1
Effects of Building Noise on Wildlife	3.5.2.1.3	1
Effects of Vehicular Collisions on Wildlife	3.5.2.1.4	1
Bird Collisions and Injury from Structures and Transmission Lines	3.5.2.1.5	1
Important Species and Habitats – Resources Regulated under the Endangered Species Act of 1973	3.5.2.1.6.1	2
Important Species and Habitats – Other Important Species and Habitats	3.5.2.1.6.2	1
Operation		
Permanent and Temporary Loss or Disturbance of Habitats	3.5.2.2.1	1
Effects of Operational Noise on Wildlife	3.5.2.2.2	1
Effects of Vehicular Collisions on Wildlife	3.5.2.2.2	1
Exposure of Terrestrial Organisms to Radionuclides	3.5.2.2.3	1
Cooling-Tower Operational Impacts on Vegetation	3.5.2.2.4	1
Bird Collisions and Injury from Structures and Transmission Lines	3.5.2.2.5	1
Bird Electrocutions from Transmission Lines	3.5.2.2.6	1
Water Use Conflicts with Terrestrial Resources	3.5.2.2.7	1
Effects of Transmission Line ROW Management on Terrestrial Resources	3.5.2.2.8	1
Effects of Electromagnetic Fields on Flora and Fauna	3.5.2.2.9	1
Important Species and Habitats – Resources Regulated under the ESA of 1973	3.5.2.2.10.1	2
Important Species and Habitats – Other Important Species and Habitats	3.5.2.2.10.2	1

Issue	Section	Category
Aquatic Ecology		
Construction		
Runoff and sedimentation from construction areas	3.6.2.1.1	1
Dredging and filling aquatic habitats to build intake and discharge structures	3.6.2.1.2	1
Building transmission lines, pipelines, and access roads across surface water bodies	3.6.2.1.3	1
Important Species and Habitats – Resources Regulated under the ESA and Magnuson-Stevens Fishery Conservation and Management Act	3.6.2.1.4.1	2
Important species and habitats – Other Important Species and Habitats	3.6.2.1.4.2	1
Operation		
Stormwater runoff	3.6.2.2.1	1
Exposure of aquatic organisms to radionuclides	3.6.2.2.2	1
Effects of refurbishment on aquatic biota	3.6.2.2.3	1
Effects of maintenance dredging on aquatic biota	3.6.2.2.4	1
Impacts of transmission line ROW management on aquatic resources	3.6.2.2.5	1
Impingement and entrainment of aquatic organisms	3.6.2.2.6	1
Thermal impacts on aquatic biota	3.6.2.2.7	2
Other effects of cooling-water discharges on aquatic biota	3.6.2.2.8	2
Water use conflicts with aquatic resources	3.6.2.2.9	1
Important Species and Habitats – Resources Regulated under the ESA and Magnuson-Stevens Act	3.6.2.2.10.1	2
Important species and habitats – Other Important Species and Habitats	3.6.2.2.10.2	1
Historic and Cultural Resources		
Construction		
Construction impacts on historic and cultural resources	3.7.2	2
Operation		
Operation impacts on historic and cultural resources	3.7.2	2
Human Health - Radiological Environment		
Construction		
Radiological dose to construction workers	3.8.1.2.1	1
Operation		
Occupational doses to workers	3.8.1.2.2.1	1
Maximally exposed individual annual doses	3.8.1.2.2.2	1
Total population annual doses	3.8.1.2.2.3	1
Nonhuman biota doses	3.8.1.2.2.4	1
Human Health – Nonradiological Environment		
Construction		
Building impacts of chemical, biological, and physical nonradiological hazards	3.8.2.2.1.1	1
Building impacts of EMFs	3.8.2.2.1.2	N/A
Operation		
Operation impacts of chemical, biological, and physical nonradiological hazards	3.8.2.2.2.1	1

Issue	Section	Category
Operation impacts of EMFs	3.8.2.2.2.2	N/A
Noise		
Construction		
Construction-related noise	3.9.2.1	1
Operation		
Operation-related noise	3.9.2.2	1
Waste Management – Radiological Environment		
Operation		
Low-level radioactive waste	3.10.1.2.1	1
Onsite spent nuclear fuel management	3.10.1.2.2	1
Mixed waste	3.10.1.2.3	1
Waste Management – Nonradiological Environment		
Construction		
Construction nonradiological waste	3.10.2.2.1	1
Operation		
Operation nonradiological waste	3.10.2.2.2	1
Postulated Accidents		
Operation		
Design Basis Accidents Involving Radiological Releases	3.11.2.1	1
Accidents Involving Releases of Hazardous Chemicals	3.11.2.2	1
Severe Accidents	3.11.2.3	2
Severe Accident Mitigation Design Alternatives	3.11.2.4	1
Acts of Terrorism	3.11.2.5	1
Socioeconomics		
Construction		
Community Services and Infrastructure	3.12.1.1.1	1
Transportation Systems and Traffic	3.12.1.1.2	1
Economic Impacts	3.12.1.1.3	1
Tax Revenue Impacts	3.12.1.1.4	1
Operation		
Community Services and Infrastructure	3.12.1.2.1	1
Transportation Systems and Traffic	3.12.1.2.2	1
Economic Impacts	3.12.1.2.3	1
Tax Revenue Impacts	3.12.1.2.4	1
Environmental Justice		
Construction		
Construction Environmental Justice Impacts	3.13.2.1	2
Operation		
Operation Environmental Justice Impacts	3.13.2.1	2
Fuel Cycle		
Operation		
Uranium Recovery	3.14.2.1	1
Uranium Conversion	3.14.2.2	1
Enrichment	3.14.2.3	1
Fuel Fabrication[(a)]	3.14.2.4	1
Reprocessing	3.14.2.5	1

Issue	Section	Category
Storage and Disposal of Radiological Wastes	3.14.2.6	1
Transportation of Fuel and Waste		
Operation		
Transportation of Unirradiated ANR Fuel	3.15.2.1	1
Transportation of Radioactive Waste from ANRs	3.15.2.2	1
Transportation of Irradiated Fuel from ANRs	3.15.2.3	1
Decommissioning		
Decommissioning	3.16.2	1
Issues Applying Across All Resources		
Climate Change	1.4.3.2.2	2
Cumulative Impacts	1.4.2.2.2	2
Non-Resource Related Issues		
Purpose and Need	1.4.3.2.3	2
Need for Power	1.4.3.2.3	2
Site Alternatives	1.4.3.2.3	2
Energy Alternatives	1.4.3.2.3	2
System Design Alternatives	1.4.3.2.3	2

ROW = right-of-way.
(a) Fuel fabrication impacts for metal fuel and liquid-fueled molten salt are not included in the staff's generic analysis

1.5 Implementation of the Rule (10 CFR Part 51)

Applicants and the NRC staff will use this GEIS as a tool to increase the efficiency and effectiveness of environmental reviews for building, operating, and decommissioning new ANRs, while at the same time ensuring that NRC's NEPA requirements are met. This GEIS presents generic analyses of environmental impacts that the staff expects will be common to most ANRs meeting a set of design conditions (termed the PPE) built on a hypothetical site meeting a set of site conditions (termed the SPE) (Appendix G). Applicants will be able to streamline ERs by referring to the generic analyses in this GEIS codified in 10 CFR Part 51 (TN250) whenever possible and focus on providing the project-specific information needed for the staff to complete environmental reviews of issues that cannot be addressed generically.

The staff will be able to streamline environmental reviews by referring to the generic analyses in this GEIS and focus their review efforts on environmental issues where a consideration of project-specific information is needed to ascertain the potential for significant environmental impacts. Upon receipt of specific ANR licensing applications, the staff will prepare SEISs tiered[5] from this GEIS, in accordance with the associated rule, that briefly identify the environmental issues that can be addressed through this GEIS, and then cover the remaining issues in more detail using project-specific information. The staff expects that use of this GEIS along with the SEIS will reduce the time and resources needed to complete environmental reviews, while still providing decision-makers and the public with a complete and robust analysis of potential environmental impacts and meeting all NEPA requirements.

Applicants for an NRC permit or license for an ANR are required as part of their application to submit a safety analysis report and an ER. The NRC then performs a safety review which results in a safety evaluation report and an environmental review that results in an EIS. This

[5] The process of tiering is described in 10 CFR Part 51, Subpart A, Appendix A.

GEIS does not evaluate the safety of a reactor design; that is a separate review done when an application is submitted.

The implementation of the rule is described in more detail below.

1.5.1 General Requirements

The regulatory requirements for conducting a NEPA review for an ANR are the same as the requirements for other major plant licensing actions. Consistent with the current NEPA practice for major plant licensing actions, an applicant will be required to submit an ER that assesses the environmental impacts associated with the proposed action, consider alternatives to the proposed action, and evaluate any alternatives for reducing adverse environmental effects. For an ANR license, the NRC will prepare a draft SEIS to this GEIS for public comment and issue a final SEIS after considering public comments on the draft.

1.5.2 Applicant's Environmental Report

The applicant's ER must contain an assessment of the environmental impacts of building, operating, and decommissioning an ANR, and alternatives that meet the purpose and need of the project. In preparing the analysis of environmental impacts contained in the ER, the applicant should refer to the information provided in Table C-1 of 10 CFR Part 51 (TN250). The applicant is not required to assess the environmental impacts of Category 1 issues listed in Table C-1 if (1) the applicant has demonstrated that its project is bounded by the applicable PPE and SPE values and assumptions in Table C-1, and (2) the applicant has not identified any new and significant information that would change the conclusions in this GEIS. If a value or assumption is not met, then the applicant may be able to limit its analysis to just the impact of not meeting the value or assumption. Similarly, if the applicant identifies new and significant information that would change the conclusions in this GEIS, then the applicant may be able to limit its analysis to just the impact of the new and significant information. For Category 2 issues listed in Table C-1, the applicant must provide a project-specific assessment of the impacts.

1.5.3 The NRC's SEIS

As required by 10 CFR 51.20(b)(2) (TN250), the NRC will be required to prepare a SEIS to this GEIS for each ANR application. The SEIS will serve as the NRC's analysis of the environmental impacts of issuing an ANR license and will compare those impacts to the environmental impacts of the alternatives. This document will also present the NRC's recommendation to approve or deny the proposed action.

1.5.4 Public Scoping and Public Comments

The NRC will conduct scoping to inform the public about the licensing process and typically will hold public scoping meetings to receive comments about the scope of the NRC's project-specific environmental review. At the conclusion of the scoping period, the NRC will review and address public comments in a scoping summary report. In addition, the draft SEIS will be issued for public comment (see 10 CFR 51.73; TN250). In both the scoping and the SEIS public comment process, the NRC will consider comments and will determine whether the comments provide any information that is new and significant compared to information previously considered in this GEIS (for Category 1 issues). If the comments are determined to provide new and significant information that could change the conclusions in this GEIS, these comments will be considered and addressed in the SEIS.

1.5.5 The NRC's Draft SEIS

The NRC's draft SEIS will include its analysis of the environmental impacts of the proposed action and the environmental impacts of the alternatives to the proposed action. The NRC will use and integrate (1) the environmental impacts of the proposed action as provided in Table C-1 of 10 CFR Part 51 (TN250) for Category 1 issues, (2) the appropriate project-specific analyses of Category 2 issues, (3) other project-specific information necessary to support the analyses (see Section 1.4.3), and (4) any new and significant information identified in the applicant's ER or during the scoping and public comment process, to arrive at a conclusion regarding the environmental impacts of issuing an ANR license. These impacts will be compared to the environmental impacts of the alternatives presented in the SEIS.

1.5.6 The NRC's Final SEIS

The NRC will issue a final SEIS in accordance with 10 CFR 51.91 and 51.93 (10 CFR Part 51-TN250) after considering (1) the public comments, (2) the analysis of Category 2 issues, and (3) any new and significant information involving Category 1 issues. The NRC will provide a record of its decision regarding the environmental impacts of the proposed action (see 10 CFR 51.102 and 51.103). All comments on the draft SEIS will be addressed by the NRC in the final SEIS in accordance with 10 CFR 51.91(a)(1).

2.0 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

The term "alternatives" is used two ways in this Generic Environmental Impact Statement (GEIS). The first use refers to alternatives to the proposed action of issuing this GEIS. Only those alternatives, outlined below in Section 2.1, are compared in this GEIS and considered in the record of decision for this GEIS. The other use refers to alternatives to building and operation of a specific advanced nuclear reactor (ANR). It is possible to identify those alternatives only after identification of a specific project on a specific site. The U.S. Nuclear Regulatory Commission (NRC) staff will evaluate and compare such alternatives in a supplemental EIS (SEIS) issued following receipt of each individual ANR licensing application.

2.1 Proposed Action and Alternatives to this GEIS

The staff developed the following proposed action and alternatives in response to the purpose and need statement outlined in Section 1.2. These alternatives were developed and informed by an exploratory process completed in January 2020, involving interested stakeholders and through the public scoping process that concluded in May 2020.

2.1.1 Proposed Action: Issue Technology-Neutral GEIS Based on Performance-Based Assumptions

The proposed action is for the NRC to issue a GEIS containing generic analyses of the environmental impacts of building, operating, and decommissioning a hypothetical ANR on a hypothetical site. The generic analyses for each Category 1 issue would be bounded by the plant design values and assumptions in the plant parameter envelope (PPE) and by the site condition values and assumptions in the site parameter envelope (SPE) presented in Appendix G. The values and assumptions in Appendix G are performance-based, where performance reflects minimization of potential environmental impacts by the applicant when choosing a plant design and site prior to submitting an application. The values and assumptions are based on environmental conditions and impact levels below which the staff believes that they may rely on a generic analysis to confidently conclude that environmental impacts would be SMALL for any location within the United States.

This GEIS presents generic analyses for Category 1 issues for which a meaningful impact assessment is possible based on reasonable values and assumptions in the PPE and SPE. Category 2 issues include those environmental issues for which a meaningful generic analysis of environmental impacts is not possible without consideration of project-specific information. As such, analysis of Category 2 issues is not included in this GEIS.

Once this GEIS is issued, applicants will be able to rely on and reference the generic analyses for each Category 1 issue for which the proposed project is bounded by the PPE and SPE values and assumptions, thereby streamlining the environmental reviews associated with an ANR application. The NRC staff will likewise be able to reference the generic analyses when it prepares a SEIS in response to an application, thereby simplifying and streamlining the environmental reviews. Instead of developing individual analyses specific to all environmental issues in any proposed ANR Environmental Report (ER) or SEIS, applicants and NRC staff may focus their efforts on the environmental issues that require individualized consideration of project-specific information (Category 1 issues where the proposed project is not bounded by the PPE and SPE values and assumptions, and Category 2 issues) to address the potential for significant environmental impacts. The shorter, more focused ERs and SEISs will help NRC staff and decision-makers concentrate on issues for which there is potential for significant environmental impacts.

2.1.2 No-Action Alternative: No GEIS – Project-Specific National Environmental Policy Act Review Only

Under the No-Action Alternative, the NRC staff would not develop a GEIS for ANRs. Without the availability of a GEIS, applicants for licensing ANRs would have to address all relevant environmental issues individually in their ERs, and staff would have to prepare individual EISs for each application received that address all relevant environmental issues (including all Category 1 and Category 2 issues). The processes for an applicant to prepare an ER and for the NRC staff to prepare an EIS would remain similar to those used in the past for new reactor licensing applications. Regardless of whether the licensing review process uses a GEIS or not, the actual environmental impacts of the project are the same. However, the No-Action Alternative would accomplish none of the benefits intended by the preparation of this GEIS, which would include (1) reducing the time and resources for the applicant's preparation of the ER, (2) reducing the time and resources for the NRC staff's preparation of the EIS, and (3) focusing the effort of applicant, NRC staff, and decision-makers on issues that involve a potential for significant environmental impacts. Because the No-Action Alternative would result in the same level of project-specific impacts without the benefit of streamlining provided by this GEIS, the NRC staff concludes that the No-Action Alternative is not environmentally preferable to the proposed action.

2.1.3 Other Alternatives Considered but Not Analyzed in Detail

2.1.3.1 Limiting this GEIS to Reactors Less than 30 MWt

Prior to scoping, the NRC staff contemplated preparing a GEIS that would analyze the potential environmental impacts of a hypothetical reactor that has a power level of approximately 30 MWt or less on a hypothetical site. The analytical approach to developing this GEIS would have been similar to that used under the proposed action, but the PPE/SPE would have been developed based on a typical reactor of 30 MWt, thereby limiting the range of reactors for which this GEIS would have been useful. Use of the power-level–based GEIS by applicants for small reactors and NRC staff would have been the same as for the environmental performance-based GEIS called for in the proposed action. During the scoping process, multiple commenters suggested that the parameters used in the generic analyses should be tied to the potential for environmental impacts rather than to an arbitrary power level. After reviewing the comments, the staff agreed that a GEIS developed using performance-based values and assumptions tied to environmental impacts might help streamline environmental reviews even for some larger ANRs that would still have a low potential for significant environmental impacts with respect to some environmental issues.

2.1.3.2 GEIS Analyzing All Potential Environmental Impacts

The staff also considered whether it would be possible to develop a GEIS that could serve as the sole technical documentation of potential environmental impacts for any ANR. However, the staff concluded that it is not technically possible to develop generic analyses addressing all potentially significant environmental impacts from any ANR without consideration of site-specific and project-specific conditions. Reliance on such a GEIS would not meet the NRC's regulations in Title 10 of the *Code of Federal Regulations* Part 51 (TN250) for compliance with the National Environmental Policy Act of 1969 (42 U.S.C. §§ 4321 *et seq.*; TN661). This GEIS would also not meet the requirements of other environmental laws, such as the Endangered Species Act (16 U.S.C. §§ 1531 *et seq*.; TN1010) or the National Historic Preservation Act (54 U.S.C. §§ 300101 *et seq*.; TN4157).

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3.0 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This chapter of the generic environmental impact statement (GEIS) describes the affected environment and environmental consequences resulting from building, operating, and decommissioning an advanced nuclear reactor (ANR). This introduction describes the concept and background behind the development and analysis of the baseline, the values and assumptions bounding the plant parameter envelope (PPE) and site parameter envelope (SPE), and impacts from building, operating, and decommissioning on the environmental resources. This chapter is organized into subsections that address each of 16 relevant environmental resources that the U.S. Nuclear Regulatory Commission (NRC) staff identified following the scoping process outlined in Chapter 1.

- **Overview of Affected Environment.** The baseline condition described as the "affected environment" in this GEIS is the environment that exists at and around a site proposed for building, operating, and decommissioning an ANR. A site could be anywhere in the United States that meets NRC reactor siting criteria in Title 10 of the *Code of Federal Regulations* Part 100 (10 CFR Part 100; TN282). The affected environment reflects the existing condition of environmental resources, as influenced by natural physical conditions and by past human activities such as agriculture, forestry, mining, urbanization, and industrial and non-industrial development. The site might be situated at an existing nuclear power plant property, and, if so, the generalized description of the affected environment at an existing nuclear power generation site presented in the License Renewal GEIS (NRC 2013-TN2654) might be informative. However, ANRs might also be proposed for sites not previously used for nuclear power generation. ANRs might be proposed for sites that have a history of industrial use or other development, or they might be proposed for greenfield sites that have not been previously developed other than for agricultural, forestry, or conservation purposes. ANRs might be proposed for sites on government-owned or managed installations such as military bases or national laboratories, or they might be proposed for privately owned sites.

  The range of existing environmental conditions that might possibly occur at any possible proposed site is too broad to characterize. The NRC staff instead developed the PPE and SPE values and assumptions presented in Appendix G. An application for a license that references this GEIS and for which the site meets the PPE and SPE values and assumptions for a Category 1 issue will be able to rely on the generic environmental impact analyses and conclusions for that issue in this GEIS. If the PPE or SPE values and assumptions relevant to an environmental impact are not met, the applicant will have to perform an analysis of that impact in the Environmental Report (ER) using project-specific environmental information. Relevant project-specific information would be presented in an application for a license that references this GEIS and in the NRC's supplemental environmental review documentation.

  Each resource-specific section that follows discusses the affected environment in terms of baseline conditions and the PPE and SPE values and assumptions as they relate to that resource.

- **Overview of Environmental Consequences.** This chapter also evaluates the potential environmental consequences of building, operating, and decommissioning an ANR that meet the values and assumptions for the parameters in the PPE and SPE. Each subsection identifies specific environmental issues involving the possible impacts of an ANR on the subject resource. Each subsection then presents generic analyses of potential environmental impacts for each issue for which a generic analysis is possible (i.e., Category 1 issues), assuming that all of the PPE and SPE values and assumptions for that issue are met. Each environmental issue is defined as either a Category 1 or a Category 2 issue.

The basis for identifying an issue as being a Category 1 issue is whether a generic analysis of the issue is sufficient for decision-makers and the public when licensing an ANR that meets the values and assumptions in the PPE and SPE. The generic analyses for all issues identified by the NRC staff as Category 1 issues support determinations of SMALL impacts. In general, however, individualized analyses that consider project-specific information are necessary for impacts of greater than SMALL significance. In addition, the fact that an individualized analysis is necessary does not mean that the supplemental environmental documentation will conclude that impacts pertaining to the issue will be greater than SMALL; it only means that more than a generic analysis is necessary to reach that conclusion.

The generic analyses presented in this chapter assume possible mitigation measures on a resource-specific basis to reduce adverse environmental impacts. If a proposed ANR application meets the PPE and SPE values and assumptions, including mitigation pertaining to an environmental issue, then the generic assessment can be relied upon in the supplemental EIS (SEIS). The staff will always individually consider the possible mitigation measures for Category 2 issues.

3.1 Land Use

3.1.1 Baseline Conditions and PPE/SPE Values and Assumptions

Baseline conditions influencing potential land use impacts associated with construction and operation of a new nuclear reactor include past and present land uses and land cover on and surrounding the site, applicable zoning regulations, and relevant planning documents such as comprehensive land use plans or installation land use plans. Land use conditions relevant to the environmental analysis include the plant site but also offsite land for affiliated uses such as construction laydown, intake and discharge structures, and any offsite rights-of-way (ROWs) for transmission lines, pipelines, or heavy-haul roads.

In developing the values and assumptions in the PPE and SPE pertaining to land use, the staff relied upon the information and analyses contained in multiple new reactor EISs prepared between 2005 and 2017, the License Renewal GEIS (NRC 2013-TN2654), other past NRC EISs, and common elements of state and local land use regulation. Some assumptions made in this section of this GEIS involve parameters and values that are developed based on previous staff environmental reviews or are the subject of Federal and State regulations; some have been appropriately scaled down to account for the size and technology differences between large light-water reactors (LWRs) and ANRs. In every case, the staff has selected a value or parameter that will ensure a minimal impact on land use from construction and operation of an ANR after considering all available information and leveraging professional judgment and expertise. The staff's assumptions that support the PPE and SPE are described below.

In addition to assuming that any proposed facilities would comply with NRC siting regulations in 10 CFR Part 100 (TN282), the staff assumes that the proposed plant site would be no larger than 100 ac (40.5 ha), within which site disturbance would affect no more than 30 ac (12 ha) of land permanently and no more than 20 ac (8.1 ha) of additional land temporarily. The staff also assumes that the site would be at least 0.5 mi (0.8 km) from the nearest existing residence. The staff established these values to ensure that dedication and disturbance of land in most settings could not substantially interfere with nearby land uses or alter regional land use characteristics and trends. The staff also assumes that construction and operation of a power plant would be consistent with applicable zoning and with the objectives of any local land use plans (typically prepared for counties or multi-county planning areas). Reliance on zoning compliance and compatibility with land use plans underlie conclusions regarding minimal land use impacts in all recent new reactor EISs, as well as most EISs prepared for other major land development projects. The staff assumes that any cooling towers built on the site would be mechanical draft towers under 100 ft (30.5 m) in height rather than the taller natural draft cooling towers. Taller cooling towers can generate drift capable of affecting sensitive land uses, such as residential uses, at greater distances from the towers. Taller towers could also pose a collision risk to birds and other flying wildlife (see Section 3.5.2.1.5). The staff also assumes that a project would not include salt evaporation ponds, whose use could potentially result in significant salt deposition in surrounding residential lands (NRC 2011-TN6437).

The staff assumes that new offsite ROWs for transmission lines, pipelines, access roads, or other new linear facilities would be no longer than 1 mi (1.6 km) and have a maximum ROW width of 100 ft (30.5 m). However, the assumptions allow for unlimited additional mileage for building new linear facilities within existing ROWs or adjacent to existing ROWs or public highways, unless in residential areas. As for the assumed site area values, the staff established the ROW values to ensure that the offsite ROWs could not substantially interfere with other land uses or alter regional land use characteristics or trends. For similar reasons, the staff assumes that the site and ROWs would not be situated closer than 0.5 mi (0.8 km) to residential areas or 1 mi (1.6 km) to sensitive land uses such as Federal, State, or local parks, wildlife refuges, conservation lands, Wild and Scenic Rivers, or Natural Heritage Rivers. The staff also assumes that the land disturbed by building activities (footprint of disturbance) could be accommodated within the site but still avoid impacts on more than 0.5 ac (0.2 ha) of wetlands and other waters of the United States, and avoid any encroachment into floodplains, shoreline, or riparian lands that may be within the site boundaries (although the SPE allows for offsite ROWs to traverse such features). The 0.5 ac (0.2 ha) limit is based on the fact that many Nationwide Permits under Section 404 of the Clean Water Act (CWA) (33 U.S.C. § 1344-TN1019) include a project-wide limitation of 0.5 ac (0.2 ha) of wetland loss. The staff also assumes that the site and ROWs do not have a history of past industrial use capable of leaving a legacy of contamination requiring cleanup to protect human health or the environment.

The staff further assumes that projects would comply with NRC siting regulations in 10 CFR Part 100 (TN282) (including 10 CFR 100.20 – Factors to be considered when evaluating sites; 10 CFR 100.21 – Non-seismic siting criteria; and 10 CFR 100.23 – Geologic and seismic siting criteria), the Coastal Zone Management Act of 1972 (CZMA; 16 U.S.C. §§ 1451 *et seq.*; TN1243) and the Farmland Protection Policy Act (FPPA; 7 U.S.C. §§ 4201 *et seq.*; TN708), including implementation of any mitigation measures necessary for compliance with these statutes and regulations. The staff will include the findings made and the data gathered as a result of this compliance in its evaluation of land use impacts, as applicable (NRC 2000-TN614). Under the CZMA, each State bordering the tidal waters of the oceans or the Great Lakes has the opportunity to identify its coastal zone and issue a plan for managing land use in that zone that balances the objectives of conservation and economic development. The CZMA is a voluntary program for States (16 U.S.C. § 1451(i) and 1452(2) and (4)). If a State has decided to participate in the CZMA program, then compliance with the CZMA is necessary for all reactor licensing projects sited in that State's coastal zone, in accordance with the State's coastal management program (CMP) (16 U.S.C. § 1456(c)). Additionally, if an applicant proposes to construct and operate a reactor outside of the State's coastal zone, compliance with the CZMA may still be required to the extent that the proposed project may have a reasonably foreseeable effect upon offsite coastal zone land uses or resources (15 CFR 930.33(a)(1); TN4475). The State's CMP is approved by the U.S. Department of Commerce National Oceanic and Atmospheric Administration.

The staff assumes there is no prime or unique farmland, or other farmland of statewide or local importance within the footprint of disturbance, unless the site does not abut other agricultural areas and is situated in a predominantly agricultural setting. The purpose of the FPPA is to minimize the extent that Federal programs contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses. The FPPA defines three categories of regulated farmland namely, prime farmland, unique farmland, and farmland of State or local importance. Prime farmland means "land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion," as determined by the Secretary of the U.S. Department of Agriculture (USDA) (7 U.S.C. 4201(c)(1)(A)). Prime farmland includes land that possesses the above characteristics but is being used currently to produce livestock and timber. Prime farmland does not include land already in or committed to urban development or water storage. Unique farmland means "land other than prime farmland that is used for production of specific high-value food and fiber crops, as determined by the Secretary. It has the special combination of soil quality, location, growing season, and moisture supply needed to economically produce sustained high quality or high yields of specific crops when treated and managed according to acceptable farming methods" (7 U.S.C. § 4201(c)(1)(B); TN708). Examples of crops grown on unique farmland include citrus fruits, olives, and cranberries. The third category is farmland, other than prime or unique farmland, which is determined to be of State or local significance as determined by the appropriate State or local agency with the concurrence of the USDA Secretary (7 U.S.C. § 4201(c)(1)(C)).

The FPPA does not apply to Federal permitting and licensing (7 U.S.C. § 4208(a); TN708), including the issuance of an NRC license for a reactor, unless the reactor is to be constructed or installed on federally owned or leased land that falls under one of the above-described FPPA categories. If the reactor is to be located on such federally owned or leased land, then the NRC must consider the impacts of its proposed action in accordance with the FPPA. Even if the FPPA does not apply to an action, impacts on farmland still constitute an environmental consideration in the context of NEPA. The FPPA definitions include land mapped by the Natural Resources Conservation Service (NRCS) that feature soils possessing optimal physical and climatic properties for food and fiber production, even if the soils are not actually in agricultural use. Soils with a past history of disturbance for urban development are excluded from the farmland designations used in the FPPA.

3.1.2 Land Use Impacts

Most land use impacts from new ANRs would take place during the preconstruction and construction phases of the project. Evaluation requires consideration of the proposed safety-related facilities such as the nuclear island as well as non-safety-related facilities such as cooling towers, administration buildings, parking lots, switchyards, and any onsite and offsite pipelines, access roads, and transmission lines. Many smaller ANRs may be housed in one or a few small buildings on a site of less than a few acres and may lack cooling towers, switchyards, or offsite pipelines or transmission lines. Larger ANRs may require some or all of these support facilities and hence larger sites. Land uses are unlikely to substantially change during operation of an ANR, although minor land use changes could be necessary to refurbish or upgrade an ANR during its operational life (NRC 2013-TN2654).

3.1.2.1 Environmental Consequences of Construction

The staff's evaluation of land use impacts for building an ANR focused on land use changes being consistent with potentially applicable zoning and land use plans. The NRC staff identified four land use issues for analysis of the building of an ANR:

- onsite land use, especially the compliance of onsite land uses with zoning and land use plans and compatibility with adjacent and nearby land uses;
- offsite land use, especially the compatibility of offsite linear facilities such as pipelines and transmission lines with adjacent land uses;
- potential impacts on prime farmland, unique farmland, and farmland of State or local significance; and
- CZMA compliance for an ANR to be constructed or installed at a site within a designated coastal zone or at a site outside of a coastal zone but the construction or the installation of the reactor may have a reasonably foreseeable effect upon a coastal zone use or resource.

3.1.2.1.1 Onsite Land Use

The PPE and SPE assume that the ANR would require the dedication of a site no larger than 100 ac (40.5 ha) in area, within which site disturbance would affect no more than 30 ac (12 ha) of land permanently and no more than 20 ac (8.1 ha) of land temporarily. A site of that size would be large enough to accommodate any exclusion areas required under 10 CFR Part 100 (TN282). Use of a site of that size is unlikely to noticeably affect the availability of land for other purposes in most settings that are rural enough to meet the NRC siting criteria for a nuclear reactor in 10 CFR Part 100. Existing land use within the 30 ac (12 ha) of permanently disturbed land would be converted to industrial land use. The remainder of the site would be available for management as buffer land surrounding the new facilities and could be left in existing natural vegetation, agricultural land uses, or other uses that do not encroach on the exclusion area defined in 10 CFR Part 100 or interfere with reactor operations. As required by 10 CFR Part 100, no land uses unrelated to operation of the reactor would be allowed within the exclusion area, although conservation and management of natural vegetation would be allowed. The staff assumes that the 20 ac (8.1 ha) of temporarily disturbed land would be restored to regionally indigenous vegetation and then be available for other allowable land uses (if it is outside of the exclusion area defined in 10 CFR Part 100). The analysis recognizes that the entire 100 ac (40.5 ha) site would be unavailable for other industrial, commercial, residential, or recreational land uses until after the reactor is fully decommissioned.

The assumptions in Section 3.1.1 include compliance with applicable zoning ordinances and compatibility with any comprehensive land use plans adopted by local governments or planning agencies for the affected area. Zoning ordinances and land use plans are prepared to ensure that future development projects are compatible with other existing and reasonably foreseeable land uses in the area. The ordinances and plans also strive to ensure that adequate land is available for reasonably foreseeable competing land use demands. Land use plans are also often prepared by government agencies or contractors for national laboratory properties or military bases. These plans help ensure that new land uses are compatible with the facility's mission and conservation objectives. The assumption in Section 3.1.1 that the site is at least 0.5 mi (0.8 km) from existing residential areas further reduces the risk that the proposed new facilities might interfere with nearby residential properties. Constructing or installing a reactor of a size encompassed by the PPE and fitting onto a site featuring the size and disturbance limitations noted above would attract only a limited construction workforce for a temporary period of time, which should not noticeably alter land use patterns in the surrounding landscape.

The NRC staff has determined that onsite land use during the building of an ANR is a Category 1 issue. The staff concludes that as long as the assumptions outlined in Section 3.1.1 for the site are met, then impacts from building an ANR can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- The proposed project, including any associated land uses, complies with NRC siting regulations in 10 CFR Part 100 (TN282).
- The site size is 100 ac (40.5 ha) or less.
- The permanent footprint of disturbance includes 30 ac (12 ha) or less of vegetated lands, and the temporary footprint of disturbance includes no more than an additional 20 ac (8.1 ha) or less of vegetated lands.
- The proposed project complies with the site's zoning and is consistent with any relevant land use plans or comprehensive plans.
- The site would not be situated closer than 0.5 mi (0.8 km) to existing residential areas or 1.0 mi (1.6 km) to sensitive land uses such as Federal, State, or local parks; wildlife refuges; conservation lands; Wild and Scenic Rivers; or Natural Heritage Rivers.
- The site does not have a history of past industrial use capable of leaving a legacy of contamination requiring cleanup to protect human health and the environment.
- The total wetland loss from use of the site, including use of any offsite ROWs, would be no more than 0.5 ac (0.2 ha).
- BMPs for erosion, sediment control, and stormwater management would be used.
- Compliance with any mitigation measures established through zoning ordinances, local building permits, site use permits, or other land use authorizations.

3.1.2.1.2 Offsite Land Use

A project meeting the assumptions outlined in Section 3.1.1 would establish no more than 1 mi (1.6 km) of new offsite ROW that is no more than 100 ft (30.5 m) in width, although unlimited offsite linear development within or adjacent to existing ROWs or roadway is assumed. Any required acquisition of land or easements is also assumed to be obtained from willing landowners without resorting to use of eminent domain[6]. Development of 1 mi (1.6 km) of ROW that is no more than 100 ft (30.5 m) in width would result in conversion of approximately 12.1 ac (4.9 ha) of existing land cover to land managed for a utility ROW. Forest cover, whether natural or managed, would be removed and converted to managed grassland, scrubland, or other land cover compatible with management of the ROW. It might be possible to continue the current use of some land in the ROW during and after the utility line construction or installation for cropland, pasture, orchards, or range, or for outdoor recreation or conservation, although some land uses would be permanently converted to build access roads, transmission towers, or other facilities.

[6] The NRC would not engage in eminent domain on behalf of an applicant or licensee.

Establishment of new ROWs across existing land uses could fragment properties and interfere with existing or potential uses, but those effects would be minimized in most settings by the 1 mi (1.6 km) limitation on new ROW length not co-located with or adjoining existing ROWs or roadways. The presence of ROWs and especially overhead transmission conductors could interfere with some agricultural operations such as aerial pesticide spraying and pivot irrigation. The presence of the ROW would not likely interfere with abutting or nearby land uses, although it could be perceived as undesirable when abutting or close to residential, recreational, or educational land uses.

Other than in residential areas, use of existing ROWs has little potential for the types of land use impacts described above for establishing new ROWs. Building utilities such as transmission lines within existing ROWs, including existing roadway ROWs, would not expose additional existing land uses to the presence of a ROW. Widening existing ROWs to accommodate new offsite utilities would also not fragment other land uses and is much less likely to interfere with other land uses or be perceived as incompatible. Additional land might be affected by widening existing ROWs, but the widened ROWs would not fragment additional land uses or expose new land uses to the presence of adjacent transmission lines or other linear utilities. However, the staff recognizes that widening an existing ROW, or even new work within an existing ROW, could have impacts in residential areas, where a consideration of site-specific conditions could be necessary to determine potential effects on residential properties.

The NRC staff has determined that offsite land use during construction of an ANR is a Category 1 issue. The staff concludes that as long as the PPE and SPE values and assumptions outlined in Section 3.1.1 for the offsite ROWs are met, the impacts of building offsite linear features associated with an ANR can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length.
- No new offsite ROW would be situated closer than 0.5 mi (0.8 km) to existing residential areas or sensitive land uses such as Federal, State, or local parks; wildlife refuges; conservation lands; Wild and Scenic Rivers; or Natural Heritage Rivers.
- No existing ROWs in residential areas would be used or widened to accommodate project features.
- No ROW has a history of past industrial use capable of leaving a legacy of contamination requiring cleanup to protect human health and the environment.
- The total wetland loss from use of the entire project, including use of the site and any offsite ROWs, would be no more than 0.5 ac (0.2 ha).
- BMPs for erosion, sediment control, and stormwater management would be used.
- There would be compliance with any mitigation measures established through zoning ordinances, local building permits, site use permits, or other land use authorizations.

3.1.2.1.3 Impacts on Prime and Unique Farmland

The PPE and SPE assume that the site is no larger than 100 ac (40.5 ha) and does not contain any prime or unique farmland, or other farmland of statewide or local importance, as defined in the FPPA (7 U.S.C. §§ 4201 *et seq.*; TN708). The assumptions do, however, allow for the presence of prime or unique farmland on the site as long as the site does not abut other land actively managed for agricultural purposes and does not occur in a predominantly agricultural landscape.

Loss of less than 100 ac (40.5 ha) of land optimal for agricultural use is unlikely to substantially affect regional agricultural production if the affected land is not positioned close to other agricultural land. Building transmission lines and other structures bounded by the PPE and SPE in offsite ROWs is also unlikely to adversely affect the use of farmland, including farmland regulated under the FPPA. Establishing up to 1 mi (1.6 km) of new offsite ROW would affect no more than approximately 12.1 ac (4.9 ha) of farmland. Additional farmland could be affected by widening ROWs but would not experience the effects of fragmentation by the presence of new utility structures. Not all of the affected land would necessarily be excluded from agricultural use because farming could continue under transmission conductors and over the top of backfilled pipeline and buried utility trenches. Some of the soils in the ROW could be disturbed to excavate trenches or build towers or access roads, thereby permanently altering the physical properties of the soils that make them optimal for agricultural use. However, the small area of disturbance allowed within the PPE and SPE ensures that the agricultural effects would be low.

The NRC staff has determined that prime and unique farmland during construction of an ANR is a Category 1 issue. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- The site size is 100 ac (40.5 ha) or less.
- The site does not contain any prime or unique farmland or other farmland of statewide or local importance; or the site does not abut any agricultural land and is not situated in a predominantly agricultural landscape.

The generic analysis can be relied on without conducting any mitigation measures. If the site includes any federally owned land, however, the agency charged with managing the land must demonstrate compliance with the FPPA by consulting with the NRCS, which may specify mitigation measures. However, the FPPA exempts actions not affecting federally owned land, even if the actions require permits or involve the acceptance of funding from Federal agencies.

3.1.2.1.4 Coastal Zone and Compliance with the Coastal Zone Management Act

The NRC staff has determined that impacts on the coastal zone during the construction or installation of an ANR is a Category 1 issue. The NRC cannot license an activity affecting the designated coastal zone without the applicant documenting that it has received a consistency determination from the applicable State agency. The State agency will not issue a consistency determination under the Act unless the potential impacts from the activity on the coastal zone are shown to be minimal or otherwise appropriately mitigated. The staff expects that only minimal impacts on the coastal zone will result from the construction/installation and operation of a reactor meeting the PPE criteria on a site meeting the SPE criteria. The staff concludes that any potential impacts on the coastal zone would be SMALL provided the applicant receives a duly authorized CZMA consistency determination from the applicable State agency. The staff relied on the following PPE and SPE assumption to reach this conclusion:

- The site is not situated in any designated coastal zone, or the applicant can demonstrate that the affected state(s) have or will issue a consistency determination or other indication that the project complies with the Coastal Zone Management Act.

3.1.2.2 Environmental Consequences of Operation

The NRC staff recognizes that the greatest potential for adverse land use impacts is during construction, when existing land cover at the site is altered to build the reactor and supporting facilities. Nevertheless, the staff identified two environmental issues for analysis of land use impacts from operation of an ANR:

- onsite land use, especially possible land use changes on the site during operation of a reactor; and
- offsite land use, especially land use changes within ROWs during operation of offsite linear facilities such as pipelines and transmission lines.

Once the project has been built, further impacts on prime and unique farmland or the coastal zone are not a potential concern.

3.1.2.2.1 Onsite Land Use

Once a site has been developed with a nuclear reactor, onsite land use would not substantially change over the course of operations. It is possible that small areas of land cover within the site could be temporarily or permanently disturbed as facilities are maintained or refurbished or to accommodate additional support facilities such as expanded parking lots. However, the entire site would still be dedicated to the reactor throughout its operational life and the overall character of the site would remain unchanged. Land use restrictions in the exclusion areas would remain restricted in accordance with 10 CFR Part 100 (TN282) throughout operations. The licensee may initiate new uses of other land within the site, such as management of undeveloped land for agriculture or conservation or for other land uses not regulated by the NRC, but those actions would not constitute substantial land use changes within a site not exceeding the PPE of 100 ac (40.5 ha). The staff has already determined on page 4-3 and 4-5 of the continued storage GEIS that land use impacts from building and operating additional onsite short-term and long-term nuclear fuel storage facilities during the operational life of the reactor would be SMALL (NRC 2014-TN4117). The continued storage GEIS recognized that only small areas of land would be needed to build and operate the facilities and could be accommodated within previously disturbed lands on operating reactor sites. The analysis presented above is also corroborated by page 4-7 of the License Renewal GEIS where the staff concluded that onsite land use impacts from operation of the existing large LWRs would be SMALL (NRC 2013-TN2654).

The NRC staff has determined that onsite land use during operation of an ANR is a Category 1 issue. The staff concludes that, as long as the PPE and SPE values and assumptions outlined in Section 3.1.1 for the site are met, the land use impacts from operating an ANR can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- The proposed project, including any associated land uses, complies with NRC siting regulations in 10 CFR Part 100.
- The site size is 100 ac (40.5 ha) or less.
- If needed, cooling towers would be mechanical draft, not natural draft; less than 100 ft (30.5 m) in height; and equipped with drift eliminators.
- Any makeup water for the cooling towers would be fresh water (less than 1 ppt salinity).

- BMPs for erosion, sediment control, and stormwater management would be used.

3.1.2.2.2 Offsite Land Use

Once a nuclear reactor is built and begins operation, substantial new offsite land use changes are unlikely. The staff has determined that the potential for offsite land use impacts from continued operation of already-built reactors is minimal (NRC 2013-TN2654). It would be possible to continue use of some land in offsite ROWs for cropland, pasture, orchards, or range, or for outdoor recreation or conservation. The License Renewal GEIS described studies in which the presence of overhead electrical transmission conductors somewhat depressed the yield of cotton, but not rice or soybeans, planted underneath, and attributed the effects either to the presence of electromagnetic fields (EMFs) or physical interference by the conductors with aerial pesticide spraying (NRC 2013-TN2654). Landowners are, however, compensated for utility easements crossing their land (unless the utility buys the land underlying the ROW outright), and the indicated yield suppressions would not limit economically viable agriculture.

Operation of cooling towers can result in fogging, icing, and salt drift that interfere with offsite land uses, including agricultural and residential uses. As reported in the original License Renewal GEIS, a review for possible visible vegetation damage from operation of natural draft cooling towers at eight nuclear plants across the United States revealed no damage, and a review for possible visible vegetation damage from 10 nuclear plants that have mechanical draft cooling towers revealed no damage more than 500 ft (152 m) from the towers (NRC 1996-TN288). The PPE and SPE assume that natural draft cooling towers, which are taller and hence capable of depositing drift farther away from the towers, would not be used; however, the fact that even they have been shown to result in minimal drift effects supports an assertion that drift impacts have only minimal potential to affect land outside of a power plant site. Furthermore, the PPE and SPE assume that there are no existing (at the time of licensing) residential properties within 0.5 mi (0.8 km) of the site, including any cooling towers, thereby ensuring conservatism with respect to the potential for drift-related impacts. The analysis presented above is also corroborated by the current License Renewal GEIS in which the staff concluded that onsite land use impacts from operation of the existing large LWRs would be SMALL (NRC 2013-TN2654).

Operation of any new ANR would result in increased employment in the surrounding region, possibly requiring the use of land to provide additional housing and services. However, accommodating any increase in regional population growth for operation of an ANR, as outlined in the PPE and SPE for the socioeconomic analysis in Section 3.12, is unlikely to result in enough increased regional development by housing and support services to lead to noticeable adverse competition for offsite land resources in most economic regions.

The staff has determined that offsite land use during operations of an ANR is a Category 1 issue. The staff concludes that as long as the PPE and SPE values and assumptions outlined in Section 3.1.1 for the offsite ROWs are met, the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length.
- BMPs for erosion, sediment control, and stormwater management would be used (wherever land is disturbed during the course of ROW management).

3.2 Visual Resources

3.2.1 Baseline Conditions and PPE/SPE Values and Assumptions

Baseline conditions influencing visual impacts include land cover and topography on the proposed site and surrounding landscape, weather patterns and conditions, the height of any existing structures and vegetation on the property, the proximity to other uses of the site, the extent of viewsheds (the area visible from a location sensitive to visual impacts, such as a residence or a park), and other landscape characteristics. Visual effects depend greatly on the setting. A nuclear power plant that might be visually obtrusive in residential or tourist settings might not raise any visual objections in areas where industrial or power generation facilities are common. Among the various visual impact assessment methodologies developed by Federal agencies, one of the best known is the Visual Contrast Rating process, which emphasizes the visual contrast between development actions and their surroundings (BLM 1986-TN6403).

In developing the values and assumptions in the PPE and SPE pertaining to visual resources, the staff relied upon the information and analyses contained in multiple new reactor EISs prepared between 2005 and 2017, the License Renewal GEIS (NUREG-1437; NRC 2013-TN2654), other past NRC EISs, and common elements of State and local land use regulation. In each case, staff has selected a value or parameter that will ensure a minimal visual impact from construction and operation of an ANR after considering all available information and leveraging professional judgment and expertise. The staff's assumptions that support the PPE and SPE are described below.

Most of the assumptions relevant to visual impacts are also ones outlined in Section 3.1.1 for land use. In addition, the staff assumes a maximum building and structure height of 50 ft (15.2 m) (except 200 ft [61 m] for meteorological towers and 100 ft [30.5 m] for transmission poles/towers and mechanical draft cooling towers). The staff assumes that projects would not include natural draft cooling towers, which are typically several hundred feet in height and therefore visible from considerable distances away from the site in most settings, depending on factors such as vegetation and topography. The staff also assumes that project structures would not be visible from Federal or State parks or wilderness areas designated as Class 1 under Section 162 of the Clean Air Act (42 U.S.C. § 7472; TN6954) or a Wild and Scenic River, a Natural Heritage River, or a river of similar State designation. The staff acknowledges that many proposed facilities may not be completely invisible at all times from all sensitive locations such as residences or parks, even if meeting all of the values and assumptions noted above. The visibility of structures from places on or eligible for listing on the National Register of Historic Places (NRHP) is addressed in Section 3.9.

3.2.2 Visual Resources Impacts

Context plays a key role in the evaluation of visual impacts; the appearance of industrial structures in established industrial settings is generally better tolerated than the same structures in pastoral or residential settings. Taller or larger structures, especially structures of a type not previously occurring on the landscape, tend to affect the visual properties of landscapes more than other structures. For example, for the proposed Greene County Nuclear Power Plant, cancelled in the 1980s because of opposition due to aesthetic concerns, greater opposition was recorded among members of the public to a natural draft cooling tower than to a cement plant, an industrial feature already existing in the generally rural landscape (Petrich 1982-TN6810). Evaluators of visual impacts often speak of effects in terms of viewsheds, defined as the landscape that can be directly seen under favorable atmospheric conditions, from a viewpoint or along a transportation corridor (BLM 1984-TN5536). Many ANRs meeting the assumptions in the PPE and SPE may consist only of, or be housed in, smaller, lower structures compared to the larger, commercial reactors that have been previously licensed by the NRC. Such smaller, lower structures meeting the values and assumptions would have little potential for visual impacts on viewsheds, whether or not those viewsheds contain existing nuclear facilities or other power generation or industrial facilities.

3.2.2.1 Environmental Consequences of Construction

The NRC staff identified two environmental issues related to visual resources for building an ANR:

- visual impacts from structures on and in the vicinity of the site, and
- visual impacts from transmission lines.

3.2.2.1.1 Visual Impacts in Site and Vicinity

Projects meeting the values and assumptions outlined in Section 3.2.1 would not likely be visually obtrusive, even from sensitive features such as residences, parks, and areas designated for conservation. Not being visually obtrusive does not necessarily imply incapable of being seen, especially from a distance. Power generation facilities are however industrial in appearance and would therefore contrast strongly with most natural settings found on greenfield (previously undeveloped) sites, although they would not likely contrast markedly if built in close proximity to existing nuclear or other power plants or other industrial facilities. In landscapes that feature substantial forest cover, structures would likely only be visible close to the site. The structures might be visible from distant high points or ridges but not be a prominent visual feature. The structures would be visible for greater distances in open landscapes characterized predominantly as agricultural, grassland, or scrub cover, but their visual prevalence would decrease with distance. In a completely open landscape such as the ocean or a grassland with no trees, the horizon visible to a standing person 6 ft (1.8 m) in height would be approximately 3 mi (4.8 km) away; even at distances of only 1 mi (1.6 km), structures would be visible although not prominent. Most landscapes, however, contain hills, trees, and other features that soften the appearance of structures relative to a completely open, flat landscape. Little or no change in the overall visual character of most landscapes would occur if structures meeting the assumed building height values noted in Section 3.2.1 were built close to existing industrial facilities such as existing nuclear generation facilities or other power plants, or in industrial parks or industrially developed areas of military bases. The structures could be aesthetically detrimental to residences or parks situated close to the site, but the structures would not likely alter the aesthetic quality of residences or parks more than 1 mi (1.6 km) from the site.

The staff has determined that visual impacts on the site and vicinity are a Category 1 issue. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- The site size is 100 ac (40.5 ha) or less.
- The site would not be situated closer than 0.5 mi (0.8 km) to existing residential areas or 1 mi (1.6 km) to sensitive land uses such as Federal, State, or local parks; wildlife refuges; conservation lands; Wild and Scenic Rivers; or Natural Heritage Rivers.
- The maximum proposed building and structure height is no more than 50 ft (15.2 m), except that the maximum height is 200 ft (61 m) for proposed meteorological towers and 100 ft (30.5 m) for transmission line poles/towers and mechanical draft cooling towers.

- The proposed project structures would not be visible from Federal or State parks or wilderness areas designated as Class 1 under Section 162 of the Clean Air Act (42 U.S.C. § 7472; TN6954); or as a Wild and Scenic River, a Natural Heritage River, or a river of similar State designation.

Note that the generic analysis assumes both that the site and ROWs are not within 1 mi (1.6 km) of exceptionally sensitive areas such as wilderness areas and special-status rivers and that the proposed new structures would not be visible from these sensitive areas. No visual simulation or other projection of visual effects is needed to corroborate this conclusion as long as the relevant PPE and SPE values and assumptions are met. If the PPE and SPE values and assumptions are met, the applicant does not need to submit visual simulations (such as an artistic rendering) or other projections of visual effects. Optional mitigation measures that might be considered include planting trees, earthen berms, walls, or other landscaping activities around any part of the perimeter of the site.

3.2.2.1.2 Visual Impacts from Transmission Lines

The assumptions in the PPE and SPE regarding transmission line ROWs and structures (poles or towers) ensure that the visual effects of any new transmission lines serving an ANR project would be minimal and that the visual integrity of sensitive features such as parks, wilderness areas, conservation lands, Wild and Scenic Rivers, and American Heritage Rivers would not be compromised. Transmission towers, poles, and conductors are visually prominent features that can contrast with and detract from the aesthetic beauty of most non-industrial landscapes. Using Bureau of Land Management terminology (BLM 1986-TN6403), these features can have “moderate” contrast with most natural landscapes. In certain cases, larger steel-lattice transmission towers or tall steel poles may have “strong” contrast relative to some natural landscapes.

However, overhead electric lines, including overhead transmission lines carried on various types of towers and poles, are a common feature in all but the most pristine of landscapes. In many landscapes, new transmission lines may be routed to follow existing transmission line ROWs and thereby avoid introducing such structures to pristine areas. Overhead electric lines on the sides of roadways are a common visual occurrence expected by most drivers. The clearing of new ROWs across forested landscapes can create a visually noticeable notch or strip that breaks the lines of the forest canopy and can be visible from substantial distances, but the limited length of new ROWs assumed under the PPE limits the extent of any such visual effects.

The NRC staff has determined that visual impacts from building transmission lines are a Category 1 issue. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length.
- No transmission line structures (poles or towers) would be over 100 ft (30.5 m) in height.
- The new offsite ROWs would not be situated closer than 1 mi (1.6 km) to existing residential areas or sensitive land uses such as Federal, State, or local parks; wildlife refuges; conservation lands; Wild and Scenic Rivers; or Natural Heritage Rivers.
- Any proposed new structures on offsite ROWs would not be visible from Federal or State parks or wilderness areas designated as Class 1 under Section 162 of the Clean Air Act

(42 U.S.C. § 7472; TN6954); or as a Wild and Scenic River, a Natural Heritage River, or a river of similar State designation.

If the PPE and SPE values and assumptions are met, the applicant does not need to submit visual simulations (such as an artistic rendering) or other projections of visual effects. The generic analysis can be relied on without conducting any mitigation measures, but possible mitigation measures to consider might include preserving or establishing tree screens at road crossings or along the edges of ROWs, or painting steel towers or poles brown or dark green.

3.2.2.2 Environmental Consequences of Operation

The NRC staff identified one environmental issue related to visual resources for operation of an ANR:

- visual impacts during operations.

3.2.2.2.1 Visual Impacts During Operations

Once structures are built, whether onsite or offsite, they are established features of the landscape. Operation of the structures for their intended purpose once built does not substantially alter their appearance. If there is a need during the operational life to refurbish structures or build new support structures on the site, those changes would most likely not substantially contrast with the already-developed industrial appearance of the site. Operating cooling towers release visible fog-like plumes, but any such plumes from mechanical draft cooling towers meeting the values and assumptions in Section 3.2.1 would likely only be visible from areas close to the site. An ANR that meets the values and assumptions would not include the tall hyperbolic natural draft cooling towers whose plumes can be visible from substantial distances. Section 3.5.2.2.4 analyzes the potential for drift from cooling towers from ANRs to injure vegetation and concludes that possible effects are localized to the immediate location of the cooling towers and would be minimal. The staff has determined that visual impacts from building transmission lines are a Category 1 issue. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- The site would not be situated closer than 1 mi (1.6 km) to existing residential areas or sensitive land uses such as Federal, State, or local parks; wildlife refuges; conservation lands; Wild and Scenic Rivers; or Natural Heritage Rivers.
- The maximum proposed building and structure height would be no more than 50 ft (15.2 m), except that the maximum height would be 200 ft (61 m) for proposed meteorological towers and 100 ft (30.5 m) for proposed transmission line poles/towers and proposed mechanical draft cooling towers.
- The proposed project structures would not be visible from Federal or State parks or wilderness areas designated as Class 1 under Section 162 of the Clean Air Act (42 U.S.C. § 7472; TN6954); or as a Wild and Scenic River, a Natural Heritage River, or a river of similar State designation.
- If needed, cooling towers would be mechanical draft, not natural draft; less than 100 ft (30.5 m) in height; and equipped with drift eliminators.
- Any makeup water for the cooling towers would be fresh water (less than 1 ppt salinity).

3.3 Meteorology and Air Quality

3.3.1 Baseline Conditions and PPE/SPE Values and Assumptions

Baseline conditions influencing potential air quality impacts associated with construction and operation of a new nuclear reactor include climatology, regional meteorology, atmospheric stability, the potential for severe weather events, and regional air quality. The atmospheric processes that occur as a result of these baseline conditions determine the transport of routine air emissions during construction and routine air emissions or accidental releases during operation, and their effects on regional air quality. Impacts on regional air quality may result not only from construction and operation at the plant site but also from construction and operations at offsite land, which could include construction of intake and discharge structures and transmission lines, pipelines, or heavy-haul roads. Activities that could potentially cause air emissions include the following:

- land clearing and material processing, handling, and removal
- excavation for structures, utilities, access roads, and other infrastructure, including transmission lines
- material replacement (e.g., subsurface preparation and concrete pouring and paving)
- driving piles and erecting structures
- construction machinery operation and maintenance
- truck deliveries of reactor modules, supplies, and materials
- soil transport and temporary stockpiling
- workforce vehicle use during daily commuting to and around the site and during refueling outages
- periodic testing of standby power generators and other support equipment
- operation of cooling towers and auxiliary systems
- operation of transmission lines
- refurbishments activities.

In developing the values and assumptions in the PPE and SPE pertaining to air quality, the staff relied upon the information and analyses contained in multiple new reactor EISs prepared between 2005 and 2017, the License Renewal GEIS (NRC 2013-TN2654), and common elements of State and local regulations. Some values and assumptions made in this section of the ANR GEIS involve parameters and values that are developed based on previous staff environmental reviews or are the subject of Federal and State regulations, and some have been appropriately scaled down to account for the size and technology differences between large LWRs and ANRs. In every case, the staff has selected a value or parameter that will ensure a minimal impact on local meteorology and air quality from construction and operation of an ANR after considering all available information and leveraging professional judgment and expertise.

The PPE and SPE values relevant to air quality assume that the proposed plant site would be no larger than 100 ac (40.5 ha), within which site disturbance would affect no more than 30 ac (12 ha) of land permanently and no more than 20 ac (8.1 ha) of additional land temporarily, and offsite ROWs for transmission lines, pipelines, or access roads would be no longer than 1 mi

(1.6 km); however, these values and assumptions allow for unlimited additional mileage for linear features built within existing ROWs or directly adjacent to existing ROWs or public highways. The staff has concluded that the values stated above used for the land use analysis (as discussed in Section 3.1) will also apply for the analysis of air quality for determining impacts during building activities. The PPE and SPE values assume the construction and operation workforce traffic would not change the level of service (LOS) determination for local road systems, which is discussed in Section 3.12. The staff has concluded that this PPE/SPE value used for socioeconomics would also apply for the analysis of air quality for determining impacts from traffic during building and operation. The PPE and SPE values assume plant cooling would be accomplished by mechanical draft cooling towers, if needed, which are equipped with drift eliminators, and are 100 ft (30.5 m) in height or less, and the makeup water would be fresh (with a salinity less than 1 ppt). These values are based on previous license renewal and new reactor environmental reviews, as discussed in Section 3.5, and will be used to determine the air quality impacts from the operation of cooling towers. Lastly, for plants using cooling towers, the air quality section also relies on an assumption that there are no existing residential areas within 0.5 mi (0.8 km) of site. This assumption is based on previous new reactor reviews analyses.

New reactor siting also includes consideration of mandatory Class I Federal areas where visibility is an important value (40 CFR 81.428-TN5047). Although there is little likelihood that activities at an ANR site could adversely affect air quality and air quality-related values (e.g., visibility or acid deposition) in Class I areas, the PPE and SPE assumes that completed structures would not be located within 1 mi (1.6 km) of areas designated as Class I under Section 162 of the Clean Air Act (42 U.S.C. § 7472-TN6954).

Air quality is generally measured by the amount of pollution present in the atmosphere. The U.S. Environmental Protection Agency (EPA) has set National Ambient Air Quality Standards (NAAQSs) for six criteria pollutants, including sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), particulate matter with a mean aerodynamic diameter of 10 μm or less (PM_{10}), particulate matter with a mean aerodynamic diameter of 2.5 μm or less ($PM_{2.5}$), and lead (Pb). Primary NAAQSs specify maximum ambient (outdoor air) concentration levels of the criteria pollutants with the aim of protecting public health with an adequate margin of safety. Secondary NAAQSs specify maximum concentration levels with the aim of protecting public welfare. States can have their own State Ambient Air Quality Standards (SAAQSs). SAAQSs must be at least as stringent as the NAAQSs and can include standards for additional pollutants. If a State has no standard corresponding to one of the NAAQSs, the NAAQSs apply (40 CFR Part 50-TN1089).

An area where criteria air pollutants are within NAAQS levels is referred to as an attainment area, and an area where criteria air pollutants exceed NAAQS levels is called a nonattainment area (40 CFR Part 81-TN255). In some cases, the EPA is not able to determine an area's status after evaluating the available information and those areas are designated as "unclassifiable" (EPA 2020-TN6772). Previous nonattainment areas where air quality has been improved to meet the NAAQSs are redesignated maintenance areas and are subject to an air quality maintenance plan. Locations of EPA-Designated Nonattainment and Maintenance Areas for each criteria pollutant, as of July 31, 2021, are available at https://www3.epa.gov/airquality/greenbook/ancl.html (EPA 2021-TN7102).

If a proposed project is in a nonattainment or maintenance area, the General Conformity Rule (40 CFR Part 93-TN2495) ensures that Federal actions comply with the NAAQSs (EPA 2020-TN6773). In accordance with Section 176(c) of the Clean Air Act (42 U.S.C. § 7506-TN4856) and the General Conformity Rule, the NRC must analyze the proposed permit action for conformity applicability; therefore, the NRC must demonstrate that the air emissions associated with activities within its authority would conform to the appropriate state implementation plans (SIPs), which are developed to improve or maintain air quality in designated nonattainment and maintenance areas. The EPA has established *de minimis* levels for each criteria pollutant (EPA 2020-TN6774). If a project is located in a nonattainment or maintenance area and the project's emissions are estimated to exceed the *de minimis* levels for any criteria pollutant as demonstrated in an applicability analysis, a conformity determination must be performed. When the total direct and indirect emissions from the proposed plant are below the *de minimis* levels, the project/action would not be subject to a conformity determination (EPA 2020-TN6773). The first step in determining whether an action conforms is to perform an applicability analysis to determine whether the action is exempt or has total net direct and indirect emissions below the *de minimis* levels. The applicability analysis must be documented. If the applicability analysis demonstrates that the total net direct and indirect emissions exceed the *de minimis* levels, the agency must prepare a written conformity determination for each pollutant for which the emissions caused by a proposed Federal action would exceed the *de minimis* levels. A conformity determination, if needed, must be completed before the action is taken. The PPE and SPE assume the proposed plant could be located in either attainment, nonattainment, or maintenance areas, but if located in a nonattainment or maintenance area the criteria pollutant(s) emitted would be less than the *de minimis* levels set by the EPA or State.

Some plant equipment such as diesel generators and cooling towers may emit some hazardous air pollutants (HAPs) during operation. The EPA coordinates with State, local, and Tribal governments to reduce the air emissions of almost 200 toxic air pollutants to the environment. The PPE assumes that these emissions are within limits established by the EPA or State.

Gases found in the Earth's atmosphere that trap heat and play a role in the Earth's climate are collectively termed GHGs. GHGs include carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); water vapor (H_2O); and fluorinated gases, such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Climate change research indicates that the cause of the Earth's warming over the last 50 years is the buildup of GHGs in the atmosphere, resulting from human activities (GCRP 2018-TN5847). The EPA has determined that GHGs "may reasonably be anticipated both to endanger public health and to endanger public welfare" (74 FR 66496-TN245). Climate change is a subject of national and international interest because of how it changes the affected environment. Commission Order CLI-09-21 (NRC 2009-TN6406) provides the current direction to the NRC staff to include the consideration of the impacts of the emissions of CO_2 and other GHGs that drive climate change in its environmental reviews for major licensing actions.[7] Estimates of GHG emissions from a reference 1,000 MWe reactor were developed using the approach in Interim Staff Guidance COL/ESP-ISG-026 (NRC 2014-TN3767), Interim Staff Guidance on Environmental Issues Associated with New Reactors (NRC 2014-TN3768), and also considered the Council on Environmental Quality's (CEQ's) 2016 final guidance on considering GHGs emissions and effects of climate changes in NEPA reviews (CEQ 2016-TN4732) and are presented in in Appendix H of this GEIS.

GHGs are emitted from equipment and vehicles used during building, operation, the uranium fuel cycle, transportation of fuel and waste, and decommissioning including extended

[7] The Commission stated that "the Staff's analysis for reactor applications should encompass emissions from the uranium fuel cycle as well as from construction and operation of the facility to be licensed." (CLI-09-21 [NRC 2009-TN6406], at 6)

SAFSTOR. Appendix H estimates GHG emissions for life-cycle phases for a reference 1,000 MWe reactor with an 80 percent capacity factor. The calculation of GHG emissions for an ANR assumes two 1,000 MW(e) ANRs could be installed on the same site, based on previous applications for sites with two or more new LWRs (NRC 2015-TN6438, NRC 2016-TN6434, NRC 2019-TN6136). GHG emission estimates for building, operating, and decommissioning, including extended SAFSTOR for a two-unit ANR plant would be based on the plant's physical size, and the estimates for these stages are assumed to be twice the value of the reference 1,000 MWe reactor emission estimates in Appendix H. However, GHG emission estimates for the uranium fuel cycle and transportation of fuel and waste would be based on the anticipated efficiency of the proposed plant. For example, the Final EIS for Turkey Point Units 6 and 7 scaled GHG emissions from the fuel cycle upward by a factor of 2.6 (NRC 2016-TN6434), and the Final EIS for the Public Service Enterprise Group (PSEG) (NRC 2015-TN6438) scaled GHG emissions from the fuel cycle upward by a factor of 3, based on plant efficiencies greater than the 80 percent assumption in Appendix H. To provide bounding values, the estimates for GHG emissions for uranium fuel cycle activities and fuel and waste transport associated with an ANR were calculated using three times the values for the reference 1,000 MWe reactor in Appendix H.

Based on the Interim Staff Guidance COL/ESP-ISG-026 (NRC 2014-TN3767) approach used in several new reactor EISs, the reference 1,000 MWe reactor emissions described in Appendix H, and the scaling factors discussed above, the PPE/SPE value for GHGs emitted by equipment and vehicles during the 97-year GHG life-cycle period for an ANR would be equal to or less than 2,534,000 MT of CO_2(e),[8] as shown in Table 3-1.

Table 3-1 PPE Values for GHG Emissions

Source	Total Emissions (Reference 1,000 MW Reactor) (MT CO_2(e))	Activity Duration (yr)	Scaling Factor	PPE Emission Values (Two 1,000 MW ANRs) (MT CO_2(e))
Construction Equipment [(a)]	39,000	7	2	78,000
Construction Workforce [(a)]	43,000	7	2	86,000
Plant Operations [(b)]	181,000	40	2	362,000
Operations Workforce [(b)]	136,000	40	2	272,000
Uranium Fuel Cycle [(b)]	540,000	40	3	1,620,000
Fuel and Waste Transportation [(b)]	14,000	40	3	42,000
Decommissioning Equipment [(c)]	19,000	10	2	38,000
Decommissioning Workforce [(c)]	8,000	10	2	16,000
SAFSTOR Workforce	10,000	40	2	20,000
TOTAL[(d)]	990,000	97		2,534,000

(a) Activities are assumed to occur over the same timeframe
(b) Activities are assumed to occur over the same timeframe
(c) Activities are assumed to occur over the same timeframe
(d) Results are rounded to the nearest 1,000 MT CO_2(e)

[8] A measure to compare the emissions from various GHGs on the basis of their global warming potential (GWP), defined as the ratio of heat trapped by one unit mass of the GHG to that of one unit mass of CO_2 over a specific time period.

3.3.2 Air Quality Impacts

Most air quality impacts from new ANRs would take place during the building of the project. Impacts would occur primarily during site preparation and the building of facility components such as the nuclear island and facilities such as cooling towers, administration buildings, parking lots, switchyards, and any onsite and offsite pipelines, access roads, and transmission lines. Air emissions from vehicles and stationary support equipment, such as auxiliary equipment, would occur during operation and would increase periodically during equipment testing and during refueling outages, depending on the plant design. Air emissions also result from operation of the cooling towers. Small amounts of ozone and NOx are produced by transmission lines during operation.

The NRC staff evaluated the total GHG emissions for a proposed ANR. Equipment and vehicles used during building, operation, uranium fuel cycle activities, transportation of fuel and waste, and decommissioning activities would emit a total of 2,534,000 MT of CO_2(e) over the assumed 97-year GHG life-cycle of the plant (see Table 3-1). For comparison, in 2019, total gross annual U.S. GHG emissions were 6,577.2 million metric tons (MMT) of CO_2(e), of which 5,410.8 MMT CO_2(e) were from the energy sector (EPA 2021-TN6965). Assuming this annual rate for energy sector emissions is constant over the same 97-year time span as the operation of the plant, the total emissions from the U.S. energy sector would be 525 billion metric tons (BMT) CO_2(e). Based on these values and assumptions, estimated annual GHGs emissions from the plant life-cycle would be about 0.0005 percent of GHG emissions from the U.S. energy sector over the same period.

The staff has determined that the contribution of GHG emissions from total plant life-cycle activities to national emissions is a Category 1 issue. The staff concludes that, as long as the PPE assumption associated with GHG emissions is met, the GHG impacts from building, operating, conducting the fuel cycle, transporting fuel and waste, and decommissioning of an ANR can be generically determined to be SMALL. The staff relied on the following PPE assumption to reach this conclusion:

- GHGs emitted by equipment and vehicles during the 97-year ANR GHG life-cycle period would be equal to or less than 2,534,000 MT of CO_2(e). Appendix H of this GEIS contains the staff's methodology for developing this value, which includes emissions from construction, operating, and decommissioning. As long as this total value is met, the impacts for the life-cycle of the project and the individual phases of the project are determined to be SMALL.

The generic analysis can be relied on without applying any mitigation measures. GHG impacts associated with building and operation (including the fuel cycle and transportation of fuel and waste) are discussed below. Air quality impacts including GHG emissions for decommissioning are evaluated in Section 3.16 of this GEIS.

3.3.2.1 Environmental Consequences of Construction

The staff's evaluation of impacts on air quality during building activities focused on emissions from construction equipment and vehicles, and fugitive dust generation. Major activities include earthmoving, open burning, placement of land fill, concrete batch plant operation, facility construction, operation of temporary boilers, and emission of vehicular exhaust. Emissions from these activities would include PM, CO, oxides of nitrogen (NOx), SO_2, and volatile organic compounds (VOCs). Building activities at the site of an ANR would result in temporary impacts on local air quality.

The NRC staff identified two air quality issues for analysis of construction of an ANR:

- emissions of criteria pollutants and fugitive dust to the atmosphere in relation to regional air quality conditions and NAAQSs for criteria pollutants; and
- emissions of GHGs.

3.3.2.1.1 Emissions of Criteria Pollutants and Dust during Construction

Equipment and vehicle emissions from building activities including passenger cars and light duty trucks of the construction workforce, delivery trucks, and heavy equipment (e.g., excavators, bulldozers, heavy-haul trucks, cranes) would contain carbon monoxide (CO), NOx, VOCs, and oxides of sulfur (SOx) to a lesser extent. Fugitive dust (such as PM_{10} and $PM_{2.5}$) would be generated during windy periods, earthmoving, concrete batch plant operation, and movement of vehicular traffic over recently disturbed or cleared areas or unpaved roads. Painting, coating, and similar operations would generate emissions of VOCs. Typically, the construction workforce would be divided into two or three shifts and the increased traffic would be distributed over the day, with periodic and short-term increases at shift changes. Construction activities are typically subject to air permits under State and Federal laws that address the impact of air emissions on any local sensitive receptors. Air emission mitigation measures that may be used to reduce potential impacts include the following:

- phasing activities and equipment use
- minimizing the idling time of vehicles
- using properly maintained equipment in compliance with applicable regulations
- minimizing speeds on unpaved roads
- watering unpaved roads and exposed areas
- minimizing soil storage piles
- locating stationary equipment (e.g., generators, temporary boilers, and compressors) away from sensitive receptors
- minimizing dust-generating activities during high winds.

Emissions of fugitive dust and construction equipment engine exhaust are generally limited in duration, are infrequent and mostly localized to the project area, and would vary based on the level and duration of a specific activity throughout the building phase of the facility. The PPE/SPE assumes the total site size is 100 ac (40.5 ha) or less, the permanent disturbed vegetated area is 30 ac (12 ha) or less, and the additional vegetated area disturbed by temporary activities is 20 ac (8.1 ha) or less, and that new offsite ROWs for transmission lines, pipelines, or access roads would be no longer than 1 mi (1.6 km) and have a maximum ROW width of 100 ft (30.5 m). The air quality impacts are therefore expected to be temporary and limited to the area within 6 mi (9.7 km) of the plant construction site. The PPE/SPE assumes the plant is located in an attainment area or that criteria pollutants emitted from vehicles and standby power equipment during construction are less than Clean Air Act *de minimis* levels set by the EPA and that the project/action is located in a nonattainment or maintenance area and, therefore, would not be subject to a conformity determination. The PPE/SPE assumes the site is not located within 1 mi (1.6 km) of a mandatory Class I Federal area where visibility is an important value.

Some communities located near the construction site may experience increases in traffic and associated increases in the amount of particulate and gaseous emissions. The impact of emissions from additional workforce and other construction traffic would be localized and temporary and have little impact on the regional air quality (NRC 2021-TN7037). Under the PPE and SPE assumption that the LOS determination associated with anticipated peak construction would not change, traffic bottlenecks that could significantly increase localized emissions from idling vehicles are not expected to occur.

The staff has determined that emissions of criteria pollutants during construction of an ANR are a Category 1 issue. The staff concludes that as long as the applicable PPE and SPE values and assumptions are met, the air quality impacts from building an ANR can be generically determined to be SMALL. The staff relied on the following PPE values and assumptions to reach this conclusion:

- The site size is 100 ac (40.5 ha) or less.
- The permanent footprint of disturbance is 30 ac (12 ha) or less of vegetated lands and the temporary footprint of disturbance is an additional 20 ac (8.1 ha) or less of vegetated land.
- New offsite ROWs for transmission lines, pipelines, or access roads would be no longer than 1 mi (1.6 km) and have a maximum ROW width of 100 ft (30.5 m).
- Criteria pollutants emitted from vehicles and standby power equipment during construction are less than Clean Air Act *de minimis* levels set by the EPA if the site is located in a nonattainment or maintenance area, or the site is located in an attainment area.
- The site is not located within 1 mi (1.6 km) of a mandatory Class I Federal area where visibility is an important value.
- The LOS determination for affected roadways does not change.
- Mitigation necessary to rely on the generic analysis includes implementation of BMPs for dust control.
- Compliance with air permits under State and Federal laws that address the impact of air emissions during construction.

3.3.2.1.2 GHG Emissions during Construction

Equipment and vehicles used during building activities, including construction worker vehicles and delivery trucks, would emit GHGs, principally CO_2. Combining the PPE values for GHG emissions for these two stages listed in Table 3-1 above, 164,000 MT CO_2(e) would be emitted during a 7-year construction period of two 1,000 MW reactors, or less than 24,000 MT/yr CO_2(e) on average. For comparison, in 2019, total gross annual U.S. GHG emissions were 6,577.2 MMT of CO_2(e), of which 5,410.8 MMT CO_2(e) were from the energy sector (EPA 2021-TN6965). Estimated annual GHG emissions from equipment used during building activities are about 0.00045 percent of the 2019 GHG emissions from the U.S. energy sector.

As noted in Section 3.3.2 above, the staff has determined that the contribution of plant life-cycle GHG emissions to national emissions is a Category 1 issue. The staff concludes that, as long as the PPE and SPE assumptions associated with the life-cycle GHG emissions are met, the GHG impacts from building an ANR can also be generically determined to be SMALL. The staff relied on the following PPE values and assumptions to reach this conclusion:

- GHGs emitted by equipment and vehicles during the 97-year ANR GHG life-cycle period would be equal to or less than 2,534,000 MT of CO_2(e). Appendix H of this GEIS contains the staff's methodology for developing this value, which includes emissions from building, operating, and decommissioning. As long as this total value is met, the impacts for the life-cycle of the project and the individual phases of the project are determined to be SMALL.

The generic analysis can be relied on without applying any mitigation measures.

3.3.2.2 Environmental Consequences of Operation

The NRC staff identified four air quality issues for analysis of the operation of an ANR:

- emissions of criteria and HAPs to the atmosphere during operation activities in relation to regional air quality conditions and thresholds for NAAQSs for criteria pollutants and HAPs;
- cooling-system impacts such as ground-level fogging/icing, plume shadowing, drift deposition from dissolved salts and chemicals found in the cooling water, and ground-level temperature and humidity increases;
- emissions to the atmosphere of ozone and NOx from transmission line operation; and
- GHG emissions during operations.

These air quality impacts would be expected to continue during the operational life of the ANR.

3.3.2.2.1 Emissions of Criteria and Hazardous Air Pollutants during Operation

The principal air emission sources for criteria pollutants would be auxiliary equipment, such as boilers for heating and startup, engine-driven emergency equipment, emergency power supply system diesel generators and/or gas turbines, depending on the plant design, and refurbishment activities. Emissions would include NOx, CO, SOx, CO_2, CH_4, N_2O, hydrocarbons in the form of VOCs, and $PM_{2.5}$ and PM_{10}.

Impacts on air quality during normal plant operations can result from operations of fossil-fuel-fired equipment needed for various plant functions, although these types of operations may be reduced, limited, or not present for small ANR designs. Each licensed plant typically employs emergency diesel generators for use as a backup power source. Emergency generators would be used on an infrequent basis and therefore pollutants discharged (e.g., particulates, SOx, CO, hydrocarbons, and NOx) would be released infrequently. Emergency diesel generators and fire pumps typically require State or local operating permits for routine (typically monthly) testing. These monthly tests have several test burns of various durations (e.g., 1 to several hours). In addition to these maintenance tests, longer-running endurance tests are typically conducted at each plant. Each generator is typically tested for 24 hours on a staggered test schedule (e.g., once every refueling outage) (NRC 2013-TN2654). Plants with nonelectric fire pumps, typically also diesel-fired, usually employ test protocols identical or similar to those used for emergency generators. Many State air pollution regulations provide exemptions for air pollution sources that are not routinely operated, which can be defined as sources that have insignificant activity, meeting specified operating criteria (e.g., so many hours of continuous operation over specified periods or so many hours of operation per year) (NRC 2013-TN2654). In addition to the emergency diesel generators, fossil-fueled (i.e., diesel-, oil-, or natural-gas-fired) boilers can be used primarily for evaporator heating, plant space heating, and/or feed water purification. Again, depending on the simplicity of the ANR design, this equipment may be reduced or eliminated.

Air emission sources associated with nuclear power plant operation would be managed in accordance with Federal, State, and local air quality control laws and regulations. A new plant at any U.S. site would comply with all regulatory requirements of the Clean Air Act, as well as any relevant State requirements to minimize impacts on state and regional air quality. When an applicant selects a project design, modeling, as required, will be conducted to demonstrate the project emissions will not result in exceedances of the NAAQS. The evaluation will include a determination of whether the project is in an attainment area for all NAAQS criteria pollutants (Clean Air Act, Part D-TN6972), and whether the proposed project is subject to a Nonattainment New Source Review (EPA 2016-TN6970). A PPE for this GEIS assumes that all operational emissions of criteria pollutants are below *de minimus* levels for NAAQSs if the project/action is located in a nonattainment or maintenance area.

Operations-related traffic would also result in vehicular air emissions. Some communities located near the construction site may experience increases in traffic and associated increases in the amount of particulate and gaseous emissions. The impact of emissions from additional workforce traffic would be localized and have little impact on the regional air quality (NRC 2021-TN7037). Nominal localized increases in emissions would occur as a result of the increased numbers of cars, trucks, and delivery vehicles that would travel to and from the plant site. Emission impacts for operation assume that LOS values can be maintained with the increased traffic volumes.

In addition to criteria pollutants, fuel oil for the diesel generators is a source of HAPs. To be considered a major source of HAPs by EPA, a facility must have the potential to emit 10 T/yr of an individual HAP or 25 T/yr or more total for all HAPs (Clean Air Act; 42 U.S.C. §§ 7401 *et seq*.; TN1141). Because diesel generators operate on a limited basis (typically monthly), the staff does not expect that HAPs associated with an ANR would meet the 10 Tons/yr threshold. The PPE assumes that HAPs emissions will be within regulatory limits.

The staff has determined that air quality during operation of an ANR is a Category 1 issue. The potential impact from emergency generators and boilers on air quality, given the infrequency and short duration of maintenance testing, would not be an air quality concern. The staff concludes that air quality impacts from operating an ANR can be generically determined to be SMALL. The staff relied on the following PPE values and assumptions to reach this conclusion:

- Criteria pollutants emitted from vehicles and standby power equipment during operations are less than Clean Air Act *de minimis* levels set by the EPA if located in a nonattainment or maintenance area.
- The site is not located within 1 mi (1.6 km) of a mandatory Class I Federal area where visibility is an important value.
- The LOS determination for affected roadways does not change.
- The generic analysis can be relied on without applying any mitigation measures.
- Compliance with air permits under State and Federal laws that address the impact of air emissions.
- HAP emissions will be within regulatory limits.

3.3.2.2.2 GHG Emissions during Operation

Equipment and vehicles used during plant operations, the uranium fuel cycle, and fuel and waste transport would emit GHGs, principally CO_2. Combining the PPE values for GHG emissions for these stages listed in Section 3.3.1 above, 2,296,000 MT would be emitted during a 40-year operation period for two 1,000 MW reactors, or about 57,400 MT/yr on average. As with construction activities, these emissions can be compared with 2019 total gross annual U.S. energy sector emissions of 5,410.8 MMT CO_2(e) (EPA 2021-TN6965). Estimated annual GHGs emissions from equipment used during operation, the uranium fuel cycle, and transportation of fuel and waste activities are about 0.001 percent of the 2019 GHG emissions from the U.S. energy sector.

As noted in Section 3.3.2 above, the staff has determined that the contribution of plant life-cycle GHG emissions to national emissions is a Category 1 issue. The staff concludes that, as long as the PPE assumption associated with GHG emissions is met, the GHG impacts from operating an ANR can also be generically determined to be SMALL. The staff relied on the following PPE values and assumptions to reach this conclusion:

- GHGs emitted by equipment and vehicles during the 97-year ANR GHG life-cycle period would be equal to or less than 2,534,000 MT of CO_2(e). Appendix H of this GEIS contains the staff's methodology for developing this value, which includes emissions from building, operating, and decommissioning. As long as this total value is met, the impacts for the life-cycle of the project and the individual phases of the project are determined to be SMALL.

The generic analysis can be relied on without applying any mitigation measures.

3.3.2.2.3 Cooling-System Emissions

The primary impacts of operating a new nuclear power plant on local meteorology would be from releases to the environment of heat and moisture from the primary cooling system. Cooling towers, if used, would remove excess heat by evaporating water. Upon exiting the tower, water vapor would mix with the surrounding air, and this process would generally lead to condensation and formation of a visible plume, which would have aesthetic impacts. Cooling towers would also produce drift. Drift is composed of small water droplets that are carried out of the cooling tower. These droplets evaporate, leaving particles that contain residual salts and chemicals from the cooling water. Drift from mechanical draft cooling towers is deposited near the cooling tower, and drift from natural draft towers is deposited farther downwind (NRC 2013-TN2654). Wet cooling towers at existing nuclear power plants generally have drift eliminators to reduce drift (NRC 2013-TN2654). Other meteorological and atmospheric impacts from cooling towers include ground-level fogging/icing, plume shadowing, and ground-level temperature and humidity increases. In addition, plumes from the cooling towers could interact cumulatively with emissions from other sources on the site.

The PPE includes an assumption of a maximum height of 100 ft (30.5 m) for mechanical draft cooling towers that have drift eliminators. The PPE also assumes that the site is not located within 1 mi (1.6 km) of a mandatory Class I Federal area where visibility is an important value. The SPE assumes there will be no existing residential areas within 0.5 mi (0.8 km) of the site.

The License Renewal GEIS (NRC 2013-TN2654) and supplemental EISs (SEISs) for individual plant relicensing evaluated the impact of the continued operation of cooling towers, including natural draft cooling towers, at existing power plants for an additional 20 years and found the impacts to be SMALL. In the License Renewal GEIS (NRC 2013-TN2654) the staff reviewed the distances and impacts from deposition of salt drift from nuclear power plants, which states the "...measurements indicate that, beyond about 1 mi (1.6 km) from nuclear plant cooling towers, salt deposition is not significantly above natural background levels." In addition, the NRC staff reviewed the recent ESP and COL EIS reviews for cooling-tower impacts and the impacts were found to be SMALL for ground-level fogging/icing, plume shadowing, drift deposition from dissolved salts and chemicals found in the cooling water, and ground-level temperature and humidity increases (NRC 2021-TN7037). For ESP and COL EISs, most of the impacts occurred within 1 mi (1.6 km) of the cooling towers except for the longest plumes which occurred typically within 5 mi (8 km) of the cooling towers, but these plume lengths were infrequent, occurring a small percentage of the time during certain times of the year. Icing impacts were infrequent and in more southern areas of the U.S. were not likely to occur (i.e., Florida, Texas, South Carolina) as compared to more northern areas of the U.S.

In addition to emissions of criteria pollutants, releases of HAP could be expected from chemical additives used in the cooling-tower water. Some examples of these chemical additives are sodium hypochlorite (NaOCl), sodium hydroxide (NaOH), hydroxyethylidine diphosphonic acid (HEDP), and petroleum distillate. Chemical additives added to cooling-tower water are within State regulatory limits or would be within the releases of HAPs listed in Section 112 of the Clean Air Act (42 U.S.C. § 7412-TN7014). The PPE assumes that the emissions of HAPs from the cooling tower will meet the regulatory limits set by EPA or the State.

The staff has determined that air quality during operation of cooling towers associated with an ANR is a Category 1 issue. The staff concludes that air quality impacts from operating cooling towers associated with an ANR can be generically determined to be SMALL. The staff relied on the following PPE values and assumptions to reach this conclusion:

- If needed, cooling towers would be mechanical draft, not natural draft.
- Cooling towers would be equipped with drift eliminators.
- The site is not located within 1 mi (1.6 km) of a mandatory Class I Federal area where visibility is an important value.
- Mechanical draft cooling towers would be less than 100 ft (30.5 m) tall.
- Makeup water would be fresh (with a salinity less than 1 ppt).
- Operation of cooling towers is assumed to be subject to State permitting requirements.
- HAP emissions would be within regulatory limits.
- No existing residential areas within 0.5 mi (0.8 km) of the site.

3.3.2.2.4 Emissions of Ozone and NOx during Transmission Line Operation

Small amounts of ozone and even smaller amounts of NOx are produced by transmission lines and associated equipment. The impacts of existing transmission lines on air quality are addressed in the License Renewal GEIS (NRC 2013-TN2654). The staff found the production of ozone and NOx to be insignificant for 765 kV transmission lines (the largest lines in operation) and for a prototype 1,200 kV transmission line (NRC 2013-TN2654). In addition, it was determined that potential mitigation measures, such as burying transmission lines, would be very costly and would not be warranted.

The staff has determined that air quality during operation of transmission lines is a Category 1 issue. The staff concludes that based on the License Renewal GEIS (NRC 2013-TN2654) and more recent new reactor EIS findings, impacts from emissions of ozone and NOx can be generically determined to be SMALL without relying on mitigation. The staff relied on the following PPE value to reach this conclusion:

- The transmission line voltage would be no higher than 1,200 kV.

3.4 Water Resources

3.4.1 Baseline Conditions and PPE/SPE Values and Assumptions

Water resources comprise surface water bodies (e.g., rivers, streams, lakes, ponds, estuaries, oceans, and manufactured reservoirs) and groundwater aquifers (including unconfined, water table aquifers, deeper confined aquifers, and perched saturated zones). Exchange between surface water bodies and groundwater systems is common (e.g., groundwater discharge to, or recharge from, abovementioned surface water bodies). Water may be used for many purposes including public and domestic supplies, industrial (including cooling) processes, building-related activities, agriculture, hydropower production, recreation, and general ecosystems support. An assessment of baseline conditions for water resources includes a description of the surface water bodies and groundwater aquifers potentially affected by the building and operation of a proposed plant, the existing and planned uses of the affected water bodies, trends in water quality, and any regulatory restrictions on water use or on discharges affecting water quality.

Nuclear power plants use water during both construction and operation. However, impacts on water resources are typically greatest during plant operations, which require water over an operating period that could last for 40 or more years. In the current fleet of power plants with large LWRs, the predominant use for water during operations is for removing excess heat generated in the reactor by condenser cooling. Some ANR designs may not use water for cooling purposes. If cooling water is not used, then the impacts from the use of cooling water do not need to be analyzed. In addition to removing heat from the reactor, cooling water is also provided to the service water system and to the auxiliary cooling-water system. However, the amount of water used by these systems is small compared to the amount of water typically required for the condenser cooling system. Nuclear power plants may also require water for other plant systems (e.g., fire suppression) and for sanitary or potable uses. During operations, nuclear power plants typically discharge warm water to a receiving water body. This discharge can contain blowdown from cooling systems, process water from other plant systems, and sanitary system discharges. Reduction or elimination of water use and discharge will increase the number of potential sites at which an ANR may be located and decrease the potential for impacts on water resources in the vicinity of the corresponding location.

Construction activities and nuclear power plant operations may contribute to changes in water quality conditions. Removal of vegetation and construction of buildings, parking lots, and other impervious surfaces can increase runoff from a site and result in the entrainment of sediments and pollutants in the runoff that ultimately discharges to nearby water bodies. Building of intake and discharge structures may temporarily disturb natural water flows similar to dredging or fill placement in waterways. Water withdrawal for plant use may affect the quality of the groundwater or surface water source. Discharge of cooling water and other plant wastewaters introduces chemical constituents of plant operations (e.g., cooling-water treatment chemicals) and thermal pollution to the receiving water body. In addition, inadvertent chemical spills or releases that are transported with runoff may contaminate surface water and groundwater resources.

During both construction and operation of a nuclear power plant, water from municipal sources may be needed to support the potable and sanitary needs of plant personnel. The potential municipal water demand is expected to be relatively small compared to a plant’s cooling-water needs. However, this water demand may affect the ability of nearby municipal water systems to meet their planned obligations. Nuclear power plants may also discharge plant effluents (e.g., sanitary and sewage discharges) to municipal wastewater systems that may affect the municipal systems' ability to meet their planned obligations.

Applicants seeking to construct and operate an ANR must obtain and comply with all applicable permits and authorizations that regulate alterations and limit impacts on the hydrologic environment. Federal regulations for water quality, use, and withdrawal stem from the CWA (codified as the Federal Water Pollution Control Act of 1972; 33 U.S.C. §§ 1251 *et seq.*; TN662).[9] Dredging and construction-related activities are regulated by provisions of the CWA Section 404 (33 U.S.C. § 1344-TN1019) and Section 10 of the Rivers and Harbors Appropriation Act of 1899 (33 U.S.C. §§ 401 *et seq.*; TN660). Federal regulations may be administered through a State permitting program, which may implement more restrictive criteria based on the unique regional or local environment or environmental issues. In addition, local or regional water boards or river authorities may require registration, notification, and permitting of the use of water from rivers, reservoirs, and aquifers. Descriptions of applicable laws, regulations, and other authorizations are provided in Appendix F.

For each potential resource impact described in the following sections, the level of information provided should be related to the amount of use and the degree of anticipated impacts. Applicants should provide a description of communications with relevant Federal, State, regional, and local authorities and agencies related to obtaining applicable permits and authorizations governing water use and quality. Compliance with environmental quality standards and permit requirements does not satisfy the need for NRC staff to evaluate environmental impacts. However, any assessment that supports the permit may be considered as part of the evaluation of environmental impacts. See footnote 3 to 10 CFR 51.71(d) (TN250).

Monitoring programs should be developed to identify potential adverse impacts and to formulate associated water resource mitigation strategies related to operation. Monitoring programs which are required as part of Federal and State permits should include identification of alternatives or engineering measures that could be implemented to mitigate impacts, if needed.

3.4.1.1 Surface Water Resources

3.4.1.1.1 Surface Water Use

Operating large LWR nuclear power plants typically withdraw large volumes of surface water to meet a variety of plant needs related primarily to use in cooling systems. Nuclear reactors could be either "dry" cooled, "wet" cooled, or use a combination of both ("hybrid"). Dry-cooled systems use no water and can significantly decrease the total water consumption of a power plant. Wet-cooled systems rely on water for cooling and use systems that interface significantly with water resources. With one exception, the current fleet of operating large LWR nuclear plants rely on surface water sources for cooling. These sources include flowing water bodies (e.g., stream, canal, or river) and non-flowing water bodies (e.g., oceans, gulfs, intertidal zones,

[9] The CWA includes Sections 401 (Water Quality Certification; 33 U.S.C. § 1341-TN4764), 402 (National Pollutant Discharge Elimination System, or NPDES, permit; 33 U.S.C. § 1342-TN4765), and Sections 316(a) and 316(b) (for cooling-water discharges and withdrawals, respectively; 33 U.S.C. § 1326-TN4823). Applicable regulations also include U.S. Environmental Protection Agency measures for spill prevention and response (40 CFR Part 9 [TN5322] and Part 112 [TN1041]).

estuaries, lakes, ponds, and reservoirs)[10] and use a variety of cooling systems. Currently, the Palo Verde Nuclear Generating Station is the only operating plant that uses treated wastewater for cooling purposes. Proposed new large LWRs may also plan to withdraw water from a variety of surface water sources to supply the cooling-water system with makeup water. Once-through systems are used for most operating units. The remaining units employ closed-cycle systems, which rely on cooling ponds, lakes, canals, and mechanical and natural draft cooling towers to transfer waste heat to the atmosphere. Compared to the large LWRs mentioned above, it is anticipated that ANRs may use cooling technologies that reduce or eliminate reliance on water for cooling purposes or for reactor shutdown.

In environmental reviews for large LWRs, the NRC staff evaluates the effects that plant water use may have on the availability of surface water resources and the impacts of uses and users of these resources. For ANRs, the staff developed plant and site parameters for water demand and available supply to provide guidance for evaluating issues arising from water use conflicts between the proposed plant and other uses and users. These parameters are presented and explained in the PPE/SPE table in Appendix G. The total plant water demand PPE was developed by the NRC staff after considering the bounding value for water requirements presented in the National Reactor Innovation Center (NRIC) PPE report for ANR designs (NRIC 2021-TN6940). This NRIC bounding value includes water use by all ANR plant systems. The NRC staff increased this value to the nearest 1,000 gpm (0.063 m^3/s) to derive the PPE for this GEIS, which specifies that the total plant water demand does not exceed a daily average of 6,000 gpm (0.379 m^3/s). The NRC staff assumed that the total plant water demand accounts for the maximum amount of water supply required for all plant needs and may include water from multiple sources.

Based on this PPE value, the total surface water use by ANR plant systems would be less than or equal to 6,000 gpm (0.379 m^3/s). Because the NRIC PPE report covers a wide range of reactor types and power outputs, the staff expects that the 6,000 gpm (0.379 m^3/s) limit would not be overly restrictive of ANR designs addressed by this GEIS. This limit also provides staff with confidence that conclusions reached in this GEIS will be valid given the wide range of site characteristics and settings to which this GEIS might be applicable.

The staff separated potential surface water sources into two broad categories in the generic analysis: (1) flowing surface water bodies (e.g., stream, canal, or river) and (2) non-flowing surface water bodies. The staff differentiated non-flowing surface water bodies into two categories that are based on water body size and correspond to the potential for hydrologic and aquatic impacts from plant water usage at the PPE withdrawal rate discussed above. The categories are large water bodies (specifically the Great Lakes, the Gulf of Mexico, estuaries, intertidal zones, and oceans) and smaller water bodies (e.g., inland lakes, ponds, and reservoirs).

To minimize the impact on flowing surface water bodies, the SPE specifies that plant withdrawals from water bodies be limited to no more than 3 percent of the 95 percent exceedance daily low flow of the source. The staff developed this SPE criterion for water withdrawal by evaluating the impacts related to plant use of flowing surface water bodies in EISs

[10] Flowing and non-flowing water bodies are distinguished primarily based on the mechanism that provides water availability. Water availability in flowing water bodies (e.g., stream, canal, or river) is primarily provided by the water body’s discharge rate and storage effects are minor. In non-flowing water bodies (e.g., oceans, gulfs, intertidal zones, estuaries, lakes, ponds, and reservoirs), water availability is primarily provided by the volume of stored water.

for new reactors and the License Renewal GEIS for operating reactors (NRC 1996-TN288, NRC 2013-TN2654). Based on the evaluations provided in these recent EISs and the License Renewal GEIS, the staff determined that the impacts would be SMALL for withdrawal rates at or below 3 percent of the water available during low flow conditions. In addition, this SPE value is bounded by the EPA 316(b) Proportional Flow Limitation (40 CFR 125.84(b)(3)(i) [TN254]), which specifies that plants not withdraw more than 5 percent of the source water body annual mean flow. The staff assumed that the 95 percent exceedance daily flow is estimated accounting for all existing withdrawals and instream flow requirements.

For large non-flowing surface water bodies, the staff recognize that project-specific conditions could result in noticeable impacts on water resources at sufficiently large withdrawal rates. However, water bodies the staff expects that the total plant water demand PPE value of 6,000 gpm (0.379 m^3/s) would not result in water use conflicts in the Great Lakes, the Gulf of Mexico, estuaries, intertidal zones, and oceans, because the plant demand would be negligible compared to water availability. For smaller non-flowing water bodies (e.g., inland lakes, ponds, and reservoirs), the impacts from competing water uses could manifest in different ways (e.g., reduction in downstream discharge from the water body, reduction in water surface elevation of the water body, and reduction in nearshore habitat suitability) that depend on site-specific hydrologic conditions. Therefore, these smaller water bodies fall outside the SPE value for Surface Water Availability – Non-flowing in Appendix G.

For both flowing and non-flowing sources, corresponding assumptions stated in Appendix G should be met. If water is supplied by municipal systems, the staff assumes that the amounts will be within the available capacity of the system. This is reflected in the PPE value for municipal water availability.

3.4.1.1.2 Surface Water Quality

In environmental reviews for large LWRs, the NRC staff typically evaluates the effects on surface water quality from both construction and operation activities in terms of the degradation of the ambient conditions of the water source and the resulting impacts on uses and users of that source. During operations, surface water quality can be affected by the numerous nonradioactive liquid effluents discharged from nuclear power plants. Discharges from the cooling system usually account for the largest volumes of water and the greatest potential impacts on water quality and aquatic systems, although other systems may contribute heat and contaminants to the effluent. Operation of these cooling systems may alter current patterns at intake and discharge structures, salinity gradients, and thermal attributes of the receiving water bodies. Water quality could be affected by temperature effects, sediment discharge, scouring, eutrophication, and the discharge of water containing biocides, sanitary wastes, heavy metals, and higher total dissolved solids (TDS) concentrations than those in the receiving water bodies. During construction, surface water quality in nearby water bodies can be affected by runoff containing sediments and other contaminants from industrial sites including any inadvertent spills that ultimately reach these water bodies.

Plant discharges must meet limits set forth in the CWA and specified in the applicable Federal, State, and local permits received for the site. Discharge criteria are determined and implemented by Federal and State agencies responsible for protection of resources based on various project-specific conditions. As a result, criteria may vary among States and among water body uses and types. To mitigate the effects of thermal discharges a mixing zone may be established in the receiving water body such that changes from ambient temperatures outside of the mixing zone are considered minor. The establishment of a mixing zone is highly project-specific, as discussed in Section 3.4.2.2.7.

The PPE/SPE specifies that if discharge water is sent to a municipal wastewater treatment facility, the available capacity of the municipal system to treat effluents will exceed the expected amount of plant effluent.

3.4.1.2 Groundwater Resources

3.4.1.2.1 Groundwater Use

Groundwater has typically been used for non-cooling-water supplies at proposed and operating nuclear power plants. Groundwater has been used for common construction activities such as dust abatement, soil compaction, and as a supply for concrete batch plants. Excavations of plant foundations may also require dewatering or groundwater removal during construction-related activities. Plants may continue dewatering during operations to maintain low water levels near buildings and foundations. During construction and operation, groundwater has also been used for systems that require a higher degree of water quality such as potable and sanitary systems, service water, fire protection water, and plant systems that require demineralized water. Applications for new large LWR nuclear power plants or early site permits (ESPs) in the past have proposed to use groundwater for construction and/or operation.

Nuclear plants that withdraw groundwater may affect the availability of groundwater for other nearby users. Impacts could occur as a direct effect of withdrawing groundwater by lowering the water table or indirectly by inducing the movement of lower quality water (e.g., saline water) toward existing well users. Nearby groundwater users could also be affected indirectly if construction or operation of the power plant were to disrupt the normal recharge of the groundwater aquifer. The impacts of large groundwater withdrawal rates are likely to be more significant for users located close to the plant boundary, and in areas where available water resources are stressed. The magnitude of impacts from groundwater withdrawals is also dependent on the site conditions and the hydrogeologic characteristics of the affected aquifer. For example, groundwater pumping from confined aquifers tends to affect larger areas than does pumping from unconfined aquifers for a given pumping rate, and for aquifers that are less transmissive.

A permit from the State or other local/regional governing body is typically required to withdraw groundwater. Permitting criteria may include the effects on water rights, availability of water, interference with other beneficial uses, lowering groundwater levels (drawdown), and water quality. The effects on connected surface water bodies (e.g., reductions in streamflow resulting from groundwater withdrawals) may be a consideration. A permit exemption may be available in areas when the withdrawal is less than a threshold value (e.g., 100,000 gpd or about equivalent to a constant pumping rate of about 70 gpm [0.004 m^3/s]), consistent with the expectation that lower withdrawal rates would typically result in fewer impacts.

For operating plants, the NRC staff has found that groundwater withdrawals of 100 gpm (0.006 m^3/s) or less created negligible or small impacts at operating nuclear power plants because this use rate would not generally lower groundwater levels beyond the site boundary (NUREG-1437; NRC 2013-TN2654). Operating plant site areas are significantly larger than the ANR site area SPE value of 100 ac (40.5 ha) considered in this GEIS. Because ANR sites would be smaller than large LWR sites, groundwater wells could be closer to the site boundary. As a result, the staff determined that the ANR GEIS PPE/SPE should include a maximum groundwater withdrawal rate less than 100 gpm (0.006 m^3/s), the rate used in the License Renewal GEIS (NRC 2013-TN2654). In addition, the staff determined that the ANR GEIS SPE should include limits on the effects of withdrawals and dewatering on groundwater levels at the site boundary.

The PPE and SPE parameter table in Appendix G specifies that groundwater withdrawals for all plant uses (excluding dewatering withdrawals) be less than or equal to 50 gpm (0.003 m^3/s) for an ANR. Based on simplified modeling, the NRC staff determined that effects on groundwater levels at the site boundary from pumping 50 gpm (0.003 m^3/s) on a 100 ac (40.5 ha) site would approximate the effects from pumping 100 gpm (0.006 m^3/s) on a larger site the size of a typical large LWR. In addition, the staff assumed that the hydrogeologic properties of the aquifer are such that groundwater withdrawals for plant uses would reasonably result in less than a 1 ft (0.3 m) reduction in groundwater levels at the site boundary. The threshold of 1 ft (0.3 m) was selected as a *de minimis* value likely to be less than the natural annual fluctuations in groundwater levels at most sites. The groundwater withdrawal parameter also includes the assumption that plant groundwater withdrawals would not occur in an aquifer designated by the EPA as a Sole Source Aquifer (SSA), or in any aquifer designated by a State, tribe, or regional authority to have special protections to limit drawdown. Groundwater withdrawals are also assumed to meet the permitting requirements of applicable State and local agencies.

The PPE/SPE specifies that groundwater withdrawals for dewatering also be no more than 50 gpm (0.003 m^3/s). The staff assumed the value of 50 gpm (0.003 m^3/s) represents the long-term, steady dewatering rate; the initial rate of dewatering may be larger. Based on simplified modeling, the NRC staff determined that, relative to the plant site area, the effects on groundwater levels caused by dewatering withdrawals of 50 gpm (0.003 m^3/s) at a 100 ac (40.5 ha) ANR site would be similar to the effects caused be dewatering withdrawals of 100 gpm (0.006 m^3/s) on a larger site the size of a typical large LWR. Consistent with the smaller site area for the ANR, the staff assumed in this simplified modeling that the area to be dewatered and the depth of groundwater drawdown at the excavation/foundation would be smaller for ANRs than for a typical large LWR. The PPE/SPE dewatering parameter also includes assumptions that the hydrogeologic characteristics of the site are such that dewatering has a negligible effect on groundwater levels at the site boundary and that dewatering discharge does not affect the quality of the receiving water body.

Because groundwater withdrawals could affect wetlands on or near the site, the SPE includes assumptions that any changes in wetland water levels and hydroperiod caused by groundwater use or dewatering are within historical annual or seasonal fluctuations to avoid adverse impacts on wetlands. Potential groundwater use impacts on wetlands are discussed in Sections 3.5.2.1.2 and 3.5.2.2.7 of this GEIS.

3.4.1.2.2 Groundwater Quality

When conducting environmental reviews for large LWRs, the staff evaluates the potential effects of plant construction and operation on current groundwater quality conditions. Groundwater withdrawals could impair groundwater quality if they result in the movement of lower quality groundwater. For example, long-term pumping of groundwater from coastal plain aquifers by industrial and municipal facilities has contributed to saltwater intrusion in areas of nearly every Atlantic and Gulf Coast state (Trapp and Horn 1997-TN1865; USGS 1990-TN6648). Groundwater quality could also be impaired at inland sites where groundwater may be replaced by poorer quality surface water through induced infiltration, or where groundwater has been previously contaminated. Groundwater quality impacts are considered to be of small significance when the plant does not contribute to changes in groundwater quality that would preclude current and future uses of the groundwater. As with water use impacts, these types of groundwater quality impacts are likely to be most significant when a plant withdrawal rate is large.

Groundwater quality may be affected by releases of potential contaminants to the subsurface. Any intentional discharge of wastewaters to the subsurface would be regulated by the EPA and/or State underground injection control requirements. Spills or leaks from nuclear power plant facilities can also impair groundwater quality. Nonradioactive materials such as fuels, solvents, and other chemicals are typically stored and used at the nuclear power plants as part of general industrial activities. Spills of these materials can occur during their use, and leaks from storage containers and associated transfer lines can occur above and below the ground surface. Storage and handling of fuels and chemicals are regulated by EPA and State requirements, and typically require that spill prevention and response procedures be considered.

NRC licensees are required to document and report the hazard of known releases of radionuclides. However, inadvertent releases of radionuclides to groundwater may not be easily detected and have resulted in groundwater contamination at operating nuclear power plants. Operating plants have implemented a voluntary groundwater protection program to detect and respond to inadvertent releases of radionuclides to groundwater (NEI 2019-TN6775). This program includes characterization of site geology and hydrology, risk assessment for releases, groundwater monitoring, establishment of a remediation protocol to prevent offsite migration of radionuclides, and reporting of leaks/spills and groundwater monitoring results. Appendix I to 10 CFR Part 50 provides the framework for the radiological environmental monitoring program (REMP) by directing licensees to establish surveillance and monitoring programs, including groundwater monitoring, for release of radionuclides. Guidance related to the REMP is provided in RG 4.1 (NRC 2009-TN3802). In addition, 10 CFR 50.36a (TN249) requires that licensees establish technical specifications to keep releases of radioactive materials as low as reasonably achievable or ALARA.

To minimize the potential groundwater quality impacts, the PPE and SPE parameter table in Appendix G specifies that the plant will not be located in the recharge area for an EPA-designated SSA, or in the recharge area for any aquifer designated by a State, tribe, or regional authority to have special protections. Under the provisions of the Safe Drinking Water Act (SDWA), States must establish demonstration programs for protection of critical aquifers. In addition, the groundwater quality parameter in Appendix G specifies that the plant will not be located in a wellhead protection area or designated groundwater recharge area for a public water supply well. It is also assumed that there are no planned plant discharges to the subsurface, that applicable requirements and guidance on spill prevention and control are followed, and that a groundwater protection program to detect and monitor inadvertent releases is established and followed. If an ANR is proposed for a site that does not conform to these groundwater quality parameters and assumptions, a project-specific evaluation would be required, and the NRC would consult with the jurisdictional authority and responsible agencies when evaluating impacts.

3.4.2 Water Resources Impacts

The NRC staff took four steps to develop a basis for determining values and assumptions for an PPE and SPE for ANRs in order to determine which issues related to water resources might be dispositioned generically (Category 1) and which would require a project-specific evaluation

(Category 2). First, the staff reviewed all EISs published since 2006 for new reactor projects that have received NRC permits and licenses to evaluate the corresponding water use and summarize the resultant impact determinations.[11] Second, the staff reviewed the License Renewal GEIS (NRC 2013-TN2654) to understand the key factors and assumptions used to determine the impact level and category designation for water resource issues. Third, the staff evaluated criteria for water withdrawal and discharge from three states (Tennessee, Idaho, and Alaska), which are representative of variable regions and climates where an ANR might be sited, to develop a bounding set of PPE and SPE parameters that are independent of a potential design or power rating. Lastly, the NRC staff reviewed the applicable Federal and State regulations and permit requirements related to water resources.

Applicants for an ANR license would be expected to obtain and comply with all applicable permits and authorizations that regulate and limit impacts on the hydrologic environment. Federal regulations administered by a State may be more restrictive than the corresponding Federal regulations in order to account for unique regional or local environment or environmental issues. As a result, the water-related authorizations may include, but not be limited to, those listed in Appendix F of this GEIS. The applicant would also comply with other applicable regional, State, tribal, and local regulations, which may include the following:

- Water withdrawal registration and notification. Some States may require notification and water withdrawal registration for amounts that exceed State-specified limits to aid in water resource management during drought conditions.
- Water and sewer connection permits. Typically issued by a city, county, or municipal district.

3.4.2.1 Environmental Consequences of Construction

Construction activities that may result in impacts on water quality, availability, and designated use include the following:

- land clearing, grading, and placement of fill and spoils associated with site preparation
- construction of drainage and detention/retention features
- construction of features at, in, or near-surface water bodies, which may include intake and outfall structures, cofferdams, bulkheads, piers, jetties, and basins
- water channel modifications, including filling or dredging
- alteration of floodplains, natural drainage features or waterways near site
- development of infrastructure such as roads, parking lots, laydown areas, and surface and subsurface transmission lines (above and below ground)
- inadvertent spills of liquids (e.g., oil, fuel, diesel, solvents, wastewater)
- excavations and dewatering of building foundations

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[11] Combined license EISs reviewed were those for Fermi Unit 3 (NRC 2013-TN6436), Levy Units 1 and 2 (NRC 2012-TN1976), North Anna Unit 3 (NRC 2010-TN6), South Texas Project Units 3 and 4 (NRC 2011-TN1722), V.C. Summer Units 2 and 3 (NRC 2011-TN1723), Vogtle Units 3 and 4 (NRC 2011-TN6439), W.S. Lee Units 1 and 2 (NRC 2013-TN6435), and Turkey Points Units 6 and 7 (NRC 2016-TN6434). ESP EISs reviewed were those for Clinton (NRC 2006-TN672), Grand Gulf (NRC 2006-TN674), North Anna (NRC 2006-TN7), Vogtle (NRC 2008-TN673), Public Service Electricity and Gas Company (PSEG) (NRC 2015-TN6438), and Clinch River NRC 2019-TN6136).

- surface water, groundwater, or municipal water use for construction-related purposes (e.g., dust suppression, concrete batch plant, potable and sanitary water)
- discharges from stormwater runoff and sanitary systems.

These construction activities may affect the quality and availability of surface water and groundwater resources in the vicinity of the proposed site. The NRC staff identified and evaluated the following environmental issues related to water use and quality, which may arise from the construction activities listed above:

- surface water use conflicts during construction
- groundwater use conflicts due to excavation dewatering
- groundwater use conflicts due to construction-related groundwater withdrawals
- water quality degradation due to construction-related discharges
- water quality degradation due to inadvertent spills during construction
- water quality degradation due to groundwater withdrawal
- water quality degradation due to offshore or in-water construction activities
- water use conflicts due to plant municipal water demand
- degradation of water quality due to plant effluent discharges to municipal systems.

Each of the above environmental issues is discussed in more detail below.

3.4.2.1.1 Surface Water Use Conflicts during Construction

During construction, surface water may be used for activities such as dust abatement, concrete mixing, and potable water needs. Construction-related water use is usually a small portion of the amount of water needed for operation of a plant that has a water-cooled heat dissipation system and because timeframes for construction are shorter. As a result, construction-related surface water use impacts on water resources are typically less than operational impacts and, as such, construction uses would be bounded by the total plant water demand limitation of 6,000 gpm (0.379 m^3/s) (a daily average) included in the PPE and SPE table (see Appendix G).

No EIS for a plant licensed since 2006 has concluded that the impacts of surface water use during construction would be greater than SMALL, even when surface water was the only source of construction-related water. An example is the EIS for VC Summer Units 2 and 3, in which the staff determined that construction-related surface water use would be about 1 percent of the average makeup water withdrawn during operations (NRC 2011-TN1723); if a plant used a mix of surface and groundwater resources for construction, then this percentage of surface water use would be expected to be less.

Acquiring water withdrawal permits and/or water rights for construction-related use has not resulted in water use conflicts at large LWR sites. In addition, ANR technologies are anticipated to require a smaller site footprint with a correspondingly reduced reliance on water resources for construction than large LWR sites. Based on the preceding discussion, the staff assumes that any applicable water withdrawal permits can be obtained, and water rights can be acquired to support construction-related use at ANR sites. Therefore, the staff determined that the impacts on surface water use from construction of an ANR is a Category 1 issue. The staff concludes that, as long as the relevant PPE and SPE criteria and assumptions are met for the applicable water body type, the impacts on surface water use from building an ANR can be generically determined to be SMALL. This conclusion relies on the following PPE/SPE parameter and the associated value and assumption:

- Total Plant Water Demand
  - Less than or equal to a daily average of 6,000 gpm (0.379 m^3/s).

If water is obtained from a flowing water body, then the following PPE/SPE parameter and the associated values and assumptions also apply:

- Surface Water Availability – Flowing
  - Average plant water withdrawals do not reduce discharge from the flowing water body by more than 3 percent of the 95 percent exceedance daily flow and do not prevent the maintenance of applicable instream flow requirements.
  - The 95 percent exceedance flow accounts for existing and planned future withdrawals.
  - Water availability is demonstrated by the ability to obtain a withdrawal permit issued by State, regional, or tribal governing authorities.
  - Water rights for the withdrawal amount are obtainable, if needed.

If water is obtained from a non-flowing water body, then the following PPE/SPE parameter and the associated values and assumptions also apply:

- Surface Water Availability – Non-flowing
  - Water availability of the Great Lakes, the Gulf of Mexico, oceans, estuaries, and intertidal zones exceeds the amount of water required by the plant.
  - Water availability is demonstrated by the ability to obtain a withdrawal permit issued by state, regional, or tribal governing authorities.
  - Water rights for the withdrawal amount are obtainable, if needed.
  - CZMA consistency determination is obtainable, if applicable, for the non-flowing water body.

3.4.2.1.2 Groundwater Use Conflicts Due to Excavation Dewatering

Excavation dewatering during construction of building foundations may be required for any ANR project. Dewatering lowers groundwater levels adjacent to and beneath an excavation to facilitate construction and increase the stability of excavation slopes (DOD 2004-TN6814). Groundwater levels in the region surrounding the excavation will also be affected, and the magnitude of the affected area will depend on the hydrogeologic conditions of the site, the duration of dewatering, and the methods used to mitigate the effects of dewatering. Changes in groundwater levels may locally affect the direction of groundwater flow, and may alter groundwater recharge or discharge rates, including discharge to wetlands.

The impacts of dewatering have been evaluated in the EIS for each of the licensed new reactor sites. At these sites, dewatering rates were expected to be minimized by using engineering practices to limit groundwater inflow to the excavations. In instances where dewatering impacts were modeled, drawdown at the site boundary was typically less than the amount of seasonal fluctuation in the surficial aquifer and water elevations were expected to rebound quickly when dewatering ceased. With a single exception (i.e., the Grand Gulf ESP), impacts were expected to be SMALL. In the Grand Gulf ESP EIS, the staff concluded that the impacts of water use, including dewatering, on the underlying EPA SSA could not be determined because of uncertainty in the plant design, planned pumping rates, and site characterization (NRC 2006-TN674). Groundwater use conflicts, including the impacts of dewatering, were evaluated in the

License Renewal GEIS (NRC 2013-TN2654) and determined to be a Category 2 issue (SMALL, MODERATE, or LARGE impacts depending on project-specific characteristics) for plants that withdraw more than 100 gpm (0.006 m^3/s). Groundwater withdrawals of less than 100 gpm (0.006 m^3/s) were determined to have SMALL impacts because the effects on groundwater levels typically do not extend beyond the site boundary (NRC 2013-TN2654).

A dewatering rate of 50 gpm (0.003 m^3/s) is specified in the ANR PPE/SPE table (Appendix G), as discussed in Section 3.4.1.2.1. While this dewatering rate is less than the rate determined to have SMALL impacts in the License Renewal GEIS, the staff determined that the 50 gpm (0.003 m^3/s) value is appropriate for the smaller site size (100 ac [40.5 ha]) specified in the ANR PPE/SPE table. The actual impacts of dewatering at any particular site will depend on the size of the site, the area and depth of the excavation, and the hydrogeologic characteristics of the site. In evaluating the impacts of dewatering for this generic analysis, staff considered that excavations for ANR sites are expected to be smaller, and the depth of groundwater drawdown at the excavation are expected to be less, than those for the licensed fleet of large LWRs. With these expectations, the staff used simplified modeling to determine that, relative to the plant site area, the effects on groundwater levels caused by dewatering withdrawals of 50 gpm (0.003 m^3/s) at a 100 ac (40.5 ha) ANR site would be similar to the effects caused by dewatering withdrawals of 100 gpm (0.006 m^3/s) on a larger site the size of a typical large LWR. Accepted methods for the design of dewatering systems (DOD 2004-TN6814) were used by staff in this impact evaluation. As specified in the PPE/SPE table, dewatering is assumed to result in negligible drawdown at the site boundary. This indicates that the radius of influence of the dewatering activities (the distance beyond which pumping of a dewatering system has no significant effect on ambient groundwater levels) does not extend beyond the site boundary. With these specifications and assumptions, the staff determined that the impacts of dewatering are likely to be localized at sites where the effective saturated hydraulic conductivity of the surficial aquifer is no more transmissive than that represented by a silty or very fine sand, or fractured/permeable rock. At smaller sites and sites that have more transmissive aquifers, the staff assumed that additional engineering controls would be used to avoid dewatering impacts beyond the site boundary.

The staff has determined that groundwater use conflicts due to excavation dewatering during construction of an ANR is a Category 1 issue. The staff concludes that the effects of dewatering activities related to the construction of new ANRs would be localized and temporary, and groundwater use conflicts from dewatering can be generically determined to have a SMALL impact for this GEIS. This conclusion relies on the following PPE/SPE parameter and the associated value and assumptions:

- Groundwater Withdrawal for Excavation or Foundation Dewatering
  - The long-term dewatering withdrawal rate is less than or equal to 50 gpm (0.003 m^3/s) (the initial rate may be larger).
  - Dewatering results in negligible groundwater level drawdown at the site boundary.

Because wetlands located on or adjacent to the site may be affected by groundwater withdrawals for excavation dewatering, the PPE/SPE includes the assumption that changes in wetland water levels and hydroperiod resulting from groundwater use are within historical annual or seasonal fluctuations, to avoid adverse impacts on nearby wetlands. Potential groundwater use impacts on wetlands are discussed in Sections 3.5.2.1.2 and 3.5.2.2.7 of this GEIS.

Engineering controls may be required to achieve the limit on drawdown. As described in Chapter 1.0, the staff anticipates that an application for an ANR license will include the appropriate data and analysis to establish with reasonable assurance that the proposed project meets the conditions of the PPE/SPE with respect to dewatering, including the limitation on drawdown at the site boundary. If the PPE/SPE conditions cannot be met, a project-specific evaluation of the impacts of excavation dewatering is required.

3.4.2.1.3 Groundwater Use Conflicts Due to Construction-Related Groundwater Withdrawals

During construction, groundwater may be used for activities such as dust abatement, concrete mixing, and potable water needs. Groundwater withdrawals from one or more wells located on the plant site will lower groundwater hydraulic head levels in the aquifer around the well(s). The magnitude of the drawdown in hydraulic head and the extent of the affected area depend on the withdrawal rate, the hydrogeologic conditions of the site, and the duration of withdrawal. Changes in groundwater levels may locally affect the direction of groundwater flow, and may alter groundwater recharge or discharge rates, including discharge to wetlands and streams.

Construction-related groundwater withdrawal rates proposed for the licensed new reactor plant and ESP sites planning to use only groundwater for construction (i.e., South Texas Project, PSEG ESP, Vogtle, and Levy) ranged from 119 gpm (0.008 m^3/s) to 420 gpm (0.026 m^3/s). In the final EIS (FEIS) for each of these proposed plants, the staff determined these pumping rates would have a SMALL impact on groundwater resources, in part due to the limited duration of construction and typical associated withdrawal rates that are less than those proposed for plant operations.

The withdrawal associated with construction use of groundwater would be subject to the limitation of 50 gpm (0.003 m^3/s) included in the ANR PPE/SPE table (Appendix G), as discussed in Section 3.4.1.2.1. This withdrawal limitation is more restrictive than the construction-related groundwater withdrawal rates proposed for the four licensed sites referenced above. In addition, the PPE/SPE assumes that withdrawals for plant use reduce groundwater heads at the site boundary by no more than 1 ft (0.3 m), as discussed in Section 3.4.1.2.1. The 1 ft (0.3 m) limit includes the potential cumulative effect of simultaneous excavation or foundation dewatering and groundwater withdrawal for plant use because dewatering is assumed to contribute negligible drawdown at the site boundary, as specified in Appendix G. The impacts of groundwater withdrawals during operation are evaluated in Section 3.4.2.2.4 and found to be SMALL when the specifications and assumptions of the PPE/SPE are met. Because the duration of groundwater withdrawal would be shorter during construction than during operation, the staff determined that the operational impacts bound those during construction for this issue. The staff therefore concludes that this is a Category 1 issue. If actions required by appropriate permits are implemented and applicable assumptions in the PPE and SPE are met (as described in Section 3.4.2.2.4), water use conflicts related to groundwater withdrawals during construction of an ANR will be minor, and impacts can be generically determined to be SMALL for the ANR GEIS.

3.4.2.1.4 Water Quality Degradation Due to Construction-Related Discharges

During construction-related activities, runoff from disturbed and laydown areas can potentially carry sediments to nearby surface water bodies. Because engineering controls (BMPs, silt fences, detention basins, etc.) regulated by a combination of National Pollutant Discharge Elimination System (NPDES) and U.S. Army Corps of Engineers (USACE) permitting are required during these activities, construction-related impacts on surface water quality would be controlled, localized, and temporary. Shallow groundwater withdrawn during dewatering of foundations during construction could be discharged to surface water bodies on or near the site. The discharge rate is limited to 50 gpm (0.003 m^3/s) by the PPE/SPE value for groundwater excavation dewatering, as discussed in Section 3.4.1.2.1. These discharges would be subject to the limits of an NPDES permit designed to avoid adverse impacts on the receiving water body.

The impacts on surface water quality from construction-related discharges were determined to be SMALL in each of the EIS evaluations for new reactors because of adherence to the conditions of the NPDES permit and because of the temporary nature of the discharge. The staff expects that these impacts would be bounding for ANRs because adherence to NPDES requirements would similarly be required and because the area disturbed would be relatively small (PPE values of 30 ac [12 ha] permanently disturbed and 20 ac [8.1 ha] temporarily disturbed). Accordingly, the staff has determined that water quality degradation due to construction-related discharges of an ANR is a Category 1 issue. The staff concludes that the effects of discharges related to the construction of new ANRs would be localized and temporary and impacts can be generically determined to be SMALL. This conclusion relies on the following PPE/SPE parameters and the associated values and assumptions:

- Permanent Footprint of Disturbance – and Temporary Footprint of Disturbance
  - The permanent footprint of disturbance includes 30 (12 ha) ac or less of vegetated lands, and the temporary footprint of disturbance includes no more than an additional 20 ac (8.1 ha) or less of vegetated lands.
- Impacts on Aquatic Biota
  - Adherence to requirements in NPDES permits issued by the EPA or State permitting program, and any other applicable permits.
- Groundwater Withdrawal for Excavation or Foundation Dewatering
  - The long-term groundwater dewatering withdrawal rate is less than or equal to 50 gpm (0.003 m^3/s).
  - Dewatering discharge has minimal effects on the quality of the receiving water body (e.g., as demonstrated by conformance with NPDES permit requirements).

The staff also concludes that water quality impacts on groundwater can be generically determined to be SMALL. This conclusion relies on the following PPE/SPE parameter and the associated value and assumption:

- Groundwater Quality
  - There are no planned discharges to the subsurface (by infiltration or injection), including stormwater discharge.

3.4.2.1.5 Water Quality Degradation Due to Inadvertent Spills during Construction

During construction, inadvertent spills of gasoline, diesel fuel, hydraulic fluid, lubricants, solvents, and wastewater used for construction equipment could affect both surface water and groundwater resources. Pursuant to 40 CFR Part 112 (TN1041) and 40 CFR Part 9 (TN5322), applicants would be required to use BMPs and implement an Integrated Pollution Prevention Plan (IPPP) to minimize the occurrence of spills and limit their effects. Impacts on water quality from inadvertent spills during construction were determined to be SMALL in the EIS evaluations for new reactors because of adherence to these spill prevention and pollution control measures.

Building an ANR is expected to involve activities and methods similar to those for building a large LWR. The associated BMPs and IPPP implementation are also expected to be similar. Therefore, the staff has determined that water quality degradation due to inadvertent spills during construction of an ANR is a Category 1 issue. The staff concludes that the impacts of inadvertent spills on water quality during construction of an ANR can generically be determined to be SMALL. This conclusion relies on the following PPE/SPE parameters and the associated values and assumptions. This conclusion relies on the following assumptions:

- Site Size and Location
  - The site size is 100 ac (40.5 ha) or less
- Permanent Footprint of Disturbance and Temporary Footprint of Disturbance
  - The permanent footprint of disturbance includes 30 ac (12 ha) or less of vegetated lands, and the temporary footprint of disturbance includes no more than an additional 20 ac (8.1 ha) or less of vegetated lands.
- Groundwater Quality
  - Applicable requirements and guidance on spill prevention and control are followed, including relevant BMPs and IPPPs.

3.4.2.1.6 Water Quality Degradation Due to Groundwater Withdrawal

Degradation of groundwater resources may occur when dewatering or withdrawal of groundwater for plant uses induces the flow of lower quality water from the surrounding aquifers or connected surface water bodies. This could result from pumping of deep confined aquifers and dewatering of shallow, unconfined surficial aquifers.

Groundwater withdrawals may induce infiltration from surface water (e.g., rivers, ponds, or lakes), or contribute to saltwater intrusion from oceans and estuaries in aquifers near the coast. In the License Renewal GEIS (NRC 2013-TN2654) the staff determined that pumping of confined groundwater at operating plants in estuary or coastal sites had a small impact on groundwater quality. The pumping rates considered in the License Renewal GEIS greatly exceed the PPE/SPE limits for groundwater withdrawals.

In EISs for new reactors, the staff has generally determined that the impacts of dewatering of the surficial aquifer would not extend far beyond the site boundary. At sites located near water bodies of lower quality, such as PSEG, the surficial aquifer can be impacted. In that case, the impacts were due to hydraulic connections with brackish Delaware River water limiting the private use of groundwater in the area and the potential for further degradation (NRC 2015-TN6438).

The PPE/SPE table limits groundwater withdrawals for excavation dewatering and plant uses to 50 gpm (0.003 m^3/s) each and assumes that groundwater withdrawals will result in no more than a 1 ft (0.3 m) lowering of groundwater levels at the site boundary, as discussed in Section 3.4.1.2.1. The 1 ft (0.3 m) limit includes the potential cumulative effect of simultaneous excavation dewatering and groundwater withdrawal for plant uses because dewatering is assumed to contribute negligible drawdown at the site boundary, as specified in the PPE/SPE table (Appendix G). In areas that have exploitable groundwater resources, the PPE/SPE withdrawal rate is expected to be a small fraction of the total withdrawal rate by other users (typically agricultural or municipal uses in rural and urban areas, respectively). With no more than a 1 ft (0.3 m) change in groundwater levels at the site boundary, the potential for PPE/SPE withdrawals to induce flow from adjacent water bodies is unlikely to be noticeable. In addition, the effects of groundwater withdrawals would be limited to the period of construction.

The staff has determined that water quality degradation due to groundwater withdrawals is a Category 1 issue. The staff concludes that water quality impacts resulting from groundwater withdrawals during construction of proposed new ANRs would be localized and temporary and can be generically determined to be SMALL for the ANR GEIS. This conclusion relies on the following PPE/SPE parameters and the associated values and assumptions:

- Groundwater Withdrawal for Excavation or Foundation Dewatering
  - The long-term dewatering withdrawal rate is less than or equal to 50 gpm (0.003 m^3/s) (the initial rate may be larger).
  - Dewatering results in negligible groundwater level drawdown at the site boundary.
- Groundwater Withdrawal for Plant Uses
  - Groundwater withdrawal for all plant uses (excluding dewatering) is less than or equal to 50 gpm (0.003 m^3/s).
  - Withdrawal results in no more than 1 ft (0.3 m) of groundwater level drawdown at the site boundary.
  - Withdrawals are not derived from an EPA-designated SSA, or from any aquifer designated by a State, tribe, or regional authority to have special protections to limit drawdown.
  - Withdrawals meet any applicable State or local permit requirements.

3.4.2.1.7 Water Quality Degradation Due to Offshore or In-Water Construction Activities

Activities that may be associated with water quality degradation in lakes, rivers, and marine environments include offshore or in-water construction of cofferdams; dredging operations; placement of fill material into the water; creation of shoreside facilities involving bulkheads, piers, jetties, basins, or other structures or activities with potential to alter existing shoreline processes; construction of intake and outfall structures; water channel modifications; and bridge or culvert construction. Activities related to in-water building are localized and temporary, lasting for the duration of the construction. These in-water building activities are regulated by provisions of the CWA Section 404 (33 U.S.C. § 1344-TN1019) and Section 10 of the Rivers and Harbors Appropriation Act of 1899 (33 U.S.C. §§ 401 *et seq*.; TN660). Adverse effects of these building activities are traditionally controlled using BMPs like installation of turbidity curtains or installation of cofferdams.

As such, the staff has determined that water quality degradation due to offshore or in-water construction activities is a Category 1 issue and that the impacts could be generically determined to be SMALL. This conclusion relies on the following PPE/SPE parameter and the associated values and assumptions:

- In-Water Structures (including intake and discharge structures)

– Constructed in compliance with provisions of the CWA Section 404 (33 U.S.C. § 1344-TN1019) and Section 10 of the Rivers and Harbors Appropriation Act of 1899 (33 U.S.C. §§ 401 *et seq.*; TN660).
– Adverse effects of building activities controlled and localized using BMPs such as installation of turbidity curtains or installation of cofferdams.
– Construction duration would be less than 7 years.

3.4.2.1.8 Water Use Conflicts Due to Plant Municipal Water Demand

Municipal water supply used to support construction-related water use (e.g., potable and sanitary needs) may affect the municipal systems' ability to meet their planned obligation to other users. This plant need would only exist during the period of plant construction. To generically assess the potential impact on municipal systems from the plant's construction-related water use, the staff assumed that the needed amount of municipal water would be available and within the existing capacity of the municipal systems, thereby accounting for all existing and planned future uses. If these assumptions are satisfied, the staff determined that the plant's construction-related municipal water use would not unduly stress the municipal systems' ability to meet their existing and planned obligations.

The staff has determined that the effect of water supply from municipal systems is a Category 1 issue. The staff concludes that, as long as the relevant PPE and SPE are met the impacts on municipal systems from building an ANR can be generically determined to be SMALL. This conclusion relies on the following PPE/SPE parameter and the associated value and assumptions:

- Municipal Water Availability
  – The amount available from municipal water systems exceeds the amount of municipal water required by the plant (gpm).
  – Municipal Water Availability accounts for all existing and planned future uses.
  – An agreement or permit for the usage amount can be obtained from the municipality.

3.4.2.1.9 Degradation of Water Quality Due to Plant Effluent Discharges to Municipal Systems

During construction, certain plant effluents (e.g., sanitary and sewer discharges) could be discharged to a municipal wastewater treatment system. This plant effluent discharge would only exist during the period of plant construction. To generically assess the potential impact on the municipal wastewater system, the staff assumed that the municipal system has an existing or planned capacity to treat all plant effluents while accounting for all existing and planned future discharges. The staff further assumed that the plant effluent constituents can be treated by the receiving system and therefore a permit can be obtained for construction-related plant effluent discharge to the municipal systems.

The staff has determined that the degradation of water quality from plant effluent discharges to municipal systems is a Category 1 issue. The staff concludes that, as long as the relevant PPE and SPE criteria are met the impacts on water quality from plant effluent discharges to municipal systems related to building an ANR can be generically determined to be SMALL. This conclusion relies on the following PPE/SPE parameter and the associated values and assumptions:

- Municipal Systems’ Available Capacity to Receive and Treat Plant Effluent
  - Municipal Systems’ Available Capacity to Receive and Treat Plant Effluent accounts for all existing and reasonably foreseeable future discharges.
  - Agreement to discharge to a municipal treatment system is obtainable.

3.4.2.2 Environmental Consequences of Operation

If the plant is water-cooled, the primary water-related impact would be associated with withdrawals and discharges related to the cooling-water system. Potential impacts on water quality, availability, and designated use may occur as a result of operations-related activities that may include the following:

- maintenance dredging and disposal of dredged spoils
- groundwater dewatering of site structures to support plant operations
- surface water withdrawal at intake structures
- surface water discharge of plant blowdown and effluents to discharge structures
- groundwater withdrawal for plant use
- inadvertent spills of chemicals, fuels, solvents, and oils
- water supply from and discharges to municipal systems.

As described in the following sections, the NRC staff identified the following environmental issues related to water use, which may arise during operation:

- surface water use conflicts during operations due to water withdrawal from flowing water bodies
- surface water use conflicts during operation due to water withdrawal from non-flowing water bodies
- groundwater use conflicts due to building foundation dewatering
- groundwater use conflicts due to groundwater withdrawals for plant uses
- surface water quality degradation due to operation of intake and discharge structures
- surface water quality degradation due to changes in salinity gradients resulting from withdrawals
- surface water quality degradation due to chemical and thermal discharges
- groundwater quality degradation due to plant discharges
- water quality degradation due to inadvertent spills and leaks during operation
- water quality degradation due to groundwater withdrawals
- water use conflict due to plant municipal water demand
- degradation of water quality due to plant effluent discharges to municipal systems.

The potential impacts related to water use conflicts and water quality degradation are discussed in the following sections.

3.4.2.2.1 Surface Water Use Conflicts during Operation Due to Water Withdrawal from Flowing Water Bodies

The staff used a performance-based approach to identify a conservative and defensible SPE criterion based on water availability at the proposed ANR site. The SPE criteria and assumptions were developed for flowing (e.g., stream, canal, or river) and non-flowing (e.g., oceans, gulfs, intertidal zones, estuaries, lakes, ponds, and reservoirs) water bodies because withdrawals affect each of these types of water bodies differently (see Appendix G). The SPE criteria and assumptions for flowing water bodies are discussed in this section. SPE criteria and assumptions for non-flowing water bodies are discussed in Section 3.4.2.2.2. Using these performance-based criteria and assumptions potentially allows a larger number of sites in a variety of hydrologic settings to fall within Category 1 under this GEIS.

As discussed in Section 3.4.1.1, the staff determined that the total amount of surface water withdrawn from surface water bodies for use by the ANR would be less than or equal to 6,000 gpm (0.379 m^3/s), which is the PPE related to total plant water demand. This PPE value was derived by considering the water needs of currently known ANR technologies. During operations, some of this water would be consumed through evaporative loss or by other plant systems. It is expected that operation-related water needs of an ANR will be much lower if the plant does not use water for cooling. The PPE limit includes water withdrawn from surface water sources for use by all plant systems (cooling water, service water, fire protection, potable, and sanitary) but does not include water from a municipal provider even if the municipal provider obtained the water from a surface water source, because the impacts of withdrawal by a municipal provider would have been considered in the provider's withdrawal permit. The staff estimated that the total plant water demand PPE is 5 to 10 times less than the average surface water withdrawal rate proposed by the recently licensed large LWRs that planned to rely predominately on flowing surface water bodies during operations (e.g., VC Summer, WS Lee, and Clinch River). In each recently licensed large LWR, the impacts of water withdrawal on surface water resources were determined to be SMALL in part due to the comparatively large amount of water available for use at each site. As a result of these factors, the NRC staff determined that the PPE for total plant water demand conservatively supports a generic impact determination when neither the design nor the site are currently known.

The SPE criteria for surface water availability of a flowing water body was determined by identifying the following:

- An appropriate low flow characteristic to be used in the water impact assessment for flowing surface water bodies. The staff chose to use the 95 percent exceedance flow of the flowing surface water body as the flow characteristic for the impact assessment because this characteristic is statistically representative of low flow conditions for that water body.
- A conservative impact measure of the low flow characteristic, which could be used to relate withdrawal to the impact and category designation. Based on the evaluation described below, the staff determined that plant withdrawals of 3 percent or less of the 95 percent exceedance flow of the flowing surface water body would result in a SMALL impact and Category 1 designation.
- Constraints on the applicability of the Category 1 determination. These constraints were developed by evaluating the previous EISs for circumstances that led to impacts that were greater than SMALL and are included as assumptions for the SPE criteria.

The staff developed the SPE criteria for water withdrawal (i.e., 3 percent of the 95 percent exceedance flow) by evaluating the impacts related to plant use of flowing surface water bodies in EISs for new reactors and the License Renewal GEIS for operating reactors (NRC 1996-TN288 and NRC 2013-TN2654). In each recent EIS for new large LWRs withdrawing from flowing surface water bodies, the staff determined that the impacts would be SMALL even though maximum withdrawal rates were above 3 percent of the water available during low flow conditions. The only exceptions to this were the proposed Grand Gulf and PSEG sites, where the ratio of maximum plant withdrawal to availability during low flow conditions was much smaller because of the size of the adjacent river resulting in SMALL impact determinations (NRC 2006-TN674). The License Renewal GEIS discusses two plants where plant withdrawals from flowing surface water bodies that exceeded 10 percent of minimum flows could result in future water use conflicts (Limerick and Duane Arnold; NRC 1996-TN288). In both cases, reducing the withdrawal to a much smaller percentage of the minimum flow, such as the SPE value of 3 percent or less, would reduce the chances of future water use conflicts and minimize impacts on other users. The SPE value of 3 percent would also comply with the EPA 316(b) Proportional Flow Limitation (40 CFR 125.84(b)(3)(i) [TN254]), which specifies that plants not withdraw more than 5 percent of the source water body annual mean flow.

The staff's generic analysis for water use impacts on flowing surface water bodies is described here. The impact of water withdrawals on the resource is expected to be SMALL when the plant withdrawal from a flowing surface water body is less than 3 percent of the 95 percent exceedance flow and when assumptions stated in Appendix G are met. The criterion may be described using the following equation:

$$Q_w \leq 0.03 \times Q_{95\%}$$

where Q_w is the plant water withdrawal rate and $Q_{95\%}$ is the 95 percent exceedance flow (rate) of the flowing surface water body.

Using this relationship, a plant withdrawing water at the 6,000 gpm (0.379 m^3/s) (the PPE limit) would need to be sited on a flowing surface water body with a 95 percent exceedance flow of at least 200,000 gpm (12.62 m^3/s) (approximately 450 cfs). Plants with lower withdrawal rates could be sited on smaller flowing surface water bodies and be included in this generic analysis, as illustrated by the shaded region in Figure 3-1. If this relationship is met, the staff has determined that surface water use conflicts during operations due to water withdrawal from flowing surface water bodies is a Category 1 issue. This conclusion relies on the following PPE/SPE parameters and the associated values and assumptions:

- Total Plant Water Demand
  - Less than or equal to a daily average 6,000 gpm (0.379 m^3/s).
- Surface Water Availability – Flowing
  - Average plant water withdrawals do not reduce discharge from the flowing water body by more than 3 percent of the 95 percent exceedance daily flow and do not prevent the maintenance of applicable instream flow requirements.
  - The 95 percent exceedance flow accounts for existing and planned future withdrawals.
  - Water availability is demonstrated by the ability to obtain a withdrawal permit issued by State, regional, or tribal governing authorities.
  - Water rights for the withdrawal amount are obtainable, if needed.

If the assumptions are not met or the plant water demand exceeds the PPE, assessing surface water use impacts would require a project-specific evaluation in the SEIS.

Radial (Ranney©) collector wells have been proposed for some new reactor sites and may be proposed to supply water for ANRs. Radial collector wells are installed within an aquifer and have a direct, productive connection to a surface water body so that they can withdraw water from the surface water body that is of better quality, due to bank filtration, while minimizing impacts such as sedimentation and scouring in the surface water body. Because these wells either directly pump surface water or are removing groundwater that is discharging to a surface water body, the PPE/SPE values and assumptions for surface water availability and the evaluation of surface water use conflicts above also apply to withdrawals from radial collector wells.

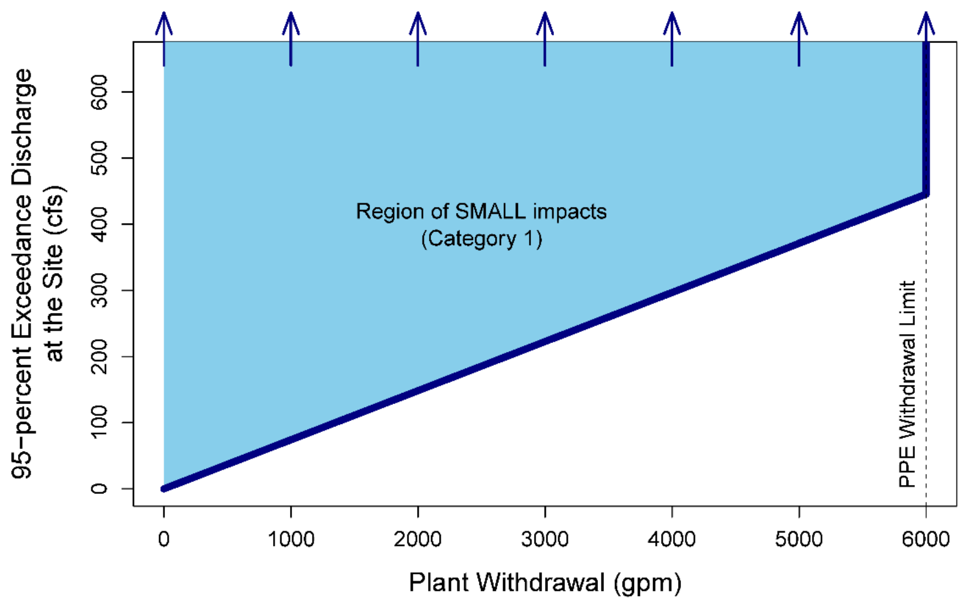

Figure 3-1 SMALL Surface Water Use Impacts for Plant Withdrawals of 6,000 gpm (0.379 m^3/s) or Less Compared to the 95 Percent Exceedance Discharge in the Flowing Surface Water Body.

3.4.2.2.2 Surface Water Use Conflicts during Operation Due to Water Withdrawal from Non-flowing Water Bodies

The staff considers the water availability of some non-flowing surface water bodies, i.e., the Great Lakes, the Gulf of Mexico, estuaries, intertidal zones, bays, and oceans, to be large water bodies compared to the total plant water demand PPE value of 6,000 gpm (0.379 m^3/s). For example, in the EIS for Fermi (NRC 2013-TN6436), the staff determined that the annual water withdrawal amounted to an inconsequential amount (0.0014 percent) of the volume of Lake Erie.

The staff considers that smaller non-flowing surface water bodies (e.g., inland lakes, manufactured ponds, and reservoirs) have limited water availability. These water bodies are not included in the staff's generic analysis. The water availability in these smaller non-flowing surface water bodies may be allocated or planned for multiple uses. Therefore, withdrawing water for use from these smaller non-flowing surface water bodies is more likely to result in surface water use conflicts. The impacts from the competing water use could manifest in different ways (e.g., reduction in downstream discharge from the water body, reduction in water surface elevation of the water body, and reduction in nearshore habitat suitability) that depend on site-specific hydrologic conditions. The staff has determined that impacts of plant water withdrawal from these smaller non-flowing surface water bodies on surface water resources will be assessed in a project-specific analysis in the SEIS.

As a result, the staff determined that the impact of surface water use from these large non-flowing surface water bodies is a Category 1 issue. The staff concludes that if the conditions and assumptions of the PPE and SPE are met the impact on surface water resources from plant water withdrawal from these large non-flowing surface water bodies would be negligible and can be generically determined to be SMALL. This conclusion relies on the following PPE/SPE parameters and the associated values and assumptions:

- Total Plant Water Demand
  - Less than or equal to a daily average of 6,000 gpm (0.379 m^3/s).
- Surface Water Availability – Non-flowing
  - Water availability of the Great Lakes, the Gulf of Mexico, oceans, estuaries, and intertidal zones exceeds the amount of water required by the plant.
  - Water availability is demonstrated by the ability to obtain a withdrawal permit issued by State, regional, or tribal governing authorities.
  - Water rights for the withdrawal amount are obtainable, if needed.
  - Coastal Zone Management Act of 1972 (16 U.S.C. §§ 1451 *et seq.*; TN1243) consistency determination is obtainable, if applicable.

The discussion related to radial collector wells that withdraw water from flowing surface water bodies in Section 3.4.2.2.1 is also relevant if water were withdrawn using radial collector wells from a non-flowing surface water body.

3.4.2.2.3 Groundwater Use Conflicts Due to Building Foundation Dewatering

The potential impacts of excavation dewatering are described in Section 3.4.2.1.2, in which the staff concluded that dewatering during construction is expected to result in a SMALL impact on groundwater resources. This conclusion relied on the PPE/SPE specification that the dewatering rate is less than 50 gpm (0.003 m^3/s) and the assumption that dewatering results in negligible alterations in groundwater levels at the site boundary. The basis for the PPE/SPE values and assumptions are discussed in Section 3.4.1.2.1. The effects of dewatering building foundations during plant operation would be similar to those occurring during construction, but the magnitude of the effects may increase because of the longer period of operation.

The combined impact of operational dewatering and plant groundwater use for large LWRs was evaluated in the License Renewal GEIS (NRC 2013-TN2654). Based on a review of operating plants, the staff concluded in the License Renewal GEIS that plants withdrawing less than 100 gpm (0.006 m^3/s) (for operational dewatering or for plant uses) would have SMALL impacts. However, the staff also determined that plants withdrawing more than 100 gpm (0.006 m^3/s) have the potential to create conflicts with other local groundwater users if groundwater levels are lowered beyond the site boundary. For these plants, the staff concluded that the impacts of groundwater withdrawals cannot be determined generically.

When evaluating the impacts of dewatering in Section 3.4.2.1.2, the staff noted that although the PPE/SPE dewatering rate of 50 gpm (0.003 m^3/s) is less than the rate determined to have SMALL impacts in the License Renewal GEIS, the actual impacts of dewatering at any particular site will depend on the size of the site, the area dewatered, the depth of groundwater drawdown at the dewatering location (i.e., the building foundations), and the hydrogeologic conditions of the site. As a result, the actual effects of dewatering on groundwater levels are uncertain and this uncertainty increases with the duration of the projected need for dewatering. The staff relied on the temporary nature of dewatering during construction in concluding that the impacts of dewatering during construction would be SMALL. Because dewatering of building foundations could occur for the duration of operations, the potential impacts of operational dewatering could be larger than those of the relatively shorter period of construction.

The effects of dewatering on groundwater levels would be monitored and appropriate mitigation would be used with the PPE/SPE conditions met, the effects of dewatering will be localized to the plant site and therefore unlikely to result in groundwater use conflicts. On this basis, the staff has determined that groundwater use conflicts due to building foundation dewatering during operation of an ANR are a Category 1 issue. The staff concludes that the effects of dewatering activities related to the operation of new ANRs would be localized to the plant site, and groundwater use conflicts from dewatering can be generically determined to have a SMALL impact for the ANR GEIS. This conclusion relies on the following PPE/SPE parameter and the associated values and assumptions.

- Groundwater Withdrawal for Excavation or Foundation Dewatering
  - The long-term dewatering withdrawal rate is less than or equal to 50 gpm (0.003 m^3/s) (the initial rate may be larger).
  - Dewatering results in negligible groundwater level drawdown at the site boundary.

Because wetlands located on or adjacent to the site may be affected by building foundation dewatering during operations, the PPE/SPE includes the assumption that changes in wetland water levels and hydroperiod resulting from groundwater use are within historical annual or seasonal fluctuations, to avoid adverse impacts on nearby wetlands. Potential groundwater use impacts on wetlands are discussed in Sections 3.5.2.1.2 and 3.5.2.2.7 of the ANR GEIS.

As discussed in Chapter 1.0, the staff anticipates that an application for an ANR license will include the appropriate data and analysis to establish with reasonable assurance that the proposed project meets the conditions of the PPE/SPE with respect to dewatering, including the limitations on groundwater withdrawal rate and on drawdown at the site boundary. If the PPE/SPE conditions cannot be met, a project-specific evaluation of the impacts of excavation dewatering is required.

3.4.2.2.4 Groundwater Use Conflicts Due to Groundwater Withdrawals for Plant Uses

Construction use of groundwater is discussed in Section 3.4.2.1.3. Groundwater may be used during operations for various plant purposes, including potable, sanitary, process, and cooling uses. The operational effects of groundwater use would be similar to those described for construction, with the principal difference being that the duration of pumping for operations would be significantly longer. When evaluating impacts, the staff considered an operational period of 40 years. Groundwater withdrawals from one or more wells located on the plant site will lower groundwater hydraulic head levels in the aquifer around the well(s), and the magnitude of the drawdown in hydraulic head and the extent of the affected area tend to increase with the duration of the withdrawal. As noted previously, changes in groundwater levels may locally affect the direction of groundwater flow, and may alter groundwater recharge or discharge rates, including discharge to wetlands and streams.

The staff reviewed recent new reactor EISs and found that the proposed groundwater pumping rates exceeding 100 gpm (0.006 m^3/s) were determined to have a SMALL impact on groundwater resources. In each case, this conclusion was made, in part, because the site locations and specific pumping rates were known and could be fully evaluated. In one instance (Grand Gulf), where the plant design and groundwater withdrawal rate were uncertain, and where withdrawals would be from an EPA-designated SSA, the staff concluded that a MODERATE impact was possible (NRC 2006-TN674).

Based on a review of groundwater withdrawals for operational purposes at existing plants, the staff reported in the License Renewal GEIS (NRC 2013-TN2654) that impacts on water resources could vary based on geographic location, especially if pumping rates exceeded 100 gpm (0.006 m^3/s). As a result, the staff determined that groundwater use conflicts are a Category 2 issue (SMALL, MODERATE, or LARGE impacts depending on project-specific characteristics) for plants that withdraw more than 100 gpm (0.006 m^3/s). For plants that withdraw less than 100 gpm (0.006 m^3/s), the staff determined that groundwater use conflicts were a Category 1 issue and concluded that these plants would have SMALL impacts because the effects on groundwater levels do not usually extend beyond the site boundary (NRC 2013-TN2654).

A groundwater withdrawal rate of 50 gpm (0.003 m^3/s) is specified in the PPE/SPE table (Appendix G), as discussed in Section 3.4.1.2.1. While this withdrawal rate is less than the rate determined to have SMALL impacts in the License Renewal GEIS, the actual impacts of groundwater withdrawals at any particular site will depend on the size of the site. The site size (100 ac [40.5 ha]) specified in the PPE/SPE table is much smaller than the areas of operating plants and licensed new reactors (e.g., the Clinch River site proposed for a small modular reactor is more than 900 ac [364 ha]). In evaluating the impacts of groundwater use for this generic analysis, the staff considered the 100-ac (40.5 ha) size specified in the PPE for ANR sites and used a distance between the pumped well and the site boundary of about 1,000 ft (305 m) (the distance of a well located at the center of a square 100 ac site). As noted below, mitigation to prevent significant impacts may be required if the well is closer to the site boundary. The staff's analysis used a single well, screened over the entire depth of an infinite (in area), homogeneous aquifer, and withdrawing 50 gpm (0.003 m^3/s) for 40 years. As specified in the PPE/SPE table, and discussed in Section 3.4.1.2.1, groundwater withdrawals are assumed to result in no more than 1 ft (0.3 m) of drawdown at the site boundary.

Given the specifications and assumptions described above, groundwater drawdown at any distance from the pumped well can be estimated with an analytical approach for radial flow to a well (e.g., Freeze and Cherry 1979-TN3275). Because drawdown depends on the hydrogeological properties of the aquifer (which is unknown for a generic site), the staff evaluated the effects of groundwater use for a representative range of aquifer properties. The staff determined that the impacts of groundwater withdrawals are likely to be localized (i.e., groundwater drawdown beyond the site boundary is less than 1 ft [0.3 m]) at sites where the effective transmissivity is greater than about 5,000 ft^2/d (465 m^2/d) for withdrawals from an unconfined aquifer and greater than 10,000 ft^2/d (929 m^2/d) for withdrawals from a confined aquifer. These transmissivity values imply aquifers that are productive sources of groundwater, with well-specific capacities in the range of 25 to 40 gpm/ft (0.0052 to 0.0083 $m^3/s/m$) of drawdown (Driscoll 1986-TN6823). At smaller sites or sites where the pumped well is located closer to the site boundary, and at sites with less transmissive aquifers, additional mitigation may be needed to avoid groundwater use conflicts (e.g., reducing the withdrawal rate or altering the location of the well with respect to other groundwater users).

The staff determined that groundwater use conflicts due to groundwater withdrawals during operation of an ANR is a Category 1 issue. The staff concludes that the effects of groundwater use related to the operation of new ANRs would be localized to the site area and groundwater use conflicts from withdrawals for plant uses can be generically determined to have a SMALL impact for the ANR GEIS. This conclusion relies on the following PPE/SPE parameter and the associated values and assumptions:

- Groundwater Withdrawal for Plant Uses
  - Groundwater withdrawal for all plant uses (excluding dewatering) is less than or equal to 50 gpm (0.003 m^3/s).
  - Withdrawal results in no more than 1 ft (0.3 m) of groundwater level drawdown at the site boundary.
  - Withdrawals are not derived from an EPA-designated SSA, or from any aquifer designated by a State, tribe, or regional authority to have special protections to limit drawdown.
  - Withdrawals meet any applicable State or local permit requirements.

Because wetlands located on or adjacent to the site may be affected by building foundation dewatering during operations, the PPE/SPE includes the assumption that changes in wetland water levels and hydroperiod resulting from groundwater use are within historical annual or seasonal fluctuations, to avoid adverse impacts on nearby wetlands. Potential groundwater use impacts on wetlands are discussed in Sections 3.5.2.1.2 and 3.5.2.2.7 of the ANR GEIS.

As described in Chapter 1.0, the staff anticipates that an application for an ANR license will include the appropriate data and analysis to establish with reasonable assurance that the proposed project meets the conditions of the PPE/SPE with respect to groundwater withdrawals for plant use. If the PPE/SPE conditions cannot be met, a project-specific evaluation of the impacts of groundwater withdrawal is required.

3.4.2.2.5 Surface Water Quality Degradation Due to Physical Effects from Operation of Intake and Discharge Structures

Cooling-water intake and discharge structures have the potential to create localized impacts on surface water quality through physical effects such as alterations of current patterns, scouring, sediment transport, and increased turbidity. The License Renewal GEIS (NRC 2013-TN2654) reports that these impacts have typically been small for operating reactors, in part due to adherence to Section 316 of the CWA (33 U.S.C. § 1326; TN4823) and because effects are limited to the area of the intake and discharge structure. Section 316(b) of the CWA requires that the "best technology available for minimizing adverse environmental impact" be used for cooling-water intake structure. This has made the use of once-through cooling-water systems unlikely for new power plants. Any applicant for an ANR license that uses intake or discharge structures as part of the cooling or water supply system would also need to comply with the same requirements of Section 316(b) of the CWA and the conditions of the NPDES permit that would be required for the site.

Because the effects of intake and discharge structures are dependent on water withdrawal and discharge rates, the staff expects that the plant discharge rate would be less than the withdrawal rate. The withdrawal rate is based on the PPE limit for Total Plant Water Demand and any applicable SPE values and assumptions for the selected water source (Surface Water Availability for Flowing or Non-flowing water bodies). For flowing water bodies, withdrawals would be limited to the total plant water demand PPE/SPE value of 6,000 gpm (0.379 m^3/s) and be 3 percent or less of the 95 percent low flow value for the water body as explained in Section 3.4.2.2.1. For non-flowing water bodies, withdrawals would also be limited to the total plant water demand PPE/SPE value of 6,000 gpm (0.379 m^3/s) and be subject to SPE values and assumptions.

The staff has determined that degradation of surface water quality due to operation of intake and discharge structures is a Category 1 issue. The staff concludes that the impacts on the aquatic environment from the alteration of current patterns, scouring, sediment transport, and increased turbidity would be localized to the vicinity of these structures, and therefore the impact on surface water quality can be generically determined to be SMALL. This conclusion relies on the following PPE/SPE parameters and the associated values and assumptions:

- Total Plant Water Demand
  - Less than or equal to a daily average of 6,000 gpm (0.379 m^3/s).
- Intake and Discharge Structures
  - Adhere to best available technology requirements of CWA 316(b) (33 U.S.C. § 1326-TN4823).
  - Operated in compliance with CWA Section 316 (b) and 40 CFR 125.83, including compliance with monitoring and recordkeeping requirements in 40 CFR 125.87 and 40 CFR 125.88, respectively (40 CFR Part 125-TN254).
  - Best available technologies are employed in the design and operation of intake and discharge structures to minimize alterations due to scouring, sediment transport, increased turbidity, and erosion.
  - Adherence to requirements in NPDES permits issued by the EPA or a given state.

If water is obtained from a flowing water body, then the following PPE/SPE parameter and the associated value and assumption also applies:

- Surface Water Availability – Flowing
  - The average rate of plant withdrawal does not exceed 3 percent of the 95 percent exceedance daily flow for the water body.

If water is obtained from a non-flowing water body, then the following PPE/SPE parameter and the associated value and assumption also apply:

- Surface Water Availability – Non-flowing
  - Water availability of the Great Lakes, the Gulf of Mexico, oceans, estuaries, and intertidal zones exceeds the amount of water required by the plant.

3.4.2.2.6 Surface Water Quality Degradation Due to Changes in Salinity Gradients Resulting from Withdrawals

Power plant withdrawals may cause alterations to salinity concentrations and salinity gradients if the source water body is an estuary or intertidal zone. As a result, States with estuaries or intertidal zones typically require consideration of the effect of power plant withdrawals on the alteration of salinity regimes as part of the development of permits.

The impacts of water withdrawal and discharge on salinity gradients near operating nuclear power plants, including those located on estuaries or intertidal zones, were evaluated by the staff for the 2013 License Renewal GEIS (NRC 2013-TN2654). The 2013 License Renewal GEIS drew upon project-specific examples provided in the 1996 License Renewal GEIS (NRC 1996-TN288) to conclude that altered salinity gradients were expected to be noticeable only in the immediate vicinity of the intake and discharge structures. The 1996 License Renewal GEIS considered the impacts to be SMALL and designated this a Category 1 issue. To develop the ANR GEIS, the staff considered the conclusions and examples provided in both the 1996 License Renewal GEIS and the 2013 revision. In one example shared in the 1996 GEIS, the staff noted that a fossil-fuel plant located on the same large estuary as a nuclear plant, was found to have altered natural salinity patterns because it was sited in a shallower area. This illustrates that, even in large estuaries, the degree of impact is somewhat dependent on the location of the plant. Siting may be an even more important factor when a smaller water body is involved. In addition, the 1996 GEIS noted that impacts were also dependent on whether alterations to salinity gradient were, "…within the normal tidal or seasonal movements of salinity gradients that characterize estuaries" (NRC 1996-TN288).

For the ANR GEIS, the staff recognizes that for water bodies other than estuaries and intertidal zones, maintaining the natural salinity regime is not a critical issue and is not typically included in water quality criteria for that water body. As noted above, in sensitive water bodies such as estuaries or intertidal zones, factors that affect the magnitude of potential impacts include the size of the water body, the placement of the plant intake structures in relation to the water body, and any changes in the normal range and movement of the salinity gradients that characterize that water body. These factors are project-specific and are considered important in the development of the impact level for ANRs that may be sited in a variety of locations and water body types.

For the ANR GEIS, the staff has determined that degradation of surface water quality due to changes in salinity gradients resulting from withdrawal is a Category 1 issue that can be generically determined to be SMALL. This conclusion relies on the following PPE/SPE parameter and the associated value and assumption:

- Total Plant Water Demand
  - Less than or equal to a daily average 6,000 gpm (0.379 m^3/s).

If water is obtained from a flowing water body, then the following PPE/SPE parameter and the associated values and assumptions also apply:

- Surface Water Availability – Flowing
  - Average plant water withdrawals do not reduce discharge from the flowing water body by more than 3 percent of the 95 percent exceedance daily flow and do not prevent the maintenance of applicable instream flow requirements.
  - The 95 percent exceedance flow accounts for existing and planned future withdrawals.
  - Water availability is demonstrated by the ability to obtain a withdrawal permit issued by State, regional, or tribal governing authorities.
  - Water rights for the withdrawal amount are obtainable, if needed.

- If withdrawals are from an estuary or intertidal zone, then changes to salinity gradients are within the normal tidal or seasonal movements that characterize the water body.

If water is obtained from a non-flowing water body, then the following PPE/SPE parameter and the associated values and assumptions also apply:

- Surface Water Availability – Non-flowing
  - Water availability of the Great Lakes, the Gulf of Mexico, oceans, estuaries, and intertidal zones exceeds the amount of water required by the plant.
  - Water availability is demonstrated by the ability to obtain a withdrawal permit issued by State, regional, or tribal governing authorities.
  - Water rights for the withdrawal amount are obtainable, if needed.
  - If withdrawals are from an estuary or intertidal zone, then changes to salinity gradients are within the normal tidal or seasonal movements that characterize the water body.

Regardless of the water body type, this GEIS assumes that a Coastal Zone Management Act of 1972 (16 U.S.C. §§ 1451 *et seq*.; TN1243) consistency determination is obtainable, if applicable. However, based on the discussion above, for estuaries and intertidal zones, the staff's impact conclusion relies on the SPE assumption, adopted from the License Renewal GEIS, that changes to salinity gradients be localized near the intake of the power plant and remain within the normal tidal or seasonal movements of salinity gradients that characterize the water body. If PPE and SPE values and assumptions are not met, then a project-specific evaluation will be required.

3.4.2.2.7 Surface Water Quality Degradation Due to Chemical and Thermal Discharges

During operations, nuclear plants may discharge water from the cooling, service, and sanitary water systems to surface water bodies near the plant. If the plant is water-cooled, the largest volume of discharge and the greatest potential impacts on water quality are associated with the heat and chemical constituents in the effluent discharged from the cooling-water system. Discharges typically contain increased TDS, salinity, biocides, heavy metals, and other contaminants that may have been included in the withdrawn cooling water but become concentrated due to evaporative loss during the cooling process. Some chemicals may also be added to the withdrawn water before it is discharged (e.g., biocides). Impacts on surface water from plant discharge may vary based on the quality and rate of the plant discharge and the characteristics of the receiving water body, some of which are related to location. These location-dependent characteristics may include natural variations in temperature, salinity levels, or normal tidal or seasonal movements of salinity gradients.

To operate, power plants must obtain an NPDES permit under Section 402 of the CWA (33 U.S.C. § 1342-TN4765). The permit specifies discharge standards and monitoring requirements, and licensees are required to be in compliance with the limits set by the permit. NPDES permits are issued by the EPA or, more commonly, a designated State water quality regulatory agency.

The staff performed a review of the historical impacts of discharges from known plant discharge designs on well-understood sites and determined that the impacts were determined to be of small significance (NRC 2013-TN2654). The staff also reviewed EISs for licensed new reactors and determined that the impacts of discharges during operations on surface water quality would be SMALL, with one exception. This exception occurred in the Grand Gulf ESP EIS, where the staff concluded that the impacts of plant discharges on the Mississippi River water quality were not able to be determined because "…the bounds of concentrations of chemical effluents" for all waste streams had not been provided in the PPE or ER (NRC 2006-TN674). For both operating and proposed sites, the conclusion that impacts on water quality would be SMALL was reached after a project-specific review. These project-specific reviews included an estimation of the extents of the mixing zones in the receiving water bodies and how the mixing zone may affect aquatic resources under site-specific conditions (e.g., geometry, ambient discharge characteristics, ambient water quality characteristics, aquatic habitat, and designated uses of the water body).

During the evaluation conducted for the ANR GEIS, the staff sought to develop a comprehensive bounding set of water quality criteria, including both thermal and chemical criteria, for use in the PPE and SPE. The staff found this to be impractical and determined that it would not ultimately be beneficial to this GEIS. Development of a bounding list for the PPE was complicated by uncertainties in how a new, advanced plant design might affect cooling systems, and the thermal and chemical characteristics of the discharges.

Development of a bounding set of characteristics for the SPE was challenging for the reasons presented below.

First, a State with delegated permitting authority may impose limitations on temperature and effluent that are tailored to the conditions of the State and they may be more stringent than those required by the EPA. These State-specific conditions include characteristics of the receiving water body such as type (e.g., ocean, lake, river), designated use (e.g., water supply, agricultural use, recreational), ambient temperature, ambient water quality and assimilative capacity, and the significance of the aquatic habitat (e.g., spawning zones). For example, contaminant concentration standards for domestic water supplies prescribed by the States of Tennessee (TN 0400-40-03-TN7038) and Alaska (18 AAC 70-TN7039) are more restrictive than the legally enforceable standards required by the National Primary Drinking Water Regulations (NPDWRs) of the SDWA.

Second, the more stringent criteria developed by States may vary. The staff reviewed the acceptable temperature ranges in discharges and the resulting thermal impacts on receiving water bodies for Tennessee, Alaska, and Idaho and found them to vary (TN 0400-40-03-TN7038; 18 AAC 70-TN7039; IDAPA 58.01.02-TN7040). This variance between States results primarily from the difference in the ambient temperature of the water bodies caused by the regional climate as well as the tolerance for temperature variations of the aquatic species present in the water bodies. In addition, States with estuaries or intertidal zones (e.g., Maryland) typically require consideration of the effect of power plant discharges on the alteration of salinity regimes at the discharge site as part of the NPDES permits. State with these zones may set more restrictive limits on salinity and require greater evaluation of potential impacts of the discharge on salinity gradients than states without these zones.

Third, if permits establish effluent limits that exceed water quality criteria a regulatory mixing zone may be determined, for which individual requirements can be established on a case-by-case basis. In theory, impacts could be negligible if the potential for significant dilution of effluent discharge and minimization of thermal and salinity impacts in the receiving water body exists. However, computation of an acceptable dilution factor for permits often factors in limits on mixing zone sizes set by States for specific water bodies, making the dilution factor project-specific.

Lastly, development of a bounding set of plant parameters for the PPE or site parameters for the SPE was not considered beneficial for the ANR GEIS, because compliance with water quality standards set forth in the NPDES permit does not necessarily equate to a SMALL impact (i.e., indicating no noticeable impact on surface water quality of the resource; see 10 CFR 51.71(d), footnote 3 [TN250]). Therefore, a project-specific evaluation would be necessary to develop the impact determination as part of a SEIS.

As a result, the staff determined that degradation of surface water quality from chemical and thermal discharges requires consideration of project-specific information on a case-by-case basis. Therefore, the staff determined that the degradation of surface water quality due to chemical and thermal discharges is a Category 2 issue (SMALL, MODERATE, or LARGE impacts depending on project-specific characteristics). The staff concludes that the impact on surface water quality due to chemical and thermal discharges should be determined on a case-by-case basis using project-specific information in a SEIS.

3.4.2.2.8 Groundwater Quality Degradation Due to Plant Discharges

Based on reviews of proposed large LWRs and existing plants, the staff has determined that the discharge to surface water bodies during operation would not noticeably impact groundwater resources. However, some existing and proposed plants discharge, or plan to discharge, plant effluents directly to groundwater via deep well injection or indirectly to groundwater via infiltration from ponds or canals. Water discharged to a cooling pond has elevated concentrations of TDS and other constituents and could infiltrate into the underlying groundwater system. The significance of the groundwater quality impacts would depend on cooling pond water quality, site hydrogeologic conditions, and the location, depth, and pumping rate of offsite wells. The potential for impacts is decreased in areas that have poorer groundwater quality, such as coastal areas and salt marshes (NRC 2013-TN2654), but all plant discharges to the subsurface have the potential to degrade groundwater quality. At the Turkey Point site, in-depth, project-specific analysis of the potential effects of discharge from an operating plant located above an EPA-designated SSA has also been conducted. The staff evaluated the impacts of infiltration of hypersaline water from the operation of Units 3 and 4 discharged into the cooling-canal system (NRC 2019-TN6824). The staff found that infiltration of plant effluents into the shallow aquifer underlying the canal has had a significant impact on groundwater quality on and off the plant site. In the Turkey Point Units 6 and 7 EIS (NRC 2016-TN6434), the staff also evaluated the potential impact of injection of plant discharge into a deep aquifer. The staff ultimately determined that deep well injection would lead to a SMALL impact. However, this determination relied upon a detailed project-specific evaluation.

Because the potential impacts on groundwater can be significant, the PPE/SPE groundwater quality parameter specifies that a proposed ANR plant be located outside the recharge area for any aquifer designated to have special protections. In addition, the PPE/SPE specifies that the plant be outside the designated contributing area for any public water supply well. Because any discharge of plant effluents to the subsurface would have significant potential impacts on groundwater quality, the PPE/SPE also assumes that there would be no planned discharges to the subsurface via either direct injection or via infiltration from ponds or canals. Based on these PPE/SPE values and assumptions, the staff has determined that groundwater quality degradation due to plant discharges during operation of an ANR is a Category 1 issue. The staff concludes that the discharges can be generically determined to have a SMALL impact on groundwater quality. This conclusion relies on the following PPE/SPE parameter and the associated values and assumptions:

- Groundwater Quality
  - The plant is outside the recharge area for any EPA-designated SSA, or any aquifer designated to have special protections by a State, tribal, or regional authority.
  - The plant is outside the wellhead protection area or designated contributing area for any public water supply well.
  - There are no planned discharges to the subsurface (by infiltration or injection).

If these PPE/SPE values and assumptions are not met, a project-specific evaluation of the impacts of groundwater withdrawal is required.

3.4.2.2.9 Water Quality Degradation Due to Inadvertent Spills and Leaks during Operation

During operation, inadvertent spills of gasoline, diesel fuel, hydraulic fluid, lubricants, solvents, and wastewater used for construction equipment could impact both surface water and groundwater resources. Pursuant to 40 CFR Part 112 (TN1041) and 40 CFR Part 9 (TN5322), applicants would be required to use BMPs and implement an IPPP to minimize the occurrence of spills and limit their effects. While not necessarily uncommon at operating nuclear power plants, minor chemical spills have not constituted widespread, consistent water quality impacts because they are readily amenable to correction (NRC 1996-TN288).

During operation, features of the stormwater discharge system, such as retention basins, may increase infiltration over the area of the basin and increase local recharge to groundwater, thereby potentially affecting groundwater quality. Stormwater discharge would be regulated under the NPDES permit and it would conform to the terms of the NPDES permit, including monitoring of discharge water quality for potential inadvertent releases. In recent EISs for proposed large LWRs the NRC staff has assumed that the system would be designed to preclude discharge to groundwater during operations and, as a result, plant runoff during operations would not affect groundwater quality.

Radionuclide leaks from plant components and pipes have occurred at numerous plants. Groundwater protection programs have been established at all operating nuclear power plants to minimize potential impacts from inadvertent releases (NEI 2019-TN6775). The License Renewal GEIS evaluated the impacts from leaks occurring at operating reactor sites and determined that that if leaks were to occur, the magnitude of impacts would be dependent on project-specific characteristics (NRC 2013-TN2654). The staff concluded in the License Renewal GEIS that, because the impacts of radionuclide leaks to groundwater could be greater than SMALL and must be based on a project-specific analysis, this is a Category 2 issue.

While contamination from inadvertent leaks have occurred at operating plants, the staff determined that this operating experience is not sufficient to preclude a generic determination on this issue for the operation of new ANRs. As a result, the staff has determined that water quality degradation due to inadvertent spills during operation of an ANR is a Category 1 issue. The staff concludes that the impacts of inadvertent spills on water quality during operation of an ANR site would be SMALL. This conclusion relies on the following PPE/SPE parameters and the associated values and assumptions:

- Groundwater Quality
  - Applicable requirements and guidance on spill prevention and control are followed, including relevant BMPs and IPPPs.

- There are no planned discharges to the subsurface (by infiltration or injection), including stormwater discharge.
- A groundwater protection program conforming to NEI 07-07 (NEI 2019-TN6775) is established and followed.

- Site Size and Location
  - The site size is 100 ac (40.5 ha) or less.
- Permanent Footprint of Disturbance
  - Use of BMPs for soil erosion, sediment control, and stormwater management.
- Impacts on Aquatic Biota
  - Adherence to requirements in NPDES permits issued by the EPA or a given State, and any other applicable permits.

If the PPE/SPE conditions are not met, a project-specific evaluation of the impacts of inadvertent spills and leaks is required.

3.4.2.2.10 Water Quality Degradation Due to Groundwater Withdrawals

Water quality degradation due to groundwater withdrawals during construction is discussed in Section 3.4.2.1.6. Degradation of groundwater resources may occur when dewatering or withdrawal of groundwater for plant uses induces the flow of lower quality water from the surrounding aquifers or connected surface water bodies. Groundwater withdrawals may induce infiltration from surface water (e.g., rivers) or contribute to increased saltwater intrusion from nearby oceans and estuaries in aquifers already impacted by saltwater intrusion. The effects of groundwater withdrawals during operation of an ANR would be similar to those during construction, but they would occur over a longer duration.

In the License Renewal GEIS (NRC 2013-TN2654) the staff reported that operating plants in estuary or coastal sites that pumped groundwater from confined aquifers at rates between 400 gpm (0.025 m^3/s) and 1,000 gpm (0.063 m^3/s) had a small effect on groundwater quality, especially when the plant's withdrawal rate was a small fraction of the regional total groundwater use. In the License Renewal GEIS (NRC 1996-TN288 and NRC 2013-TN2654) the staff reported that operating plants in estuary or coastal sites that pumped groundwater from confined aquifers at rates between 400 gpm (0.025 m^3/s) and 1,000 gpm (0.063 m^3/s) had a small effect on groundwater quality, especially when the plant's withdrawal rate was a small fraction of the regional total groundwater use. In the EISs for new large LWRs, groundwater pumping during operation was determined to have a SMALL impact on groundwater resources at all sites except for Grand Gulf. In the Grand Gulf ESP EIS (NRC 2006-TN674) the staff evaluated a range of potential pumping rates because the estimates of the pumping rate were not provided. The staff determined that high groundwater withdrawal rates (from radial collector wells) could induce flow of lower quality groundwater from deeper aquifers upward into the Catahoula (an EPA-designated SSA) and significantly degrade water quality.

The PPE/SPE table limits groundwater withdrawals for building foundation dewatering and plant uses to 50 gpm (0.003 m^3/s) and assumes that groundwater withdrawals will result in no more than a 1 ft (0.3 m) lowering of groundwater levels at the site boundary. The basis for the PPE/SPE values and assumptions is discussed in Section 3.4.1.2.1. The 1 ft (0.3 m) limit includes the potential cumulative effect of simultaneous dewatering and groundwater withdrawal for plant uses because dewatering is assumed to contribute negligible drawdown at the site boundary, as specified in the PPE/SPE table (Appendix G). In areas that have exploitable groundwater resources, the PPE/SPE withdrawal rate is expected to be a small fraction of the total withdrawal rate by other users (typically agricultural or municipal uses in rural and urban areas, respectively). With minimal changes in groundwater levels at the site boundary, the potential for PPE/SPE withdrawals to induce flow from adjacent water bodies is unlikely to be noticeable.

The staff has determined that water quality degradation due to groundwater withdrawals is a Category 1 issue. The staff concludes that water quality impacts resulting from groundwater withdrawals during operation of the proposed new ANRs would be localized and can be generically determined to be SMALL for the ANR GEIS. This conclusion relies on the following PPE/SPE parameters and the associated values and assumptions:

- Groundwater Withdrawal for Excavation or Foundation Dewatering
  - The long-term dewatering withdrawal rate is less than or equal to 50 gpm (0.003 m^3/s) (the initial rate may be larger).
  - Dewatering results in negligible groundwater level drawdown at the site boundary.
- Groundwater Withdrawal for Plant Uses
  - Groundwater withdrawal for all plant uses (excluding dewatering) is less than or equal to 50 gpm (0.003 m^3/s).
  - Withdrawal results in no more than 1 ft (0.3 m) of groundwater level drawdown at the site boundary.
  - Withdrawals are not derived from an EPA-designated SSA, or from any aquifer designated by a State, tribe, or regional authority to have special protections to limit drawdown.
  - Withdrawals meet any applicable State or local permit requirements.

If any of the PPE/SPE conditions are not met, a project-specific evaluation of the water quality impacts of groundwater withdrawals is required. For example, use of a radial collector well during operation is likely to involve withdrawals that exceed the 50 gpm (0.003 m^3/s) PPE/SPE value, which will require a project-specific evaluation of potential water quality degradation.

3.4.2.2.11 Water Use Conflict Due to Plant Municipal Water Demand

Municipal water supply used to support water use (e.g., potable and sanitary needs) during plant operations may affect the municipal systems' ability to meet their planned obligation to other users. To generically assess the potential impact on municipal systems from the plant's operation-related water use, the staff assumed that the needed amount of municipal water is available and within the existing or planned capacity of the municipal systems while accounting for all existing and planned future uses. If these assumptions are satisfied, the staff determined that the plant's operation-related municipal water use will not unduly stress the municipal systems' ability to meet their existing and planned obligations.

The staff has determined that the effect of water supply from municipal systems is a Category 1 issue. The staff concludes that, as long as the relevant PPE and SPE are met the impacts on municipal systems from operating an ANR can be generically determined to be SMALL. This conclusion relies on the following PPE/SPE parameter and the associated values and assumptions:

- Municipal Water Availability
  - Usage amount is within the existing capacity of the system(s), accounting for all existing and planned future uses.
  - An agreement or permit for the usage amount can be obtained from the municipality.

3.4.2.2.12 Degradation of Water Quality Due to Plant Effluent Discharges to Municipal Systems

During operation of a plant, certain plant effluents (e.g., sanitary and sewer discharges) could be discharged to a municipal wastewater treatment system. To generically assess the potential impact on the municipal wastewater system, the staff assumed that the municipal system has an existing or planned capacity to treat all plant effluent while accounting for all existing and planned future discharges. The staff further assumed that the plant effluent constituents can be treated by the receiving system and therefore a permit can be obtained for operation-related plant effluent discharge to the municipal systems.

The staff has determined that the degradation of water quality from plant effluent discharges to municipal systems is a Category 1 issue. The staff concludes that, as long as the relevant PPE and SPE are met (e.g., the plant effluent discharge is bounded by municipal wastewater systems' capacity) and appropriate permits can be obtained, the impacts on water quality from plant effluent discharges to municipal systems from operating an ANR can be generically determined to be SMALL. This conclusion relies on the following PPE/SPE parameter and the associated values and assumptions:

- Municipal Systems' Available Capacity to Receive and Treat Plant Effluent
  - Municipal Systems' Available Capacity to Receive and Treat Plant Effluent accounts for all existing and reasonably foreseeable future discharges.
  - Agreement to discharge to a municipal treatment system is obtainable.

3.5 Terrestrial Ecology

3.5.1 Baseline Conditions and PPE/SPE Values and Assumptions

Any site proposed for an ANR would contain terrestrial habitat of some type. Even land areas with past industrial or urban development provide habitat for terrestrial species. The NRC staff expects that most proposed ANR sites would contain some naturally vegetated land such as forest, scrub, grassland, or wetlands; landscaped land such as lawns or mowed areas; or agricultural land such as cropland, pasture, and orchard. Sites may also contain active or abandoned structures, pavement, rubble, borrow pits, or strip-mined lands. In natural habitats, the vegetation present may be the climax vegetation featuring species composition typical for the landscape position after long periods without human or natural disturbance, or it may be successional vegetation influenced by more recent disturbance. Sites may be greenfield, without a history of nonagricultural development, or all or part of a proposed site may contain operating or abandoned power generation facilities or other industrial facilities. More information about how the NRC staff defines and characterizes terrestrial habitats is available in RG 4.11 (NRC 2012-TN1967).

Vegetation varies greatly across the United States. Vegetation is typically forest in humid settings receiving high rainfall but may be grassland (prairie); shrubland or desert vegetation in drier or rockier settings or areas subject to past disturbance; or taiga (boreal forest) or tundra in permafrost settings. Wetlands are intermediate between terrestrial and aquatic habitat types. Wetlands are delineated using the *Corps of Engineers Wetlands Delineation Manual* (USACE 1987-TN2066), regional supplemental guidance recognized by the USACE, and relevant scientific literature. Wetlands may or may not be under the jurisdiction of the CWA protecting wetlands and threatened and endangered species. Some assumptions made in this section of the ANR GEIS involve parameters and values adapted from previous staff environmental reviews or are the subject of Federal regulations; some have been appropriately scaled down to account for the size and technology differences between large LWRs and ANRs. In every case, the staff has selected a value or parameter that will ensure a SMALL impact on terrestrial resources from building and operation of an ANR after considering all available information and leveraging professional judgment and expertise.

Based on information contained in past new reactor EISs and the staff's ability to scale that information to ANRs, the staff includes an assumption in the PPE and SPE that calls for the permanent disturbance of no more than 30 ac (12 ha) of vegetated (unpaved) terrestrial habitat, and temporary disturbance of an additional 20 ac (8.1 ha) of vegetated terrestrial habitat. However, the PPE and SPE assume that any temporarily disturbed habitat would be restored using regionally indigenous vegetation once the new facilities are built. The staff reasons that disturbance to larger areas could potentially result in substantial effects on regional ecosystems. The assumptions also recognize limitations on the type and quality of terrestrial habitat disturbed. There can be no ecologically sensitive features within the disturbed areas (footprint of disturbance), such as floodplains, shorelines, riparian vegetation, late-successional vegetation, land specifically designated for conservation, or habitat known to be potentially suitable for one or more Federal or State threatened or endangered species. In addition, the PPE assumes that there can be no more than 0.5 ac (0.2 ha) of wetlands or other surface waters impacted by the entire project. This value is based on the fact that many nationwide permits (NWPs) established under the CWA (33 CFR Part 330-TN4318) allow up to 0.5 ac (0.2 ha) of project-wide disturbance to wetlands and other waters of the United States. Additionally, drawing from analyses in past new reactor EISs, the staff included an assumption in the PPE and SPE of a maximum building height of 50 ft (15.2 m), except for 200 ft (61 m) for meteorological towers, and 100 ft (30.5 m) for transmission line poles/towers and mechanical draft cooling towers. The PPE and SPE likewise assume no noise generation greater than 85 dBA at a point 50 ft (15.2 m) from the source. The assumptions in the PPE and SPE regarding site employment (Section 3.12.1) also apply to the staff's evaluation of potential impacts on wildlife from vehicular traffic.

As presented in Section 3.1, the staff assumes that offsite ROWs for transmission lines, pipelines, and access roads are not more than 1 mi (1.6 km) in length or 100 ft (30.5 m) in width but may be unlimited in mileage for linear features built within existing ROWs or in widened ROWs directly adjacent to existing ROWs or public highways. The staff recognizes that these values would effectively minimize disturbance to terrestrial habitats and wildlife in most surrounding landscapes. Additionally, the staff assumes that the total disturbance to wetlands and other surface waters from the entire project (including onsite and offsite activities) would not exceed 0.5 ac (0.2 ha) (based on criteria underlying many NWPs). Otherwise, the staff does not assume other qualitative limitations on other habitats that may be present in proposed offsite ROWs, because only a small fraction of the area would be disturbed by support foundations and most of the ROW area would be spanned by overhead power lines. In addition, the staff assumes there would be no physical disturbance to streams greater than 10 ft (3 m) in width below the ordinary high-water mark. While the potential impacts on most such narrow streams would be localized, physical disturbance to larger streams could potentially affect more distant connected wetland and shoreline habitats.

The staff assumes that licensees would comply with State and local regulatory requirements for implementing BMPs for soil erosion, sediment control, and stormwater management whenever ground-disturbing activities take place either onsite or offsite. Even if a project is proposed for somewhere lacking such regulatory requirements, the staff assumes for purposes of its generic analyses that licensees would voluntarily implement BMPs similar to those commonly required by most States and local jurisdictions. The staff also assumes that any impacts on wetlands or other waters of the United States can be permitted through general permits rather than individual permits, and that licensees would implement any mitigation called for in the permits.

The NRC staff typically evaluates effects on terrestrial resources in terms of habitats and broad groupings of wildlife, as well as on the individual species and habitats that meet the definition of "important" species and habitats outlined in RG 4.2 (NRC 2022-TN7081). Determining which species and habitats potentially affected by a project meet the criteria for "important" is not possible until a specific site and ROWs are identified. While the analysis in Section 3.5.2 is able to consider the potential effects on many types of important species generically, it reserves consideration of potential effects on federally listed threatened or endangered species until after receipt of an application. Several available mapping tools and databases contain relevant information about potential important species for sites anywhere in the United States. The U.S. Fish and Wildlife Service (FWS) maintains online mapping tools and databases regarding the potential occurrence of threatened, endangered, proposed, or candidate species and critical habitats designated under the Federal Endangered Species Act (ESA,16 U.S.C. §§ 1531 *et seq*.; TN1010). Most States have Natural Heritage Programs with databases containing known locations of species and habitats with Federal or State special designations.

3.5.2 Terrestrial Ecology Impacts

For most new ANRs, terrestrial ecology impacts related to loss, conversion, and fragmentation of upland and wetland habitats and habitats for threatened or endangered species would primarily take place during preconstruction, especially during site preparation work such as clearing, grubbing, and grading. Potential impacts related to exposure of wildlife to noise or the potential for collision of birds and bats with structures and transmission lines could continue throughout the building period and extend into operations. Issues related to the exposure of flora and fauna to cooling-tower drift, radiological releases, EMFs, or the risk of avian electrocution on powerlines are more of a concern during operations.

3.5.2.1 Environmental Consequences of Construction

The NRC staff identified the following environmental issues for analysis for the building of an ANR:

- permanent and temporary loss, conversion, fragmentation, and degradation of habitats;
- permanent and temporary loss, conversion, and degradation of wetlands;
- effects of building noise on wildlife;
- effects of vehicular collisions on wildlife; and
- bird collisions with structures.

In addition to evaluating the issues noted above, the NRC staff addressed as a separate issue any impacts on important species and habitats as defined for NRC environmental reviews in RG 4.2 (NRC 2022-TN7081).

3.5.2.1.1 Permanent and Temporary Loss, Conversion, Fragmentation, and Degradation of Habitats

Because of the assumptions in the PPE and SPE outlined in Section 3.5.1, building an ANR would not require permanent disturbance of more than 30 ac (12 ha) of land or temporary disturbance of more than 20 ac (8.1 ha) of additional land, within a site no larger than 100 ac (40.5 ha). The assumptions also limit impacts on wetlands (addressed further in Section 3.5.2.1.2) and exclude impacts on floodplains, riparian land, late-successional vegetation, land specifically designated for conservation, or habitat potentially suitable for one or more Federal or State threatened or endangered species. These assumptions are conservative regarding parameters related to terrestrial ecology and recognize the high degree of variability in the sensitivity of various habitats and species in various landscape settings. Habitat that is permanently lost to build a reactor would no longer provide food or cover for terrestrial flora or fauna. However, loss of 50 ac (20 ha) of habitat not situated in sensitive settings is unlikely to noticeably reduce the overall availability of such habitat for most species in the surrounding landscape. Many of the EISs for new LWRs over the last 10 years have identified noticeable impacts on terrestrial habitats (e.g., those for Levy and Turkey Point; NRC 2012-TN1976 and NRC 2016-TN6434, respectively), but these proposed reactors have each encompassed hundreds of acres of habitat loss, substantially exceeding the PPE used in this GEIS for ANRs. Much of the terrestrial habitat outside of sensitive settings consists of current or former agricultural land, pasture or degraded range land, forest monocultures, or ruderal habitat compromising the presence of invasive plant species such as cheatgrass (*Bromus tectorum*), red brome (*Bromus rubens*), garlic mustard (*Alliaria petiolate*), stiltgrass (*Microstegium vimineum*), or ailanthus (*Ailanthus altissima*). Losses of such degraded habitat on ANR sites are unlikely to noticeably limit resources for most species in the surrounding landscape. Even for higher-quality habitats such as late-successional forest, scrub, or prairie vegetation, the loss of only 50 ac (20 ha) is unlikely to result in a noticeable decline in the ecological quality of the surrounding landscape.

However, the staff recognizes the typically long time horizon following past disturbance that is necessary for late-successional vegetation to develop, particularly in arid regions where vegetation recovery and succession are poorly understood (Abella 2010-TN6722; Engel and Abella 2011-TN6721; McAuliffe 1988-TN6723). Thus, project-specific review of the plans would be necessary to evaluate the value of late-successional habitats and the consequences of losing the ecological services they provide. In many settings, the individualized review may reveal that impacts from losses of those habitats might be minimal, but the staff considers individualized review to be necessary. The assumptions in the PPE and SPE therefore exclude late-successional vegetation from the onsite footprint of disturbance. Applicants would likely select sites located in areas of relatively low habitat value.

Habitat conversion involves changing habitat to a different habitat type. Habitat conversion typically involves a change from a more mature to a less mature vegetational stage (Abella 2010-TN6722) that may be then maintained indefinitely (e.g., from forest to shrub or grassland within a ROW). Habitat conversion may also include the cutting of forest near new reactors to open sightlines for security purposes. Unlike habitat loss, converted habitat continues to provide food or cover for terrestrial flora or fauna, but food or cover that is different from and perhaps inferior to that provided by the original habitat. When habitat changes, basic elements of an ecosystem upon which a species relies for shelter, food, and reproduction may be altered or may no longer be available. Habitat generalists may be able to adapt more readily to such changes than habitat specialists. Habitat conversion may result in a shift in species dominance and composition (Abella 2010-TN6722). Disturbance to convert habitats may also provide an opportunity for increased establishment of invasive species. Habitat conversion over small parcels is unlikely to noticeably limit resources for most species in the surrounding landscape.

Fragmentation of mature forests or rangeland habitats, and other high-quality terrestrial habitats can be as harmful to wildlife as habitat losses, because it can limit wildlife movement and migration and limit access to food, water, and other resources, as well as increase the amount of edge habitat and invasive species resulting in habitat degradation and increased predation. Fragmentation can result from new clearings or the establishment of new features such as roads or fences that can interfere with the movement of wildlife. Fragmentation of natural habitats by human activity is recognized as being a key contributor to biodiversity losses over five continents (Haddad et al. 2015-TN6563). In North America, forest fragmentation has been shown to have adverse effects on neotropical migratory birds (birds that nest in the tropics and migrate north to breed in summer) through small forest-patch size, reduced proximity of patches, more edge, and negative interactions with non-forest species, in addition to those from habitat loss (Boulinier et al. 2001-TN6724, Critical Area Commission 2000-TN6564). Lynch (1987-TN6726) described the negative insular effects of forest fragmentation on neotropical migrants in terms of reduced patch size and isolation in the eastern United States. Yahner (2000-TN6565) demonstrated that the probability of four neotropical migratory bird species favoring forest interiors in the eastern United States declined sharply in forest tracts of less than 247 ac (100 ha). Initially, forest fragmentation triggers effects on a local scale, resulting in a range retraction of populations to less fragmented parts of a region (Rolstad 2008-TN6725). Similar effects have been shown to result from fragmentation of rangeland vegetation in the Midwest and Western North America. Schoerlbel (2003-TN6727) and Knick and Rotenberry (1995-TN6728, 2002-TN6729) demonstrated the effects of shrub-steppe fragmentation on songbirds requiring sagebrush (*Artemisia* spp.) habitat. Smith (2016-TN6730) demonstrated that the fragmentation of 1 mi^2 (2.6 km^2) of shrub-steppe habitat for agricultural development can reduce sage-grouse (*Centrocercus urophasianus*) population persistence within an area 12 times that size. The FWS highlighted similar implications of fragmentation by energy development to sage-grouse, other sagebrush-dependent species, and the greater sagebrush ecosystem (FWS 2014-TN6731).

The assumptions in the PPE and SPE would effectively ensure minimization of losses and fragmentation of late-successional vegetation. Technical guidance on minimization of loss and fragmentation of habitats is available for most habitat types. Most call for locating new infrastructure on the periphery of already-developed areas and clustering or sharing ROWs for new infrastructure to avoid affecting late-successional habitats where possible (Critical Area Commission 2000-TN6564; Paige and Ritter 1999-TN6802).

Clearing new offsite ROWs, even those under 100 ft (30.5 m) in width, can fragment large blocks of forest and rangeland, reducing the availability of habitat to forest-interior and area-sensitive wildlife to an extent greater than suggested by the acreage of clearing. Rich et al. (1994-TN6732) demonstrated that narrow forest-dividing corridors as small as 26 ft (8 m) can substantially reduce the abundance of forest-interior neotropical migrant birds. Creating new offsite ROWs with upright structures such as poles and towers increases perching habitat for predators and can increase predation for populations of at-risk species in sagebrush ecosystems (e.g., sage-grouse) (Manier et al. 2014-TN6746). However, the PPE limits the length of new offsite ROWs not co-located with or adjacent to existing utilities or roads to less than 1 mi (1.6 km), ensuring that the potential fragmentation of habitat and associated indirect risks to wildlife (e.g., predation) would be minimal. The NRC staff anticipates (but does not assume, for purposes of this analysis) that applicants would strive to locate new offsite ROWs whenever possible in areas of low extant habitat value and sufficiently distant from any seasonal habitats (e.g., nesting areas) to minimize predation risk.

The staff has determined that permanent or temporary loss, conversion, fragmentation, or degradation of nonsensitive habitats is a Category 1 issue. The staff concludes that, as long as the applicable assumptions in the PPE and SPE are met, impacts from building an ANR can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- The permanent footprint of disturbance would include 30 ac (12 ha) or less of vegetated lands, and the temporary footprint of disturbance would include no more than an additional 20 ac (8.1 ha) or less of vegetated lands.
- Temporarily disturbed lands would be revegetated using regionally indigenous vegetation once the lands are no longer needed to support building activities.
- New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length.
- The footprint of disturbance (permanent and temporary) would contain no ecologically sensitive features such as floodplains, shorelines, riparian vegetation, late-successional vegetation, land specifically designated for conservation, or habitat known to be potentially suitable for one or more Federal or State threatened or endangered species.
- Total wetland impacts from use of the site and any offsite ROWs would be no more than 0.5 ac (0.2 ha) (see Section 3.5.2.1.2 below).
- Applicants would demonstrate an effort to minimize fragmentation of terrestrial habitats by using existing ROWs, or widening existing ROWs, to the extent practicable.
- BMPs would be used for erosion, sediment control, and stormwater management.

3.5.2.1.2 Permanent and Temporary Loss and Degradation of Wetlands

The assumptions would ensure that there would be no more than 0.5 ac (0.2 ha) of wetlands within the footprint of disturbance on the site, and hence subject to filling, and in the offsite ROWs (except for building intake and discharge structures if needed). A project meeting the assumptions would most likely not require an Individual Permit under Section 404 of the CWA (33 U.S.C. § 1344-TN1019).

Wetlands for purposes of the analyses contained in this GEIS include the lands that meet the criteria for delineation as wetlands as established in the USACE Wetlands Delineation Manual (USACE 1987-TN2066) and applicable regional supplementary wetland delineation guidance, regardless of whether they meet other criteria required for jurisdiction under the CWA (33 CFR Part 328-TN1683). Many wetlands not meeting the criteria for jurisdiction under the CWA, sometimes termed “isolated wetlands” or “non-jurisdictional wetlands,” can still provide beneficial ecological services such as contributing to groundwater recharge, attenuating overland surface runoff thereby reducing flooding potential, and providing specialized habitat for many wetland-dependent wildlife species. Many depressional features such as vernal pools, prairie potholes, Carolina bays, and playa lakes play key roles in flood control and groundwater recharge, and provide specialized habitat required by many wildlife species that are declining rapidly in many regions, yet are isolated from navigable waterways and surface tributary systems and hence not under the jurisdiction of the CWA. Because the functions and values of wetlands are not dependent on whether the wetland is under CWA jurisdiction, the staff established the 0.5 ac (0.2 ha) assumed limit on wetland disturbance to be inclusive of impacts on any wetlands regardless of jurisdictional status under the CWA.

The 0.5 ac (0.2 ha) of wetlands might be physically lost or disturbed by site preparation work, commonly referred to as “discharge of dredged or fill material,” or by other types of disturbances. The hydrology of wetlands, and hence biota that rely on the hydrological properties of wetlands, can also be altered by changes in landscape drainage patterns and overland runoff. Wetlands are also subject to sedimentation from upgradient soil disturbances. Wetland losses and disturbances cause the loss or reduction of multiple hydrological functions such as groundwater recharge and discharge, flood flow abatement, and shoreline stabilization; ecological functions such as fish and wildlife habitat, production export, and providing specialized habitat for many threatened or endangered species; and societal values such as recreation and aesthetics (USACE 1999-TN1793).

Excavations to build a reactor can cause temporary drawdowns of the water table, thereby influencing the hydrology and hence the water levels, hydroperiod (number and timing of days per year that soils remain saturated or covered with water), spatial extent, and function of nearby wetlands. Even for large reactors, however, analyses in recent EISs have indicated that some hydrological effects on wetlands might be brief and localized. A conservative analysis of the drawdown effects of excavating 56 ft (17 m) deep to build a large pond component for the proposed Bell Bend nuclear power plant in Pennsylvania, and pumping groundwater at a rate of 235 to 310 gpm (0.015 to 0.02 m^3/s), estimated that the effects of water table drawdown on nearby wetlands would last only as much as 24 months and not extend more than about 1,200 ft (366 m) from the excavation (NRC and USACE 2016-TN6562). Analysis of water table drawdowns during excavations for the proposed Levy Units 1 and 2 in a landscape in north-central Florida containing extensive wetlands concluded that the drawdown effects on adjoining wetlands would be temporary and within the range of expected seasonal water table fluctuations to which the wetlands are adapted (NRC 2012-TN1976). Both analyses assumed, however, that nearby wetlands would be monitored over the period of excavation and action would be taken to restore water levels as necessary. Based on these analyses, for an ANR bounded by the assumptions for groundwater withdrawals and dewatering in the SPE (50 gpm [0.003 m^3/s] with negligible effect on groundwater levels at the site boundary), onsite wetlands with a groundwater connection could be affected, but similar wetlands offsite would not be affected. Temporary adverse impacts on onsite wetlands can result if groundwater dewatering causes changes in water levels or hydroperiod that exceed historical annual or seasonal fluctuations. This applies to all onsite wetlands with a groundwater connection and may be accentuated in wetlands that only have a surface water connection. The staff expects that applicants relying on the generic analysis would demonstrate that the assumption regarding the influence of groundwater withdrawal for dewatering on connected wetlands (changes in wetland water levels and hydroperiod are within historical annual or seasonal fluctuations) in the SPE are met. If this assumption is not met, then project-specific analysis would be necessary to demonstrate that impacts are minimal.

Wetlands may also be affected by habitat conversion. One of the most notable types of habitat changes in wetland water levels and hydroperiod within historical annual or seasonal fluctuation conversions that may occur in association with ANRs is forest clearing for the purpose of spanning wetlands with transmission lines (EPA 2018-TN6747). The removal of vertical habitat structure reduces the diversity of species and creates corridors that fragment forests (addressed in previous section) (EPA 1994-TN6748). Canopy and subcanopy trees are typically removed, eliminating nesting habitat for forest-interior bird species. Extant shade-tolerant forest understory vegetation may change to herbaceous and/or shrub species adapted to full-sun conditions. Amphibian breeding pools may become unsuitable because of increased solar exposure and change to an unsuitable temperature regime. The amount of edge habitat would increase, thereby increasing the risk of invasive species establishment and habitat degradation. Ultimately, early successional plants and wildlife could become established in the converted area, which subsequently could be maintained over the long term as an emergent or scrub-shrub wetland in order to avoid vegetation interference with overhead transmission lines. There would be a net reduction in wetland functions and values due to conversion of forested wetland to emergent or scrub-shrub wetland (DOE 2019-TN6749; NextEra Energy 2020-TN6750). However, the 0.5 ac (0.2 ha) limit on wetland disturbance renders minimal the potential effects of wetland habitat conversion, degradation, or fragmentation.

The staff recognizes that up to 0.5 ac (0.2 ha) of wetlands can be disturbed by building utility lines in NWP 12 under the CWA, which the USACE recognizes as not having a significant impact on waters of the United States (33 CFR 330.1(b); TN4318). The staff assumes that the applicant would implement any mitigation required by the USACE under the CWA or required by State agencies that have similar wetland regulatory authority. Even if a project may not require a permit under the CWA or State wetland protection regulations, the staff expects that applicants relying on the generic analysis would provide a wetland delineation demonstrating that assumptions regarding wetlands in the PPE are met. The PPE includes assumptions, based on information contained in most recent new reactor EISs, that applicants would be required by State or local governments to implement BMPs as mitigation to minimize sedimentation and erosion of nearby wetlands. Additionally, because hydrology is one of the most important factors in the establishment and maintenance of wetlands and wetland processes (SFWMD 1995-TN6799), the PPE includes an assumption that licensees relying on the generic analysis would demonstrate that the assumption regarding the influence of groundwater withdrawal for dewatering on connected wetlands in the SPE (changes in wetland water levels and hydroperiod are within historical annual or seasonal fluctuations) is met. If this assumption is not met, then project-specific analysis would be necessary to demonstrate that impacts would be minimal. The staff developed this assumption in the PPE based on experience from past reviews supporting EISs for proposed new reactors in Levy County, Florida (NUREG-1941; NRC 2012-TN1976) and Berwick, Pennsylvania (NUREG-2179; NRC and USACE 2016-TN6562).

The staff has determined that permanent or temporary loss or degradation of wetlands during building of an ANR is a Category 1 issue. The staff concludes that as long as the relevant assumptions in the PPE and SPE are met, the impacts from building an ANR can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- Applicant would provide a delineation of potentially impacted wetlands, including wetlands not under CWA jurisdiction.
- Total wetland impacts from use of the site and any offsite ROWs would be no more than 0.5 ac (0.2 ha).
- If activities regulated under the CWA are performed, those activities would receive approval under one or more NWPs (33 CFR Part 330-TN4318), or other general permits recognized by the USACE.

- Temporary groundwater withdrawals for excavation or foundation dewatering would not exceed a long-term rate of 50 gpm (0.003 m^3/s).
- Applicants would be able to demonstrate that the temporary groundwater withdrawals would not substantially alter the hydrology of wetlands connected to the same groundwater resource.
- Any required state or local permits for wetland impacts would be obtained.
- Any mitigation measures indicated in the NWPs or other permits would be implemented.
- BMPs would be used for erosion, sediment control, and stormwater management.

3.5.2.1.3 Effects of Building Noise on Wildlife

Activities to build reactor facilities are usually performed in a series of steps or phases, and noise associated with different phases can vary greatly depending on the type of equipment used. Average maximum noise levels of typical building equipment 50 ft (15.2 m) from the source may range from about 73 to 101 dBA for non-impact heavy equipment (earthmoving equipment such as bulldozers), 79 to 110 dBA for impact equipment (jackhammers, pile drivers, etc.), and 68 to 88 dBA for stationary equipment (pumps, etc.) (WSDOT 2017-TN5313), but an overall noise level of approximately 85 dBA at 50 ft (15.2 m) from the source is typical (DOT 2017-TN5383). Noise from operating construction equipment can startle and interfere with the behavior and movement of wildlife. The effects can be exacerbated by the fact that some building noise occurs episodically rather than continuously over extended periods, and hence wildlife may be less capable of habituating to it (Shannon et al. 2016-TN6566). A comprehensive literature review of wildlife responses to anthropogenic noise indicated that some species adversely respond to noise levels as low as 40 dBA, but 20 percent of the literature documented responses only above 50 dBA (Shannon et al. 2016-TN6566). Restrictions have been placed on noise at similar levels within the habitat of sensitive wildlife species. For example, the U.S. Department of Energy (DOE) considers an increase in noise levels greater than 6 dBA above ambient to constitute a disturbance to the Mexican spotted owl (*Strix occidentalis lucida*) on the Los Alamos Site in New Mexico (Hathcock et al. 2017-TN6789).

The assumptions in the PPE and SPE include no noise generation greater than 85 dBA at a point 50 ft (15.2 m) from the source. However, noise levels decrease by approximately 6 dBA per doubling of distance over hard site conditions (i.e., substrate such as concrete or open water) in accordance with the inverse square law (DOT 2017-TN6567), and by an additional 1.5 dBA decrease if soft site conditions (e.g., unpacked earth) are present (WSDOT 2017-TN5313). Therefore, typical building noise of 85 dBA at a distance of only 50 ft (15.2 m) from the source may diminish to only around 50 dBA at about 1,200 ft (366 m) from the source (assuming soft ground conditions). This noise level would not generally disturb most wildlife. Furthermore, this value is conservative because it likely overestimates the actual noise level because the calculation does not take into account additional noise attenuation by vegetation and topography (WSDOT 2017-TN5313), which are difficult to consider without project-specific analysis.

The staff therefore expects that potential noise impacts would extend over a sufficiently small part of the landscape and that any effects on wildlife would be minor and thus be a Category 1 issue. The staff concludes that as long as the assumption in the PPE regarding a maximum noise generation of 85 dBA 50 ft (15.2 m) from the source is met, the impacts can be generically determined to be SMALL. Effects on wildlife from building noise over 85 dBA would extend over a greater distance and area and thus require project-specific evaluation. The staff relied on the following PPE and SPE value and assumption to reach this conclusion:

- Noise generation would not exceed 85 dBA 50 ft (15.2 m) from the source.

3.5.2.1.4 Effects of Vehicular Collisions on Wildlife

Wildlife can also be killed or injured through collisions with vehicles, although the low number of construction workers needed to build a reactor of a size fitting the assumptions in the PPE and SPE suggests that vehicular usage, and hence the potential for collisions, would be minimal. While roadkill may increase somewhat during the building period, except for special situations (e.g., ponds and wetlands crossed by roads where large numbers of migrating amphibians would be susceptible), traffic mortality rates rarely limit population size (Forman and Alexander 1998-TN2250). The potential for significant vehicular collisions with wildlife is limited by the assumptions in the PPE and SPE regarding site size, size of the footprint of disturbance, and by limitations on traffic growth, as evidenced by traffic LOSs on roads near the site.

Federal and State wildlife conservation agencies commonly suggest practices to reduce the potential for vehicular collisions with wildlife species regarded as regionally sensitive or desirable. For example, an EIS recently prepared by the NRC (NRC 2013-TN6436) acknowledged the potential for injury and mortality of eastern fox snakes, a rare (and State-listed) species known to occur near the site, related to construction equipment while building a proposed reactor, but it also concluded that readily implemented mitigation measures suggested by the State could prevent noticeable impacts on the regional population of that species. Some specific mitigation measures proposed included signage along roads, worker education, and reduced speed limits. Another recent NRC EIS (NRC 2016-TN6434) recognized the potential for mortality of American crocodiles (a federally listed threatened species known to inhabit the site and surrounding landscape) by construction vehicle collisions, but concluded that similar easily implemented mitigation measures recommended by the FWS, such as signage and speed limits, could prevent substantial population effects.

The staff has therefore determined that traffic effects on wildlife are a Category 1 issue. The staff concludes that as long as the project fits within the PPE regarding site size (no more than 100 ac [40.5 ha], with a permanent building footprint of no more than 30 ac [12 ha] and a temporary footprint of no more than 20 ac [8.1 ha]) and site employment, the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- The site size would be 100 ac (40.5 ha) or less.
- The permanent footprint of disturbance would include 30 ac (12 ha) or less of vegetated lands, and the temporary footprint of disturbance would include no more than an additional 20 ac (8.1 ha) or less of vegetated lands.
- There would be no decreases in the LOS designation for affected roadways.
- The licensee would communicate with Federal and State wildlife agencies and implement mitigation actions recommended by those agencies to reduce potential for vehicular injury to wildlife.

Mitigation measures that Federal and State wildlife agencies might recommend include the use of signage, worker education, reduced speed limits where construction equipment crosses habitat potentially containing regionally rare or declining wildlife, and discussion of these and other possible mitigation measures with relevant Federal, State, and local conservation offices.

3.5.2.1.5 Bird Collisions and Injury from Structures and Transmission Lines

Birds and other flying wildlife such as bats can be injured and killed when colliding with tall structures such as buildings, towers, and transmission lines. The assumptions in the PPE and SPE are that the tallest building or structure height would be no more than 50 ft (15.2 m), although the PPE and SPE allow for taller meteorological or communications towers or mechanical draft cooling towers. Additionally, during construction, cranes that are taller than the structures they are being used to build may be in place temporarily. It is possible that some birds or bats could be injured or killed by flying into and colliding with buildings, towers, transmission lines, or cranes. In the License Renewal GEIS, the NRC reviewed the scientific literature about bird collisions with buildings and indicated that collisions with buildings and windows account for the vast majority of annual avian collision mortality in the United States (NRC 2013-TN2654). Researchers have estimated that the annual mortality rate for each building 1 to 3 stories tall (approximately 42 ft [13 m] in height) is about 2 birds and about 16 birds for each building 4 to 11 stories tall (approximately 56 to 154 ft [17 to 47 m] in height) (Loss et al. 2014-TN6568). The PPE assumes, based on the staff's experience from recent new reactor EISs and on the scientific literature cited above, that most buildings and structures developed on ANR sites would be less than 50 ft (15.2 m) in height, and only a few would be over 50 ft (15.2 m) in height (mechanical draft cooling towers). The low per-building mortality rate for buildings 1 to 3 stories tall plus the 100 ac (40.5 ha) bound on the size of the site, which limits and localizes the number of 50 ft (15.2 m) or less tall structures, render negligible the potential for building collision injury and mortality. Although the mortality rate for each mechanical draft cooling tower is expected to be somewhat higher because of its greater height (typically 50–100 ft [15.2–30.5 m]), in the License Renewal GEIS the NRC considered avian collision mortality from mechanical draft cooling towers to be negligible and therefore did not address the subject (NRC 2013-TN2654). The staff has determined this conclusion to also be appropriate for mechanical draft cooling towers on ANR sites.

The License Renewal GEIS reviewed the scientific literature about bird collisions with structures, including nuclear power plant structures, transmission lines, and communication towers, and evaluated the potential for bird collisions with several operating large LWRs containing natural draft cooling towers over 400 ft (122 m) in height and concluded that the effects on bird populations were minimal (NRC 2013-TN2654). This GEIS found the overall effect from operating these plants constitutes a small fraction of annual avian collision mortality from all sources nationwide. The onsite plant structures and communication towers would all be clustered within the 100 ac (40.5 ha) site fitting the PPE. For most ANRs, the only new transmission lines would likely be those needed to connect the plant to the regional power distribution system. The assumptions in the PPE and SPE limit the length of new transmission lines and other offsite linear facilities to less than 1 mi (1.6 km) of new ROW not adjoining existing utilities or roads, and they limit the height of transmission structures (poles or towers) to no more than 100 ft (30.5 m). The PPE allows for additional co-located transmission line ROWs, but co-location would not introduce the potential for collisions to new areas of the landscape. The transmission lines at ANR sites would constitute both a very low fraction of transmission lines nationwide as well as related collision mortality.

An ANR facility within the bounds of the assumptions would have only one or a few towers or other tall structures clustered on a site of less than 100 ac (40.5 ha). Meteorological towers could be about 197 ft (60 m) aboveground level (the prescribed height at which wind speed and direction should be measured) and could be guyed (NRC 2007-TN278). The PPE allows for a single meteorological tower of any height on a site. Meteorological towers (Kerlinger et al. 2012-TN4401), as well as other types of towers such as communication towers (Longcore et al. 2008-TN4398, Longcore et al. 2013-TN4399), have been implicated in avian collision mortality with predominantly neotropical night-migrating songbirds being affected (Longcore et al. 2013-TN4399). Estimated rates of avian fatality from collision with ten 164 ft (50 m) and eight 197 ft (60 m) temporary meteorological towers supported by guy wires near wind turbines in central California were about seven total birds per tower per year, including night-migrating songbirds (Kerlinger et al. 2012-TN4401). Collision mortality increases with increasing tower height; the highest rate of collision mortality is associated with towers taller than 1,000 ft (305 m) that use guy wires, and the use of continuously (as opposed to intermittently) illuminated lights (Longcore et al. 2008-TN4398; Gehring et al. 2011-TN6581). Meteorological towers at ANR sites, regardless of whether they are guyed or whether or how they may be lit, would cause only negligible avian collision mortality due to their relatively low height. It is also possible that communication towers could be present on ANR sites. Any communication towers would make up only a very minute fraction of all such towers nationwide and of the collision mortality posed by such towers noted above. The 100 ac (40.5 ha) maximum size of the site assumed in the PPE limits the possible number of communication towers.

Any effects from buildings, towers, and transmission lines would be localized and not likely to noticeably contribute to bird mortality in the surrounding landscape. The staff has therefore determined that bird collisions with structures and transmission lines during building are a Category 1 issue. The staff concludes that as long as the applicable assumptions in the PPE and SPE regarding site size and building and structure height are met, the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- The site size would be 100 ac (40.5 ha) or less.
- New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length.
- No transmission line structures (poles or towers) would be more than 100 ft (30.5 m) in height.
- Licensees would implement common mitigation measures such as those provided by the American Bird Conservancy (ABC 2015-TN6763) for buildings, by FWS (2013-TN6764) for towers, and by the Avian Power Line Interaction Committee (APLIC) for transmission lines (APLIC 2012-TN6779).

Examples of possible mitigation measures include using building designs that use less glass, screens and shutters that partly obscure glass, and two-dimensional patterns that birds perceive as barriers (ABC 2015-TN6763); using unguyed lattice or monopole structures where possible, keeping towers unlit if the Federal Aviation Administration (FAA) regulations permit but otherwise using flashing (as opposed to steady) lights (FWS 2013-TN6764); marking devices to enhance the visibility of existing power lines; and considering migratory patterns and high-use areas when planning new power lines (APLIC 2012-TN6779).

3.5.2.1.6 Important Species and Habitats

Species and habitats meeting the NRC criteria (NRC 2022-TN7081) for a given site can only be determined once an application is received that identifies the site boundaries. Because of differing regulations and sensitivities to impacts, two separate issues are analyzed below regarding important species and habitats: (1) resources regulated under the ESA (16 U.S.C. §§ 1531 *et seq.*; TN1010), and (2) other important species and habitats.

Resources Regulated under the Endangered Species Act of 1973

The FWS has developed online databases and mapping tools that identify threatened, endangered, proposed, and candidate species under the ESA, as well as critical habitats designated and proposed under the Act. Because these federally regulated resources occur in the same setting and are subject to the same types of impacts as those considered in Sections 3.5.2.1.1 through 3.5.2.1.5, the limitations placed upon the extent and intensity of ecological impacts by meeting the assumptions in the PPE and SPE would likewise limit the potential for impacts on these resources. However, the staff would need to consult individually with the FWS under ESA Section 7 regarding the potential effects of each specific licensing action. Furthermore, the criteria for listing species under the ESA are based on the potential for the most severe of potential ecological impacts: extinction of species, subspecies, or distinct population segments. Species that have experienced previous impacts so severe that they are now, or could imminently become, in danger of extinction may also be substantially more sensitive to impacts that might only pose minimal threat to other species. The staff has therefore determined that building impacts on resources regulated under the ESA is a Category 2 issue. Because of their potential for future regulation over the course of a licensing action, the Category 2 designation extends also to proposed and candidate species and critical habitat proposed under the Act. Even if the assumptions in the PPE and SPE that are referenced in Section 3.5.1 are met, the NRC staff is unable to determine the significance of potential impacts without consideration of project-specific factors, including the specific species and habitats affected and the types of ecological changes potentially resulting from each specific licensing action. Furthermore, completing the required consultation requires individualized action by the staff for each application.

Other Important Species and Habitats

Most States maintain natural heritage databases that identify known occurrences of species and habitats receiving various categories of State regulation or recognition. Many species and habitats that do not display the potential for extinction necessary for regulation under the ESA are still recognized by States because of declining numbers within State boundaries. However, extirpation from a State is not as severe an impact as range-wide extinction. Regarding other types of important species and habitats, most sites containing undeveloped land may support commercially or recreationally valuable species such as whitetail deer (*Odocoileus virginianus*), wild turkey (*Meleagris gallopavo*), and ring-necked pheasant (*Phasianus colchicus*), and nuisance or invasive species such as Canada thistle (*Cirsium arvense*), johnsongrass (*Sorghum halepense*), cheatgrass (*Bromus tectorum*), European starlings (*Sturnus vulgaris*), Burmese pythons (*Python bivittatus*), and nutria (*Myocastor coypus*). Research of and communication with State and local agencies, private conservation organizations, and other stakeholders would be necessary to determine other important species and habitats potentially present on a site, such as species with monitoring requirements, State threatened or endangered species, other State status species, protected habitats, habitats with high priority for protection, or other habitats of interest such as nesting or nursery grounds.

The analyses presented above regarding impacts on terrestrial habitats and wildlife from specific terrestrial ecological issues suggest that the potential impacts on many important species and habitats (NRC 2022-TN7081) from building an ANR meeting the PPE and SPE assumptions discussed in Section 3.5.1 would likely be minimal regardless of site location and the important species specifically present on a given site. The assumptions in the PPE and SPE limit the potential for adverse impacts, especially limitations on the size of the footprint of disturbance and the assumed absence of sensitive habitat types potentially containing rare species within the footprint.

The staff has therefore determined that building impacts on important species and habitats other than those regulated under the ESA is a Category 1 issue. The staff concludes that as long as the assumptions regarding the size and habitat quality within the building footprint, wetlands, building height, noise generation, and employment in the PPE and SPE are met, the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE value and assumption to reach this conclusion:

- Applicants would communicate with State natural resource or conservation agencies regarding wildlife and plants and implement mitigation recommendations of those agencies.

3.5.2.2 Environmental Consequences of Operation

The NRC staff identified the following environmental issues for analysis for operation of an ANR:

- permanent and temporary loss or disturbance of habitats;
- effects of operational noise and traffic on wildlife;
- exposure of terrestrial organisms to radionuclides;
- cooling-tower operational impacts on vegetation;
- bird injury and mortality related to collisions with structures and transmission lines;
- bird electrocutions by transmission lines;
- water use conflicts with terrestrial resources;
- effects of transmission line ROW management on terrestrial resources; and
- effects of EMFs on flora and fauna.

In addition to evaluating the issues noted above, the NRC staff addressed as a separate issue any impacts on important species and habitats as defined for NRC environmental reviews (NRC 2022-TN7081).

3.5.2.2.1 Permanent and Temporary Loss or Disturbance of Habitats

Substantial losses or changes in habitats on ANR sites are unlikely during operations, although small areas of vegetated land might have to be disturbed to maintain, upgrade, or expand structures or add support structures. In reviewing the environmental effects of operating large LWRs, the NRC staff explained that most unpaved lands in the developed areas on nuclear sites are maintained as modified habitats with lawns and other landscaped areas or may contain early successional habitats (NRC 2013-TN2654). Even if other habitats are present in developed areas, they can be expected to be small, fragmented, and heavily influenced by noise and human activity associated with reactor operations. Based on the License Renewal GEIS (NRC 2013-TN2654), the NRC staff expects that there would be no wetlands in such areas, or that any wetland disturbances (except for intake and discharge structures [Section 3.6.2.1]) would not cause total wetland impacts for the project to exceed the PPE value of 0.5 ac (0.2 ha) (Section 3.5.2.1.2). Wetland impacts for projects within the PPE value of 0.5 ac (0.2 ha) would most likely not require an Individual Permit under CWA Section 404

(33 U.S.C. § 1344-TN1019) and may result from “discharge of dredged or fill material” or other types of disturbances. The License Renewal GEIS explains that habitats in such settings are generally tolerant of disturbance (NRC 2013-TN2654), as are associated populations of birds, mammals, and lizards (Samia et al. 2015-TN6790). Small areas of such habitats could be lost or disturbed as facilities on the site are refurbished, upgraded, or expanded, although the ecological effects of any losses on the surrounding landscape are likely to be minimal. Not only would the effects be minimized because of the limited spatial extent of facilities meeting the PPE, but also because of the previously altered character of the affected areas.

The staff has determined that this is a Category 1 issue. The staff concludes that the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- Temporarily disturbed lands would be revegetated using regionally indigenous vegetation once the lands are no longer needed to support building activities.
- The total wetland loss from site disturbance over the operational life of the plant would be no more than 0.5 ac (0.2 ha).
- Any State or local permits for wetland impacts would be obtained.
- Any mitigation measures indicated in the NWPs or other wetland permits would be implemented.
- BMPs would be used for erosion, sediment control, and stormwater management.

3.5.2.2.2 Effects of Operational Noise and Vehicular Collisions on Wildlife

The effects of operational noise and traffic on wildlife would be as described above for building in Sections 3.5.2.1.3 and 3.5.2.1.4, respectively, but the effects would occur over an extended period of time covering the operational lifespan of the reactor. Operational noise would tend to be lower in intensity and steadier than building noise, and wildlife may therefore be better able to habituate to and tolerate the noise. As for during construction, the potential for injury or mortality of wildlife caused by vehicular collisions would be limited by the low employment at the reactor established in the PPE. Furthermore, it is unlikely that new roads would be constructed through substantial blocks of natural habitat thereby exposing additional wildlife to noise or collision threats during operations. The staff has therefore determined that operational noise and traffic are Category 1 issues. The staff concludes that as long as the applicable assumptions in the PPE and SPE regarding noise generation and employment are met, the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- Noise generation would not exceed 85 dBA 50 ft (15.2 m) from the source.
- There would be no decreases in the LOS designation for affected roadways.
- The licensee would communicate with Federal and State wildlife agencies and implement mitigation actions recommended by those agencies to reduce potential for vehicular injury to wildlife.

3.5.2.2.3 Exposure of Terrestrial Organisms to Radionuclides

The NRC staff recognizes that small amounts of radioactive particulates can be vented to the exterior environment during operation of LWRs and evaluated the potential effects of those releases on terrestrial ecological receptors in the License Renewal GEIS (NRC 2013-TN2654).

Section 3.8.1.2.2 of this GEIS concludes that the impact of routine radiological releases from past and current operations on terrestrial biota would be SMALL. To support that conclusion, Table 3-6 (in Section 3.8.1 in this GEIS) presents radiological exposure estimates for two mammal and two bird species modeled using NRCDose code, as presented in 15 EISs for proposed new LWRs published between 2006 and 2019. All estimates were substantially lower than exposure levels considered protective of terrestrial animal populations by the International Atomic Energy Agency (IAEA).

In the License Renewal GEIS (NRC 2013-TN2654), the staff also used the RESRAD-BIOTA dose evaluation model developed by DOE (DOE 2004-TN6460) to calculate estimated dose rates to terrestrial biota receptors using REMP reports submitted by licensees for 15 operating LWRs in the United States. RESRAD-BIOTA accounts for bioaccumulation of radionuclides in the tissues of biological organisms and biomagnification, whereby radionuclides become concentrated at higher levels in organisms occupying higher positions in the food chain. The staff calculated estimated doses for three terrestrial ecological receptors: riparian animals (animals estimated to spend approximately half their time in aquatic environments and half in terrestrial environments), terrestrial animals, and terrestrial plants. None of the estimated doses exceeded levels recognized by DOE as being protective of riparian or terrestrial animals (0.1 rad/d [0.001Gy/d]) or terrestrial plants (1.0 rad/d [0.01 Gy/d]) (DOE 2002-TN4551).

While many ANRs may use fuels containing different compositions of radionuclides than the LWRs considered in the analyses presented above, a reactor meeting the PPE for Radiological Environmental Hazards in Appendix G would not be likely to result in greater releases of radioactivity. The staff has determined that this is a Category 1 issue. The staff concludes that as long as the assumptions in the PPE underlying the analysis in Section 3.8 are met, the impacts can be generically determined to be SMALL without mitigation. The staff relied on the following PPE and SPE value and assumption to reach this conclusion:

- Applicants would demonstrate in their application that any radiological nonhuman biota doses would be below IAEA (1992-TN712) and NCRP (1991-TN729) guidelines.

3.5.2.2.4 Cooling-Tower Operational Impacts on Vegetation

The PPE assumes that an ANR would use only fresh makeup water that has a salinity of under 1 part per thousand (ppt) for operation of any cooling towers. The staff has found in past new reactor EISs that salt drift modeling sometimes indicates potentially significant impacts on vegetation when brackish water is used as makeup water (NRC 2012-TN1976, NRC 2016-TN6434, NRC 2016-TN6840). The PPE also assumes that any cooling towers would be the mechanical draft type rather than natural draft cooling towers and under 100 ft (30.5 m) in height. While mechanical draft cooling towers are typically under 100 ft (30.5 m) in height, natural draft cooling towers can be more than 400 ft (122 m) in height. Natural draft towers release drift higher into the atmosphere and therefore can spread drift farther across the landscape than can mechanical draft towers. Drift from mechanical draft towers tends to affect only vegetation in close proximity to the towers, which is mostly limited to disturbed lawns and other successional vegetation typical of existing industrially developed areas. The PPE also assumes that any cooling towers would be equipped with drift eliminators to minimize the amount of drift.

The NRC staff recognizes that salt deposition rates between 0.89 and 1.78 lb/ac/mo (1 and 2 kg/ha/mo) are generally not damaging to plants, while rates approaching or exceeding 8.92 lb/ac/mo (10 kg/ha/mo) in any month during the growing season could cause leaf damage in many species (NRC 2000-TN614). Even 8.92 lb/ac/mo (10 kg/ha/mo) is a conservative estimate representing documented acute injury only of the most sensitive of crop and native vegetation plant species (NRC 1996-TN288). It is reasonable to expect that substantially higher deposition rates would be needed to cause noticeable injury to vegetation consisting of a mixture of plant species of differing sensitivities.

Estimates for TDS (total dissolved solids, referred to hereafter as "salt") deposition rates were less than 8.92 lb/ac/mo (10 kg/ha/mo) for several recently completed new reactor EISs where mechanical draft cooling towers were to be operated using fresh makeup water. Estimates for maximum salt drift deposition from operation of four mechanical draft cooling towers serving the proposed Comanche Peak Units 3 and 4 in inland Texas were approximately 3.11 lb/ac/mo (3.49 kg/ha/mo), at a point 328 ft (100 m) north of the towers (NRC 2011-TN6437). Estimates for maximum salt drift deposition from operation of four mechanical draft cooling towers serving the proposed William States Lee Units 1 and 2 in western South Carolina were 0.009 lb/ac/mo (0.0103 kg/ha/mo), at a point 656 ft (200 m) north of the towers (NRC 2013-TN6435). The estimates for building small modular reactors (SMRs) of unspecified technology at the Clinch River site in Oak Ridge, Tennessee, were as high as 100.5 lb/ac/mo (112.7 kg/ha/mo) at a point approximately 328 ft (100 m) from the towers but were less than 8.9 lb/ac/mo (10 kg/ha/mo) at 984 ft (300 m) from the towers. Even though the Clinch River data suggest possible vegetation damage in close proximity to operating mechanical draft cooling towers, such close-in areas to a nuclear power plant are usually industrial in character and any vegetation present would likely be ruderal or highly disturbed vegetation of low ecological value. The low estimated drift rate for areas 1,000 ft (305 m) from the towers suggests that the potential effects of vegetation damage on the surrounding landscape would be low.

There is less of a record to draw from for cooling towers operated using brackish water or seawater makeup sources. The maximum deposition for the proposed Turkey Point Units 6 and 7, which were modeled using mechanical draft cooling towers with makeup water as salty as seawater, was estimated to be as high a 93.7 lb/ac/mo (105 kg/ha/mo) close to the towers (NRC 2016-TN6434) but diminishes rapidly with distance to under 8.9 lb/ac/mo (10 kg/ha/mo) within 1 mi (1.6 km) from the towers (NRC 2016-TN6434). Although the Turkey Point EIS concluded that the effects would be minimal, the proposed site was situated on an island with an existing nuclear plant where the nearest high-quality natural habitat was nearly 1 mi (1.6 km) distant (NRC 2016-TN6434). Had high-quality natural habitats been present close to those reactors, habitat function could have been noticeably compromised due to leaf injury. The maximum deposition for the proposed Levy Units 1 and 2 in north-central Florida, which was to use natural draft cooling towers with brackish makeup water of about 24 ppt, was estimated to be 9.59 lb/ac/mo (10.75 kg/ha/mo) (NRC 2012-TN1976). Such deposition suggests the possibility of noticeable leaf damage in terrestrial habitats close to the site. The Levy plant, however, was designed with natural draft cooling towers, which tend to disburse drift farther from the towers than mechanical draft towers.

The NRC staff recognizes that damage to forested habitats can result from icing of cooling-tower drift but recognizes such damage as being "rare, minor, and localized" (NRC 2013-TN2654). The recently completed new reactor EISs discussed above dismiss the effects of icing on terrestrial habitats from cooling-tower operation as being minimal. Even in arctic or very cold habitats, the existing vegetation would have to already be adapted to heavy snow and ice accumulation.

The staff has determined that cooling-tower effects on vegetation are a Category 1 issue. The staff concludes that as long as the applicable assumptions regarding cooling towers in the PPE and SPE are met, including that the source of makeup water is fresh (salinity of less than 1 ppt), the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- If needed, cooling towers would be mechanical draft, not natural draft; less than 100 ft (30.5 m) in height; and equipped with drift eliminators.
- Any makeup water for the cooling towers would be fresh water (less than 1 ppt salinity).

The staff recognizes that vegetation damage from the operation of cooling towers using brackish water or seawater as makeup water may also have a low probability of noticeable adverse effects on terrestrial habitats, but less evidence is available to support high confidence in that conclusion without completion of project-specific analysis.

3.5.2.2.5 Bird Collisions and Injury from Structures and Transmission Lines

The structures and transmission lines discussed in Section 3.5.2.1 for building would continue to be present during operations, and no new structures or transmission lines would be introduced during operations that were not previously considered. Thus, the analyses in Section 3.5.2.1 also apply during operations. As for construction, the staff has determined that bird collisions with structures and transmission lines during operations are a Category 1 issue. The staff concludes that as long as the assumptions regarding structure heights and transmission lines are met, the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- The site size would be 100 ac (40.5 ha) or less.
- New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length.
- No transmission line structures (poles or towers) would be more than 100 ft (30.5 m) in height.
- Licensees would implement common mitigation measures such as those provided by the American Bird Conservancy (ABC 2015-TN6763) for buildings, by FWS (2013-TN6764) for towers, and by the Avian Power Line Interaction Committee (APLIC) for transmission lines (APLIC 2012-TN6779).

See Section 3.5.2.1.5 for a brief discussion of the types of possible mitigation measures.

3.5.2.2.6 Bird Electrocutions from Transmission Lines

The potential for avian electrocutions from energized transmission conductors depends on a combination of biological, environmental, and electrical design factors (APLIC 2006-TN794). Biological and environmental factors include proximate habitat, bird species (body size, behavior, distribution, and abundance), and prey availability. The key electrical design factor is the physical separation between energized conductors (wires). If the distance between energized conductors is less than that of the head-to-foot or wrist-to-wrist distance of a bird, electrocution may occur. APLIC (2006-TN794) recommends that conductors be spaced a minimum of 60 in. (152 cm) apart horizontally and 40 in. (102 cm) apart vertically, with 60 in. (152 cm) vertical separation recommended near sensitive avian habitats. Contact between a single conductor and a bird does not generally result in electrocution, but simultaneous contact by a bird with more than one conductor (or air space very close to a conductor) can cause electrocution because of the phase differences in voltage. Most electrocutions are of birds that have large wingspans, such as eagles, hawks, vultures, and ravens. Of particular concern are bald eagles (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*), which are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. §§ 668 *et seq.;* TN1447) (APLIC and EEI 2018-TN6809). Electrocution mortality is not known to have been a concern at existing nuclear power plants in the United States; thus, the NRC did not address the subject in its License Renewal GEIS (NRC 2013-TN2654).

The staff expects the likelihood of avian electrocution mortality, up to and including population level effects, would be low for new ANR transmission lines in any environmental setting and has concluded this is a Category 1 issue. As long as the assumptions regarding transmission lines in the PPE and SPE are met, the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length.
- Common mitigation measures, such as those recommended by APLIC (2006-TN794), would be implemented.

The potential for electrocutions is limited by the PPE that assumes a maximum of 1 mi (1.6 km) of ROW not co-located with existing ROWs or roads. APLIC (2006-TN794) recognizes that co-location of new power lines with existing power lines reduces the potential for electrocutions. The greatest potential for electrocutions is where power lines cross open treeless areas (APLIC and EEI 2018-TN6809), but even in these areas the limitations assumed under the PPE are expected to keep impacts at low significance. Examples of mitigation measures recommended by APLIC include separation of phase conductors and grounded hardware, and installation of covers on phases or grounds where adequate separation is not feasible (APLIC 2006-TN794).

3.5.2.2.7 Water Use Conflicts with Terrestrial Resources

Water levels and hydroperiod are important factors in determining the composition of wetland plant and animal species present (EPA 1996-TN6800; SFWMD 1995-TN6799). Through physiological stress and habitat alteration, water-level fluctuations create temporal and spatial heterogeneity that shapes littoral zone (shoreline and nearshore) habitats. Freshwater littoral zones typically harbor diverse ecological communities that serve numerous ecosystem functions that are influenced, in part, by water-level fluctuations (Carmignani and Roy 2017-TN6795). For example, some native plants and animals have adapted to the range of hydrologic conditions that occur in natural wetlands (SFWMD 1995-TN6799).

Large anthropogenic water withdrawals can influence the water levels and hydroperiod in wetlands, floodplains, riparian, and other terrestrial habitats connected to flowing water bodies; non-flowing freshwater, brackish, and marine water bodies; and groundwater sources supplying water to meet the demands. Adverse effects on these habitats can occur when the water levels or hydroperiod are changed beyond historical annual or seasonal fluctuations. In the License Renewal GEIS, which addresses large LWRs operating as of 2013 that typically use water-based cooling systems requiring large quantities of water, the NRC staff concluded that project-specific analyses were necessary to characterize the potential impacts from water use conflicts on terrestrial habitats (NRC 2013-TN2654).

Flowing Water Bodies

The staff's assumption regarding surface water availability for flowing systems (i.e., withdrawals from rivers under low flow conditions of less than or equal to 3 percent of the 95 percent exceedance flow, or extreme low flow conditions) would result in the loss of an even much smaller percentage of the full or out-of-bank flows typically required to maintain riparian habitats and connected wetlands, floodplains, and riparian areas (Hill et al. 1991-TN6791; Navratil 2006-TN6792; Poff et al. 1997-TN6794; Kendy et al. 2012-TN6793). The 95 percent exceedance flow accounts for cumulative hydrologic impacts because it includes existing withdrawals and planned future withdrawals. Although there are no standard metrics for determining the flow quantity or duration needed to maintain wetland, floodplain, and riparian habitats (Hill et al. 1991-TN6791), a minor water withdrawal such as 3 percent of the 95 percent exceedance flow is unlikely to reduce water levels or alter hydroperiods in such habitats enough to cause noticeable adverse effects, even when added to existing or planned water withdrawals. If the low flow withdrawal assumption is not met, project-specific analysis would be required to determine potential impacts on connected wetland, floodplain, and riparian habitats.

Non-flowing Water Bodies

Human activities that reduce lake water levels and hydroperiods below historical annual or seasonal fluctuations may threaten littoral zone ecological integrity (Carmignani and Roy 2017-TN6795; SFWMD 1995-TN6799) as described above for withdrawals from flowing water bodies. Freezing or drying out of root systems and compaction of sediment may stress emergent and aquatic plants. Reduced plant productivity, cover, and food supplies may result in a decrease in dependent microorganisms, invertebrates, fish, and wildlife. Forage species that supply food for birds and other wildlife might be replaced by species more tolerant of desiccation and/or freezing, thereby having detrimental ecological effects on existing communities. For example, a U.S. Bureau of Reclamation (USBR) EIS (USBR 2004-TN6796) evaluated a proposed 5 ft (1.5 m) drawdown of Banks Lake in eastern Washington State lasting up to 2 months and concluded that there would be adverse impacts on the distribution of vegetation, fish, and wildlife; prompting the USBR to propose vegetation mitigation and further investigate potential effects on wildlife. Flat, shallow habitats are anticipated to incur greater areal exposure than steeper habitats during a given drawdown.

The staff assumes a maximum surface water use rate of 6,000 gpm (0.379 m^3/s) (Section 3.4.1) for total plant water demand, applying to non-flowing water bodies such as the Great Lakes, the Gulf of Mexico, oceans, estuaries, and intertidal zones. The staff assumes for the generic analysis that the quantity of surface water withdrawn from these water bodies would not result in a reduction in water levels or hydroperiod that could adversely affect connected wetlands, floodplains, or riparian or other habitats. However, for other non-flowing bodies of freshwater (e.g., inland lakes, ponds, and reservoirs) the staff assumes that applicants relying on the generic analysis would demonstrate that the assumption regarding connected wetlands, floodplains, or riparian habitats (changes in water levels and hydroperiod are within historical annual or seasonal fluctuations) is met. If the applicant cannot so demonstrate, project-specific analysis would be necessary to determine potential impacts on connected wetland, floodplain, and riparian habitats. Such a demonstration would only be necessary if the site contains more than just low value wetlands or other terrestrial habitats, such as drainage ditches or manufactured depressions within uplands, or dominated by invasive vegetation.

Estuaries and Intertidal Zones

Water withdrawals from brackish non-flowing water bodies such as estuaries (partially enclosed, coastal water body where freshwater mixes with marine water) could affect connected terrestrial habitats and wildlife due to potential changes in water quality. Many different terrestrial habitat types are found in estuaries, including freshwater and saltwater tidal marshes, tidal swamps, sandy beaches, mud and sand flats, rocky shores, mangrove forests, and river deltas. The most influential gradient in estuaries is salinity because it structures the spatial patterns of physical properties, biogeochemical processes, and plants and wildlife with species-specific adaptations to different salinity ranges (Cloern et al. 2017-TN6967). The salinity gradient in such settings depends on the relative exchanges of both fresh and marine water, which may be altered beyond historical annual or seasonal fluctuations by withdrawal of either fresh or marine water (40 CFR 230.25; TN427). Water withdrawals in estuaries may alter both the physical extent of saltwater influence and salinity levels and thereby affect populations of salinity-dependent food sources that could in turn affect the survival of dependent wildlife. The staff therefore assumes that applicants relying on the generic analysis would demonstrate that the assumption for estuaries regarding connected terrestrial habitats (changes in the physical extent of saltwater influence and salinity gradients are within historical annual or seasonal fluctuations) is met. If the assumption is not met, further project-specific analysis would be necessary to determine potential impacts on the physical extent of saltwater influence and salinity gradients as well as associated food chain effects.

Water withdrawals from marine or brackish non-flowing water bodies such intertidal zones (area of shoreline between low and high tides) could affect habitat and wildlife due to potential changes in water quality. Intertidal zones can encompass terrestrial habitats such as sandy beaches, mud and sand flats, and rocky shores. Intertidal zones are characterized by unique environmental conditions, including variable temperatures (depending on the status of the tide), microclimates, and ecological factors that provide habitat for a wide variety of plant and animal species. The vulnerability of intertidal zones to water withdrawals depends to a large extent on the degree of enclosure from the open ocean. Partially enclosed intertidal zones with little connectivity or current exchange with the open ocean would be more susceptible to water withdrawals affecting salinity gradients than intertidal zones that are more open and connected to the ocean. The irregularity in the geomorphology of coastal environments in terms of the vertical and horizontal degree of enclosure from the open ocean varies widely, as does the degree of vulnerability of intertidal zones to the effects of water withdrawal on changes in salinity levels. The staff therefore assumes that applicants relying on the generic analysis would demonstrate that the assumption for intertidal zones (changes in salinity levels are within historical annual or seasonal fluctuations) is met. If the assumption is not met, further project-specific analysis would be required to determine potential impacts on salinity gradients as well as associated habitat and food chain effects.

Groundwater

The water use assumptions established in the PPE and SPE for surficial groundwater depletion that could influence terrestrial habitats include withdrawal of less than or equal to 50 gpm (0.003 m^3/s) resulting in drawdown of no more than 1 ft (0.3 m) at the site boundary. Withdrawals of surficial groundwater during plant operations would be continual and thus have the potential for permanent impacts on connected terrestrial habitats. Localized shoreline habitats throughout the United States and internationally have undergone changes consistent with a loss or reduction of groundwater discharge (EPA 1996-TN6800). High-risk hydrologic settings include groundwater-fed wetlands without a surface water connection (EPA 1996-

TN6800; MBWSR 2016-TN6801), such as many prairie potholes, pocosins, peat bogs, fens, and Carolina bays. Long-term lowering of groundwater levels may impact groundwater-fed isolated wetlands in much the same way as surface water withdrawals (described above for flowing and non-flowing water bodies), but very few studies provide quantitative analysis. Some data suggest that chronic reductions of groundwater levels result in a reduction in hydroperiod and can have significant effects on plant community structure in wetlands (SFWMD 1995-TN6799). A less than 1 ft (0.3 m) modeled drawdown of groundwater has been shown to be associated with actual drawdowns of several feet in isolated wetlands, and an extended modeled drawdown of groundwater from 0.6 (0.2 m) to 1.0 ft (0.3 m), within seasonally to semi-permanently flooded isolated wetlands, has been shown to correspond with significant changes in plant community composition and structure (SFWMD 1995-TN6799). Thus, there was ample evidence that a drawdown criterion of less than 1 ft (0.3 m) may be appropriate in some areas of Florida (SFWMD 1995-TN6799). However, most of the studies reviewed by the South Florida Water Management District (SFWMD 1995-TN6799) did not establish a threshold of harm corresponding to specific groundwater drawdown level (modeled or actual).

Desert springs, often the sole sources of water for some wildlife in the arid west, often support wetland and wetland/upland transition ecosystems including rare and endemic species. Groundwater withdrawal may lower the local water table, reducing the areal cover of wetland and wetland/upland transition vegetation and reduce the amount of upland phreatophytic vegetation (deep-rooted plants that obtain water from the water table or the layer of soil just above it) by causing water levels to drop below plant rooting depths. Percolation of salts to surface soils may be reduced, eventually altering desert shrub cover from halophytes (plants adapted to growing in saline conditions) to nonhalophytes. The extent of these effects will vary among springs, based on their distance from groundwater extraction sites and location relative to regional groundwater flow paths (Patten et al. 2007-TN6968). For example, outflow distance at springs that have low discharge rates generally may not be more than 200 m, while outflow distance at springs that have large discharges can be many kilometers (Patten et al. 2007-TN6968).

Based on the above information related to the extraction of surficial groundwater, the staff has no assurance that relying on assumed PPE/SPE values of groundwater drawdown of no more than 50 gpm (0.003 m^3/s) and no more than 1 ft (0.3 m) at the site boundary, would adequately protect wetlands with a groundwater connection, either within or outside of the site boundary. Based on these analyses, even for an ANR bounded by the assumptions for groundwater withdrawals for dewatering in the PPE and SPE (50 gpm [0.003 m^3/s] with no more than a 1 ft (0.3 m) drawdown of groundwater levels at the site boundary), some onsite and offsite wetlands in certain settings with a groundwater connection could be affected. Adverse impacts on onsite and offsite wetlands could result if groundwater dewatering causes changes in water levels or hydroperiod that exceed historical annual or seasonal fluctuations. This applies to wetlands with a groundwater connection but may be accentuated in such wetlands without a surface water connection. The staff expects that applicants relying on the generic analysis would demonstrate that the terrestrial resources assumption regarding wetlands (changes in water levels and hydroperiod are within historical annual or seasonal fluctuations) in the SPE is met. It might be possible to demonstrate that there are no wetlands, or only wetlands of minimal value, present on or in the immediate vicinity of the site. Or it might be possible to demonstrate that the only wetlands on or near the site belong to hydrogeomorphic (HGM) classes not typically influenced by groundwater, such as the HGM classes of riverine wetlands or tidal or lacustrine fringe wetlands (Brinson et al. 1995-TN6969). Other tools might be available from various regulatory agencies or other institutions and could be used. Such a demonstration would also have to provide evidence that the maximum depth to groundwater lay substantially below the surface. If this assumption is not met, further project-specific analysis would be required.

<u>Conclusion</u>

The staff has determined that water use conflicts with terrestrial resources are a Category 1 issue under the assumptions discussed above for flowing water bodies, non-flowing water bodies (including freshwater, brackish, and marine), and surficial groundwater. If the applicable assumptions for terrestrial resources in the relevant water body type are not met, project-specific analyses would be necessary to characterize potential impacts on habitats connected to such water bodies as well as on dependent wildlife. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- Total plant water demand would be less than or equal to a daily average of 6,000 gpm (0.379 m^3/s).
- If water is withdrawn from flowing water bodies, average plant water withdrawals would not reduce flow by more than 3 percent of the 95 percent exceedance daily flow, and would not prevent maintenance of applicable instream flow requirements.
- Any water withdrawals would be in compliance with any EPA or State permitting requirements.
- Applicants would be able to demonstrate that hydroperiod changes are within historical or seasonal fluctuations.

3.5.2.2.8 Effects of Transmission Line ROW Management on Terrestrial Resources

Once a transmission line is built, ROWs in potential forest habitat will require routine maintenance to keep them free of trees tall enough to cause electrical current to arc through vegetation to the ground, which may ignite fires and cause power outages. It may also be necessary to trim or remove trees growing near the edge of the ROW that are capable of falling too close to the conductors (commonly termed "danger trees"). Trimming or removing individual danger trees is unlikely to substantially alter the ecological properties of terrestrial habitats adjoining the ROW. Some utilities also maintain "screens" of low trees under transmission line conductors where they cross aesthetically sensitive suburban roadways; those tree screens require frequent maintenance. The ecological properties of the screens are unlikely to be substantially altered by trimming the entire screen or by removal of individual trees. Sometimes relatively level upland areas on transmission line ROWs, especially in aesthetically sensitive residential areas, are periodically mowed. But the most common techniques used in managing transmission line ROWs involve the use of herbicides. Herbicides can be applied directly to vegetation in the ROW, or herbicides can be applied to cut stump surfaces once trees are felled.

The NRC staff performed a comprehensive literature review of the potential effects of transmission line ROW management on terrestrial resources as part of the License Renewal GEIS (NRC 2013-TN2654). The analysis considered various common ROW management practices including tree trimming and clearing, mowing, and herbicide application and concluded that the overall ecological effects were neither substantially adverse nor beneficial. Limitations on the length and routing of transmission lines in the PPE further reduce the potential for adverse impacts.

The staff has determined that this is a Category 1 issue. The staff concludes that as long as the assumptions regarding transmission lines in the PPE and SPE are met, the impacts can be generically determined to be SMALL. The PPE includes an assumption that licensees would implement integrated vegetation management practices to maintain ROWs in areas where vegetation growth may interfere with power lines. Mitigation measures necessary to rely on the generic analysis include ensuring that all work is performed in compliance with all applicable laws and regulations and that herbicides are applied only by licensed applicators in compliance with the applicable manufacturer label instructions. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- Vegetation in transmission line ROWs would be managed following a plan consisting of integrated vegetation management practices.
- All ROW maintenance work would be performed in compliance with all applicable laws and regulations.
- Herbicides would be applied by licensed applicators, and only if in compliance with applicable manufacturer label instructions.

3.5.2.2.9 Effects of Electromagnetic Fields on Flora and Fauna

Electric current moving through transmission lines generates an electromagnetic field (EMF) in the surrounding airspace. The NRC staff performed a comprehensive literature review of the potential effects of EMFs on terrestrial resources, including flora, honeybees, and wildlife and livestock and identified no significant impacts (NRC 2013-TN2654). Based on the literature review in the License Renewal GEIS, the staff determined that this is a Category 1 issue and impacts would be SMALL regardless of the length, location, or size of the transmission lines. The staff did not recommend any mitigation in the License Renewal GEIS (NRC 2013-TN2654); hence, none is needed here. The staff did not rely on any PPE and SPE values or assumptions in reaching this conclusion.

3.5.2.2.10 Important Species and Habitats

As noted for building, important species and habitats meeting the NRC criteria (NRC 2022-TN7081) for a given site can only be determined once the site is identified. Because of different regulations and sensitivities to impacts, two separate issues are analyzed below regarding important species and habitats: (1) resources regulated under the ESA (16 U.S.C. §§ 1531 *et seq.*; TN1010), and (2) other important species and habitats.

Resources Regulated under the Endangered Species Act of 1973

For the same reasons noted for building in Section 3.5.2.1.6, the staff has determined that operational impacts on resources regulated under the ESA are a Category 2 issue. Because of their potential for future regulation over the course of a licensing action, the Category 2 designation extends also to candidate species and species and critical habitat proposed for designation under the Act. Even if the applicable assumptions in the PPE and SPE outlined in Section 3.5.1 are met, the NRC staff is unable to determine the significance of potential impacts without consideration of project-specific factors, including the specific species and habitats affected and the types of ecological changes potentially resulting from each specific licensing action. Furthermore, completing the required consultation requires individualized action by the staff for each application.

Other Important Species and Habitats

The analyses presented in Section 3.5.2.1.6 also apply to operations and suggest that the potential impacts on other important species and habitats as defined in RG 4.2 (NRC 2022-TN7081) from operating an ANR that meets the PPE and SPE would likely be minimal regardless of site location and the important species specifically present on a given site. The assumptions in the PPE and SPE limit the potential for adverse impacts, especially limiting the size of the disturbance footprint and the assumed absence of sensitive habitat types potentially containing rare species within the footprint. The staff has therefore determined that operational impacts on important species and habitats other than those regulated under the ESA are a Category 1 issue. The staff concludes that as long as the applicable assumptions regarding the size and habitat quality of the building footprint, wetlands, building height, noise generation, and employment in the PPE and SPE are met, the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE value and assumption to reach this conclusion:

- Applicants would communicate with State natural resource or conservation agencies regarding wildlife and plants and implement mitigation recommendations of those agencies.

3.6 Aquatic Ecology

3.6.1 Baseline Conditions and PPE/SPE Values and Assumptions

Some sites proposed for an ANR may include (or be adjacent to) aquatic habitats in streams, rivers, ponds, lakes, or other surface water features. Other sites may lack aquatic habitats within their perimeters, but activities there could still affect aquatic habitats because the sites lie in the watershed, thereby contributing overland runoff to down-gradient surface water features containing aquatic habitats. Some watersheds may drain directly to large bodies of waters such as oceans, estuaries, or large lakes; while others may instead drain into tributary systems that flow into the larger bodies of water. In some landscapes, sites may drain into depressions where the accumulated water forms permanent or temporary lakes or ponds, or ephemeral features such as playas and vernal pools, from which it evaporates to the atmosphere or leaches into the groundwater. In landscapes overlying limestone (karst landscapes), sites may drain into streams whose flow disappears into the underlying groundwater and may emerge at springs elsewhere in the landscape.

The separation between aquatic and terrestrial habitats is not always sharp; the edges of some aquatic habitats are clearly bounded by an ordinary high-water mark, while elsewhere the transition is gradual and may include interim zones of wetlands. The NRC staff typically considers wetlands that contain persistent emergent vegetation, including most swamps and marshes, to be terrestrial habitats (addressed in Section 3.5), while considering wetlands dominated only by submerged aquatic vegetation to be aquatic habitats (NRC 2022-TN7081). More information about how the NRC staff defines and characterizes aquatic habitats is available in RG 4.24 (NRC 2017-TN6720).

Aquatic habitats may be marine, estuarine, or freshwater. Marine habitats in oceans or bays broadly open to the ocean generally are saltwater, with a typical seawater salinity of approximately 35–37 ppt. Seawater that accumulates in depressions may attain higher salinities due to partial evaporation. Estuaries are surface water areas where freshwater entering through tributaries or runoff mixes with seawater carried by the tides, resulting in brackish water between 0.5 ppt and less than 35 ppt. Estuarine habitats are typically in continuous flux in response to changing tides, freshwater inflow, and freshwater runoff. Freshwater habitats, with salinities generally 0.5 ppt or less, are sometimes characterized as either lotic, situated in portions of streams or rivers containing running water; or lentic, situated in ponds, lakes, or portions of streams or rivers containing standing water. Biota at the base of aquatic food chains are photosynthetic (capable of using sunlight to produce biomass), including photosynthetic bacteria, phytoplankton (free-floating microscopic algae), larger floating algae or algae fixed to solid substrates by holdfasts, or rooted submerged vascular plants. Other components of the aquatic food chain can include zooplankton (free-floating microscopic animal-like biota), benthic organisms (generally larval insects or other fauna that attach to rocks and other solid underwater substrates), fish, crustaceans, and shellfish. Many fish and shellfish include microscopic life stages that behave more like plankton than the independently mobile adults. The aquatic food chain is intimately connected to the terrestrial food chain and can be influenced by terrestrial organisms such as birds, mammals, reptiles, amphibians, and insects.

The NRC staff developed the values and assumptions in the PPE and SPE pertaining to aquatic ecology based on the information and analyses contained in multiple new reactor EISs prepared between 2005 and 2017, the License Renewal GEIS (NRC 2013-TN2654), other past NRC EISs, and Federal and State regulations protecting waters of the United States and threatened and endangered species.

Based on experience gained from preparing past new reactor EISs, the NRC staff included an assumption in the PPE and SPE that permanent disturbance would encompass no more than 30 ac (12 ha) of vegetated land, with temporary disturbance of as much as an additional 20 ac (8.1 ha) of vegetated land. The NRC staff also assumes the temporarily disturbed land will be restored once it is no longer needed using regionally indigenous vegetation. Disturbances to land in the watershed of surface water bodies can result in sedimentation and stormwater runoff reaching habitats of aquatic flora and fauna. The NRC staff would have to consider project-specific factors if greater disturbances were necessary. Also, based on the staff's experience with past new reactor EISs, the PPE and SPE additionally assume that the footprint of disturbance (other than for building intake or discharge structures) would not encompass aquatic habitats. However, as explained in Section 3.5.1, the assumptions in the PPE and SPE allow for impacts on as much as 0.5 ac (0.2 ha) of wetlands or other waters of the United States, based on disturbance area limits built into several NWPs established by the USACE under Section 404 of the CWA (33 U.S.C. § 1344-TN1019). The PPE and SPE also recognize that transmission lines, pipelines, and access roads might extend across or under streams or small surface water features (as long as the project's total impact on wetlands and other surface water bodies is less than 0.5 ac [0.2 ha]).

Recognizing that the evaluation of aquatic impacts in the License Renewal GEIS (NRC 2013-TN2654) and past new reactor EISs identified substantial impacts from certain types of plant cooling systems, the staff included an assumption in the PPE and SPE that allows for use of recirculated-water cooling towers, but not once-through cooling systems, cooling ponds, or new cooling-water reservoirs. However, the assumptions still recognize that any cooling towers would have to be mechanical draft type rather than natural draft type, and that any makeup water for cooling would have to be fresh (salinity less than 1 ppt). EISs for proposed new reactors in Levy County, Florida (NRC 2012-TN1976) and Homestead, Florida (NRC 2016-TN6434) identified potentially damaging salt drift at certain locations close to cooling towers using brackish makeup water. The PPE and SPE also assume that any intake would meet the requirements established by the EPA in 40 CFR 125.83 (TN254) for protection of aquatic biota from entrainment or impingement. Because of the potential for contamination by dissolved metals in cooling-system blowdown water that are toxic to aquatic biota, the PPE also assumes no use of copper alloy tubes in cooling systems. Based on information in past new reactor EISs, the staff established assumptions in the PPE and SPE regarding features such as transmission lines and other linear utilities. The PPE and SPE assume that any new poles or towers would be built outside of wetlands and floodplains and that any pipelines would be directionally drilled under surface water features such as streams without disturbance to shorelines or bottom substrates. Finally, the PPE and SPE assumptions relevant to aquatic ecology include all of the assumptions developed for hydrology (Section 3.4.1) with respect to withdrawal of surface water and groundwater.

The NRC staff typically evaluates impacts on aquatic habitats, as well as on the individual species and habitats that meet the definition of "important," as outlined in RG 4.2 (NRC 2022-TN7081). Determining which species and habitats potentially affected by a project meet the criteria for "important" is not possible until a specific site is identified. While the analysis in Section 3.6.2 is able to consider the potential impacts on many types of important species generically, it reserves a consideration of potential impacts on federally listed threatened or endangered species and species regulated under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act; 16 U.S.C. §§ 1801 *et seq.*; TN1061) until after receipt of an application. The generic analyses of environmental consequences presented below therefore address potential impacts on aquatic habitats, food chains, and groupings of biota, while reserving consideration of potential impacts on federally listed threatened or endangered species and species regulated under the Magnuson-Stevens Act for project-specific documentation for the review of a specific license application.

A number of available databases contain relevant information about aquatic biota for sites anywhere in the United States. The FWS and National Marine Fisheries Service (NMFS) maintain online databases regarding the potential occurrence of threatened, endangered, proposed, or candidate species and critical habitats designated under the Federal ESA (16 U.S.C. §§ 1531 *et seq*.; TN1010); and the NMFS maintains maps depicting the geographic extent of essential fish habitat regulated under the Magnuson-Stevens Act (16 U.S.C. §§ 1801 *et seq*.; TN1061). Most States have Natural Heritage Programs with databases that contain information about the locations of species and habitats that have Federal or State special designations.

3.6.2 Aquatic Ecology Impacts

For a nuclear plant meeting the assumptions in the PPE and SPE, the potential for significant impacts on aquatic ecological resources would generally be minor. There would be a potential for runoff and sedimentation to affect aquatic habitats during preconstruction and construction, but the PPE and SPE assume BMPs would be used to minimize adverse effects. There would also be a potential for limited impacts on wetlands and other shallow surface waters, although the potential impacts would be limited by the assumptions in the PPE and SPE. It may be necessary to build transmission lines, pipelines, or access roads spanning rivers, streams, or other surface waters; and the assumptions in the PPE and SPE allow for limited occurrence of such encroachments. For plants operated using water-based cooling, operational impacts on aquatic resources could also result from entrainment and impingement or thermal discharges. The evaluation below also considers the potential for impacts on aquatic resources from releases of radionuclides or nonradiological contamination during operations. The evaluation also considers the possible impacts on aquatic habitats from operation and maintenance of transmission lines and other facilities on offsite ROWs.

3.6.2.1 Environmental Consequences of Construction

The NRC staff considered the following environmental issues related to aquatic resources for the building of an ANR meeting the PPE and SPE:

- runoff and sedimentation from building areas;
- dredging and filling aquatic habitats to build intake and discharge structures;
- building transmission lines, pipelines, and access roads across surface water bodies; and
- impacts on important species and habitats.

The NRC staff addressed as a separate issue any impacts on important species as defined for NRC environmental reviews (NRC 2022-TN7081).

3.6.2.1.1 Runoff and Sedimentation from Construction Areas

Even though the PPE and SPE assume no more than 0.5 ac (0.2 ha) of disturbance of aquatic habitats, physical disturbance of surface soils could cause runoff and sediment to enter nearby streams, rivers, lakes, and other surface water features. Precipitation can dislodge soil particles from surface soils exposed by clearing, grubbing, and grading; and those dislodged particles can become suspended in surface runoff and be carried overland into nearby surface water features. Upon entering surface waters, sediment can settle onto the bottom substrate and smother benthic (substrate-borne) flora and fauna. Runoff and sediment can also block sunlight needed by photosynthetic organisms that form the base of the aquatic food chain, and runoff can carry soil-borne nutrients such as phosphorus and nitrogen to surface waters where they can cause rapid growth of algae, plants, or microorganisms in a process termed eutrophication. These “blooms” of aquatic organisms can rapidly deplete oxygen carried in the water (dissolved oxygen) needed by fish and other aquatic organisms, causing suffocation. Runoff and sediment can also carry pesticides and other chemical contaminants from terrestrial to aquatic settings. The entry of large volumes of runoff can increase currents and scour bottom sediments, dislodging benthic biota and increasing sedimentation of downstream habitats. As soil is compacted by building equipment and structures are built, soil permeability is reduced, and precipitation is prevented from slowly entering the soil column and is instead directed overland toward aquatic habitats. Rapid flushes of stormwater following intense precipitation can generate flood flows capable of carrying large volumes of nutrients or contaminants into aquatic habitats and scouring benthic biota (biota attached to underwater surfaces).

Significant erosion and sedimentation of aquatic habitats caused by construction could be effectively prevented by implementing BMPs. Common BMPs for sedimentation and erosion control include, but are not limited to, placing silt fences at the perimeter of areas prior to soil disturbance, installing sediment traps to catch sediment, and temporarily and permanently stabilizing exposed soil using straw or fast-growing vegetation. Stormwater runoff from impervious surfaces could be managed by building basins to detain runoff so that more ultimately moves into the soil column rather than overland to surface waters. Many States or localities require developers to implement detailed plans for soil erosion and sediment control and stormwater management.

Because of the widespread availability of effective BMPs, the staff has determined that runoff and sedimentation from building areas is a Category 1 issue. The staff concludes that as long as the applicable PPE and SPE assumptions regarding the permanent and temporary areas of disturbance are met, the impacts from building an ANR can be generically determined to be

SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- BMPs would be used for erosion and sediment control.
- Temporarily disturbed lands would be revegetated using regionally indigenous vegetation once the lands are no longer needed to support building activities.

Applicants relying on the generic determination would prepare and implement a soil erosion and sediment control plan and a stormwater management plan that have been approved by all applicable State and local authorities. If a project involves building in an area where there are no requirements for regulatory approval of those plans, the PPE and SPE still assume that for purposes of relying on the generic conclusions in this GEIS, applicants would develop and implement BMPs commonly recognized as being effective.

3.6.2.1.2 Dredging and Filling Aquatic Habitats to Build Intake and Discharge Structures

Based on recent license applications for new reactors, building intake and discharge structures for cooling typically require disturbing no more than 200 linear feet of shoreline and affect less than 1–2 ac (0.4–0.8 ha) of aquatic habitat per structure. The Tennessee Valley Authority recently estimated that it would have to build an intake structure measuring approximately 50 ft by 50 ft (15.2 m by 15.2 m) and a discharge structure containing two 3 ft (0.9 m) pipes to support mechanical draft cooling towers for a future SMR project in Tennessee (NRC 2019-TN6136). Building those structures would likely disturb less than 200 ft (61 m) of shoreline on the reservoir and less than 1 ac (0.4 ha) of bottom sediment in the reservoir. An application for a new reactor in Pennsylvania proposed disturbing approximately 0.61 ac (0.25 ha) within a river to build an intake structure and approximately 0.46 ac (0.19 ha) in the river to build a discharge structure (NRC and USACE 2016-TN6562). Positioning excavation and building equipment may also require temporarily disturbing a small area of adjoining riparian habitat, likely under 0.5 ac (0.2 ha) per structure. The structures are typically built in the same river, lake, or other source water body but usually have to be established at separate locations, so discharges do not interfere with intakes. The staff has typically concluded that the impacts of building the intakes and discharges would be minimal as long as the structures qualify for a NWP 7 under the CWA Section 404 (33 CFR Part 330-TN4318), BMPs are followed, and any mitigation measures required by the USACE under CWA permits are implemented.

The PPE does not assume any limitations on the extent of land, shoreline, and riparian disturbance because of the ability to perform mitigation. Excavation to build the intake and discharge structures would disturb a small area of aquatic habitat as well as a small area of adjoining riparian vegetation, thereby influencing the quality of aquatic habitat. The resulting habitat losses or disturbance would not substantially alter the overall aquatic ecosystem in most surface water features large enough to function as sources of makeup water. Excavation would briefly generate plumes of sediment capable of being carried by currents to distant aquatic habitats; however, it is usually possible to construct small temporary cofferdams around excavation locations to limit the escape of sediment. Cofferdams temporarily surround the excavation area with a physical structure that blocks movement of suspended sediment into adjoining waters. Most surface water bodies large enough to serve as makeup water sources are navigable or situated on tributary systems and would therefore be regulated as waters of the United States under the CWA (33 U.S.C. §§ 1251 *et seq.;* codified as the Federal Water Pollution Control Act of 1972-TN662). Work to build intake and discharge structures would therefore require a permit from the USACE under CWA Section 404 but would be covered in most instances by one or more NWPs (33 CFR Part 330-TN4318).

The staff has determined that this is a Category 1 issue. The staff concludes that as long as the assumptions in the PPE and SPE regarding the intake structure are met, the impacts from this issue can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- Applicant would obtain approval, if required, under NWP 7 in 33 CFR Part 330.
- Applicant would implement any mitigation required under NWP 7 in 33 CFR Part 330.
- Applicant would minimize any temporarily disturbed shoreline and riparian lands needed to build the intake and discharge structures and restore those areas with regionally indigenous vegetation suited to those landscape settings once the disturbances are no longer needed.
- BMPs would be used for erosion and sediment control.

3.6.2.1.3 Building Transmission Lines, Pipelines, and Access Roads across Surface Water Bodies

Transmission conductors of any voltage can be built to span rivers, streams, and narrow lakes without physically disturbing shorelines, sediments, or other components of the channel or basin. The conductors would not cast a substantial shadow capable of reducing sunlight reaching the water surface or otherwise altering the condition of the aquatic habitat. The PPE and SPE assume that conductors would be mounted on towers situated only in uplands and that no new towers would be built within surface water bodies or adjacent wetlands or floodplains. Pipelines can typically be built under waterways using directional horizontal drilling, thereby avoiding physical disturbance of overlying surface water bodies. The PPE and SPE assume that pipelines would be extended under (or over) surface water bodies through directional drilling (or aboveground placement) without physically disturbing shorelines or bottom substrate.

Access roads can be built across smaller streams using a bridge or ford. It is usually possible to place matting over shallow water areas to facilitate fording with minimal physical disturbance of shorelines and bottom substrate. Building the bridge abutments or a ford would temporarily disturb small areas of shoreline and bottom substrate and use of a ford could disturb substrate each time a vehicle passes. Fish and other mobile aquatic biota may briefly disperse from areas near a crossing each time the crossing is used due to noise and vibrations caused by the vehicles. A bridge could also limit the occurrence of aquatic plants and other photosynthetic organisms because of shading. The assumptions in the PPE and SPE regarding the length of offsite ROW and the 0.5 ac (0.2 ha) limit on impacts on wetlands and surface waters function to limit the number of possible crossings by access roads. Another assumption is that no access roads would be extended across stream channels over 10 ft (3 m) in width (at ordinary high water). Crossing wider streams would likely require building fords or bridges that involve a potential for aquatic resource impacts and would require project-specific analysis to assess their significance. The PPE and SPE also assume that no more than 0.5 ac (0.2 ha) of surface waters or wetlands would be disturbed. Limiting crossings to streams of that width would limit the potential for habitat disturbance, disturbance of mobile biota, or generation of sediment.

No impacts on aquatic resources would likely result from spanning or horizontal drilling under a surface water body. Extending roadways across waters of the United States typically qualifies under one or more NWPs (33 CFR Part 330-TN4318), the availability of which supports the staff's conclusions. The USACE issues NWPs only for classes of activity determined to generally not result in significant adverse impacts on aquatic resources and are subject to public review every 5 years. NWP 12 (temporarily vacated at the present time) applies to utility lines such as pipelines or transmission lines and NWP 14 applies to linear transportation projects associated with any project. Both NWPs limit the total disturbance to waters of the United States and adjacent wetlands to 0.5 ac (0.2 ha); additional limitations apply to tidal areas. Applicants relying on the generic determination would be expected to demonstrate that the USACE has approved any impacts on waters of the United States under one or more NWPs or that the crossings meet the criteria for approval. Applicants would also be expected to implement BMPs as mitigation to minimize runoff and sedimentation to surface water features from building transmission lines, access roads, or pipelines.

Like other CWA permitting requirements, the need for approval under a NWP applies only to wetlands under CWA jurisdiction. Building transmission lines, pipelines, and access roads could impact both jurisdictional and non-jurisdictional wetlands or surface water features. The PPE and SPE therefore includes an assumption that access roads crossing non-jurisdictional surface water features meet the substantive requirements of NWPs 12 or 14 regarding limits on disturbance and requirements for mitigation. Both permits limit the cumulative disturbance from a "single and complete project" to no more than 0.5 ac (0.2 ha) of jurisdictional surface water features that can serve as an equivalent benchmark for non-jurisdictional surface water features as well. While greater impacts on non-jurisdictional surface waters might not be significant, the staff can only make that determination after review of project-specific information.

The staff has determined that this is a Category 1 issue. The staff concludes that as long as the PPE and SPE assumptions established for offsite ROWs are met, the impacts from this issue can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- If activities regulated under the Clean Water Act are performed, they would receive approval under one or more NWPs (33 CFR Part 330-TN4318) or other general permits recognized by the USACE.
- Pipelines would be extended under (or over) surface through directional drilling without physically disturbing shorelines or bottom substrate.
- Access roads would span streams and other surface waterbodies with a bridge or ford, and any fords would include placement and maintenance of matting to minimize physical disturbance of shorelines and bottom substrates.
- No access roads would be extended across stream channels over 10 ft (3 m) in width (at ordinary high water).
- Any bridges or fords would be removed once no longer needed, and any exposed soils or substrate would be revegetated using regionally indigenous vegetation appropriate to the landscape setting.
- Any mitigation measures indicated in the NWPs or other permits would be implemented.
- BMPs would be used for erosion and sediment control.

3.6.2.1.4 Important Species and Habitats

Important species and habitats meeting the NRC criteria (NRC 2022-TN7081) for a given site can only be determined once the site is identified. Because of differing regulations and sensitivities to impacts, two separate issues are analyzed below regarding important species and habitats: (1) resources regulated under the ESA (16 U.S.C. §§ 1531 *et seq.*; TN1010) and the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act; 16 U.S.C. §§ 1801 *et seq.*; TN1061), and (2) other important species and habitats.

Resources Regulated under the Endangered Species Act and Magnuson-Stevens Act

The FWS has developed online databases and mapping tools that identify threatened, endangered, proposed, and candidate species under the ESA (16 U.S.C. §§ 1531 *et seq.*; TN1010), as well as critical habitats designated under the Act. The NMFS maintains similar information for marine or anadromous species protected under the Act. NMFS also maintains maps and other information about essential fish habitats regulated under the Magnuson-Stevens Act.

Because these federally regulated resources occur in the same setting and are subject to the same types of impacts as those considered in Sections 3.5.2.1.1 through 3.5.2.1.5, the limitations placed upon the extent and intensity of ecological impacts by meeting the assumptions in the PPE and SPE would likewise limit the potential for impacts on these resources. However, the staff would need to consult individually with the FWS and/or NMFS (depending on the specific setting) under the ESA and Magnuson-Stevens Act regarding the potential impacts from each specific licensing action. Furthermore, with respect to the ESA, the criteria for listing species are based upon the potential for the most severe of potential ecological impacts: extinction of species, subspecies, or distinct population segments. Species that have experienced previous impacts so severe that they are now, or could imminently become, in danger of extinction may also be substantially more sensitive to impacts that might only pose minimal threat to other species.

The staff has therefore determined that building impacts on resources regulated under the ESA and Magnuson-Stevens Act are a Category 2 issue. Because of their potential for future regulation over the course of a licensing action, the Category 2 designation extends also to proposed and candidate species designated under the ESA. Even if the assumptions in the PPE and SPE discussed in Sections 3.6.2.1.1 through 3.6.2.1.3 are met, the NRC staff is unable to determine the significance of potential impacts without consideration of project-specific factors, including the specific species and habitats affected and the types of ecological changes potentially resulting from each specific licensing action. Furthermore, the ESA and Magnuson-Stevens Act require consultations for each licensing action that may affect regulated resources.

Other Important Species and Habitats

Most States maintain natural heritage databases that identify known occurrences of species and habitats receiving various categories of State regulation or recognition. Many species and habitats that do not display the potential for extinction necessary for regulation under the ESA are still recognized by States because of declining numbers within state boundaries. However, extirpation from a State is not as severe an impact as complete extinction. Regarding other types of important species and habitats, most sites containing aquatic habitats may support commercially or recreationally valuable fisheries, as well as nuisance or invasive species such as zebra mussels (*Dreissena polymorpha*), Asiatic clams (*Corbicula fluminea*), northern snakehead fish (*Channa argus*), and invasive aquatic vegetation such as common water hyacinth (*Pontederia crassipes*) and Eurasian watermilfoil (*Myriophyllum spicatum*). Invasive aquatic species not only adversely affect native aquatic species but can also interfere with navigation and recreational use of waterways. The NRC staff expects that applicants will communicate with State and local agencies, private conservation organizations, and other stakeholders as necessary to determine what other important species and habitats are potentially present on a site, such as species that have a Federal or State monitoring requirement or other species of known interest, protected habitats, habitats identified by Federal or State agencies as being of high priority for protection, or other habitats of interest such as nesting or nursery grounds.

The analyses presented above regarding impacts on aquatic resources from specific ecological issues suggest that the potential impacts on many important species and habitats (NRC 2022-TN7081) from building of an ANR that meets the PPE and SPE would likely be minimal regardless of site location. The NRC staff is confident in this conclusion for any site meeting the assumptions in the PPE and SPE discussed in Sections 3.6.2.1.1 through 3.6.2.1.3, even without identifying the important species specifically present on a given site. The assumptions in the PPE and SPE limit the potential for adverse impacts, especially limitations on the size of the footprint of disturbance and the assumed absence of sensitive habitat types potentially containing rare species. The staff has therefore determined that building impacts on important species and habitats other than those regulated under the ESA and Magnuson-Stevens Act are a Category 1 issue. The staff concludes that as long as the assumptions in the PPE and SPE discussed in Sections 3.6.2.1.1 through 3.6.2.1.3 are met, the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- Applicants would communicate with State natural resource or conservation agencies regarding aquatic fish, wildlife, and plants and implement mitigation recommendations of those agencies.

3.6.2.2 Environmental Consequences of Operation

The NRC staff considered the following environmental issues related to aquatic resources for building of an ANR meeting the PPE and SPE assumptions:

- stormwater runoff,
- exposure of aquatic organisms to radionuclides,
- impacts of refurbishment on aquatic biota,
- impacts of maintenance dredging on aquatic biota,
- impacts of transmission line ROW management on aquatic resources,
- impingement and entrainment of aquatic organisms,
- thermal impacts on aquatic biota,
- other impacts of cooling-water discharges on aquatic biota,
- water use conflicts with aquatic resources, and
- impacts on important species and habitats.

The list of issues considered is similar to that presented for operations in the License Renewal GEIS (NRC 2013-TN2654). However, the PPE assumes there will be no use of once-through cooling systems, cooling ponds, or building of new reservoirs. The PPE also assumes limits on the quantities of water taken in and discharged for ANRs with dry or water-cooled cooling towers. The License Renewal GEIS addresses losses from predation, parasitism, and disease among organisms exposed to sublethal stresses (NRC 2013-TN2654), but those impacts are encompassed herein as part of the interrelated issues noted above. Any possible impacts from cooling-tower drift falling on aquatic habitats are addressed as part of the same issue in Section 3.5.2.

3.6.2.2.1 Stormwater Runoff

Stormwater runoff generated by impervious surfaces during building is addressed above in Section 3.6.2.1.1. The potential for stormwater runoff continues as long as impervious surfaces remain on the site. Typical impervious surfaces at a reactor site include the tops of buildings and other structures, roads and parking lots, exterior paved areas, walkways, and other exterior "hardscaping" areas. Unpaved but heavily compacted soils can also function as mostly impervious surfaces and generate substantial quantities of runoff. Chemicals such as pesticides, paints, and petroleum products are sometimes stored or handled on impervious surfaces and contribute chemical contamination to runoff. Runoff from roads and parking lots can contain oil and grease leaked from vehicles. Exterior areas, including landscaped areas, can also contribute pesticides to runoff potentially reaching aquatic habitats. The potential for stormwater runoff reaching aquatic habitats is typically minimized through implementation of stormwater management plans as explained in Section 3.6.2.1.1. As noted in Section 3.10.2.1, the PPE assumes that licensees would comply with any additional requirements established through permits for the storage and use of hazardous materials issued by Federal and State agencies under the Resource Conservation and Recovery Act (RCRA; 42 U.S.C. §§ 6901 *et seq*.; TN1281). The staff has determined that stormwater runoff during operations is a Category 1 issue. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- Preparation, approval by applicable regulatory agencies, and implementation of a stormwater management plan.
- Obtaining and complying with any required permits for the storage and use of hazardous materials issued by Federal and State agencies under RCRA.
- BMPs would be used for stormwater management.

3.6.2.2.2 Exposure of Aquatic Organisms to Radionuclides

The NRC staff recognizes that small amounts of radioactive particulates can be released to the exterior environment during operation of LWRs and evaluated the potential impacts of those releases on aquatic ecological receptors in the License Renewal GEIS (NRC 2013-TN2654). Section 3.8.1.2.2 of this GEIS concludes that the impact of routine radiological releases from past and current operations on aquatic biota would be SMALL. To support that conclusion, Table 3-5 (in Section 3.8.1 of this GEIS) presents radiological exposure estimates for fish, invertebrates, and algae modeled using the NRCDose code, as presented in 15 EISs for proposed new LWRs published between 2006 and 2019. All estimates were substantially lower than exposure levels considered protective of terrestrial animal populations by the IAEA.

Additionally, in the License Renewal GEIS (NRC 2013-TN2654), the staff used the RESRAD-BIOTA dose evaluation model developed by DOE (2004-TN6460) to calculate estimated dose rates to aquatic biota receptors using REMP reports submitted by licensees for 15 operating LWRs in the United States. RESRAD-BIOTA accounts for possible bioaccumulation of radionuclides in biological organisms and biomagnification, whereby radionuclides become concentrated at higher levels in organisms occupying higher positions in the food chain. The total estimated doses for aquatic biota were all less than 0.2 rad/d (0.002 Gy/d), considerably less than the guideline value of 1 rad/d (0.01 Gy/d) recognized by DOE as being protective (DOE 2002-TN4551).

- While many ANRs may use fuels containing differing distributions of radionuclides than the LWRs considered in the analyses presented above, a reactor meeting the PPE and SPE would not be likely to result in greater releases of radioactivity. The staff has determined that exposure of aquatic organisms to radionuclides is a Category 1 issue. The staff concludes that as long as the project meets the assumptions in the PPE and SPE underlying the analysis in Section 3.8, the impacts can be generically determined to be SMALL, and mitigation would not be warranted. The staff relied on the following PPE and SPE value and assumption to reach this conclusion:

- Applicants would demonstrate in their application that any radiological nonhuman biota doses would be below IAEA (1992-TN712) and NCRP (1991-TN729) guidelines.

3.6.2.2.3 Effects of Refurbishment on Aquatic Biota

Refurbishment constitutes the replacement, improvement, or addition of new facilities within the site of an ANR throughout its operating life. Examples of possible new facilities might include additional or expanded storage buildings, parking lots, administration buildings, or independent spent fuel storage installation. Existing facilities might be demolished or rebuilt in part. The SPE assumes that there are no surface water features on a site prior to the building of an ANR, although it is possible that developers of a new facility might build artificial ponds or ditches as part of the stormwater management system for the site. These would be the only possible locations for aquatic habitats on a site that meets the SPE. Any aquatic habitats that form in these artificial features over time would be simpler and of lower ecological value than most natural aquatic habitats and because they were generated after development of the site, they would be easily replaceable. Loss or degradation of these artificial habitats to accommodate refurbishment would not constitute a noticeable loss of aquatic habitat function in the landscape. It is possible that over the operational lifetime of an ANR that work in or near natural aquatic habitats may be necessary to maintain or replace intake or discharge structures or pipelines. The impacts would be bounded by the analyses presented above for the building of those facilities.

The staff has determined that the impacts of refurbishment on aquatic organisms at an operating ANR are a Category 1 issue. Impacts can be generically determined to be SMALL as long as assumptions in the PPE regarding the area of disturbance and the SPE regarding features within the area of disturbance are met. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- BMPs would be used for erosion, sediment control, and stormwater management.
- Exposed soils would be restored as soon as possible with regionally indigenous vegetation.

3.6.2.2.4 Effects of Maintenance Dredging on Aquatic Biota

The NRC staff recognizes that maintenance dredging of sediment is sometimes necessary during the operational life of a nuclear power plant, for purposes such as keeping intake screens free of sediment or removing sediment from areas where boats are used (NRC 2013-TN2654). As explained in the License Renewal GEIS, accumulation of sediment in standing or slow-moving waters over time is a natural and unavoidable process that requires attention in order to maintain facilities or navigational capabilities. The License Renewal GEIS describes the potential impacts on aquatic biota from maintenance dredging at a LWR and concludes that the impacts would be minimal because of its infrequency and the small areas affected. The extent of the effects is not likely to be increased by the fuels or technologies of ANRs. Dredging of any type is considered under the CWA to constitute “discharge of dredged or fill material” requiring a permit from the USACE under Section 404 (33 U.S.C. § 1344-TN1019); however, dredging for the purpose of maintaining existing navigation capabilities such as marina basins or boat slips is covered under NWP 35. There are no area or volume limitations established for NWP 35, although certain conditions regarding the presence of sensitive resources such as threatened or endangered species or wild and scenic rivers must be met, and specific mitigation must be implemented. By issuing this NWP, the USACE acknowledges that such maintenance dredging has minimal potential for having significant environmental impacts on aquatic resources.

The staff has determined that the impacts on aquatic organisms of maintenance dredging of any type at an operating ANR are a Category 1 issue. Impacts can be generically determined to be SMALL as long as relevant assumptions in the PPE and the SPE are met. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- If activities regulated under the Clean Water Act are performed, those activities would receive approval under one or more NWPs (33 CFR Part 330-TN4318) or other general permits recognized by the USACE.
- Any mitigation measures indicated in the NWPs or other permits would be implemented.
- BMPs would be used for erosion and sediment control.

3.6.2.2.5 Impacts of Transmission Line ROW Management on Aquatic Resources

Once a transmission line is built, the ROW requires routine maintenance to keep it free of trees tall enough to cause electrical current to arc through vegetation to the ground. It may also be necessary to remove or trim trees growing near the edge of the ROW capable of falling too close to the conductors (commonly termed “danger trees”). Some utilities also maintain “screens” of low trees under transmission line conductors where they cross aesthetically sensitive suburban roadways; such tree screens require frequent maintenance. Sometimes relatively level upland areas on transmission line ROWs, especially in aesthetically sensitive residential areas, are periodically mowed. But the most common techniques in managing transmission line ROWs involve use of herbicides. Herbicides can be applied directly to vegetation in the ROW, or to cut stump surfaces once trees are felled. Even when applied in uplands, herbicides can be carried in overland runoff to streams or other surface water features. Herbicides can also leach into groundwater under application sites and be carried to surface waters. Herbicides entering aquatic habitats vary in their lethality to aquatic organisms depending on their active ingredient but also on how they are formulated. For example, formulations of the nonselective herbicide glyphosate labeled for use in upland settings are more lethal to aquatic biota than are glyphosate formulations labeled for use in wetlands or near aquatic features (Langeland and Gettys 2015-TN6461).

Operation of spray equipment or mowers on ROWs can physically disturb soils, thereby generating small amounts of sedimentation that can enter aquatic habitats (see Section 3.6.2.1.1 for an explanation of the impacts of sedimentation on aquatic biota). Maintenance of service roads on the ROW can also cause small amounts of sedimentation. Heavy equipment traversing streams or wetlands can physically damage aquatic biota and the soils and sediment supporting aquatic biota. The potential for noticeable adverse impacts on aquatic habitats from sedimentation can be readily prevented using BMPs. Physical disturbance of soils and sediments in aquatic habitats by fording equipment can be prevented by use of temporary matting that can be removed once it is longer needed. The NRC staff considered possible impacts of transmission line ROW maintenance on aquatic habitats associated with relicensing of existing LWRs and concluded that impacts would be minimal because they would be infrequent, localized, and temporary (NRC 2013-TN2654).

The staff has determined that the impacts of transmission line maintenance on aquatic biota are a Category 1 issue. The staff concludes that as long as the assumptions in the PPE and SPE regarding work in offsite ROWs are met, the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- Vegetation in transmission line ROWs would be managed following a plan consisting of integrated vegetation management practices.
- All ROW maintenance work would be performed in compliance with all applicable laws and regulations.
- Herbicides would be applied by licensed applicators, and only if in compliance with applicable manufacturer label instructions.
- BMPs would be used for erosion and sediment control.

3.6.2.2.6 Impingement and Entrainment of Aquatic Organisms

Impingement and entrainment of aquatic organisms is a consideration only for facilities whose operation involves use of intake structures for cooling water. The PPE assumes recirculating cooling-water systems using cooling towers but not using once-through cooling systems that require intake of substantially larger volumes of water. The potential for impingement or entrainment generally increases with the volume of water withdrawn and the velocity of movement through the intake screen. For purposes of regulation under CWA Section 316(b), the EPA defines impingement as the entrapment of all life stages of fish and shellfish on the outer part of an intake structure or against a screening device during periods of water withdrawal (40 CFR 125.83; TN254). The EPA defines entrainment as incorporation of all life stages of fish and shellfish with intake water flow entering and passing through a cooling-water intake structure and into a cooling-water system (40 CFR 125.83). Impingement can immobilize organisms rendering them subject to starvation or predation. Organisms that are entrained may pass through the cooling system and emerge in the discharge but are usually killed or substantially injured in the process. Although the EPA regulatory definitions address only fish and shellfish, plankton, comprising both faunal (zooplankton) and floral (phytoplankton) organisms carried by water currents, may also be entrained. Impacts on plankton can harm fish and shellfish by altering supportive food chains.

The PPE includes limits on flow rates at intake structures based on regulatory limits established by EPA in 40 CFR 125.84 (TN254) to protect fish and shellfish. The regulations establish a maximum through-screen velocity of 0.5 ft/s (0.15 m/s). The total design intake flow must generally be no more than 5 percent of the mean annual flow of rivers or streams and low enough to not disturb natural thermal stratification or turnover in lakes or reservoirs. Thermal stratification is the formation of layers of water of differing temperatures in standing water bodies due to temperature-related differences in water density. Turnover is the shifting of layers in the water column in response to seasonal changes in temperature. Both the stratification and seasonal turnover can be highly influential on the development and survival of aquatic biota. For intakes in tidal water bodies, the regulations limit intake to less than 1 percent of the volume of the water column centered around the opening to the intake structure. The regulations establish additional requirements, including monitoring requirements, to ensure that these rates of intake are protective of fish and shellfish.

The NRC staff included a description of the potential impacts of impingement and entrainment of aquatic biota from operation of large LWRs in Section 4.6.1.2 of the License Renewal GEIS

(NRC 2013-TN2654). Even though the staff identified potentially significant impacts from impingement and entrainment for operating plants with once-through cooling systems (NRC 2013-TN2654), they also noted that substantial reductions of aquatic biota populations did not occur during operation of plants that have cooling towers because of the smaller volume of water intake (NRC 2013-TN2654). Cooling towers require less water intake because they recirculate the same water for multiple cycles of cooling before discharge and replacement. Cooling systems for nuclear as well as non-nuclear power plants operate independently of the fuel or power generation technology; hence, the minimal impacts observed with large LWRs suggest that similarly minimal impacts would result from operation of ANRs using any fuel or technology.

The staff has determined that impingement and entrainment of aquatic biota is a Category 1 issue. The staff concludes that as long relevant PPE and SPE are met, the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- Intakes would comply with regulatory requirements established by EPA in 40 CFR 125.84 (TN254) to be protective of fish and shellfish.
- Best available control technology would be employed in the design of intakes to minimize entrainment and impingement, such as use of screens and intake rates recognized to minimize effects.

3.6.2.2.7 Thermal Impacts on Aquatic Biota

Operation of power plants requires the disposition of excess heat generated by the fuel but not converted into electricity. Although some ANRs may be air-cooled, whereby the waste heat is transferred to air, others, like most large LWRs, may be water-cooled, whereby the waste heat is transferred to water. The PPE assumes no use of once-through cooling systems, whereby makeup water is withdrawn and passed over-heat exchangers only once before being discharged. ANRs within the PPE may however use recirculated-water cooling systems where makeup water is passed over the heat exchangers and run through a cooling tower to dissipate most of its heat content to the air before being recirculated to dissipate more heat in the same way. After recirculation for a specified number of passes (cycles of concentration), the cooling water is discharged as blowdown to a river, lake, or other surface water body (usually the same body that provided the makeup water). The thermal quality of discharges is regulated under CWA Section 316(a), under which the EPA and States can issue thermal variances as part of NPDES permits.

If water is discharged at a temperature higher than that of the receiving water, the discharges can affect aquatic biota. Aquatic biota are adapted to seasonal patterns of water temperatures, including seasonal turnover of stratified water column layers. A particularly serious problem is heat shock: fish and other aquatic biota favoring warmer water temperatures congregate in the vicinity of heated water discharges that persist only as long as a power plant is in operation, but are faced with suddenly colder water whenever operations cease for maintenance or refueling. Increased water temperatures can also encourage growth of invasive aquatic species such as hydrilla (*Hydrilla verticillata*) and Eurasian watermilfoil (*Myriophyllum spicatum*).

The NRC staff included a description of the potential thermal impacts on aquatic biota from operation of large LWRs in Section 4.6.1.2 of the License Renewal GEIS (NRC 2013-TN2654). Even though staff identified potentially significant impacts from thermal impacts for operating nuclear plants with once-through cooling systems (NRC 2013-TN2654), the staff also concluded that the impacts were minimal from nuclear plants using cooling towers because of the smaller discharge plumes resulting from the reduced volume of water being discharged (NRC 2013-TN2654). Cooling systems operate independently of the fuel or power generation technology; hence, the minimal impacts observed with large LWRs provide evidence that similarly minimal impacts would result from operation of ANRs using any fuel or technology. However, the conclusion in the License Renewal GEIS that impacts would be minimal was reached after a review of a series of existing reactors under known conditions. As discussed in Section 3.4.2.2.7, project-specific reviews included an estimation of the extents of the mixing zones in the receiving water bodies and how the mixing zone may affect aquatic resources under project-specific conditions.

The staff concludes that the impact of thermal impacts on aquatic biota is a Category 2 issue. The staff concludes that it is not possible to generically evaluate the potential impacts of the thermal impacts on aquatic ecosystems without first considering project-specific factors. The staff would have to first review the discharge plume analysis (as described in Section 3.4.2.2.7) and the aquatic biota potentially present before being able to reach a conclusion regarding the possible significance of impacts on that biota.

3.6.2.2.8 Other Effects of Cooling-Water Discharges on Aquatic Biota

The NRC staff recognizes that discharges of cooling-tower blowdown water from operating nuclear power plants can release nonradiological contaminants to aquatic habitats (NRC 2013-TN2654). The License Renewal GEIS discusses copper introduced into cooling water when it passes over copper alloy tubes used in a few existing LWRs but notes that those tubes have been replaced by tubes made of other metals such as titanium as mitigation. The PPE therefore assumes that copper alloy tubes would not be used in new reactors. Operators of nuclear power plants that use cooling towers typically add biocides to the cooling water to prevent the buildup of microorganisms, algae, and invasive species such as zebra mussels and Asiatic clams that can interfere with water conveyance. As explained in the License Renewal GEIS (NRC 2013-TN2654), NPDES permits include restrictions on biocide use to protect non-target organisms in receiving waters such as indigenous mussels and fish. Various methods are available to minimize biocide use in order to comply with NPDES permits. Cooling water can also affect dissolved oxygen levels and cause eutrophication in receiving waters, and discharges can cause localized areas of gas supersaturation (gas bubbles) that are detrimental to aquatic biota, but the staff has concluded in the License Renewal GEIS that the impacts would be minor (NRC 2013-TN2654). However, development of a bounding set of plant parameters for the PPE or site parameters for the SPE that are adequately protective of aquatic biota is not possible, because compliance with standards set forth in an NPDES permit would not necessarily result in only minimal impacts on aquatic biota in all settings. This is especially true for discharges to waters not under the CWA jurisdiction and hence not requiring an NPDES permit.

The staff therefore concludes that the impact of cooling-water discharges on aquatic biota is a Category 2 issue. The staff concludes that it is not possible to generically evaluate the potential impacts of the discharges on aquatic ecosystems without first considering project-specific factors. The staff would have to first review the discharge plume analysis (as described in Section 3.4.2.2.7) and the aquatic biota potentially present before being able to reach a conclusion regarding the possible significance of impacts on that biota.

3.6.2.2.9 Water Use Conflicts with Aquatic Resources

The water demands for operating a nuclear reactor are typically low unless water is used for cooling purposes. The more substantive demands for cooling water could however reduce water levels in some aquatic habitats. Recirculating cooling-water systems withdraw water and repeatedly cycle it through multiple passes over the heat exchangers, evaporating a portion of the water in each cycle. Substantially less water is therefore discharged back to the source water body than is withdrawn. The reduced water availability can reduce flow in streams and rivers, reduce water elevations in lakes and reservoirs, contract shorelines, and periodically dry out shallow areas and wetlands. As discussed in Section 3.5.2.2.7, the assumption in the SPE regarding water use and surface water availability applies to flowing systems. Water withdrawals from streams or rivers would constitute less than 3 percent of the 95 percent exceedance daily flow (essentially, extreme low flow conditions), which would ensure that aquatic fauna and flora in riverine habitats would not experience adverse effects caused by hydrological changes during droughts.

The staff recognizes that it is not as easy to estimate the potential impacts of water withdrawals on non-flowing surface water bodies. The PPE value of 6,000 gpm (0.379 m^3/s) (Section 3.4.1) for total plant water demand applies to non-flowing water bodies such as the Great Lakes, the Gulf of Mexico, oceans, estuaries, and intertidal zones. The staff recognizes that the quantity of water withdrawals for ANRs from very large water bodies such as oceans, the Great Lakes, and the Gulf of Mexico would not result in a reduction in water levels or hydroperiod that could adversely affect the ecological integrity of aquatic habitats or biota. However, water withdrawals from smaller or more sensitive non-flowing freshwater bodies such as inland lakes and reservoirs, estuaries, and intertidal zones could require project-specific review of the potential impacts of changes in water level and hydroperiod (Section 3.5.2.2.7). The staff assumes that applicants relying on the generic analysis can demonstrate that hydroperiod changes are within historical annual or seasonal fluctuations. If the applicant cannot so demonstrate, project-specific analysis would be needed to determine potential impacts on aquatic habitats.

The water losses resulting from operation of cooling-water systems for power plants are unlikely to result in substantial changes to most aquatic ecosystems under normal conditions but could be noticeable during times of extended drought. In the License Renewal GEIS, the NRC staff determined that evaluating the potential impacts of water use conflicts with aquatic biota requires a project-specific analysis for the individual reactor undergoing relicensing (NRC 2013-TN2654). However, for this ANR GEIS (unlike in the License Renewal GEIS), the staff relies on assumptions in the PPE and SPE regarding water use that the staff developed to limit potential adverse effects on aquatic habitats. The staff has therefore determined that water use conflicts with aquatic biota are a Category 1 issue. The staff concludes that as long as relevant values and assumptions in the PPE and SPE regarding cooling systems (Section 3.6.1) and assumptions regarding surface water withdrawal (Section 3.4.1) are met, including that it is possible to demonstrate that hydroperiod changes are within historical or seasonal fluctuations, the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE values and assumptions to reach this conclusion:

- If needed, cooling towers would be mechanical draft, not natural draft; less than 100 ft (30.5 m) in height; and equipped with drift eliminators.
- Any makeup water for the cooling towers would be fresh water (less than 1 ppt salinity).
- Total plant water demand would be less than or equal to a daily average of 6,000 gpm (0.379 m^3/s).

- If water is withdrawn from flowing waterbodies, average plant water withdrawals would not reduce flow by more than 3 percent of the 95 percent exceedance daily flow and would not prevent maintenance of applicable instream flow requirements.
- Any water withdrawals would be in compliance with any EPA or State permitting requirements.
- Applicants would be able to demonstrate that hydroperiod changes are within historical or seasonal fluctuations.

3.6.2.2.10 Important Species and Habitats

As noted for building, important species and habitats that meet the NRC criteria (NRC 2022-TN7081) on a given site can only be determined once the site is identified. Because of differing regulations and sensitivities to impacts, two separate issues are analyzed below regarding important species and habitats: (1) resources regulated under the ESA (16 U.S.C. §§ 1531 *et seq.*; TN1010) and the Magnuson-Stevens Act (16 U.S.C. §§ 1801 *et seq.*; TN1061), and (2) other important species and habitats.

Resources Regulated under the Endangered Species Act and Magnuson-Stevens Act

For the same reasons noted for building in Section 3.6.2.1.4, the staff has determined that operational impacts on resources regulated under the ESA and Magnuson-Stevens Act are a Category 2 issue. Because of their potential for future regulation over the course of a licensing action, the Category 2 designation extends also to proposed and candidate species designated under the ESA. Even if the applicable assumptions in the PPE and SPE are met, the NRC staff is unable to determine the significance of potential impacts without consideration of project-specific factors, including the specific species and habitats affected and the types of ecological changes potentially resulting from each specific licensing action. Furthermore, the ESA and Magnuson-Stevens Act require consultations for each licensing action that may affect regulated resources.

Other Important Species and Habitats

The analyses presented in Section 3.6.2.1.4 also apply to operations and suggest that the potential impacts on other important species and habitats from operation of an ANR that meets the PPE and SPE would likely be minimal regardless of site location. The NRC staff is confident in this conclusion for any site that meets the assumptions in the PPE and SPE associated with cooling systems and meets the regulatory limits in 40 CFR 125.84 (TN254) and requirements associated with applicable NPDES permits, even without identifying the important species specifically present on a given site. The assumptions in the PPE and SPE limit the potential for adverse impacts, especially limitations on the amount of water used and the assumed absence of sensitive habitat types potentially containing rare species. Licensees would also likely communicate with multiple State and local authorities, who may recommend following routine BMPs to prevent the introduction of invasive species to affected water bodies.

The staff has therefore determined that operational impacts on important species and habitats other than those regulated under the ESA and Magnuson-Stevens Act are a Category 1 issue. The staff concludes that as long as the applicable assumptions in the PPE and SPE are met, the impacts can be generically determined to be SMALL. The staff relied on the following PPE and SPE value and assumption to reach this conclusion:

- Applicants would communicate with State natural resource or conservation agencies regarding aquatic fish, wildlife, and plants and implement mitigation recommendations of those agencies.

3.7 Historic and Cultural Resources

3.7.1 Baseline Conditions

Historic and cultural resources are the remains of past human activities and include precontact (i.e., prehistoric) and historic era archaeological sites, districts, buildings, structures, and objects. Precontact era archaeological sites pre-date the arrival of Europeans in North America and may include small temporary camps, larger seasonal camps, large village sites, or specialized-use areas associated with fishing or hunting or with tool and pottery manufacture. Historic era archaeological sites post-date European contact with American Indian Tribes and may include farmsteads, mills, forts, residences, industrial sites, and shipwrecks. Architectural resources include buildings and structures. Historic and cultural resources also include elements of the cultural environment such as landscapes, sacred sites, and other resources that are of religious and cultural importance to American Indian Tribes, such as traditional cultural properties (TCPs) important to a living community of people for maintaining its culture.[12]

A historic or a cultural resource is deemed to be historically significant, and thus, a "historic property" within the scope of the National Historic Preservation Act of 1966 (NHPA; 54 U.S.C. §§ 300101 *et seq*.; TN4157), if it has been determined to be eligible for listing or is listed on the NRHP.[13] The NRHP is maintained by the U.S. National Park Service in accordance with its regulations in 36 CFR Part 60 (TN1682). The NRHP criteria to evaluate the eligibility of a property are set forth in 36 CFR 60.4.[14] In this regard, a historic property is at least 50 years old, although exceptions can be made for properties determined to be of "exceptional significance."[15]

3.7.1.1 National Historic Preservation Act and NEPA

NEPA (42 U.S.C. §§ 4321 *et seq*.; TN661) requires Federal agencies to consider the potential effects of their actions on the "affected human environment," which includes "aesthetic, historic, and cultural resources as these terms are commonly understood, including such resources as sacred sites" (CEQ and ACHP 2013-TN4603). For NEPA compliance, impacts on cultural

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[12] According to U.S. National Park Service (NPS) guidance, a "traditional cultural property" is associated "with the cultural practices or beliefs of a living community that (a) are rooted in that community's history, and (b) are important in maintaining the continuing cultural identity of the community" (Parker and King 1998-TN5840).

[13] Historic property is defined in 36 CFR 800.16(l)(1) (TN513) as "... any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the [NRHP] maintained by the Secretary of Interior. This term includes artifacts, records, and remains that are related to and located within such properties." As defined in 36 CFR 800.16(l)(2), "The term eligible for inclusion in the National Register includes both properties formally determined as such in accordance with regulations of the Secretary of the Interior and all other properties that meet National Register listing criteria."

[14] The eligibility of a resource for listing on the NRHP is evaluated based on four criteria and is articulated in 36 CFR 60.4 (TN1682), as follows: Criterion a: Associated with events that have made a significant contribution to broad patterns of our history; Criterion b: Associated with the lives of persons significant in our past; or Criterion c: Embodies the distinctive characteristics of a type, period, or method of construction, or represents the work of a master, or that possesses high artistic values, or that represents a significant and distinguishable entity whose components may lack individual distinction; and Criterion d: Has yielded, or is likely to yield, information important to prehistory and history.

[15] 36 CFR 60.4(g).

resources that are not eligible for or listed on the National Register would also need to be considered (CEQ and ACHP 2013-TN4603). The Advisory Council on Historic Preservation (ACHP) is an independent Federal agency that oversees the NHPA Section 106 review process in accordance with its implementing regulations in 36 CFR Part 800, Protection of Historic Properties (TN513). Section 106 of the NHPA (54 U.S.C. §§ 300101 *et seq.*; TN4157) requires Federal agencies to take into account the effects of their undertakings[16] on historic properties and consult with the appropriate consulting parties as defined in 36 CFR 800.2 (TN513). Consulting parties consist of the State Historic Preservation Officer (SHPO), ACHP, Tribal Historic Preservation Officer (THPO), American Indian Tribes that attach cultural and religious significance to historic properties on a government-to-government basis, and other parties that have a demonstrated interest in the effects of the undertaking, including local governments and the public, as applicable. Issuing a license for an ANR is an undertaking that requires compliance with NHPA Section 106.

Historic and cultural resources vary widely from site to site; there is no generic way of determining their existence or significance. Historic and cultural resource impacts must be analyzed on a project-specific basis, and the NRC is required to complete a NEPA and NHPA Section 106 review (NRC 2022-TN7081) prior to issuing a license.[17]

For a specific application, in accordance with 36 CFR Part 800 (TN513), the NRC would establish the undertaking, identify consulting parties, and determine the scope of potential effects from the undertaking by defining the area of potential effect (APE). The ANR APE is the area that may be directly (e.g., physical) or indirectly (e.g., visual and auditory) affected by activities during construction or plant operations. The APE typically encompasses the nuclear power plant site where onsite ground-disturbing activities may occur, its immediate environs including viewshed, and in-scope transmission lines. The APE may extend beyond the nuclear plant site and transmission lines when building and operation activities may affect historic properties at offsite locations. The NRC will rely on cultural resource investigations of the APE and NRHP-eligibility evaluations completed by qualified professionals, who meet the Secretary of Interior's standards at 36 CFR Part 61 (TN4848), in consultation with the SHPO and other consulting parties to determine whether historic properties are present in the APE.

When preparing project-specific supplements to this GEIS (see 36 CFR 800.8(c); TN513), the NRC's practice is to fulfill the requirements of NHPA Section 106 through the NEPA review process.

Additional historic and cultural resource laws could apply if a proposed project is located on Federal lands (see Appendix F).

3.7.2 Historic and Cultural Resources Impacts

The NRC considers impacts on historic and cultural resources in this GEIS through its NEPA requirements in 10 CFR Part 51 (TN250). Any new construction activity, including the building and operation of an ANR, parking areas, access roads, or transmission lines, is particularly

[16] An undertaking is defined as "a project, activity, or program funded in whole or in part under the direct or indirect jurisdiction of a Federal agency, including those carried out by or on behalf of a Federal agency; those carried out with Federal financial assistance; and those requiring a Federal permit, license, or approval" (see CFR 800.16(y); TN513).

[17] The NRC is required to comply with the NHPA including the anticipatory demolition clause, Section 110(k) of the NHPA (54 U.S.C. 306113). See Section 4.6 of RG 4.2 (NRC 2022-TN7081)

important to an analysis of impacts on historic and cultural resources. Building- and operation-related ground-disturbing activities or alterations to buildings or structures that are NRHP-eligible can result in direct effects on archaeological sites, aboveground resources, and TCPs. Introduction of noise or visual intrusions (i.e., use of reflective materials, tall structures, building design that is inconsistent with surrounding environment) that are either temporary or permanent in nature can result in both direct and indirect effects on aboveground resources and TCPs.

If historic and cultural resource investigations do not identify historic properties, or if the area has been documented to be extensively disturbed such that historic properties cannot exist, the NRC will conclude a finding of no historic properties affected in accordance with 36 CFR 800.4(d)(1) (TN513). The NRC will provide documentation of these findings for review and concurrence to SHPO/THPO, American Indian Tribes, and interested members of the public in accordance with documentation standards set forth in 36 CFR 800.11(d).

If historic properties have been identified, and cannot be avoided by the proposed construction and operation activities, the NRC will apply the criteria of adverse effects outlined in 36 CFR 800.5(a) (TN513). Adverse effects result when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion on the NRHP in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Examples of adverse effects are described in 36 CFR 800.5(a)(2). These include physical destruction or alteration of a property's characteristics that contribute to its historic significance. If the criteria for adverse effect are not met, and impacts can either be minimized or avoided, the NRC staff will conclude a finding of no adverse effect on historic properties. The NRC will provide documentation of these findings for review and concurrence to SHPO/THPO, American Indian Tribes, and interested members of the public in accordance with documentation standards set forth in 36 CFR 800.11(e).

If the criteria of adverse effect are met, a finding of adverse effect on historic properties is determined and the NRC will provide documentation of this finding to the ACHP, SHPO/THPO, American Indian Tribes, and interested members of the public for review and concurrence in accordance with documentation standards set forth in 36 CFR 800.11(e) (TN513). The NRC will consult with the same parties regarding the resolution of adverse effects and develop measures to avoid, minimize, or mitigate the adverse effects. Such measures to address adverse effects are typically documented in a Memorandum of Agreement (MOA) or a Programmatic Agreement (PA).

The NRC will rely on preliminary recommendations made by qualified professionals, who meet the Secretary of Interior's standards at 36 CFR Part 61 (TN4848), in consultation with the SHPO and other consulting parties in its determination of whether historic properties will be adversely or will not be adversely affected. For a historic or cultural resource that does not meet the criteria to be considered a historic property under the NHPA, the NRC will assess whether there are any potential significant impacts on this resource through the NEPA process.

3.7.2.1 Environmental Consequences of Construction

The NRC staff identified one environmental issue:

- construction impacts on historic and cultural resources.

Most impacts on historic and cultural resources would occur during the construction phase. Impacts would occur primarily from both onsite and offsite preparation-related ground-disturbing activities (e.g., land clearing, grading and excavation, and road work) and the construction of safety-related facilities such as the nuclear island and non-safety-related facilities such as cooling towers, administration buildings, parking lots, switchyards, pipelines, access roads, and transmission lines. Archaeological sites are sensitive to disturbance and even a small amount of ground disturbance (e.g., ground clearing and grading) could affect a significant resource. Much of the information contained in an archaeological site is derived from the spatial relationships between soil layers and associated artifacts. Once these spatial relationships are altered, they can never be reclaimed (NRC 2013-TN2654). Alterations to the visual setting, whether temporary or permanent, could also affect other types of historic and cultural resources such as cultural landscapes, architectural resources, or TCPs.

Direct and indirect impacts from construction on historic and cultural resources and historic properties can be avoided or minimized if the undertaking is modified or if the applicant takes the appropriate mitigation measures. Impacts on archaeological resources can typically be avoided by re-siting ground-disturbing activities. Minimization efforts can include but are not limited to use of geomembranes or geotextile fabric to protect and/or stabilize archaeological deposits, construction monitoring, and development of inadvertent discovery plans. Direct impacts on aboveground resources can be avoided by not altering any of the exterior or interior physical components of the building that contribute to its NRHP eligibility. Indirect impacts can be avoided by existing natural topography or vegetation screening. Minimization efforts for aboveground resources can include but are not limited to vegetation restoration, creative landscaping, integration of structures with the surrounding environment, minimization of the use of bright flashy surfaces, and other considerations related to overall design. Adaptive reuse of an aboveground resource is often viewed as a beneficial effect depending on the scope of modifications necessary.

If impacts on a historic property cannot be avoided or minimized, they can be mitigated through the development of mitigation measures that are formalized in an MOA or a PA. Historic and cultural resources are nonrenewable, hence certain activities depending upon the resource and its significance can result in an irretrievable loss of the resource. Mitigation efforts for archaeological sites typically entail data recovery and controlled excavation if in situ stabilization is not possible. Despite being a form of mitigation, archaeological data recovery results in an irretrievable loss of the historic and archaeological information. Mitigation efforts for aboveground resources can include but are not limited to formal documentation in a Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) study and public education activities. Development of avoidance, minimization, and mitigation measures for adverse effects on TCPs must be done in consultation with the Tribe or community that has an interest in that TCP.

This GEIS does not identify any specific sites for NRC licensing actions that would trigger NHPA Section 106 consultation requirements that are normally conducted during project-specific licensing reviews. Development of this GEIS is not a licensing action; it does not authorize the building or operation of any ANR. Because the analysis requires project-specific information, the impact of building an ANR on historic and cultural resources is a Category 2 issue.

3.7.2.2 Environmental Consequences of Operation

The NRC staff identified one environmental issue:

- operation impacts on historic and cultural resources.

Continued operations can affect historic and cultural resources through ground-disturbing activities associated with plant operations and ongoing maintenance of existing onsite and offsite facilities, roads, and transmission lines; and changes to the appearance of the nuclear power plant and transmission lines. Impacts from operation and maintenance activities on historic and cultural resources and historic properties can be avoided or minimized through the development of historic and cultural resource protection procedures. These procedures outline stop work and notification protocols in the event that archaeological materials or human remains are inadvertently discovered during building, operating, or maintenance activities. The procedures should follow State burial laws if the ANR is sited on non-Federal land or the Native American Graves Protection and Repatriation Act (NAGPRA; 25 U.S.C. §§ 3001 *et seq*.; TN1686) if it is sited on Federal land. Development of avoidance, minimization, and mitigation measures (i.e., stop work and notification procedures) for addressing adverse effects on historic properties must be done in consultation with SHPO/THPO and American Indian Tribes.

This GEIS does not identify any specific sites for NRC licensing actions that would trigger NHPA Section 106 consultation requirements that are normally conducted during project-specific licensing reviews. Development of this GEIS is not a licensing action; it does not authorize the construction or operation of any ANR. Because the analysis requires project-specific information, the impact of operating an ANR on historic and cultural resources is a Category 2 issue.

3.8 Environmental Hazards

3.8.1 Radiological Environment

3.8.1.1 Baseline Conditions and PPE/SPE Values and Assumptions

Radiological exposures from nuclear power plants include offsite doses to members of the public and onsite doses to the workforce. Each of these impacts is common to all commercial U.S. reactors. The Atomic Energy Act of 1954 (42 U.S.C. §§ 2011 *et seq*.; TN663) requires the NRC to promulgate, inspect, and enforce standards that provide an adequate level of protection for public health and safety and the environment. The NRC continuously evaluates the latest radiation protection recommendations from international and national scientific bodies to establish the requirements for nuclear power plant licensees. The NRC has established multiple layers of radiation protection limits to protect the public from potential health risks related to exposure to radioactive materials effluent discharges from nuclear power plant operations. If the licensees exceed a certain fraction of these dose levels in a calendar quarter, they are required to notify the NRC, investigate the cause, and initiate corrective actions within the specified timeframe.

An assessment of the radiological environment for a proposed site on which to build and operate a nuclear power plant would depend on the characteristics of the site relative to prior and adjacent activities. If the site has not been used for any prior industrial activities, i.e., it is a greenfield site, then the environment is only affected by natural radioactive background. However, if the footprint of the proposed nuclear power plant is within an existing licensed nuclear facility's property, there is an adjacent or nearby nuclear facility (e.g., nuclear power plant, nuclear fuel cycle facility, or another NRC-licensed, Agreement State-licensed, or Federal nuclear facility), or the site was a former nuclear facility, then radiological effects from such nuclear facilities, such as direct radiation or residual radionuclides in the soil on the proposed site, should already have been assessed for their impacts with respect to regulatory requirements (10 CFR 20.1101, CFR 20.1201, 10 CFR 20.1301, 10 CFR Part 20 Appendix B [10 CFR Part 20-TN283]).

Existing licensed nuclear facilities have a REMP. The limits for all radiological releases are specified in a nuclear power plant's Offsite Dose Calculation Manual, and these limits are designed to meet Federal standards and requirements. The REMP includes monitoring of the aquatic environment (fish, invertebrates, and shoreline sediment), atmospheric environment (airborne radioiodine, gross beta, and gamma), terrestrial environment (vegetation), and direct radiation. These reports have shown that doses to individuals around the nuclear site were a small fraction of the limits specified in Federal environmental radiation standards (10 CFR Part 20 [TN283], 10 CFR Part 50 [TN249], Appendix I, and 40 CFR Part 190 [TN739]).

In an Atomic Safety Licensing Board initial decision for the North Anna ESPs (ASLB 2007-TN6826) it was ruled that the limits in 40 CFR 190.10 (TN739)—and hence 10 CFR 20.1301(e) (TN283)—do not apply to non-LWRs. EPA's radiation protection standard applies to operations within the "uranium fuel cycle," which it defines as the processes involved in the production of uranium fuel, "generation of electricity by a light-water cooled nuclear power plant using uranium fuel," and reprocessing spent uranium fuel. This definition excludes gas-cooled, molten salt-cooled, liquid metal-cooled, and heat pipe-cooled nuclear power reactors, regardless of fuel composition. Therefore, under the current regulatory scheme, non-LWR nuclear power reactors would not be subject to the dose limits of 10 CFR 20.1301(e) for the applicable environmental radiation standards in 40 CFR 190.10. In addition, 10 CFR Part 50 (TN249), Appendix I, provides "numerical guidance on design objectives for [LWRs] to meet the requirements that radioactive material in effluents released to unrestricted areas be kept [ALARA]." No similar specific numerical guidance on design objectives currently exists for non-LWRs. However, the staff assumes that the ALARA design objective requirements in 10 CFR 50.34a (see below) and radiation protection programs under 10 CFR 20.1101 (TN283), which are applicable to non-LWR licensees, will ensure that radioactive effluent releases from non-LWRs should remain below applicable regulatory limits. The use of 40 CFR Part 190 (TN739) limits and results in the preceding tables are provided as examples for demonstrating small impacts.

3.8.1.1.1 Regulatory Requirements and Guidance

Nuclear power reactors in the United States must be licensed by the NRC and must comply with NRC regulations and conditions specified in the license in order to operate. The application must provide assurance that the limits on the release of radioactive liquid and gaseous effluents during normal operation (including expected operational occurrences) will meet the requirements in 10 CFR Part 20 (TN283), Subpart B, "Radiation Protection Programs," Subpart C, "Occupational Dose Limits for Adults," and Subpart D, "Radiation Dose Limits for Individual Members of the Public." In addition, an ANR applicant would need to meet the following 10 CFR Part 20 and 10 CFR Part 50 (TN249) regulations concerning radioactive effluent releases:

- applicable 10 CFR Part 20, Appendix B (TN283) regulatory standards for discharge radioactive effluents;
- the requirements in 10 CFR 50.34a, "Design objectives for equipment to control releases of radioactive material in effluents—nuclear power reactors" (TN249); and
- the special license conditions a reactor design shall meet to minimize the radiological impacts associated with plant operations, as provided in 10 CFR 50.36a, "Technical specifications on effluents from nuclear power reactors" (TN249).

Additional details and discussion of the radiation protection regulatory requirements to be addressed in an ANR application, excluding Appendix I to 10 CFR Part 50, which only applies to LWRs, can be found in Section 3.9.1.1, Regulatory Requirements, of Revision 1 to NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (NRC 2013-TN2654), which is incorporated by reference.

The PPE assumes that the application contains sufficient technical information, both in scope and depth, for the NRC staff to complete the detailed technical review and render an independent assessment with regard to applicable regulatory requirements and the protection of public health, safety, and security. The level of detail provided in each section of the Final Safety Analysis Report/Preliminary Safety Analysis Report is expected to be commensurate with the safety significance of the topic. The PPE also assumes that the staff will find the application to be in compliance with the above regulations that will ensure that effluent release limits will be met during normal operations for the life of the plant.

3.8.1.1.2 Radiological Exposure Pathways

There are various environmental pathways by which radiation and radioactive effluents can be transmitted from an ANR to living organisms, assuming there are radiological effluent releases. The scope of this radiological health evaluation for the dose to the maximally exposed individual (MEI) and to the population includes consideration of (1) the pathways by which gaseous and liquid radioactive effluents can be transported to individual receptors (MEI, construction workers, and occupational workers) along with the surrounding population, and (2) the location of these receptors.

For the radiological gaseous effluent releases, the following exposure pathways may exist:

- immersion in airborne activity in the plume;
- inhalation of airborne activity in the plume;
- direct radiation exposure from deposited activity on the ground; and
- ingestion of locally grown meats, fruits, vegetables, and milk from the absorption of the released radionuclides into the production of major types of foods within 50 mi (80 km) of the plant.

The radiological liquid effluent exposure pathways may include the following:

- ingestion of water from downstream sources;
- ingestion of aquatic organisms as food (i.e., fish and invertebrates);
- ingestion of locally grown meats, fruits, vegetables, and milk within 50 mi (80 km) of the plant that is irrigated by water drawn from a body of water into which the liquid effluent is discharged; and
- radiation exposure from swimming and boating activities in the same body of water.

Similar pathways exist to expose nonhuman biota to the radiological effluent releases from an ANR. Radiological exposure for construction and occupational workers is expected to be from inhalation of the airborne plume, direct radiation from deposited plume activity on the ground or from radiation sources due to byproduct material devices used during construction, and from the plant or other co-located nuclear facility operations. In addition, there is the potential for these receptors to be exposed to radionuclides via the ingestion of water from downstream sources if they are the plant’s potable water source.

Representative diagrams of the radiological exposure pathways to be considered are provided in Figure 3-2 for human exposure and Figure 3-3 for nonhuman exposure.

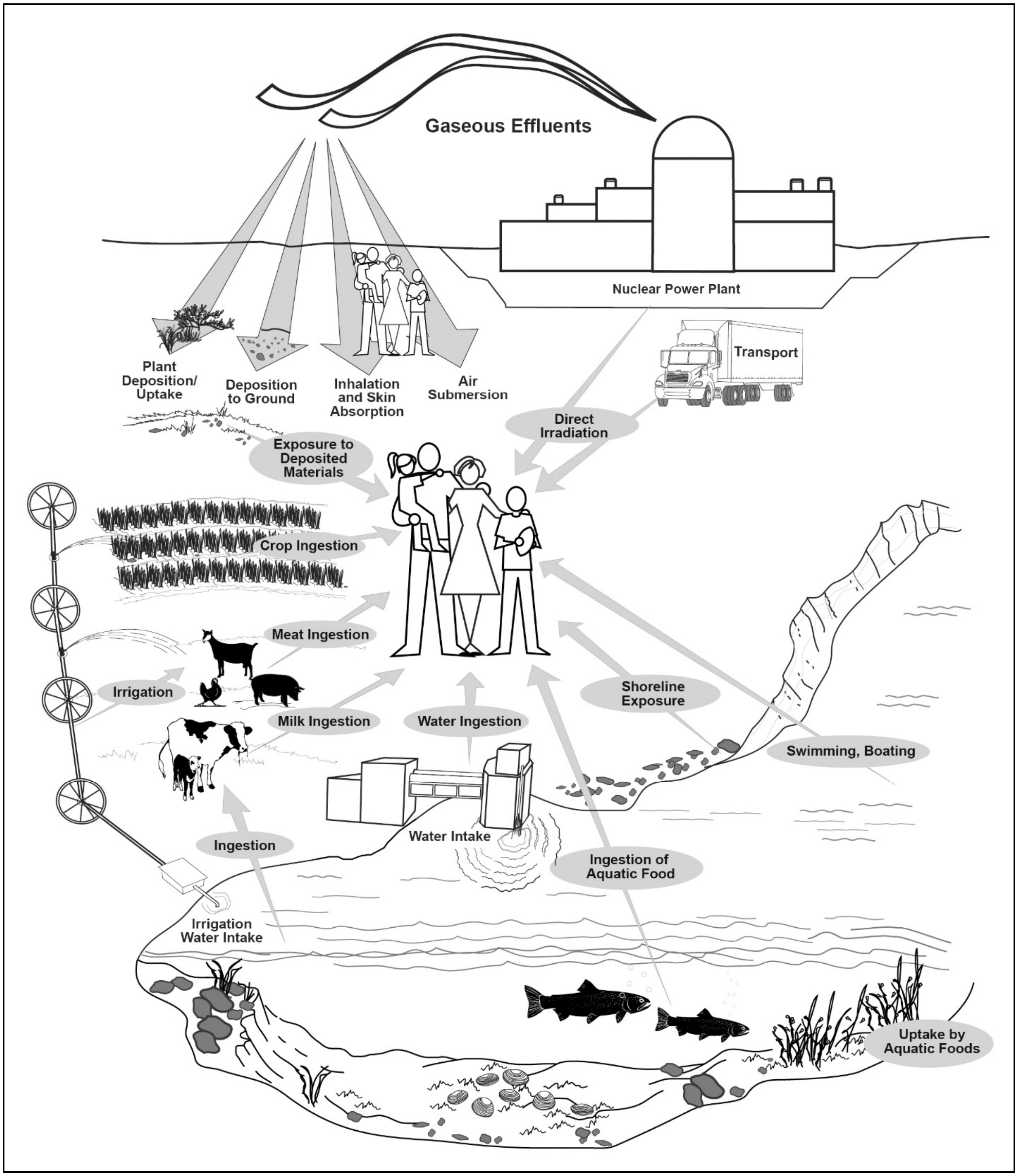

Figure 3-2 Representative Radiological Exposure Pathways to Humans (Source: Modified from Soldat et al. 1974-TN710)

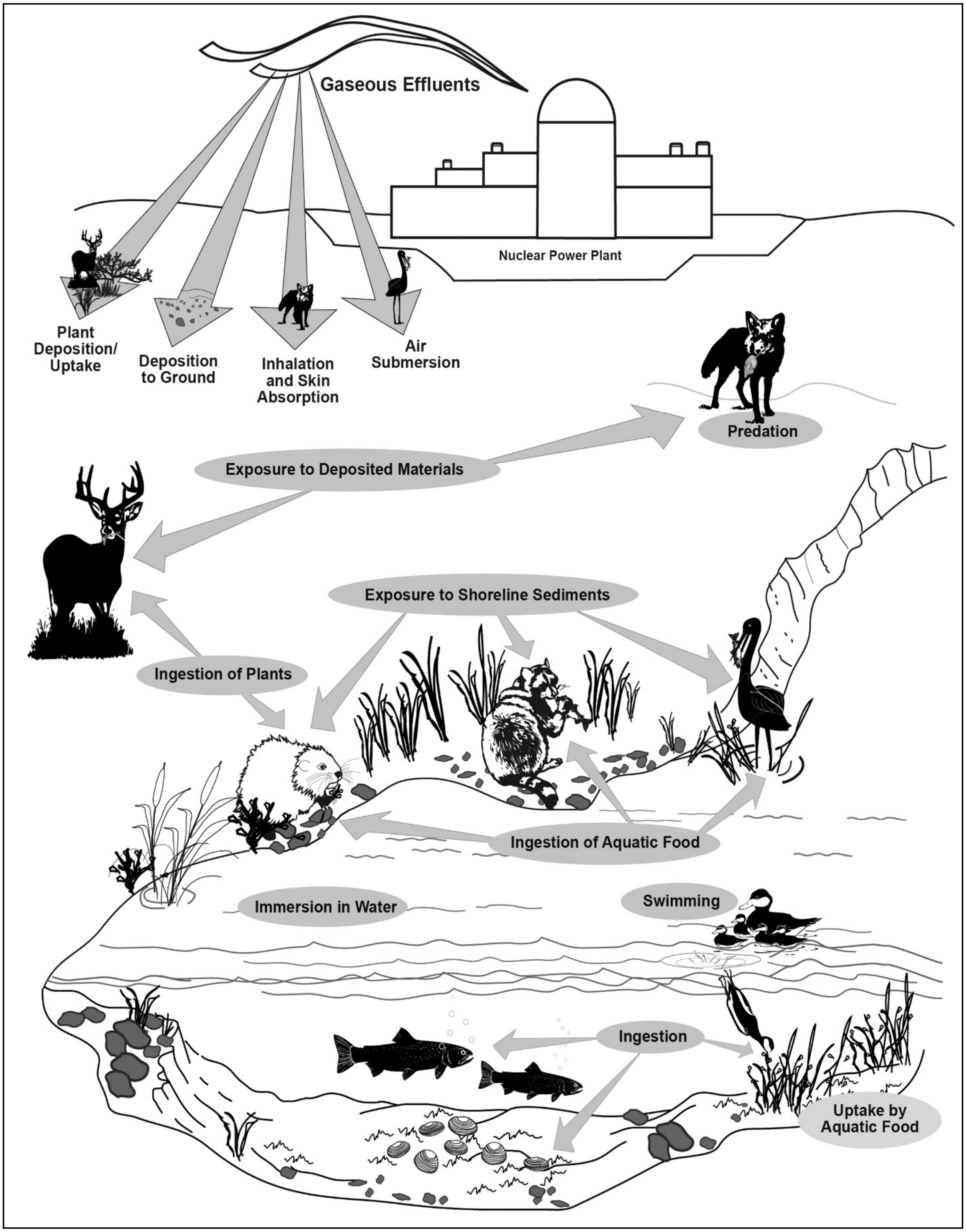

Figure 3-3 Representative Radiological Exposure Pathways to Nonhuman Biota (Source: Modified from Soldat et al. 1974-TN710)

3.8.1.2 Radiological Environment Impacts

This section characterizes the environmental impacts of the liquid and gaseous effluent releases, the onsite radiological waste management systems, solid low-level radioactive waste management (LLRW), and onsite storage of spent fuel. This analysis includes assessing potential radiological impacts on construction workers as well as radiological impacts on humans (occupational workers and members of the public) and nonhuman biota from operation of an ANR. Building a nuclear power station is a project that may affect construction workers as a result of direct radiation and radiological releases from co-located operating nuclear facilities. Radiological health impacts on occupational workers can occur from operation of the radioactive waste systems, onsite storage of waste, and from operation of the nuclear power station. The impacts on members of the public and nonhuman biota can come from the ingestion of food and water, external exposure from water immersion, inhalation of airborne radionuclides, and external exposure to immersion in gaseous effluent plume.

The radiological environmental impacts provided in this section should also bound a potential fusion reactor. Such an ANR would still need to meet the regulatory requirements for the radiological protection of public health and safety in effect at the time of the application. For example, the effluent release limits of 10 CFR Part 20 (TN283) for the principal radioactive material of concern, namely tritium, would apply. Occupational exposures are also expected to be controlled for any fusion reactor within the cell holding the fusion device with a high radiation area due to the activation of structural material.

3.8.1.2.1 Environmental Consequences of Construction

The NRC staff identified one environmental issue associated with construction:

- radiological dose to construction workers.

If the site for the ANR is a greenfield site (i.e., no adjacent or nearby nuclear facilities), then there are no potential radiation exposure pathways, and no analysis of construction worker dose is necessary. For sites that have adjacent nuclear facilities (LWRs, other ANRs, independent spent fuel storage installation [ISFSIs], nuclear research facilities, nuclear fuel cycle facilities, etc.) that are already operational, potential sources of radiation exist that will expose construction workers to radiation during the site preparation and construction phases of building. Similarly, if the site for the ANR is a brownfield site (i.e., a site characterized by the potential presence of hazardous substances, pollutants, or contaminants; EPA 2021-TN6848) potential sources of radiation exist that could expose construction workers to radiation during the site preparation and construction phases of building. If a reactor building could hold multiple cores, it is also assumed that once the first reactor core became critical, construction on any other modules would be performed by properly trained and qualified radiation workers whose radiation exposure would be controlled under the regulatory limits of 10 CFR 20.1201 (TN283).

ANRs could be manufactured at an offsite location and either major components or, if small enough, the complete reactor system with a fueled subcritical core, could be delivered to the site. Thus, the onsite time required for construction and installation of a packaged reactor system for an ANR is expected to be noticeably less than that for a large LWR employing traditional construction methods. This offsite manufacturing process reduces radiation exposures to construction workers by reducing the amount of time they would be working near operating units.

Construction worker radiation doses must remain below the radiation dose limit for individual members of the public (100 mrem/yr [10 CFR 20.1301; TN283]) pursuant to 10 CFR Part 20, Subpart D (TN283), “Radiation Dose Limits for Individual Members of the Public.” Because of the variability in ANR designs, power levels, and timeframes for the construction stage, the potential radiation exposure levels could range from not measurable to close to the 100 mrem/yr regulatory limit. It is also expected that the applicant, if issued a license, would mitigate the construction worker radiation exposures by following radiation protection best practices to maintain radiation dose ALARA standards in accordance with 10 CFR 20.1101 (TN283), “Radiation Protection Programs.”

New reactor licensing actions for LWRs have shown that the anticipated radiological doses to construction workers would be within regulatory limits for members of the public, as shown in Table 3-2. These results show that even for sites with co-located nuclear power plants, dose levels are generally significantly below 100 mrem/yr. The only exception is for the Fermi 3 licensing action, which involved an anticipated dose slightly less than 100 mrem/yr, and this was in part due to the type of reactor in operation at Fermi 2 and having an ISFSI adjacent to the Fermi 3 construction site that would have a number of storage casks in place during the construction timeframe. Therefore, it is important that exposure pathways from any adjacent or nearby nuclear facility, whether licensed by the NRC, an Agreement State, or if next to another Federal nuclear facility, be properly accounted for when assessing annual doses to construction workers.

Based on these considerations, the NRC concludes that radiological impacts during construction would be SMALL for all ANRs independent of power level or design and the doses would be less than the regulatory limits, which will be demonstrated in the application. This is a Category 1 issue. The staff relied on the following PPE assumptions to reach this conclusion:

- For protection against radiation, the applicant must meet the regulatory requirements of:
  - 10 CFR 20.1101 Radiation Protection Programs (10 CFR Part 20-TN283) if issued a license
  - 10 CFR 20.1201 Occupational dose limits for adults
  - 10 CFR 20.1301 Dose limits for individual members of the public
  - Appendix B of 10 CFR Part 20 Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage
  - 10 CFR 50.34a (10 CFR Part 50-TN249) Design objectives for equipment to control releases of radioactive material in effluents—nuclear power reactors
  - 10 CFR 50.36a Technical specifications on effluents from nuclear power reactors.
- Application contains sufficient technical information for the staff to complete the detailed technical safety review.
- Application will be found to be in compliance by the staff with the above regulations through a radiation protection program and an effluent release monitoring program.

3.8.1.2.2 Environmental Consequences of Operation

If the ANR design does not have radiological gaseous and liquid effluent releases and no significant quantities of solid radioactive waste are being stored onsite, then there are no

Table 3-2 Construction Worker Individual and Collective Doses

Site Name	Worker Population	Individual Construction Worker Dose (mrem/yr)	Cumulative Construction Worker Dose (person-rem/yr)
Clinton Exelon ESP (NRC 2006-TN672)	3,150	25	80
Grand Gulf ESP (NRC 2006-TN674)	3,150	36	112
North Anna Power Station Unit 3 ESP (NRC 2010-TN6)	3,500	29	102
Calvert Cliffs Unit 3 COL (NRC 2011-TN1980)	3,950	38.81	4.6
South Texas Units 3 and 4 COL (NRC 2011-TN1722)	5,950	19	---
Virgil C. Summer Units 2 and 3 COL (NRC 2011-TN1723)	3,600	1.2	4.7
Levy Units 1 and 2 COL (NRC 2012-TN1976)	3,300	2.7	---
Comanche Peak Units 3 and 4 COL (NRC 2011-TN6437)	4,953	2.5	---
Vogtle Units 3 and 4 ESP (NRC 2008-TN673)	3,500	26.3	92
Enrico Fermi Unit 3 COL (NRC 2013-TN6436)	2,900	96.6	---
William States Lee Units 1 and 2 COL (NRC 2013-TN6435)	2,100	0.4	0.83
PSEG ESP (NRC 2015-TN6438)	4,100	18.7	77
Turkey Point Units 6 and 7 COL (NRC 2016-TN6434)	2,800	6	17
Bell Bend COL (NRC and USACE 2016-TN6562)	3,950	16.4	10.3
Clinch River ESP (NRC 2019-TN6136)	3,300	53	170

potential offsite radiation exposure pathways and no environmental analysis of offsite radiological dose is necessary. To receive an NRC license, the applicant must provide assurances that the ANR's operations would not exceed regulatory limits for occupational doses and doses to individual members of the public, as set forth in 10 CFR Part 20 (TN283). Under the safety review, the staff would review and confirm in the Final Safety Evaluation Report (FSER) that the application demonstrates adequate protection of the public's health and safety by meeting the appropriate regulatory limits through all operational phases. The application's safety analysis does not assess the collective dose to the surrounding population or doses to nonhuman biota.

The NRC staff identified four environmental issues related to radiological environment impacts for operation of an ANR:

- occupational doses to workers
- MEI annual doses
- total population annual doses
- nonhuman biota doses.

Variability in radiological waste management systems between ANR designs is expected. Some ANRs may be designed to have no radiological effluent releases and very small quantities of onsite solid radioactive waste. Other ANR, such as liquid-fueled molten-salt reactors, may have industrial processes for removing fission products from the nuclear fuel as part of their normal operating procedures with accompanying releases of noble and volatile radioactive gases, and liquid waste from processing stream(s). This would necessitate an appropriately designed and approved 10 CFR Part 50 (TN249) or Part 52 (TN251) radioactive waste management system and an associated processing and storage facility to support plant operations. It is also expected that the various ANR designs' lower power levels and inherent design features, while satisfying the regulatory limits for effluent releases of 10 CFR Part 20 (TN283), would not necessarily have the same level of effluent releases as the LWRs previously assessed in the new reactor ESP and COL EISs. Thus, based on the assumption that ANRs will meet regulatory effluent release limits, the previous new reactor environmental impacts for LWRs would provide bounding impacts for ANRs with radioactive waste streams leading to offsite doses.

Occupational Doses to Workers

The licensee of a new plant would need to maintain individual doses to workers to within 5 rem annually as specified in 10 CFR 20.1201 (TN283) and incorporate provisions to maintain doses ALARA. Section 3.9.1.2, Occupational Radiological Exposures, of Revision 1 to NUREG-1437 (NRC 2013-TN2654) provides a detailed analysis of occupational doses to workers at LWR nuclear power plants. This analysis shows improvements have been implemented over the years of operational experience to reduce occupational doses to workers and that the average annual doses are well within regulatory limits, and Revision 1 to NUREG-1437 (NRC 2013-TN2654) is incorporated by reference.

ANR applicants' radiation protection programs should be able to build upon and apply the lessons learned through LWR operational experience to maintain their workers' occupational doses well below regulatory limits and would ensure that occupational exposures are maintained ALARA. In addition, ANR applicants could establish plans for worker training, monitoring, and radiation safety programs.

The staff concludes that the health impacts from occupational radiation exposure would be SMALL based on individual worker doses being maintained within 10 CFR 20.1201 (TN283) limits and collective occupational doses for ANRs should be in line with the radiation protection practices at current operating LWRs. Additional mitigation would not be warranted because the operating plant would be required to maintain doses ALARA. This is a Category 1 issue. The staff relied on the following PPE assumptions to reach this conclusion:

- For protection against radiation, the applicant must meet the regulatory requirements of:
  - 10 CFR 20.1101 Radiation Protection Programs (10 CFR Part 20-TN283) if issued a license
  - 10 CFR 20.1201 Occupational dose limits for adults
  - Appendix B of 10 CFR Part 20 Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage
  - 10 CFR 50.34a (10 CFR Part 50-TN249) Design objectives for equipment to control releases of radioactive material in effluents—nuclear power reactors
  - 10 CFR 50.36a Technical specifications on effluents from nuclear power reactors.
- Application contains sufficient technical information for the staff to complete the detailed technical safety review.
- Application will be found to be in compliance by the staff with the above regulations through a radiation protection program and an effluent release monitoring program.

Maximally Exposed Individual Annual Doses

Prior new reactor EISs have assessed the total dose to the MEI as part of meeting the requirements of the 10 CFR Part 20 (TN283) based on the methodology provided in RG 1.109, *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I* (NRC 1977-TN90). The MEI total dose is usually assessed from the nuclear power plant to the nearest resident assuming all appropriate exposure pathways are at that location. This assumption provides for a conservative or bounding analysis for demonstrating compliance with regulatory dose limits. Prior LWR new reactor ESP and COL MEI annual doses are provided in Table 3-3. The table demonstrates that the MEI annual dose assessed not only met the regulatory limit of 100 mrem/yr in 10 CFR 20.1301(a) (TN283) but also met the lower regulatory limits in 40 CFR Part 190 (TN739), which is incorporated into NRC regulations under 10 CFR 20.1301(e) (TN283), even for sites with co-located nuclear power plants.

An ANR applicant must provide the necessary information on the docket for the staff to reach a regulatory finding that the regulatory requirements have been met, such as annual dose limits to members of the public provided in 10 CFR 20.1301 (TN283). Additionally, 10 CFR Parts 20 (TN283) and 50 (TN249) require that a REMP be established to provide data about measurable levels of radiation and radioactive materials in the site environs. Licensees would rely on the REMP or a similar program to satisfy the requirements of Criterion 64, "Monitoring Radioactivity Releases," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, *Domestic Licensing of Production and Utilization Facilities* (NRC 2016-TN6463) or applicant-developed project-specific Principal Design Criteria for non-LWRs (NRC 2018-TN7066). Therefore, the environmental impacts on the MEI are expected to be SMALL where ANR applicants demonstrate in their application that any radiological effluent releases and annual doses would be within regulatory limits, or where the staff during their safety review finds the applicant would be in compliance with the applicable 10 CFR Part 20 regulations. This is a Category 1 issue. The staff relied on the following PPE assumptions to reach this conclusion:

- For protection against radiation, the applicant must meet the regulatory requirements of:
  - 10 CFR 20.1101 Radiation Protection Programs (10 CFR Part 20-TN283) if issued a license
  - 10 CFR 20.1301 Dose limits for individual members of the public
  - Appendix B of 10 CFR Part 20 Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage
  - 10 CFR 50.34a (10 CFR Part 50-TN249) Design objectives for equipment to control releases of radioactive material in effluents—nuclear power reactors
  - 10 CFR 50.36a Technical specifications on effluents from nuclear power reactors.
- Application contains sufficient technical information for the staff to complete the detailed technical safety review.
- Application will be found to be in compliance by the staff with the above regulations through a radiation protection program and an effluent release monitoring program.

Total Population Annual Doses

If there are radiological effluent releases, they will move beyond the site into the surrounding area exposing the surrounding population, and the impacts from such releases need to be assessed under NRC's NEPA obligations. For the past new reactor ESP and COL application reviews, this analysis of total population doses was provided using the NRCDose code, which was also applied as part of the safety analysis and was evaluated out to a distance of 50 mi. (80 km). These total population dose results from the various ESPs and COLs approved by the NRC are provided in Table 3-3. As part of these reviews, the staff compared the total population dose associated with the licensing action to the collective dose from natural background radiation based on an average annual individual natural background dose of 310 mrem/yr. The results from the various ESP and COL radiological assessments show that the surrounding population would receive a very small fraction of what would be expected from natural background.

Both the National Council on Radiation Protection and Measurements (NCRP) and the International Council on Radiation Protection and Measurements (ICRP) suggest that when the collective effective dose is smaller than the reciprocal of the relevant risk detriment (i.e., less than 1/0.00057, which is less than 1,754 person-rem), the assessment should find that the most likely number of excess health effects is zero (NCRP 1995-TN728; ICRP 2007-TN422). As noted above, all of the ESP and COL total population doses are significantly less than the 1,754 person-rem value that both ICRP and NCRP suggest would most likely result in zero excess health effects (NCRP 1995-TN728; ICRP 2007-TN422).

The combination of these radiological impacts demonstrates a low MEI dose correlates to a small total population dose, even out to 50 mi. (80 km), where zero excess health effect in the general population would be expected. Therefore, the environmental impacts on the surrounding population are expected to be SMALL where ANR applicants demonstrate in their application that any radiological effluent releases and annual doses to the population would be within regulatory limits of 10 CFR Part 20 (TN283). This is a Category 1 issue. The staff relied on the following PPE assumptions to reach this conclusion:

- For protection against radiation, the applicant must meet the regulatory requirements of:
  - 10 CFR 20.1101 Radiation Protection Programs (10 CFR Part 20-TN283) if issued a license
  - 10 CFR 20.1301 Dose limits for individual members of the public
  - Appendix B of 10 CFR Part 20 Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage
  - 10 CFR 50.34a (10 CFR Part 50-TN249) Design objectives for equipment to control releases of radioactive material in effluents—nuclear power reactors
  - 10 CFR 50.36a Technical specifications on effluents from nuclear power reactors.
- Application contains sufficient technical information for the staff to complete the detailed technical safety review.
- Application will be found to be in compliance by the staff with the above regulations through a radiation protection program and an effluent release monitoring program.

Nonhuman Biota Doses

The Commission position on nonhuman biota doses is that the current set of radiation protection controls is protective of the environment. Therefore, the NRC radiation protection regulations, by protecting members of the public, also protect nonhuman biota and there is no need to have separate radiation protection regulations for plant and animal species (SECY-04-0223 [NRC 2004-TN6431], SECY-06-0168 [NRC 2006-TN6430], SECY-08-0197 [NRC 2008-TN6432], SECY-04-0055 [NRC 2004-TN7100], and related Staff Requirements Memorandums SRM-SECY-04-0223 [NRC 2005-TN6649], SRM-SECY-06-0168 [NRC 2005-TN6650], SRM-SECY-08-0197 [NRC 2009-TN6651]), SRM-SECY-04-0055 [NRC 2004-TN7101]. The IAEA (1992-TN712) and the NCRP (1991-TN729) report that a chronic dose rate of no greater than 10 mGy/d (1,000 mrad/d) to the MEI in a population of aquatic organisms would ensure protection of the population. The IAEA (IAEA 1992-TN712) also concluded that chronic dose rates of 1 mGy/d (100 mrad/d) or less do not appear to cause observable changes in terrestrial animal populations. These two guidelines (1,000 mrad/d for aquatic biota, 100 mrad/d for terrestrial biota) have been applied in various NRC environmental reviews. For example, the impact of radionuclides on aquatic organisms has been raised as an issue by the public for several of the nuclear plants that have undergone license renewal. The License Renewal GEIS Revision 1 (NRC 2013-TN2654) concludes that the impact of routine radionuclide releases from past and current operations on aquatic and terrestrial biota would be SMALL for all nuclear plants and would not be expected to appreciably change during the renewal period.

Nonhuman biota doses have also been assessed in the new reactor ESP and COL FEISs. The results from the new reactor reviews for the seven surrogate species (three aquatic species and four terrestrial species analyzed within the NRCDose code) are shown in Table 3-5 and Table 3-6. These tables clearly show the absorbed dose rates for all surrogate species were much lower than the IAEA and NCRP guidelines (IAEA 1992-TN712; NCRP 1991-TN729). Thus, the conclusion in all of the new reactor environmental reviews was the radiological impact on nonhuman biota from a new nuclear power plant at the selected site would be SMALL.

Table 3-3 Maximally Exposed Individual Doses[(a)]

Site Name	Total Body (mrem/yr)[b]	Thyroid (mrem/yr)	Organ (mrem/yr)
Clinton Exelon ESP (NRC 2006-TN672)	3.21	9.47	5.04
Grand Gulf ESP (NRC 2006-TN674)	8.9	17	21
North Anna Power Station Unit 3 ESP (NRC 2010-TN6)	6.9	18	14
Calvert Cliffs Unit 3 COL (NRC 2011-TN1980)	0.458	0.88	1.3
South Texas Units 3 and 4 COL (NRC 2011-TN1722)	5.71	4.55	1.94
Virgil C. Summer Units 2 and 3 COL (NRC 2011-TN1723)	2.2	14	3.5
Levy Units 1 and 2 COL (NRC 2012-TN1976)	5.5	12.9	19.5
Comanche Peak Units 3 and 4 COL (NRC 2011-TN6437)	3.7	3.1	7.8
Vogtle Units 3 and 4 ESP (NRC 2011-TN6439)	2.36	12.39	8.88
Enrico Fermi Unit 3 COL (NRC 2013-TN6436)	5.66	13.99	2.32
William States Lee Units 1 and 2 COL (NRC 2013-TN6435)	3.74	20	9.05
PSEG ESP (NRC 2015-TN6438)	2.94	6.86	3.97
Turkey Point Units 6 and 7 COL (NRC 2016-TN6434)	7.8	15	8.4
Bell Bend COL (NRC and USACE 2016-TN6562)	4.52	6.80	7.32
Clinch River ESP (NRC 2019-TN6136)	11	25	24

(a) 40 CFR 190.10 (a) (TN739) states "the annual dose equivalent does not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as the result of exposures to planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and to radiation from these operations."
(b) These values meet the restrictions stated in 40 CFR 190 (a) (TN739) as well as the restrictions in 10 CFR 20.1301(a)(1) (TN283) Dose Limits.

Table 3-4 50-Mile Total Population and Collective Natural Background Doses[(a)]

Site Name	50 mi (80 km) Population	50 mi (80 km) Population Collective Dose (person-rem/yr)	Collective Dose from Natural Background Radiation (person-rem/yr)
Clinton Exelon ESP (NRC 2006-TN672)	800,000	1.83	230,000
Grand Gulf ESP (NRC 2006-TN674)	332,369	3.20	102,000
North Anna Power Station Unit 3 ESP (NRC 2010-TN6)	2,800,000	8.70	840,000
Calvert Cliffs Unit 3 COL (NRC 2011-TN1980)	6,418,570	3.9	2,000,000
South Texas Units 3 and 4 COL (NRC 2011-TN1722)	514,000	0.58	160,000
Virgil C. Summer Units 2 and 3 COL (NRC 2011-TN1723)	2,131,394	34.50	663,000
Levy Units 1 and 2 COL (NRC 2012-TN1976)	1,440,000	13.8[(a)]	520,000
Comanche Peak Units 3 and 4 COL (NRC 2011-TN6437)	3,490,000	8.00	985,000
Vogtle Units 3 and 4 ESP (NRC 2011-TN6439)	674,101	1.84	243,000
Enrico Fermi Unit 3 COL (NRC 2013-TN6436)	7,710,000	21.60	2,400,000
William States Lee Units 1 and 2 COL (NRC 2013-TN6435)	4,195,000	10.6	1,305,000
PSEG ESP (NRC 2015-TN6438)	8,138,635	65.90	2,531,000
Turkey Point Units 6 and 7 COL (NRC 2016-TN6434)	7,500,000	8.00	2,500,000
Bell Bend COL (NRC and USACE 2016-TN6562)	2,640,368	8.54	821,154
Clinch River ESP (NRC 2019-TN6136)	2,658,157	68.00	830,000

(a) The 50 mi (80 km) population collective dose for one unit was multiplied by 2 to account for a two-unit site.

Table 3-5 Aquatic Nonhuman Biota Doses[a]

Site Name	Fish (mrad/d)	Invertebrate (mrad/d)	Algae (mrad/d)
Clinton Exelon ESP (NRC 2006-TN672)	0.0171	0.0376	0.0762
Grand Gulf ESP (NRC 2006-TN674)	0.068[b]	0.452[b]	0.405[b]
North Anna Power Station Unit 3 ESP (NRC 2010-TN6)	0.009[b]	0.033[b]	0.047[b]
Calvert Cliffs Unit 3 COL (NRC 2011-TN1980)	0.00077	0.0064	0.015
South Texas Units 3 and 4 COL (NRC 2011-TN1722)	0.0068	0.015	0.0015
Virgil C. Summer Units 2 and 3 COL (NRC 2011-TN1723)	0.0022	0.0063	0.018
Levy Units 1 and 2 COL (NRC 2012-TN1976)	0.01	0.02	0.03
Comanche Peak Units 3 and 4 COL (NRC 2011-TN6437)	0.052	0.088	0.11
Vogtle Units 3 and 4 ESP (NRC 2011-TN6439)	0.00044[c]	0.0012[c]	0.0036[c]
Enrico Fermi Unit 3 COL (NRC 2013-TN6436)	0.0063	0.021	0.033
William States Lee Units 1 and 2 COL (NRC 2013-TN6435)	0.0016	0.0044	0.013
PSEG ESP (NRC 2015-TN6438)	0.0045	0.0161	0.0225
Turkey Point Units 6 and 7 COL (NRC 2016-TN6434)	0.00	0.00	0.00
Bell Bend COL (NRC and USACE 2016-TN6562)	0.00052	0.0018	0.0058
Clinch River ESP (NRC 2019-TN6136)	0.0045	0.021	0.0067

(a) The International Atomic Energy Agency (IAEA) and National Council on Radiation Protection and Measurements (NCRP) reported a chronic absorbed dose rate of no greater than 1,000 mrad/d would ensure protection of aquatic organism populations (IAEA 1992-TN712; NCRP 1991-TN729).
(b) Dose converted from mGy/yr to mrad/d.
(c) Dose converted from mGy/d to mrad/d.

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Table 3-6 Terrestrial Nonhuman Biota Doses[(a)]

Site Name	Muskrat (mrad/d)	Racoon (mrad/d)	Heron (mrad/d)	Duck (mrad/d)
Clinton Exelon ESP (NRC 2006-TN672)	0.0471	0.0222	0.191	0.0470
Grand Gulf ESP (NRC 2006-TN674)	0.227[(b)]	0.058[(b)]	0.534[(b)]	0.227[(b)]
North Anna Power Station Unit 3 ESP (NRC 2010-TN6)	0.112[(b)]	0.056[(b)]	0.082[(b)]	0.112[(b)]
Calvert Cliffs Unit 3 COL (NRC 2011-TN1980)	0.0038	0.00075	0.0011	0.0038
South Texas Units 3 and 4 COL (NRC 2011-TN1722)	0.03	0.031	0.03	0.036
Virgil C. Summer Units 2 and 3 COL (NRC 2011-TN1723)	0.020	0.023	0.044	0.027
Levy Units 1 and 2 COL (NRC 2012-TN1976)	0.02	0.01	0.01	0.02
Comanche Peak Units 3 and 4 COL (NRC 2011-TN6437)	0.19	0.060	0.55	0.19
Vogtle Units 3 and 4 ESP (NRC 2011-TN6439)	0.0055[(c)]	0.0066[(c)]	0.01[(c)]	0.0071[(c)]
Enrico Fermi Unit 3 COL (NRC 2013-TN6436)	0.071	0.032	0.049	0.071
William States Lee Units 1 and 2 COL (NRC 2013-TN6435)	0.016	0.011	0.030	0.015
PSEG ESP (NRC 2015-TN6438)	0.0199	0.0170	0.0203	0.0206
Turkey Point Units 6 and 7 COL (NRC 2016-TN6434)	0.14	0.14	0.14	0.14
Bell Bend COL (NRC and USACE 2016-TN6562)	0.010	0.0090	0.013	0.010
Clinch River ESP (NRC 2019-TN6136)	0.24	0.23	0.25	24

(a) The IAEA concluded that a chronic absorbed dose rate of 100 mrad/d or less does not appear to cause observable changes in terrestrial animal populations (IAEA 1992-TN712).
(b) Dose converted from mGy/yr to mrad/d.
(c) Dose converted from mGy/d to mrad/d.

Therefore, the environmental impacts on nonhuman biota are expected to be SMALL where ANR applicants demonstrate in their application that any radiological effluent releases and annual doses would be within regulatory limits. This is a Category 1 issue. The staff relied on the following PPE assumption to reach this conclusion:

- Applicants would demonstrate in their application that any radiological nonhuman biota doses would be below IAEA (1992-TN712) and NCRP (1991-TN729) guidelines.

3.8.2 Nonradiological Environment

3.8.2.1 Baseline Conditions and PPE/SPE Values and Assumptions

Baseline conditions influencing potential public and occupational health impacts associated with the building and operation of an ANR include consideration of nonradiological chemical hazards, biological hazards, EMFs, the distance to receptors (occupational workers or a member of the public), the number of people potentially exposed, and other industrial physical concerns, such as falls, burns from high temperature, shock, or asphyxiation. Relevant public and occupational health conditions involve not only industrial processes at the plant itself, but also consider other sources of public and occupational exposure, such a neighboring chemical facilities and current road conditions. Section 3.3 includes information about air quality. Section 3.4 includes information about water resources. Section 3.9 includes information about noise. Section 3.11 includes information about postulated accidents. Section 3.12 includes information about traffic impacts. Section 3.15 includes information about transportation of fuel and waste, while Section 3.10 includes information about waste impacts. The overall well-being of these resource areas is important to maintaining the quality of public and occupational health.

The assumption of the PPE/SPE developed for this ANR GEIS is that the applicant must adhere to applicable Federal, State, local and tribal public and occupational health regulatory limits and BMPs regarding chemical hazards, biological hazards, EMFs, and physical hazards.

3.8.2.1.1 Chemical Hazards

A chemical hazard occurs when workers or members of the public are exposed to a nonradiological hazardous substance by inhalation, skin absorption, or ingestion. Chemical hazards can have immediate effects (nausea, vomiting, acid burns, asphyxiation—also known as acute hazards) or the effects might take time to develop (dermatitis, asthma, liver damage, cancer—also known as chronic hazards).

For large LWRs, there are multiple pathways by which humans can be exposed to pollutants from a plant. For example, a direct pathway would be a human breathing in a gaseous effluent or swimming in water that was contaminated by a liquid effluent. An indirect pathway would be a human eating a fish that had absorbed a pollutant into its body or eating crops that had been irrigated with water contaminated by a liquid effluent. One advantage of an ANR is that pathways for exposure could be limited based on the design.

The Occupational Safety and Health Administration sets enforceable permissible exposure limits for about 500 hazardous chemicals to protect workers against the health effects of exposure to hazardous substances, including limits on the airborne concentrations of hazardous chemicals in the air and skin contact. Most permissible exposure limits are 8-hour time-weighted averages, although there are also ceiling and peak limits. Regulatory limits for chemical hazards are found in 29 CFR Part 1910 (TN654).

The EPA is responsible for the regulation of most chemicals that can enter the environment through the following Federal Acts: the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. §§ 136 *et seq*.; TN4535); Toxic Substances Control Act (15 U.S.C. §§ 2601 *et seq.*; TN4454); RCRA (42 U.S.C. §§ 6901 *et seq*.; TN1281); Clean Water Act (codified as the Federal Water Pollution Control Act of 1972; 33 U.S.C. §§ 1251 *et seq.;* TN662); SDWA (42 U.S.C. §§ 300f *et seq*.; TN1337); Clean Air Act (42 U.S.C. §§ 7401 *et seq*.; TN1141); and the Comprehensive Environmental Response Compensation and Liability Act (42 U.S.C. §§ 9601 *et seq*.; TN6592). Discharged biocides, liquid wastes, chemicals, and heavy metals are regulated by the NPDES permitting system.

3.8.2.1.2 Biological Hazards

Biological hazards are organic substances that pose a threat to the health of humans and other organisms. Biological hazards include pathogenic microorganisms, insects, animals, viruses, toxins, spores, and fungi. Biological hazards, such as mosquitos, bees, and ticks could be present at any industrial site, either while building the facility itself or while the facility is in operation. Microbiological hazards occur when workers or members of the public come into contact with disease-causing microorganisms, also referred to as etiological agents. Examples of etiological agents are Salmonella spp., Shigella spp., Legionella spp., Pseudomonas aeruginosa, or thermophilic fungi. NUREG-1437, Volume 1 (NRC 2013-TN2654), provides further background information about microorganisms of concern at large LWRs and a description of studies of microorganisms in cooling towers.

3.8.2.1.3 Electromagnetic Fields

An EMF is caused by a combination of electric and magnetic fields of force or moving electric charges. The strength of the EMF will increase with an increase in voltage. EMFs are generated by natural phenomena (for example the Earth's magnetic field) or any electrical equipment (WHO 2020-TN6561). There are no U.S. Federal standards limiting residential or occupational exposure to EMFs from power lines, but some states, such as Florida, Minnesota, Montana, New Jersey, New York, and Oregon, have set electric field and magnetic field standards for transmission lines (NIEHS 2002-TN6560). EMFs resulting from a 60 Hz power transmission line falls under the category of non-ionizing radiation. A voluntary occupational standard has been set for EMFs by the International Commission on Non-Ionizing Radiation Protection. For occupational workers who are exposed to 60 Hz (power lines), the electric field standard is 8.3 kV/m and the magnetic field standard is 4,200 milligauss, while for the general public who are exposed to 60 Hz, the electrical field standard is 4.2 kV/m and the magnetic field standard is 833 milligauss (ICNIRP 1998-TN6591). The National Institute of Occupational Safety and Health does not consider EMFs to be a proven health hazard (NIOSH 1996-TN6766). NUREG-1437, Volume 1 (NRC 2013-TN2654), provides further background information about EMFs at large LWRs.

In 1996, the World Health Organization began a multidisciplinary research study regarding the possible health effects from exposure to EMF sources (WHO 2020-TN6561) and concluded current evidence does not support the existence of any health consequences from exposure to low-level EMFs. Two additional reports, one from the U.S. National Academy of Science (National Research Council 1997-TN6595), and another from the National Institute of Environmental Health Sciences, concluded similar findings (NIEHS 2002-TN6560).

3.8.2.1.4 Physical Hazards

A physical hazard is an action, agent, or condition that can cause harm upon contact. Physical hazards include actions such as slips, trips, and falls. Physical hazards from agents include noise (see Section 3.9), shock, vibration, ionizing radiation, and ergonomic factors from heavy lifting and repetitive motion. Physical conditions could include high heat, cold, pressure, or confined space. An ANR is an industrial facility and will have many of the typical occupational hazards found at other electric power generation utilities. Physical hazards such as ladder safety, fall protection, noise exposure, non-ionizing radiation, and personal protective equipment are regulated by 29 CFR Part 1910 (TN654).

If an ANR were to be a power-producing facility, transmission lines to support the power grid would be necessary. Occupational workers and members of the public could be exposed to acute electric shock from transmission lines or electrical equipment needed to support the facility. Secondary shock currents are also produced when humans make contact with (1) capacitively charged bodies, such as a vehicle parked near a transmission line, or (2) magnetically linked metallic structures, such as fences near transmission lines. The National Electrical Safety Code contains the basic provisions that are considered necessary for the safety of employees and the public under specific conditions. NUREG-1437, Volume 1 (NRC 2013-TN2654), provides further information about electric shock.

3.8.2.2 Nonradiological Environment Impacts

The NRC has assessed the impacts on nonradiological public and occupational health from the existing operating reactor fleet during license renewal assessments and from proposed new reactors as part of the COL and ESP process under 10 CFR Part 52 (TN251). Impacts on nonradiological public and occupational health from the continued operation and refurbishment of typical large LWRs in the existing U.S. fleet are evaluated in the License Renewal GEIS (NRC 2013-TN2654). Impacts from the building and operation of new reactors have been evaluated in several EISs. The NRC staff assumes that the impacts on nonradiological public and occupational health from the construction and operation of ANR s would generally be bounded by the large LWRs.

3.8.2.2.1 Environmental Consequences of Construction

The NRC staff identified two environmental issues:

- building impacts of chemical, biological, and physical nonradiological hazards, and
- building impacts of EMFs.

The primary impacts of building an ANR on nonradiological public and occupational health would be from building activities. Potential occupational worker impacts would come from chemical hazards, biological hazards, EMFs, and physical hazards typical of large-scale building construction. This would include exposure to the following:

- equipment engine exhaust
- heavy metals in solder or welding fumes
- solvent vapors
- fugitive dust
- plant toxins, insects, and other biological hazards
- vibration
- slips, trips, falls from scaffolding

- heat or cold stress, burns, frost-bite
- noise (see Section 3.9 regarding information about this subject)
- heat stress
- non-ionizing radiation from welding
- shock from electrical equipment
- repetitive motion (ergonomic concerns), strains, and sprains
- traffic-related impacts from construction worker and supply transportation (see Section 3.12 regarding information about this subject).

Building Impacts of Chemical, Biological, and Physical Nonradiological Hazards

Chemical exposure would exist in the form of dust, fumes, fibers (solids), liquids, mists, gases, or vapors. Examples of chemical hazards found in construction work could include lead, silica, cadmium, carbon monoxide, oxides of nitrogen, VOCs, welding fumes, spray paints, cutting oil mists, solvents, and hexavalent chromium. Fugitive emissions of dust in particular would be generated during windy periods, earthmoving, and movement of vehicular traffic over recently disturbed areas. Exposure to plant and insect toxins could occur during earthmoving activities. Physical impacts common to any large-scale industrial project would also occur.

Potential impacts on members of the public during building would be from chemical hazards and physical hazards typical of large-scale building construction. This would include exposure to some of the hazards that occupational workers would face, such as equipment engine exhaust, fugitive dust, vibration, noise, and traffic-related impacts from construction worker and supply transportation. Members of the public could be exposed to building impacts due to the proximity of their house, work, school, recreational site, or via a water source. Applicable liquid and air permits and regulations would also regulate impacts on members of the public, similar to the regulation for occupational workers.

Occupational and public health mitigation measures that may be used to reduce potential impacts during building, include phasing activities and equipment use; BMPs such as proper equipment maintenance and use; and watering and stabilizing roads and spoils.

Building activities are typically subject to air permits under State and Federal laws to address impacts of air emissions on any local sensitive receptors. Mitigation could also consist of providing administrative and engineering design features, such as dikes around large liquid chemical tanks.

The staff has determined that nonradiological public and occupational health impacts associated with chemical, biological, and physical hazards during construction of an ANR are a Category 1 issue. The staff concluded that as long as the applicable PPE and SPE values and assumptions are met, the nonradiological public and occupational health impact from building an ANR can be generically determined to be SMALL. Any planned exposure or release over the regulatory limit would require project-specific analysis. The staff relied on the following PPE values and assumptions to reach this conclusion:

- The applicant must adhere to all applicable Federal, State, local or Tribal regulatory limits and permit conditions for chemical hazards, biological hazards, and physical hazards.

- The applicant will follow nonradiological public and occupational health BMPs and mitigation measures, as appropriate.

Building Impacts of EMFs

Occupational workers would be exposed to EMFs during the use of any electronic tool or equipment. However, the staff has determined that nonradiological public and occupational health impacts from EMFs during construction are uncertain.

Studies of 60 Hz EMFs have not uncovered consistent evidence linking harmful effects with field exposures. Because the state of the science is currently inadequate, no generic conclusion on human health impacts is possible. If, in the future, the Commission finds that a general agreement has been reached by appropriate Federal health agencies that there are adverse health effects from EMFs, the Commission will require applicants to submit project-specific reviews of these health effects as part of their application. Until such time, applicants are not required to submit information about this issue.

3.8.2.2.2 Environmental Consequences of Operation

The NRC staff identified two environmental issues:

- operation impacts of chemical, biological, and physical nonradiological hazards, and
- operation impacts of EMFs.

The primary impacts of operating an ANR on nonradiological public and occupational health would be from chemical hazards, biological hazards, EMFs, and physical hazards. Hazards present during operation for occupational workers would be the same as those listed for construction.

Operation Impacts of Chemical, Biological, and Physical Nonradiological Hazards

For ANRs, operations-related chemical hazards could result from the releases of liquid effluents or gaseous emissions from industrial operations, sanitary discharges, leaching of heavy metals from tanks or pipes, and improper storage or handling of chemicals. Various ANR operational systems may require treatment using chemicals or biocides to avoid scaling. The rate of flow into water systems would be managed, while facility discharges that may contain low-level concentrations of chemicals or biocides, would be managed through engineering and administrative controls necessary to maintain requirements of an NPDES permit or other standards. Industrial processes at an ANR could also use backup diesel generators, boilers, cooling condensers, or cooling towers. Impacts on occupational workers can result from operations of engine-driven equipment, although these types of operations may be reduced, limited, or not present for some ANR designs. The regulations in 10 CFR Part 50 (TN249) dictate that safety-related diesel generators and other emission-releasing equipment be tested throughout the year for various durations. Diesel generators that function as standby equipment would also typically be tested throughout the year for various durations. Primary cooling systems, operation of process equipment, mobile emissions, and emergency power supply systems would all release either a liquid effluent or gaseous emission. Emissions could include nitrogen oxide, carbon monoxide, sulfur dioxide, VOCs, and particulate matter, depending upon the plan design. Additionally, ANRs would either have a stand-alone sanitary system or connect to a municipal sanitary system.

Chemical effects could also be caused by the improper storage or handling of chemicals or waste. For example, improper storage of acids and bases, chemicals commonly used in onsite laboratories for testing of effluents, could cause an explosion. In addition, there could be impacts from accidental chemical spills either in the laboratory or when chemistries of the primary and secondary coolant systems are being adjusted, if multiple coolant systems are part of the ANR design.

Occupational workers would be exposed to biological hazards at an ANR, as workers at any industrial facility would be. The staff assumes the applicant to employ industry BMPs to minimize biological hazards to occupational workers.

Conditions at cooling towers, spent fuel pools, and other thermal discharges could provide ideal living conditions for etiological agents unless those conditions are managed properly. Occupational workers could come into contact with microbiological hazards when cleaning condenser tubes or cooling towers. Management of microbiological hazards could include the use of engineering and administrative controls, such as PPE. NUREG-1437, Volume 1, provides an impact description of microorganisms of concern at large LWRs (NRC 2013-TN2654). The impacts of microbiological hazards would be expected to be similar at an ANR if the reactor design operates with similar conditions (cooling ponds, lakes, canals, or discharge to a river). However, the NRC staff assumes that some ANR designs will minimize the use of cooling ponds, lakes, canals, or discharges to rivers and will adhere to a NPDES permit.

Physical hazards from actions such as slips, trips, falls from ladders, forklift operation, burns from high temperatures, and electrical shock would be present for occupational workers. Physical agents, such as noise (see Section 3.9), vibration, and ionizing radiation, and ergonomic factors from heavy lifting and repetitive motion would also be expected. Occupational workers could face potentially hazardous physical conditions, such as high heat, cold, pressure, or performing work in confined spaces or using electrical equipment. Regulations in 29 CFR Part 1910 (TN654) have been set in place to minimize physical hazards. The staff assumes BMPs will be put in place by the applicant, and that the applicant will adhere to the regulations in 29 CFR Part 1910 for nonradiological occupational health.

Potential impacts on members of the public during operation from chemical hazards, biological hazards, and physical hazards at an ANR would be those typical of large LWRs and electric power generating facilities. Hazards present during operation for members of the public are the same as those listed for building, with the addition of planned or accidental chemical releases from industrial processes.

Members of the public could be exposed to operation impacts due to the proximity of their house, work, school, recreational site, or via a water source. Applicable liquid and air permits and regulations would also regulate impacts on members of the public, similar to the regulation for occupational workers. The staff assumes that proper emergency management procedures will be put in place.

Members of the public could come into contact with microbiological hazards if in contact with a water body that receives runoff or discharge from an ANR or air deposition from gaseous releases. Changes in microbial populations and in the public use of water bodies might be caused by the operation of an ANR that uses water as a coolant or a moderator. The staff assumes an applicant would use advanced system designs, distance, dilution, and security measures to minimize microbiological hazards to the public and adhere to NPDES permit limitations.

The greatest hazard from a transmission line is direct contact with the conductors. There is a potential for members of the public to be exposed to acute electrical shock from these lines. The issue of electrical shock is generic to all electrical power plants. Tower designs preclude direct public access to the conductors. However, electrical contact can be made without physical contact between a grounded object and the conductor. A person who contacts a metallic structure or a charged object could receive a secondary shock and experience a painful sensation at the point of contact. The staff assumes the applicant would construct and operate transmission lines in adherence with the National Electrical Safety Code criteria (IEEE SA 2017-TN6762).

Occupational and public health mitigation measures that may be used to reduce potential impacts during operation, include adherence to industrial hygiene and safety practices and locating noisy equipment away from sensitive receptors.

The staff has determined that the impacts of nonradiological public and occupational health impacts associated with chemical, biological, and physical hazards during operation is a Category 1 issue. The staff concluded that as long as the applicable PPE and SPE values and assumptions are met, the nonradiological public and occupational health impact from building an ANR can be generically determined to be SMALL. Any planned exposure or release over the regulatory limit would require project-specific analysis. The staff relied on the following PPE values and assumptions to reach this conclusion:

- The applicant must adhere to all applicable Federal, State, local or Tribal regulatory limits and permit conditions for chemical hazards, biological hazards, and physical hazards.
- The applicant will follow nonradiological public and occupational health BMPs and mitigation measures, as appropriate.

Operation Impacts of EMFs

Occupational workers would be expected to be exposed to low-frequency EMFs at an ANR if the primary purpose of the facility is to produce electrical power and electrical equipment would be present. The median magnetic field measurement during a workday for a distribution substation worker at an electric utility is 7.2 milligauss (NIEHS 2002-TN6560). The staff assumes that occupational workers at an ANR would experience similar fields. Distance and shielding have been shown to be effective mitigation tools for EMFs. Members of the public could also be exposed to EMFs from powerlines associated with the ANR. However, the staff has determined that nonradiological public and occupational health impacts from EMFs during operation are uncertain.

Studies of 60 Hz EMFs have not uncovered consistent evidence linking harmful effects with field exposures. Because the state of the science is currently inadequate, no generic conclusion on human health impacts is possible. If, in the future, the Commission finds that a general agreement has been reached by appropriate Federal health agencies that there are adverse health effects from EMFs, the Commission will require applicants to submit project-specific reviews of these health effects as part of their application. Until such time, applicants are not required to submit information on this issue.

3.9 Noise

This section describes the baseline conditions, PPE and SPE values and assumptions, and environmental consequences associated with noise, as heard by humans. Wildlife-related noise impacts are described in Section 3.5.

3.9.1 Baseline Conditions and PPE/SPE Values and Assumptions

Noise levels associated with the building and operation of an ANR (and associated transmission line ROWs) that may influence human health include the volume and duration of the noise, the distance to receptors (where dwelling units or other sites of frequent human use exist), and landscape characteristics such as topography and foliage. Noise from nuclear plant building and operations can often be detected offsite relatively close to the plant site boundary. Major sources of noise during building include earthmoving activities and building of safety- and non-safety-related facilities. Major sources of noise at operating nuclear power plants are cooling towers, turbines, transformers, large pumps, and cooling-water system motors.

Sound pressure levels are typically measured by using the logarithmic decibel (dB) scale. To assess potential noise impacts on humans, a special weighting scale was developed to account for human sensitivities to certain frequencies and duration of sounds. The A-weighted scale (dBA) is widely used in environmental noise assessments because it correlates well with a human's subjective reaction to sound (Cowan 1994-TN3905).

U.S. Department of Housing and Urban Development regulations for exterior noise standards (24 CFR 51.101(a)(8); TN1016), Section 5.3.4 of NUREG-1555 (NRC 2000-TN614) states noise levels are acceptable (i.e., SMALL) if the day-night average sound level outside a residence is less than 65 dBA. Threshold noise levels from industrial sites are subject to threshold values from the National Institute for Occupational Safety and Health (NIOSH) under the Occupational Safety and Health Act of 1970 (Public Law 91-596; 29 U.S.C. §§ 651 *et seq*.; TN4453). Noise abatement issues are also handled by State and local governments because there is no overarching Federal noise abatement program.[18] The assumption underlying the PPE is that the proposed ANR will not exceed a 65 dBA threshold at the site boundary, unless a relevant State or local noise abatement law or ordinance sets a different threshold, which would then be the presumptive threshold for PPE purposes. If an applicant cannot meet the 65 dBA threshold through mitigation, then the applicant must obtain a variance or exception from the relevant State or local regulator. Based upon the NRC's past experience reviewing new reactor and license renewal applications for large LWRs, noise impacts during both building and operation have generally not exceeded 65 dBA (except for very short periods of time such as alarm and equipment testing) or these impacts have been successfully mitigated (e.g., through the implementation of BMPs, including modeling, foliage planting, building of noise buffers, and the timing of construction activities). Therefore, the PPE assumes that applicable BMPs and potential mitigation measures would be applied to reduce noise impacts to below a 65 dBA threshold on applicable receptors, particularly during building.

3.9.2 Noise Impacts

Noise impacts associated with new ANRs and associated transmission line ROWs would take place during the building and operation phases of the project. The mitigation measures that could be conducted to be able to rely on the generic analysis may include implementation of BMPs, such as modeling, foliage planting, building noise buffers, and the timing of building and/or operation activities.

[18] In the 1970s, the EPA coordinated all Federal noise control activities pursuant to the Noise Control Act of 1972 (42 U.S.C. §§ 4901 *et seq*.; TN4294), as amended by the Quiet Communities Act of 1978 (TN7029). The EPA's implementing regulations are at 40 CFR Parts 201 to 211 (TN7030). The EPA phased out the program's funding in 1982 and transferred the primary responsibility of regulating noise to State and local governments.

3.9.2.1 Environmental Consequences of Construction

Impacts would occur during site preparation and the building of both safety-related and non-safety-related facilities. Some smaller ANR designs can be placed in one or a few small buildings on a small site and may lack structures such as cooling towers, switchyards, or offsite pipelines. As a result, the noise associated with building ANRs could produce lower overall noise impacts relative to what has been typical for a large LWR. Larger ANRs may require the building of facilities similar to those associated with a large LWR and most likely have noise levels similar to those of a large LWR.

In certain cases, sound modeling in accordance with industry standards may be necessary to estimate noise levels associated with the building of the reactor. While post-mitigated noise associated with construction may exceed the noise thresholds during certain activities, these impacts are expected to be temporary and short in duration. As part of the ER, the applicant should conduct a noise survey in the relevant area, identify the peak day and night noise levels in dBA at each survey point, and establish the likely source of that noise level (e.g., road traffic, industrial and construction noises, etc.). Therefore, the NRC staff concludes that building-related human noise impacts from an ANR power plant would be SMALL and a Category 1 issue. The staff relied upon the following PPE assumptions to reach this determination:

- The noise level would be no more than 65 dBA at site boundary, unless a relevant State or local noise abatement law or ordinance sets a different threshold, which would then be the presumptive threshold for PPE purposes.
- If an applicant cannot meet the 65 dBA threshold through mitigation, then the applicant must obtain a various or exception with the relevant State or local regulator.
- The project would implement BMPs, including such as modeling, foliage planting, construction of noise buffers, and the timing of construction and/or operation activities.

3.9.2.2 Environmental Consequences of Operation

Impacts associated with the operation of the ANR would also occur. However, the noise associated with the operation of the reactor, while longer in duration, is expected to be generated at a lower level than during building. Therefore, building-generated noise impacts establish the upper bound for operations-related noise.

The NRC staff assumes that the noise associated with the operation of a proposed ANR would be mitigated and would not routinely exceed 65 dBA at the site boundary. Therefore, the NRC staff concludes that operation-related human noise impacts from an ANR power plant would be SMALL and a Category 1 issue. The NRC staff assumes that any mitigation necessary to achieve the noise thresholds from construction would remain in place and that no additional mitigation would be needed to maintain those thresholds for the duration of operations. The staff relied upon the following PPE assumptions to reach this determination:

- The noise level would be no more than 65 dBA at site boundary, unless a relevant State or local noise abatement law or ordinance sets a different threshold, which would then be the presumptive threshold for PPE purposes.
- If an applicant cannot meet the 65 dBA threshold through mitigation, then the applicant must obtain a various or exception with the relevant State or local regulator.
- The project would implement BMPs, including such as modeling, foliage planting, construction of noise buffers, and the timing of construction and/or operation activities.

3.10 Waste Management

3.10.1 Radiological Waste Management

3.10.1.1 Baseline Conditions and PPE/SPE Values and Assumptions

There are three types of radiological wastes that could be associated with an ANR: LLRW (low-level radioactive waste), high-level radioactive waste (HLRW), and mixed wastes. Regulations regarding the how a licensee shall dispose of licensed materials is regulated in accordance with 10 CFR Part 20 (TN283) Subpart K. These wastes are described in the sections below.

The NRC staff assumes that an ANR could be installed at an existing licensed facility. The ANR could be a physically separate nuclear facility or, if there is adequate land, it could be integrated within the boundaries of an existing nuclear power plant or other nuclear facility. If the ANR is a stand-alone facility, the space needed to store onsite radiological wastes would be within the planned footprint of the facility. If the ANR is sited at an existing nuclear facility, the existing radiological waste infrastructure and management program could likely support the additional radiological wastes generated by the ANR. For an existing site, information should be available about the radiological waste management facilities onsite, such as the information developed for that facility's NRC licensing activities and documented, for example, in annual environmental monitoring reports. This and other applicable documentation can be incorporated by reference into the SEIS.

3.10.1.1.1 Low-Level Radioactive Wastes

The Commission's licensing requirements for the land disposal of LLRW are set forth in 10 CFR Part 61 (TN252), *Licensing Requirements for Land Disposal of Radioactive Waste*. Part 61 defines LLRW as "radioactive waste not classified as high-level radioactive waste [HLRW], transuranic [TRU] waste, spent nuclear fuel, or byproduct material as defined in paragraphs (2), (3), and (4) of the definition of byproduct material set forth in § 20.1003 of this chapter."[19] The NRC's regulation 10 CFR 61.55 (TN252) established a classification system that categorizes LLRW as Class A, B, C, or Greater Than Class C (GTCC). Class A wastes contain radionuclides at relatively low concentrations, whereas the half-lives and concentrations of radionuclides in the Class B and C wastes are progressively higher. In addition, Class B wastes must meet more rigorous requirements with regard to their form to ensure their stability after disposal (e.g., by adding chemical stabilizing agents such as cement to the waste or placing the waste in a disposal container or structure that provides stability after disposal). Class C wastes must not only meet the more rigorous requirements above but also require the implementation of additional measures at the disposal facility to protect against inadvertent intrusion (e.g., by increasing the thickness and hardness of the cover over the waste disposal cell). GTCC is LLRW with concentrations of radionuclides that exceed the limits established by the Commission for Class C LLRW (NRC 2019-TN6440). Under the NRC's current regulations, GTCC waste is considered to be generally unacceptable for near-surface disposal and must be disposed of in a geologic repository unless the Commission approves, on a case-by-case basis, disposal of such waste in a disposal site licensed pursuant to 10 CFR 61.55(a)(2)(iv) (TN252). These regulations form the basis for the PPE guidance in Appendix G of this GEIS.

For this GEIS, the NRC staff assumes that the quantities of LLRW generated at an ANR would be less than the quantities of LLRW generated at existing nuclear power plants, which generate

[19] 10 CFR 61.2 (TN252) (definition of "waste").

an average of 21,200 ft^3 (600 m^3) and 2,000 Ci (7.4 × 10^{13} Bq) per year for boiling water reactors and half that amount for pressurized water reactors (NRC 2013-TN2654). The LLRW generated at an ANR would likely be similar to LLRW wastes from existing facilities: these wastes typically consist of contaminated protective shoe covers and clothing, wiping rags, mops, filters, equipment and tools, and other contaminated objects depending on the nuclear application (NRC 2017-TN6545). The radioactivity can range from just above the background levels found in nature to very highly radioactive. LLRW that contains radionuclides that have shorter decay times can be stored onsite by licensees until it can be released in accordance with 10 CFR Part 20, Subpart K (TN283). LLRW that contains radionuclides that have longer decay times can be stored onsite until material inventory amounts are large enough for shipment to a low-level waste disposal site. Applicable regulations from the NRC (10 CFR Part 71-TN301, "Packaging and Transportation of Radioactive Material") and/or the U.S. Department of Transportation (49 CFR-TN7054) must be used when offering licensed material for transport.

The NRC requires that all licensees implement measures to minimize, to the extent practicable, the generation of radioactive waste (10 CFR 20.1406 [TN283]). Additionally, the ANR licensee could do the following:

- Build additional temporary radiological storage facilities on the site.
- Enter into an agreement with a third-party contractor to process, store, own, and ultimately dispose of LLRW from the ANR site.

The Low-Level Radioactive Waste Policy Amendments Act of 1985 (Public Law 99-240; TN6517)[20] gave States the responsibility for disposal of the LLRW generated at commercial facilities within their states. States are encouraged to enter into compacts that allow them to dispose of the waste at a common disposal facility shared by multiple states. Depending on the location of the ANR site, the ANR licensee could contract with one or more licensed LLRW disposal sites. There are currently four operating disposal facilities in the United States that are licensed to accept LLRW from commercial facilities (including nuclear power plants) (NRC 2020-TN6516). They are located at Clive, Utah; Andrews County, Texas; Barnwell, South Carolina; and near Richland, Washington. The Energy*Solutions* disposal facility at Clive, Utah, is licensed by the State of Utah to accept Class A LLRW from all regions of the United States. The Waste Control Specialists, LLC (WCS) site in Andrews County, Texas, is licensed to accept Class A, B, and C LLRW from the Texas Compact generators (Texas and Vermont) and from outside generators with permission from the Texas Compact. Energy*Solutions* Barnwell Operations located near Barnwell, South Carolina, accepts waste from the Atlantic Compact states (Connecticut, New Jersey, and South Carolina) and is licensed by the State of South Carolina to dispose of Class A, B, and C LLRW. U.S. Ecology, located near Richland, Washington, accepts LLRW from the Northwest and Rocky Mountain Compact states (Washington, Alaska, Hawaii, Idaho, Montana, Oregon, Utah, Wyoming, Colorado, Nevada, and New Mexico) and is licensed by the State of Washington to dispose of Class A, B, and C waste. An ANR licensee would likely have to choose one or a combination of these options. Section 3.10.1.2 addresses the potential environmental impacts of using LLRW disposal facilities. The NRC staff anticipates that an ANR licensee would enter into an agreement with one of the four above facilities or make alternative arrangements in accordance with 10 CFR Part 20 Subpart K (TN283).

[20] The Low-Level Radioactive Waste Policy Amendments Act superseded, in its entirety, an earlier law, the Low-Level Radioactive Waste Policy Act of 1980 (Public Law 96-573; TN6606).

3.10.1.1.2 High-Level Waste

The only two types of HLW generated at ANRs would be spent nuclear fuel and, potentially, waste from fuel reprocessing (e.g., removal of fission products during operation from liquid-fueled molten-salt reactors) (NRC 2020-TN6955). The regulations for the storage of HLW are found in 10 CFR Part 72 (TN4884) and apply to the proper storage and handling of spent nuclear fuel in an ISFSI (independent spent fuel storage installation). Section 3.14.2.6 provides more information about the storage and disposal of spent nuclear fuel.

ANR designs may not require onsite spent nuclear fuel storage, for example, in cases where the depleted core would be shipped offsite after a short period after shutdown (see Section 3.14 for away-from-reactor impacts during continued storage).

If spent nuclear fuel or any treated, reprocessed waste needs to be stored temporarily at an ANR facility, it would be stored either in a spent fuel pool or in non-water-based spent nuclear fuel storage. After an appropriate holding period, it would be transferred to dry cask storage in an at-reactor ISFSI under a general license or a stand-alone ISFSI under specific license.

3.10.1.1.3 Mixed Wastes

Mixed waste, regulated under the RCRA (TN1281) and the Atomic Energy Act of 1954 (42 U.S.C. §§ 2011 *et seq.*; TN663), is waste that is both radioactive and hazardous (EPA 2019-TN6956). These wastes are subject to dual regulation by the EPA or an authorized State for their hazardous component, and by the NRC or an Agreement State for the radioactive component. Nuclear power plants generate small quantities of mixed waste, typically accounting for less than 3 percent by volume of the annual LLRW (NRC 1996-TN288). The NRC staff assumes that ANRs would be similar as small-quantity generators and generate mixed wastes similar to those wastes generated at currently operating nuclear power plants. If any proposed ANR would generate more mixed wastes than is assumed in this GEIS, the associated impacts would need to be assessed in the site-specific Environmental Report developed for the licensing of that facility.

The types of mixed wastes generated at nuclear power plants include organics (e.g., liquid scintillation fluids, waste oils, halogenated organics), metals (e.g., lead, mercury, chromium, and cadmium), solvents, paints, cutting fluids, cleaning and refrigeration effluents, and corrosives from acids. The quantity of mixed waste generated varies considerably from plant to plant (NRC 1996-TN288). Overall, the quantities generated during operations are generally relatively small, but because of the added complexity of dual regulation, it is more problematic for plant owners to manage and dispose of mixed wastes than the other types of wastes. Similar to hazardous waste, mixed waste is generally accumulated onsite in designated areas as authorized under RCRA, then shipped offsite for treatment as appropriate and for disposal. The only disposal facilities that are authorized to receive mixed LLRW for disposal at present are the Energy*Solutions* and the WCS facilities (NRC 2013-TN2654).

The NRC staff assumes that an ANR licensee would manage mixed waste in accordance with appropriate regulations and BMPs. In addition, the NRC staff assumes that a licensee for an ANR would produce waste in quantities that would allow classification as a small-quantity generator of hazardous waste, based on the design features of ANRs and the fact that other large LWRs can meet the classification.

3.10.1.2 Radiological Waste Impacts

The NRC staff identified three environmental issues for analysis of waste management associated with an ANR:

- LLRW
- onsite spent nuclear fuel management
- mixed waste.

3.10.1.2.1 Low-Level Radioactive Waste

The NRC staff assumes the ANR site would have sufficient storage for LLRW. The NRC dose limitations (10 CFR Part 20-TN283) would apply for both public and occupational radiation exposure for any onsite facilities (see Section 3.8.1 of this GEIS). The radiological environmental monitoring programs around nuclear power plants that operate such facilities show that the increase in radiation dose at the site boundary is not significant (NRC 2013-TN2654). The NRC staff has concluded that doses to members of the public from the operation of onsite LLRW storage facilities would have a minimal impact.

In addition, the NRC staff assessed in the License Renewal GEIS the impacts of onsite LLRW storage at currently operating nuclear power plants and concluded that the radiation doses to offsite individuals from onsite LLRW storage are not significant (NRC 2013-TN2654). The expected types of LLRW generated by ANRs would be very similar to those generated by currently operating nuclear power plants (i.e., LLRW in the form of contaminated protective shoe covers and clothing, wiping rags, mops, filters, equipment and tools, etc.), although the amount is expected to be less because the ANR designs involve sealed reactor systems (e.g., microreactors) and fewer operational maintenance activities, which include only typical sources of LLRW (listed above). The building and operation activities for these onsite ANR LLRW storage facilities would be similar to those of LLRW storage facilities for existing nuclear power plants. However, the magnitude of the impact is expected to be less, based on factors such as less complex reactor systems, remote maintenance operations, and reduced maintenance activities generating reduced volumes of LLRW.

For the shipment of LLRW offsite to a licensed disposal site (as discussed in Section 3.10.1.1.1), the NRC staff assumes that the quantities shipped and associated impacts would be bounded by the impact assessment provided in Section 4.11.1.1 and by the data in Table 3.11-1 of the License Renewal GEIS (NRC 2013-TN2654) related to the volume and activity of LLRW shipped offsite in 2006 for 10 power plant sites. This information is incorporated here by reference.

The NRC staff concluded that there should be no significant issues or environmental impacts associated with onsite storage of LLRW generated by nuclear power plants, including ANRs. Onsite storage facilities would be used until the wastes could be safely shipped to licensed LLRW disposal facilities as previously discussed. The NRC staff considers impacts of LLRW management to be SMALL and a Category 1 issue, because of expected compliance with regulations and policies governing radiological waste management. The staff relied on the following PPE assumptions to reach this conclusion:

- Applicants must meet the regulatory requirements of 10 CFR Part 20 (TN283) (e.g., 20.1406 and Subpart K), 10 CFR Part 61 (TN252), 10 CFR Part 71 (TN301), and 10 CFR Part 72 (TN4884).

- Quantities of LLRW generated at an ANR would be less than the quantities of LLRW generated at existing nuclear power plants, which generate an average of 21,200 ft^3 (600 m^3) and 2,000 Ci (7.4×10^{13} Bq) per year for boiling water reactors and half that amount for pressurized water reactors (NRC 2013-TN2654).

As discussed above, in previous assessments the NRC staff concluded that there would be no significant environmental impacts associated with onsite storage of LLRW generated by nuclear power plants, and this conclusion can be applied to ANRs addressed in this GEIS. Onsite storage facilities would likely be used at ANRs until these wastes could be safely shipped to licensed LLRW disposal facilities as previously discussed. Currently operating LLRW disposal facilities have adequate capacity to accommodate the increased demand from ANRs. The NRC staff considers impacts of LLRW management to be SMALL and a Category 1 issue based on the information already available about LLRW management for currently operating nuclear facilities and because of expected compliance with regulations and policies governing radiological waste management.

3.10.1.2.2 Onsite Spent Nuclear Fuel and High-Level Waste Management

Because an ANR is assumed to generate less spent nuclear fuel than currently operating reactors in the United States (i.e., due to smaller cores and longer core lifetimes), the NRC staff assumes that the impacts of onsite spent nuclear fuel management at ANR facilities would be bounded by the impacts of spent nuclear fuel storage at current nuclear power plants. The environmental impacts of storage are assessed for current nuclear power plants in the context of operating license renewal in Section 4.11.1.2 of the License Renewal GEIS (NRC 2013-TN2654). Current and potential environmental impacts from spent nuclear fuel storage onsite at the reactor sites are well understood and the environmental impacts during the license renewal term were found to be small (NRC 2013-TN2654). Offsite spent nuclear fuel storage and disposal impacts are addressed in Section 3.14.2.6 of this GEIS. During the operational lifetime of the ANR, appropriate handling and storage of spent nuclear fuel must be performed in accordance with NRC regulations (e.g., 10 CFR Part 72-TN4884). While liquid-fuel molten-salt reactors (MSRs) could process the molten salt to remove fission products and other radionuclides, the resulting high-level and TRU waste must be handled and stored in accordance with NRC regulations (see Section 3.14.2.5 for discussion of reprocessing). Assuming an appropriate decay time, ANR management of spent nuclear fuel would be similar to current reactor sites and use similar ISFSIs, with a currently approved cask design or a specially designed spent nuclear fuel storage facility or dry cask storage system. The NRC staff assumes that radiological impacts would be within regulatory limits; thus, the environmental impacts of onsite storage during operations would be SMALL. The NRC staff's overall conclusion about onsite management of spent nuclear fuel, high-level waste, and TRU waste during the licensed lifetime of ANR operations is that the environmental impacts would be minor. This is a Category 1 issue. The staff relied on the following PPE assumptions to reach this conclusion:

- Compliance with 10 CFR Part 72 (TN4884).

3.10.1.2.3 Mixed Waste

ANRs could also be expected to generate small quantities of mixed waste. The waste at the ANR site would either be treated onsite or sent offsite for treatment followed by disposal at a permitted landfill licensed to accept mixed waste. The comprehensive regulatory controls and the facilities and procedures that are in place at nuclear power plants ensure that the mixed waste is properly handled and stored. The NRC staff assumes that the radioactive dose and exposure to toxic materials from mixed waste should have a small contribution to LLRW impacts based on existing impacts at current LWRs, as was assessed in the License Renewal GEIS (NRC 2013-TN2654 [see Section 4.11.1.4, Mixed Waste Storage and Disposal]). Therefore, the radiological and nonradiological environmental impacts from the long-term disposal of mixed waste for any individual ANR is considered SMALL. This is a Category 1 issue. The staff relied on the following PPE assumptions to reach this conclusion:

- RCRA Small-Quantity Generator (EPA 2020-TN6590) for Mixed Waste.

3.10.2 Nonradiological Waste Management

3.10.2.1 Baseline Conditions and PPE/SPE Values

Baseline conditions influencing nonradiological waste impacts associated with building and operation of an ANR include consideration of waste forms, classifications, and exposure pathways. Nonradiological waste can exist in a gaseous, liquid, or solid form. Nonradiological waste can further be classified as hazardous or nonhazardous. When hazardous waste is combined with radiological waste it is referred to as mixed waste. Mixed waste is addressed in Section 3.10.1.2.3. Exposure pathways to nonradiological waste can be either through inhalation, ingestion, or absorption. See Section 3.3.1 for information regarding air quality, Section 3.4.1 for water resources, Section 3.8.1 for public and occupational health information, Section 3.11.1 for postulated accidents, and Section 3.15.1 for transportation of fuel and waste.

The assumption of the PPE/SPE developed for this ANR GEIS is that the licensee must meet all applicable permit conditions and regulations, and perform all appropriate BMPs related to solid, liquid, and gaseous waste. The NRC staff also assumes that licensees would implement mitigation measures, such as recycling, along with using the least hazardous substance in its operations, as appropriate.

Hazardous waste is defined by the EPA in 40 CFR Part 261 (TN5092). Hazardous wastes may be wastes that are specifically listed as known hazardous wastes or wastes that have one or more characteristics of ignitability, corrosivity, reactivity, or toxicity. Types of hazardous wastes common to ANRs or electric power generation facilities include waste paints, lab packs, and solvents. Per the License Renewal GEIS (NRC 2013-TN2654), most LWRs accumulate their hazardous waste onsite as authorized under RCRA (42 U.S.C. §§ 6901 *et seq.*; TN1281) and transport it to treatment facilities for processing (NRC 2013-TN2654). The remaining residues are sent to permanent disposal facilities. A class of hazardous waste called universal waste is handled differently than hazardous waste, and includes batteries, pesticides, mercury-containing equipment, light bulbs, and aerosol cans. Federal universal waste regulations can be found in 40 CFR Part 273 (TN6587). All aspects of hazardous waste, such as generation, treatment, transportation, and disposal, are regulated by the EPA or by States under agreements with the EPA per the regulations set forth under RCRA.

RCRA also defines categories of hazardous waste generators (EPA 2020-TN6590). These types include large-quantity generators, small-quantity generators, and very small-quantity generators. Very small-quantity hazardous waste generators create 220 lb (100 kg) or less per month of hazardous waste or 2.2 lb (1 kg) or less per month of acutely hazardous waste. Small-quantity hazardous waste generators create more than 220 lb (100 kg) but less than 2,200 lb (1,000 kg) of hazardous waste per month. Large-quantity hazardous waste generators create 2,200 lb (1,000 kg) per month or more of hazardous waste or more than 2.2 lb (1 kg) per month of acutely hazardous waste. The ESPs application for the Clinch River small modular reactor expected the facility to qualify as a small-quantity generator (TVA 2019-TN6589). The ESPs application for the Public Service Enterprise Group stated that it maintains the program required of a small-quantity generator (PSEG 2014-TN3452). The assumption of the PPE/SPE developed for the ANR GEIS is that the proposed plant would conform to RCRA regulations.

Nonhazardous waste is waste that is not contaminated with either radionuclides or hazardous chemicals. These wastes include office trash, paper, wood, oils not mixed with hazardous waste or radiological waste, and sewage. Solid wastes, defined as nonhazardous by 40 CFR Part 261 (TN5092) are collected and disposed of in a landfill. Sanitary wastes defined as nonhazardous by 40 CFR Part 261 are treated either at an onsite sewage treatment plant (as in the case of many large-scale industrial facilities), discharged directly to a municipal sewage system for treatment, or discharged to onsite septic tanks. The assumptions of the PPE/SPE developed for the ANR GEIS is that the quantity of water discharged to a municipal system would be within the receiving system's capacity, as noted in Appendix G.

Large LWRs have nonradioactive waste management systems in place that manage both hazardous and nonhazardous wastes. For example, boiler blowdown, water treatment wastes, boiler metal cleaning wastes, laboratory and sampling wastes, floor and yard drains, and stormwater runoff are all managed by these systems and are regulated by an NPDES permit, with the exception of wastes in solid form (NRC 2013-TN2654). See Section 3.4 for further discussion of water resources. The NRC staff assumes that ANRs would have some of the same systems as a large LWR, although ANR designs may vary.

3.10.2.2 Nonradiological Waste Impacts

The NRC has assessed nonradiological waste impacts arising from the existing operating fleet during license renewal assessments and from proposed new reactors as part of the COL and ESP process under 10 CFR Part 52 (TN251). Nonradiological waste impacts resulting from the refurbishment and operation of typical large LWRs in the existing U.S. fleet are evaluated in the License Renewal GEIS (NRC 2013-TN2654). Nonradiological waste impacts from building and operating LWRs have been evaluated in several EISs and the impacts were found to be SMALL. Impacts of nonradiological waste from building and operating an ANR would generally be bounded by the impacts associated with large LWRs. See Section 3.3.2 for impacts on air quality, Section 3.4.2 for impacts on water resources, Section 3.8 for impacts on public and occupational health, Section 3.11.2 for impacts of postulated accidents, and Section 3.15.2 for impacts of the transportation of fuel and waste.

3.10.2.2.1 Environmental Consequences of Construction

The primary nonradiological waste impacts of building a new ANR would be those associated with building activities. Impacts would include the generation, handling, and disposal of waste and would be bounded by those of any large-scale construction project. Building waste impacts would depend on whether the ANR was built at a greenfield (undeveloped land), brownfield (previously developed land available for redevelopment), or currently industrialized site. Potential types of nonradioactive wastes expected from building an ANR would include construction debris, spoils, stormwater runoffs, municipal and sanitary waste, dust, hazardous waste from construction equipment maintenance (e.g., oils and solvents), and air emissions. Impacts are categorized into one of three waste types: solid, liquid, and gaseous.

Building an ANR could result in solid waste materials such as construction debris from excavation, land clearing, and municipal waste. Debris could either be shipped to a local construction debris landfill or the licensee could construct and operate its own onsite landfill. For example, the Tennessee Valley Authority proposed to construct and operate an onsite landfill in its application for an ESPs (TVA 2019-TN5854). The NRC staff assumes municipal and hazardous solid waste would be handled and shipped to the appropriate licensed disposal facility in accordance with applicable regulations. If a licensee were to construct an onsite landfill, those impacts would be considered in a project-specific EIS.

Building activities related to building an ANR could result in liquid waste, such as stormwater runoffs. Surface water and groundwater have the potential to be affected by building activities. The NRC staff assumes the applicant for an ANR would obtain an NPDES permit for stormwater discharges and maintain a Stormwater Pollution Prevention Plan to minimize potential impacts. The NRC staff also assumes that an erosion and sediment control plan would be implemented as part of the NPDES permit. In addition, the NRC staff assumes sanitary wastes would be handled and shipped to the appropriate license disposal facility, such as a local municipal sanitary waste facility. Mitigation for stormwater runoff could include creation of berms around temporary spoils areas, trenching, drainpipes, culverts, and swales to direct runoff to retention ponds. Dewatering at the construction site could be expected for the nuclear island area if the design of the ANR calls for subsurface installation of major components. Mitigation could include use of horizontal drains to direct water to sumps, grouting to prevent inflow of groundwater, and pumping water from sumps to construction-stormwater management systems. Impacts of dewatering are discussed in Section 3.4.

In addition, building activities could result in gaseous waste. Examples of gaseous waste include construction equipment and vehicle emissions and fugitive dust from earthmoving activities. Air permits are required for construction activities. In addition, the NRC staff assumes licensees would use BMPs, such as stabilizing construction roads and spoil piles, covering haul trucks, watering unpaved construction roads, and maintaining equipment in proper working order, as discussed in Section 3.3.

The staff has determined that nonradiological waste impacts during construction of an ANR are a Category 1 issue. The staff concluded that as long as the applicable PPE and SPE values and assumptions are met, the nonradiological waste impacts from building an ANR can be generically determined to be SMALL. The staff relied on the following PPE values and assumptions to reach this conclusion:

- The applicant must meet all the applicable permit conditions, regulations, and BMPs related to solid, liquid, and gaseous waste management.
- For hazardous waste generation, applicants must meet conformity with hazard waste quantity generation levels in accordance with RCRA.
- For sanitary waste, applicants must dispose of sanitary waste in a permitted process.
- For mitigation measures, the applicant would perform mitigation measures to the extent practicable, such as recycling, process improvements, or the use of a less hazardous substance.

3.10.2.2.2 Environmental Consequences of Operation

The NRC staff assumes the nonradiological waste impacts of operating a new ANR would be smaller than those experienced during building and would depend on the design of the ANR. Impacts would result from the generation, handling, and disposal of nonradiological waste. Such waste can be classified as either hazardous or nonhazardous and found in solid, liquid, or gaseous forms. Depending on the ANR design, some waste streams may be reduced or eliminated relative to a large LWR. For instance, reactors moderated by substances other than water may not have a significant water footprint.

ANR operational activities could result in solid waste materials such as office waste, cardboard, wood, metal, sewage treatment sludge, and resins. The NRC staff assumes municipal (office trash) and hazardous solid waste would be handled and shipped to the appropriate licensed disposal facility in accordance with the applicable regulations, while cardboard, paper, wood pallets, and metal would be recycled, as appropriate. BMPs regarding solid waste for an ANR would be similar to those already in use for large LWRs.

The operation of an ANR could result in liquid waste materials such as chemicals, biocides (for control of algae), and stormwater runoff. These discharges would be from cooling or other operations of the ANR and would be managed in accordance with Federal, State, local or tribal regulations. Sanitary waste would either be discharged to a permitted municipal sanitary system or treated in an onsite sanitary system. The NRC staff assumes the licensee would comply with all applicable permits and use BMPs to control liquid waste materials.

Gaseous waste materials would come from operation of diesel generators, fossil-fuel boilers, and from the coolant system (i.e., if the ANR was a gas-cooled reactor). Section 3.3 contains further information about air quality impacts. Gaseous wastes include carbon monoxide (CO), nitrogen oxides (NO_x), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), particulate matter (PM), and VOCs for diesel-, natural-gas-, and oil-fired units. Gaseous waste materials associated with an ANR would be managed in accordance with Federal, State, local, or tribal regulations. In addition, the NRC staff assumes the licensee to comply with all applicable permits and use BMPs for these wastes.

Mitigation for waste management could include recycling, improving an operational process, or using a less hazardous chemical, such as using aqueous ammonium versus anhydrous ammonia.

The staff has determined that nonradiological waste impacts during operation of an ANR are a Category 1 issue. The staff concluded that as long as the applicable PPE and SPE values and assumptions are met, the nonradiological public and occupational health impact from building an ANR can be generically determined to be SMALL. The staff relied on the following PPE values and assumptions to reach this conclusion:

- The applicant must meet all the applicable permit conditions, regulations, and BMPs related to solid, liquid, and gaseous waste management.
- For hazardous waste generation, applicants must meet conformity with hazard waste quantity generation levels in accordance with RCRA.
- For sanitary waste, applicants must dispose of sanitary waste in a permitted process.
- For mitigation measures, the applicant would perform mitigation measures to the extent practicable, such as recycling, process improvements, or the use of a less hazardous substance.

3.11 Postulated Accidents

3.11.1 Baseline Conditions and PPE/SPE Values and Assumptions

3.11.1.1 Design Basis Accidents Involving Radiological Releases[21]

Radiological effects from a postulated accident from such nuclear facilities are considered for their impacts with respect to the following regulatory requirements:

- 10 CFR 50.34(a)(1) (TN249), "Contents of applications; technical information"
- 10 CFR 52.79(a)(1)(A) (TN251), "Contents of applications; technical information in final safety analysis report."

Based on the regulations, whether it is a non-LWR or LWR design, the ANR design basis accident (DBA) analysis must satisfy the following:

- For the exclusion area boundary, the maximum total effective dose equivalent (TEDE) for any 2-hour period during the radioactivity release should be calculated.
- For the low-population zone, the TEDE should be calculated for the duration of the accident release (i.e., 30 days, or other duration as justified).
- Comparison of the DBA doses with the dose criteria given in regulations related to the application (e.g., 10 CFR 50.34(a)(1) [TN249], 10 CFR 52.17(a)(1) and 10 CFR 52.79(a)(1) [10 CFR Part 52-TN251]), standard review plans (SRPs) (e.g., SRP criteria, Table 1 in SRP Section 15.0.3 of NUREG-0800 [NRC 2007/2019-TN6221]), and RGs, (e.g., RG 1.183 [NRC 2000-TN517]), as applicable.

The radiological environmental impacts provided in this section would also bound a potential fusion reactor. Such an ANR must still meet the same regulatory requirements as previously presented. In addition, the expected radionuclide inventory (e.g., principally tritium with some activated dust particles), release amounts (such as several kilograms of tritium), and motive force from the spectrum of postulated fusion accidents should be significantly less than the fission products and transuranic elements released from a fission reactor undergoing a core-melt accident.

3.11.1.2 Accidents Involving Releases of Hazardous Chemicals

The effects of hazardous chemical releases from nearby facilities have traditionally been reviewed as part of safety reviews for their effects on control room habitability (see NUREG-0800, Section 2.2.1–2.2.2, Identification of Potential Hazards in Site Vicinity, and Section 6.4, Control Room Habitability System; NRC 2007-TN613).

EPA also regulates hazardous chemicals. For example, the Risk Management Plan Rule (40 CFR Part 68-TN5494) requires facilities that produce, process, or store extremely hazardous substances must identify hazards associated with an accidental release, design and maintain a safe facility, prepare a Risk Management Plan (RMP) and minimize consequences of accidental releases that occur. Facilities holding more than a threshold quantity (TQ) of a

[21] For the purposes of this GEIS, "Design Basis Accidents" are related to a spectrum of accidents that will be evaluated for satisfying siting requirements (e.g., 10 CFR Part 100) and the safety analysis requirements (e.g., 10 CFR Part 50, Part 52) or the applicable NRC safety and siting regulations in place at the time the application is docketed).

regulated substance in a process are required to comply with 40 CFR Part 68 (TN5494). As provided in 40 CFR 68.130, Tables 1, 2, 3, and 4 list the regulated substances and their TQs.

The Emergency Planning and Community Right-to-Know Act (EPCRA) requires that if an extremely hazardous substance (EHS) in quantities at or above the Threshold Planning Quantity (TPQ) is present at a facility, then certain emergency planning activities must be conducted. For example, Local Emergency Planning Committees (LEPCs) must develop emergency response plans and the facility owner or operator must notify the State Emergency Response Commission or Tribal Emergency Response Commission and their LEPC if any of the EHS is present at the facility or above its TPQ. The EHSs and their TPQs are listed in 40 CFR Part 355, Appendices A and B (40 CFR Part 355-TN5493).

Because of the potential for the use of hazardous chemicals in the operation of an ANR, there is also the potential for releases of hazardous chemicals as a result of postulated accidents. In developing the PPE values and assumptions pertaining to accidents involving releases of hazardous chemicals, the staff assumed that if a regulated substance or EHS is present at an ANR facility in quantities less than the requirement for establishing an RMP and offsite emergency planning, then the consequences of releases of these hazardous chemicals would be small. To establish the PPE, the staff is applying the list of regulated substances and TQs contained in 40 CFR 68.130, and the list of EHSs and TPQs contained in 40 CFR Part 355, Appendices A and B (TN5493). The PPE assumptions are as follows:

- ANR inventory of a regulated substance is less than its TQ. TQs are found in 40 CFR 68.130, Tables 1, 2, 3, and 4 (TN5494); and
- ANR inventory of an EHS is less than its TPQ. TPQs are found in 40 CFR Part 355, Appendices A and B (TN5493).

If the PPE above is exceeded and an ANR facility has the potential to release hazardous chemicals from licensed operations, the applicant should provide an analysis in the ER that estimates the consequences to members of the public in the event of such a release. Generally available information or protective emergency guidelines can be useful when characterizing the consequences (e.g., Acute Exposure Guideline Levels (AEGLs), [22] Emergency Response Planning Guidelines,[23] Temporary Emergency Exposure Limits (TEELs),[24] or Protective Action Criteria for Chemicals (PACs).[25] Relevant analysis prepared for compliance with other State or Federal regulations (e.g., an RMP submitted under 40 CFR Part 68 [TN5494]) should be provided as applicable.

3.11.1.3 Severe Accidents

The Commission provided direction to the staff for the environmental assessment of severe accidents in their policy statement entitled "Nuclear Power Plant Accident Considerations Under

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[22] Acute Exposure Guideline Levels (AEGLs) are guidelines designed to help responders deal with emergencies involving chemical spills or other catastrophic events during which members of the general public are exposed to a hazardous airborne chemical (NOAA ORR 2019-TN7023).

[23] Emergency Response Planning Guidelines (ERPGs) are guidelines designed to anticipate the health effects from exposure to certain airborne chemical concentrations (NOAA ORR 2019-TN7024).

[24] Temporary Emergency Exposure Limits (TEELs) are guidelines designed to predict the response of members of the general public to different concentrations of a chemical during an emergency response incident (NOAA ORR 2020-TN7025).

[25] The Protective Action Criteria for Chemicals data set is a hierarchy-based system of the three common public exposure guideline systems (AEGLs, ERPGs, and TEELs) (NOAA ORR 2020-TN7026).

the National Environmental Policy Act of 1969," which includes the following statements (45 FR 40101-TN4270):

> It is the position of the Commission that its Environmental Impact Statements, pursuant to Section 102(c)(i) of the National Environmental Policy Act of 1969 [42 U.S.C. §§ 4321 *et seq.*; TN661], shall include a reasoned consideration of the environmental risks (impacts) attributable to accidents at the particular facility or facilities within the scope of each such statement. In the analysis and discussion of such risks, approximately equal attention shall be given to the probability of occurrence of releases and to the probability of occurrence of the environmental consequences of those releases. Releases refer to radiation and/or radioactive materials entering environmental exposure pathways, including air, water, and groundwater.

and

> The environmental consequences of releases whose probability of occurrence has been estimated shall also be discussed in probabilistic terms. Such consequences shall be characterized in terms of potential radiological exposures to individuals, to population groups, and, where applicable, to biota. Health and safety risks that may be associated with exposures to people shall be discussed in a manner that fairly reflects the current state of knowledge regarding such risks. Socioeconomic impacts that might be associated with emergency measures during or following an accident should also be discussed. The environmental risk of accidents should also be compared to and contrasted with radiological risks associated with normal and anticipated operational releases.

The technical rationale for evaluation of the applicant's severe accident analysis is discussed in Section 7.2 of the Environmental Standard Review Plan (ESRP; NRC 2007-TN5141) as follows:

> The Commission has determined that the evaluation of events or accident sequences that lead to releases shall include, but not be limited to, those events or sequences that can reasonably be expected to occur. It has also stated that the environmental consequences of releases whose probability of occurrence has been estimated shall be discussed in probability terms. The consequences of the accidents that can reasonably be expected to occur are expressed in terms of potential exposure to individuals; the consequences of severe accidents referred to as probabilistic accidents in the policy statements [50 FR 32138-TN4519, 51 FR 30028-TN594] are characterized in terms of exposure to population groups.
>
> Releases refer to radiation or radioactive materials or both entering environmental exposure pathways, including air, water, and groundwater. In-plant accident sequences that can lead to a spectrum of releases shall be discussed and shall include sequences that can result in inadequate cooling of reactor fuel and melting of the reactor core. The events arising from causes external to the plant that are considered possible contributors to the risk associated with the plant should be discussed. Socioeconomic impacts associated with emergency measures during or following an accident should also be discussed, and the environmental risks compared to and contrasted with

radiological risks should be associated with normal and anticipated operational releases.

The Commission also takes the position that detailed quantitative considerations that form the basis of probabilistic estimates of releases do not need to be incorporated into the EIS, but may be referenced, including references to safety evaluation reports.

3.11.1.4 Severe Accident Mitigation Design Alternatives

The purpose of the evaluation of severe accident mitigation alternatives (SAMAs) is to determine whether there are severe accident mitigation design alternatives (SAMDAs), procedural modifications, or training activities that can be justified to further reduce the risks of severe accidents (NRC 2000-TN614). Because ANRs are not anticipated to have established appropriate training and procedures to address severe accidents, this review will only focus on SAMDAs.

The current guidance for SAMAs is based on several documents, including NUREG/BR-0058, *Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission* (NRC 2004-TN670), and NUREG/BR-0184, *Regulatory Analysis Technical Evaluation Handbook* (NRC 1997-TN676), with industry guidance for license renewals provided in Nuclear Energy Institute (NEI) 05-01, *Severe Accident Mitigation Alternatives (SAMA) Analysis, Guidance Document* (NEI 2005-TN1978). However, the expected probabilities for an ANR severe accident could be very low. In such a case, a simple SAMA screening could determine whether a detailed SAMA evaluation is necessary, or that a potentially cost-beneficial SAMA does not exist.

The screening process should be based on the available risk information from the Final Safety Analysis Report (FSAR)/Preliminary Safety Analysis Report (PSAR) and apply selected cost formulas from NUREG/BR-0184 (NRC 1997-TN676) as a first step rather than a last step, as prescribed under current SAMA practices. The cost formulas for occupational exposure risk cost, cleanup and decontamination risk cost, and replacement power risk cost are all independent of offsite consequences and have input parameters that should be readily available. If the resulting partial maximum benefit cost is clearly low enough that even the largest hypothetical offsite population dose and offsite economic risks for the ANR design could not raise the maximum benefit to match or exceed the lowest possible implementation cost for any design alternative, then there cannot be a potentially cost-beneficial SAMA. However, if the screening cannot reach such a conclusion, then a detailed SAMA evaluation is necessary using the abovementioned guidance documents.

The current guidance referenced above uses core damage frequency (CDF) to express the probability of severe accidents that have a potential effect on the environment, including in cost formulas. CDF is a value that is determined in LWR probabilistic risk assessments (PRAs). However, such a parameter may not be available or applicable to non-LWR PRAs. For non-LWR SAMA screening and assessments, event or release category frequency could be used in place of CDFs.

3.11.1.5 Acts of Terrorism

Previous U.S. Courts of Appeals decisions addressed the circumstances under which the NRC must assess the environmental impacts of potential acts of terrorism and sabotage. The U.S.

Court of Appeals for the Ninth Circuit held that the NRC could not categorically refuse to consider the consequences of a terrorist attack in an analysis under NEPA.[26] The Commission thereafter stated it would adhere to the Ninth Circuit's decision by considering the potential impacts of a terrorist attack in making licensing decisions for facilities located within the Ninth Circuit's jurisdiction but it would not consider terrorist attacks in licensing decisions outside of that court's jurisdiction.[27]

The U.S. Court of Appeals for the Third Circuit disagreed with the Ninth Circuit's analysis of NEPA case law.[28] Instead, as the Commission had originally held, the Third Circuit concluded that the issuance of a facility license would not be the "proximate cause" of a terrorist attack on the facility.[29] Moreover, the Third Circuit noted that the License Renewal GEIS (NRC 1996-TN288) had reviewed the possible impacts of a sabotage event, which is a form of terrorism. The License Renewal GEIS found that the consequences of a sabotage event would be no worse than those expected from an internally initiated severe accident. As a result, the Third Circuit found that, even if the Commission were required to analyze the impacts of a terrorist attack, the NRC could not have evaluated the risks more meaningfully than it had already done for internally initiated severe accidents.[30]

These court decisions related to NEPA evaluations of terrorist attacks and the NRC staff's subsequent evaluations to address them are discussed in Section E.3, Accident Risk and Impact Assessment, of Appendix E, Environmental Impact of Postulated Accidents, to the License Renewal GEIS (NRC 2013-TN2654), and in Section 4.19, Potential Acts of Sabotage or Terrorism, of NUREG-2157 (NRC 2014-TN4117), which are incorporated herein by reference.

As a result of these court decisions, the NEPA evaluation of an application for an ANR to be located at a site within the Ninth Circuit's jurisdiction would need to address acts of terrorism. For sites not within the jurisdiction of the Ninth Circuit, the NEPA evaluation would not address acts of terrorism.

As described in Appendix E of the License Renewal GEIS (NRC 2013-TN2654) and in Section 4.19 of NUREG-2157 (NRC 2014-TN4117), the NRC will continue to address facility physical security measures, including the prevention of and response to terrorist attacks, through its ongoing regulatory and inspection processes. The NRC routinely assesses threats and other information provided by a variety of Federal agencies and sources. The NRC also ensures that licensees meet appropriate security-level requirements. In this regard, the NRC views facility physical security measures as a current, ongoing, and generic regulatory issue that affects all nuclear facilities.

3.11.2 Postulated Accidents Impacts

The risks from ANR accidents may be limited. A major emphasis for the development of ANRs is the minimization (i.e., a very low probability of an accident with an offsite radiological or hazardous chemical release) or the elimination of radioactive or hazardous chemical releases

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[26] *San Luis Obispo Mothers for Peace v. NRC*, 449 F.3d 1016 (9th Cir. 2006) (San Luis Obispo Peace v. Nuclear Regulatory 2006-TN6959).
[27] *AmerGen Energy Co., LLC* (Oyster Creek Nuclear Generating Station), CLI-07-8, 65 NRC 124, 126, 128 (NRC 2007-TN6957).
[28] *New Jersey Dep't of Environmental Protection v. NRC*, 561 F.3d 132 (3rd Cir. 2009) (NJ Dept. of Environmental Protection v. NRC-TN6958).
[29] *Id.*, 561 F.3d at 140.
[30] *Id.*, 561 F.3d at 134, 136, 143-44.

from accidents. Thus, the risks from ANR accidents may be limited as presented in the FSAR/PSAR of the ANR application. However, the staff cannot prejudge the level of safety of an ANR design a priori and, therefore, cannot rule out the need for a postulated accident analysis in future license applications. To this end, this section also incorporates the related guidance on postulated accidents and SAMAs from ISG-029, "Environmental Considerations Associated with Micro-reactors" (NRC 2020-TN6710).

To support the licensing of non-LWR designs, the staff developed and published RG 1.233, *Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors* (NRC 2020-TN6441). The selection of licensing-basis events; classification and special treatments of structures, systems, and components (SSCs); and assessment of defense-in-depth are fundamental to the safe design of non-LWRs. The guidance provided in RG 1.233 may assist in the development of the ANR applicant's accident analysis in the FSAR/PSAR. Regardless of whether or not an ANR applicant chooses to conform to RG 1.233, the applicant is required to provide an evaluation of events including accident analyses, and for Part 52 applicants, a description, and the results of the project-specific probabilistic risk assessment in the FSAR/PSAR, which may be incorporated by reference in the ANR application's ER in order to meet the PPE assumptions.

Although many ANR designs are for non-LWRs, because of the variety of potential ANR designs, the development of an LWR ANR design is possible. Thus, this section addresses both classes of ANRs because the accident analysis is tied to possible radioactive releases from postulated accidents and not for a specific type of an ANR design.

Based on the analyses in Section 3.11.1 above, the following five environmental issues related to impacts from postulated accidents associated with an ANR are discussed:

- design basis accidents involving radiological releases
- design basis accidents involving releases of hazardous chemicals
- severe accidents
- severe accident mitigation design alternatives
- acts of terrorism.

3.11.2.1 Design Basis Accidents Involving Radiological Releases

The environmental guidance for LWR DBA evaluations is provided in the current versions of RG 4.2 (NRC 2022-TN7081) and Section 7.1 of NUREG-1555 (NRC 2013-TN3547). Prior LWR DBA environmental evaluations were slightly different than the DBA analysis considered in the safety reviews. Specifically, the environmental review of DBAs was based on applying dispersion coefficients based on 50th percentile weather data (i.e., "realistic" weather conditions) versus the 95th percentile weather data applied in the applicant's DBA analysis in Chapter 15 of the FSAR/PSAR. All other factors, such as accident categories and timeframes, were the same for the two assessments. At the conclusion of the staff's safety review, the applicant's DBA analysis would have to demonstrate to the staff that no regulatory limits were exceeded, in part, for the NRC to issue the license. This also meant that 50th percentile weather conditions used in the environmental DBA evaluation would also meet the same regulatory limits, resulting in an environmental finding of SMALL. However, given that the safety evaluation must reach a safety determination for DBAs for a license to be issued, it is reasonable to conclude that the staff can also reach an environmental finding of SMALL (i.e., by meeting regulatory requirements for safety) by relying on the DBA analysis in the applicant's FSAR/PSAR. Therefore, in future ANR applications, the staff should be able to incorporate by reference into the environmental evaluation the DBA analysis from the FSAR/PSAR and the staff's safety evaluation of DBAs.

DBAs involving radiological releases are a Category 1 issue. The FSAR/PSAR must demonstrate that the reactor falls within the regulatory limits discussed in Section 3.11.1; with incorporation by reference to the ER, the PPE values would be met, and the impacts would be SMALL. The staff relied on the following PPE assumptions to reach this conclusion:

- For the exclusion area boundary, the maximum TEDE for any 2-hour period during the radioactivity release should be calculated.
- For the low-population zone, the TEDE should be calculated for the duration of the accident release (i.e., 30 days, or other duration as justified).

The above calculations should demonstrate that the DBA doses satisfy the dose criteria given in regulations (e.g., 10 CFR 50.34(a)(1) [TN249], 10 CFR 52.17(a)(1) and 10 CFR 52.79(a)(1) [10 CFR Part 52-TN251]), SRPs (e.g., SRP criteria, Table 1 in SRP Section 15.0.3 of NUREG-0800 [NRC 2007/2019-TN6221]), and RGs, (e.g., RG 1.183 [NRC 2000-TN517]), as applicable.

3.11.2.2 Accidents Involving Releases of Hazardous Chemicals

Accidents involving releases of hazardous chemicals are a Category 1 issue. The applicant can rely on the on the generic analysis in this GEIS if the ANR inventories of regulated substances and EHSs are less than their TQs and TPQs, respectively, and the impacts would be SMALL. The staff relied on the following PPE assumptions to reach this conclusion:

- ANR inventory of a regulated substance is less than its TQ. TQs are found in 40 CFR 68.130, Tables 1, 2, 3, and 4 (TN5494); and
- ANR inventory of an EHS is less than its TPQ. TPQs are found in 40 CFR Part 355, Appendices A and B (TN5493).

3.11.2.3 Severe Accidents

Severe accidents are a Category 2 issue. Based on the analysis in the FSAR/PSAR regarding severe accidents and PRAs, if an ANR design has severe accident progressions that involve radiological or hazardous chemical releases, then an environmental risk evaluation must be performed.

3.11.2.4 Severe Accident Mitigation Design Alternatives

It is expected that for severe accidents, although a Category 2 issue, the probabilistic risk assessment provided in the safety analysis would have CDFs that would likely be substantially less than the CDFs associated with the current reactor fleet. For non-LWR SAMA screening and assessments, event or release category frequency could be used in place of CDFs. A cost screening analysis could determine that the maximum benefit of avoiding an accident is so small that a SAMDA is not justified based on the minimum cost to design an appropriate SAMDA. This is a Category 1 issue. The staff relied on the following PPE assumption to reach this conclusion:

- If a cost-screening analysis determines that the maximum benefit for avoiding an accident is so small that a SAMDA analysis is not justified based on a minimum cost to design an appropriate SAMDA.

This cost-screening process would be based on the available risk information derived from the FSAR/PSAR and would apply the cost formulas from NUREG/BR-0058 (NRC 2004-TN670). If SAMDAs are not screened out, the bounding assumption is not met, and a project-specific analysis is required. For example, the NuScale SMR 50 MWe single module has eight accident release categories and seven out of eight accident release categories have release frequencies of 2.4×10^{-9} per reactor-year or smaller (NuScale 2020-TN6811). The total estimated maximum benefit of these seven low-probability release categories would be less than $100. It is unlikely that a design mitigation alternative could be developed costing less than $100, so there is no need to develop potential mitigation strategies.

3.11.2.5 Acts of Terrorism

The NRC staff has determined that the environmental impacts of acts of terrorism and sabotage only need to be addressed if an ANR facility is subject to the jurisdiction of the U.S. Court of Appeals for the Ninth Circuit. Because the environmental impacts of a facility subject to the jurisdiction of this court cannot be determined without the consideration of project-specific factors, the potential impacts of terrorism and sabotage for these facilities would require a project-specific analysis. The necessary environmental evaluation would be performed based on the design features that provide for physical protection of the ANR from acts of terrorism and sabotage. The impacts of acts of terrorism can be mitigated by complying with the physical protection requirements under 10 CFR Part 73 (TN423), *Physical Protection of Plants and Materials*, that provide reasonable assurance that the risk from sabotage is small. If a facility is not subject to the jurisdiction of the U.S. Court of Appeals for the Ninth Circuit, then this would be a Category 1 issue, since no other jurisdiction currently requires consideration of the consequences of a terrorist attack in an analysis under NEPA.

3.12 Socioeconomics

3.12.1 Baseline Conditions and PPE/SPE Values and Assumptions

Baseline conditions influencing potential socioeconomic resources associated with the building and operation of a new nuclear reactor include the economic and social service conditions found currently in the vicinity of the site. The analysis will depend on information supplied by the applicant. The applicable NRC guidance is Section 4.4 of RG 4.2, Revision 3, *Preparation of Environmental Reports for Nuclear Power Stations* (NRC 2022-TN7081).

The NRC's Environmental Standard Review Plan (NRC 2000, 2007-TN614) suggests beginning an analysis of the economic and demographic impacts of building and operating a nuclear power reactor on an area within a 50-mile radius from the proposed plant. Depending on the size and inherent safety features of ANR designs, the radius of the analytical areas may be reduced from that starting point. The demographic region is the geographic area within a defined radius from the site for which demographic data are analyzed. Facility sites are located within economic regions defined by the local labor market. The economic region for any facility is based on the geographic area from which the facility will draw its workforce—typically a grouping of counties surrounding the site. The economic region and the demographic region may not be the same size or shape.

The socioeconomic characteristics of potential sites for new ANRs can vary widely, from sparsely populated remote outposts to industrial facilities located in major metropolitan centers. Thus, the staff adopted PPE/SPE values that are proportional metrics based on percentage changes from baseline conditions, rather than absolute values.

The PPE and SPE assume that most socioeconomic impacts are driven by changes in the local workforce employed as a result of the proposed action. The in-migration of workers and their families into an economic region for project building and operations, including outage activities, imposes new demands on local infrastructure and community services. Previous new reactor reviews also have shown that traffic impacts on local access routes may be greater than minor, but not typically destabilizing. Beneficial impacts from increased tax revenues associated with the increased assessed value of new reactor projects also tend to be noticeable within the affected economic region or local taxing jurisdiction.

Based on staff experience with new license applications for large LWRs, the NRC staff has developed PPE/SPE values for each socioeconomic resource, which, if met, allow the staff to reach a generic conclusion of beneficial or SMALL adverse impacts for that resource. The principal assumption is that the project-related workforce together with associated families would not result in a net increase in the population of the economic region that would be greater than the planned growth for that region by local agencies over the same time period. Based on workforce migration into the economic region, staff determined demand increases for infrastructure (e.g., housing availability) and services (e.g., public schools) would not result in specific thresholds being crossed. Similarly, the staff assumes that the LOS values for the affected roadways would not change as a result of the added traffic pressure from the project workforce traffic.

In summary, the NRC staff provides the following PPE/SPE values (also summarized in Appendix G):

- The peak project-related in-migrating workforce including families does not exceed established local planning and growth projections for infrastructure and service demands.
- The housing vacancy rate in the affected economic region does not change by more than 5 percent, or at least 5 percent of the housing stock remains available.
- The student:teacher ratios in the affected economic region’s classrooms do not exceed locally mandated levels after including the school age children of the in-migrating worker families.
- The LOS determination for affected roadways does not change with the addition of the commuting patterns of the building or operations workforce.

3.12.1 Socioeconomic Impacts

Socioeconomic impacts from new ANRs would occur during the building and operations phases of the project. Impacts are linked to the size of the local workforce during site preparation and the construction of safety-related facilities such as the nuclear island and non-safety-related facilities such as cooling towers, administration buildings, parking lots, switchyards, and any onsite and offsite pipelines, access roads, and transmission lines. Many smaller ANRs may lack cooling towers, switchyards, or offsite pipelines or transmission lines and may require a site of only a few acres. Larger ANRs may require some or all of these support facilities and hence require larger sites. During operations, the principal socioeconomic impacts would be from employment of the operations workforce and tax revenue generated based on the assessed value of the project.

3.12.1.1 Socioeconomic Consequences of Construction

Historically, the staff's evaluation of socioeconomic impacts for building an ANR primarily focused on the in-migration of construction workers and their resulting impacts on local community resources and infrastructure, and related economic impacts. These impacts can vary considerably from site to site and between building and operations. The NRC staff identified four socioeconomic issues for analysis of building an ANR:

- community services and infrastructure demands (specifically, housing and schools) altered by construction workers and families migrating to the local economic region; traffic impacts on local site access roadways and associated road networks; economic impacts such as employment, economic output, and local labor income; and
- tax revenue impacts, such as sales and property taxes.

3.12.1.1.1 Community Services and Infrastructure

To the degree that the size of the construction project requires the acquisition of workers from outside the economic region, impacts related to worker migration would be expected. These impacts occur as workers, including families, relocate temporarily or permanently to be closer to the site. Impacts from local workers already residing within the economic region are assumed to result in no net changes in service demands across the economic region, except as a part of traffic impacts.

The impacts of migration from outside the economic region are found by obtaining the applicant's estimate of the peak construction workforce anticipated to come from outside the economic region. In recent new reactor reviews, the NRC staff evaluated the impacts from in-migrating workers and their families in the context of the local planning authority's estimate of population growth in the economic region. If the percentage of in-migrating construction workers and their families relative to the total population of the economic region is less than the planned rate of population growth in the economic region during the construction period, the reviewer can determine the construction-related impact on housing, community services, and infrastructure are within the planning authority's management capabilities and, therefore, would be minor.

Recent new reactor reviews have shown that the principal community service affected by building a new reactor is public school systems. As families migrate into the economic region, local schools may observe increased class sizes at all levels. The PPE value of student:teacher ratio is the principal metric used to assess classroom crowding impacts. The NRC staff assumes that the impact of the new students would be minor as long as the addition of new students from in-migrating worker's families does not increase the student:teacher ratio beyond the locally mandated level.

Based on recent reviews of new reactors, the key infrastructure impact metric is housing availability. This metric is assessed in terms of the proportion of the housing stock that is available for residency. The staff assumes that the combination of available unoccupied single-family dwellings and rental housing should remain greater than 5 percent in a healthy housing market with relatively stable prices. The impact on housing would be minor, if the addition of the in-migrating workers does not change the housing supply by 5 or more percent, or if the available number of rental units in the economic region is 5 percent or more after accounting for the rental units needed for the in-migrating construction workers.

Experience reviewing new reactors has shown that other community service and infrastructure impacts are generally minor. These include impacts on first-responder resources, public utilities including potable water resources, healthcare resources, and other public services (e.g., community aid providers).

The staff has determined that the public school system and housing availability are the most likely places where impacts on community services and infrastructure can be observed during building of an ANR. The staff concludes that, as long as the applicable PPE and SPE assumptions are met, the community services and infrastructure impacts from building an ANR can be generically determined to be SMALL, and mitigation would not be warranted. Therefore, the socioeconomic impacts from building an ANR are a Category 1 issue. The staff relied upon the following PPE assumptions to reach this determination:

- The housing vacancy rate in the affected economic region does not change by more than 5 percent, or at least 5 percent of the housing stock remains available after accounting for in-migrating construction workers.
- Student:teacher ratios in the affected economic region do not exceed locally mandated levels after including the school age children of the in-migrating worker families.

3.12.1.1.2 Transportation Systems and Traffic

Facility building activities result in physical impacts on two aspects of local transportation systems in the vicinity of the site: improvements and repairs to roads in anticipation of the project, and traffic-related impacts (the decline in road service quality from construction worker commutes). Transporting materials and equipment to the proposed site may require the applicant to build or refurbish access roads, heavy-haul roads, rail spurs, and barge landing facilities. Local road access routes also may see increased wear from building-related traffic associated with the workforce commuting and deliveries. Experience from previous NEPA reviews of large nuclear power plant construction shows the adverse impacts of making road improvements are typically minor and temporary.

Construction-related traffic impacts occur as construction-related truck traffic and the workforce travel to and from the site in competition with the baseline local traffic. At the peak of building employment, these impacts can be substantial, depending on the characteristics of the access route(s). To give context to any expected traffic impacts affecting the site and local vicinity, the NRC staff uses baseline traffic statistics for the principal roadway access routes to and from the site. State and County transportation departments typically publish annual average daily traffic counts (FHWA 2018-TN6584) at key points of principal roads and highways. In addition, the NRC staff analyzes LOS information (FHWA 2017-TN6585) used by transportation planners for principal road access routes. Table 3-7 provides a summary of LOS values.

Table 3-7 Level of Service Value Descriptions

LOS	General Operating Conditions
A	Free flow, with low volumes and high speeds.
B	Reasonably free flow, but speeds beginning to be restricted by traffic conditions.
C	Stable flow, but most drivers are restricted in the freedom to select their own speeds.

LOS	General Operating Conditions
D	Approaching unstable flow; drivers have little freedom to select their own speeds.
E	Unstable flow; may be short stoppages.
F	Forced or breakdown flow; unacceptable congestion; stop-and-go.

One indicator of a noticeable impact would be a change in a LOS value for a specific roadway. The PPE and SPE values and assumptions analyzed in this GEIS assume no change in a LOS value as a result of increased traffic during peak building activities. The staff assumes such impacts would be of temporary duration (months) and limited to typical day-shift commuting patterns for the affected roadways. Section 4.4 of RG 4.2, *Preparation of Environmental Reports for Nuclear Power Stations* (NRC 2022-TN7081) regarding traffic studies and the timing of peak building activities recommends that the applicant use LOS studies to demonstrate that its project falls within the PPE value.

The NRC staff has determined that as long as the applicable PPE and SPE values and assumptions are met, the traffic impacts and impacts on the local transportation systems from building an ANR can be generically determined to be SMALL and a Category 1 issue. The staff relied upon the following PPE assumptions to reach this determination:

- The LOS determination for affected roadways does not change. Mitigation measures may include implementation of traffic flow management, management of shift-change timing, and encouragement of ride-sharing and use of public transportation options, such that LOS values can be maintained with the increased volumes.

3.12.1.1.3 Economic Impacts

Building ANR projects has financial and economic impacts on the economic region. These impacts include construction-related expenditures expected to be made by the applicant in the local economy, wages and salaries to be paid to construction workers, and the associated economic activity enabled by these expenditures. Depending on the size of the local economy, these beneficial impacts may range from substantial in small rural economies to minimal in large metropolitan economies, when viewed in the context of the overall economic activity in the region.

The NRC staff has assessed the economic impacts of building new nuclear reactors since 2005. To estimate the economic impacts of anticipated construction-related expenditures made in the local economy, the NRC relies upon simple economic input-output modeling of those expenditures to reveal the economic multiplier effect, which estimates the gross output, employment, and income effects of the direct local expenditures. Economic multiplier effects depend on several factors including the size of the initial annual expenditures and the diversity of the local economy. Economic diversity refers to how fast local expenditures leak from the economy as various rounds of economic activity occur. The more diverse the structure of the local economy, the longer direct expenditures will circulate in the economy, generating a higher multiplier effect and greater total impact on output, employment, and income. Because sites can be located in widely varying local economies, economic multiplier values range widely—typically between 1.5 and 4. For example, in the case of an employment multiplier of 3, this indicates that for each direct job created by the construction expenditures, an additional two jobs are also added as a result of the economic activity generated by the one direct construction job. The economic impacts of construction and operation of an ANR are expected to be beneficial; therefore, this is a Category 1 issue. If, during the project-specific environmental review, the NRC staff determines that detailed analysis of economic costs and benefits is needed for analysis of the range of alternatives considered or relevant to mitigation, the staff may require further information from the applicant.

3.12.1.1.4 Tax Revenue Impacts

While the greatest tax revenue impacts are generally associated with plant operations, some revenue impacts would be expected during the building of a plant. These include any local sales and use taxes paid on local or in-State purchases, service fees from local regulatory bodies (local licenses and permits, etc.), any local taxes paid by in-migrating workers and their families, or payments in lieu of taxes arranged by agreement between the applicant and the jurisdiction. Each site will have differing conditions and agreements with applicants and their contractors and thus revenue impacts during building must be considered site by site. For example, some States and local governments may offer incentives for new industrial construction projects, such as deferred property taxes or sales tax exemptions, which might minimize State and local tax revenues compared to other sites where such incentives are not offered.

As with economic impacts, the scale of construction-related tax revenue impacts attributable to the proposed action may range from substantial in small rural economies to minimal in large metropolitan economies, when viewed in the context of baseline revenues of the affected taxing jurisdiction(s) and the size of the proposed action. The staff concludes that if the ANR project would not generate tax revenues exceeding 5 percent of the revenue of any affected jurisdiction or taxing authority during building, then the impacts would be minor and may be offset by other year-to-year changes in local revenues.

The tax revenue impacts of construction and operation of an ANR are expected to be beneficial; therefore, this is a Category 1 issue. If, during the project-specific environmental review, the NRC staff determines detailed analysis of tax revenue costs and benefits is needed for analysis of the range of alternatives considered or relevant to mitigation, the staff may require further information from the applicant.

3.12.1.2 Socioeconomic Consequences of Operations

The staff's evaluation of socioeconomic impacts for operating an ANR primarily focused on workforce-induced migration, the resulting impacts on local community resources and infrastructure, and related economic impacts. Tax revenue impacts from an operating ANR facility also provide beneficial impacts on local taxing jurisdictions. These impacts can vary considerably from site to site and between building and operations. The NRC staff identified four environmental issues for analysis of operation of an ANR:

- community services and infrastructure demands (e.g., housing, schools) altered by operations workers and families migrating into the local economic region;
- traffic impacts on local site access roadways and associated road networks;
- economic impacts such as employment, economic output, and local labor income; and
- tax revenue impacts, such as sales and property taxes.

3.12.1.2.1 Community Services and Infrastructure

Based on experience with large LWRs in the current fleet, the staff assumes that an ANR's operations workforce is smaller than its construction workforce, but their presence would be more permanent. The increased number of workers at nuclear power plants during regularly scheduled plant refueling and maintenance outages creates a short-term increase in the demand for temporary housing units in the region around each plant, generally in local hotels and motels, but also in campgrounds and RV parks. However, because of the short duration and the repeated nature of these scheduled outages, as well as the general availability of rental housing units (including portable trailers) in the vicinity of nuclear power plants, employment-related housing impacts would have little or no long-term impact on the price and availability of rental housing. Refurbishment or unit replacement impacts would be similar to what is experienced during routine plant refueling and maintenance outages. Consequently, the staff determined that if the PPE assumption holds, the building-related impacts on housing are a Category 1 issue. The staff relied upon the following PPE assumption to reach this determination:

- The housing vacancy rate in the affected economic region does not change by more than 5 percent, or at least 5 percent of the housing stock remains available after accounting for in-migrating operations workers.

Experience reviewing new reactors has shown that the operations-related impacts of other community service and infrastructure resources are bounded by the building-related impacts and are generally minor. These include impacts on first-responder resources, public utilities including potable water resources, healthcare resources, and other public services (e.g., community financial aid providers, etc.). Minor impacts on public school systems might be expected because of the addition of children of the operations workforce, as families migrate into the economic region. However, because much of the building workforce would leave the area once operation begins, the impacts of the in-migrating operations workforce would be bounded by the size of the construction workforce's impact on the school system. If the building impacts on schools met the criteria for a Category 1 issue, then the operations impacts on housing and schools, being bounded by that, must also be Category 1 issue. The staff concludes that, as long as the applicable PPE and SPE assumptions are met, the community services and infrastructure impacts from operating an ANR can be generically determined to be SMALL, and mitigation would not be warranted. Therefore, the socioeconomic impacts from operating an ANR are a Category 1 issue. The staff relied upon the following PPE assumptions to reach this determination:

- Student:teacher ratios in the affected economic region do not exceed locally mandated levels after including the school age children of the in-migrating worker families.

3.12.1.2.2 Transportation Systems and Traffic

Transportation impacts depend on the size of the workforce, the capacity of the local road network, traffic patterns, and the availability of alternate commuting routes to and from the plant. Because most sites have only a single access road, there is often congestion on these roads during shift changes. Because rail and barge facilities would only be used intermittently during operations, only minimal physical impacts on transportation systems, apart from roadways (e.g., rail or barge facilities), would be expected during operations.

The transportation impact of plant operations would be bounded by the peak construction employment-related impacts and is not likely to result in degradation of LOS values. Operations-related transportation impacts continue for the life of the plant and become well established within the affected communities for all nuclear power plants. The increased number of workers at nuclear power plants during outage activities including unit replacement creates a short-term increase in traffic volumes, and this impact would vary based on the site location and size of the plant. Refurbishment impacts including unit replacement would be similar to what has been experienced during routine plant refueling and maintenance outages. However, because of the relative short duration of these outages, increased traffic volumes have had little or no lasting impact. Therefore, as long as LOS values for affected roadways do not degrade, there would be minor traffic impacts during operations.

The staff has determined that transportation system and traffic impacts during operations of an ANR are a Category 1 issue, as long as the applicable PPE and SPE assumptions are met. The staff assumes any mitigation measures needed to be able to rely on this GEIS for construction impacts would be continued during operations, such that LOS values can be maintained with expected volumes during operations. The staff relied upon the following PPE assumptions to reach this determination:

- The LOS determination for affected roadways does not change. Mitigation measures may include implementation of traffic flow management, management of shift-change timing, and encouragement of ride-sharing and use of public transportation options, such that LOS values can be maintained with the increased volumes.

3.12.1.2.3 Economic Impacts

Economic multiplier effects during operations, including outages or unit replacement activities, would be bounded by peak construction-related economic impacts, and the staff assumes that at least minor beneficial economic impacts, such as induced increases in local employment, labor income, and output, would result. The magnitude of these impacts would depend on the size and diversity of the local economy. For most anticipated ANR projects covered by this GEIS, these impacts would be minor in the context of the economic region in which they would occur.

The economic impacts of construction and operation of an ANR are expected to be beneficial; therefore, this is a Category 1 issue. If, during the project-specific environmental review, the NRC staff determines the need for detailed analysis of economic costs and benefits is needed for analysis of the range of alternatives considered or relevant to mitigation, the staff may require further information from the applicant.

3.12.1.2.4 Tax Revenue Impacts

Nuclear power plants and the workers who operate them are an important source of tax revenue for many local governments and public school systems. Tax revenues from nuclear power plants mostly come from property tax payments or other forms of payments such as payments in lieu of (property) taxes, or payments in lieu of taxes (PILT) payments, although taxes on energy production have also been collected from a number of nuclear power plants. County and municipal governments and public school districts receive tax revenue either directly or indirectly through State tax and revenue-sharing programs.

In addition to the potentially substantial contribution of property tax revenues, County and municipal governments in the vicinity of an operating nuclear power plant also receive tax revenue from sales taxes and service fees from the power plant and its employees. Changes in the number of workers and the amount of taxes paid to counties, municipal governments, and public schools can affect socioeconomic conditions in the counties and communities around the nuclear power plant.

Outage activities including unit replacement are not expected to have a noticeable effect on the assessed value of nuclear plants, thus only minimal changes in tax revenues would be anticipated from future refurbishment activities. Refurbishment activities involving the one-for-one replacement of existing components and equipment are generally not considered a taxable improvement. The addition of any nuclear reactor units beyond the scope of the license may result in increased assessed value but would be considered under separate licensing actions. Also, property tax assessments; proprietary PILT stipulations, settlements, and agreements; and State tax laws are continually changing the amount of taxes paid to taxing jurisdictions by nuclear plant owners. These changes are independent of operations activities.

The tax revenue impacts of construction and operation of an ANR are expected to be beneficial; therefore, this is a Category 1 issue. If, during the project-specific environmental review, the NRC staff determines the need for detailed analysis of tax revenue costs and benefits is needed for analysis of the range of alternatives considered or relevant to mitigation, the staff may require further information from the applicant.

3.13 Environmental Justice

3.13.1 Baseline Conditions and PPE/SPE Values and Assumptions

Under Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (59 FR 7629-TN1450), certain Federal agencies, mostly Executive Departments, are responsible for identifying and addressing potential disproportionately high and adverse human health and environmental effects on minority and low-income populations that may arise from their programs, policies, and activities. Tribal populations are included within the scope of the Order. Additionally, an affected population can be a minority population, a low-income population, or both. As an independent Federal agency, the NRC voluntarily complies with this Executive Order.

Environmental justice (EJ) effects are not assigned impact levels. They either have the potential to occur or not occur, but the effect on the minority or low-income population must be both disproportionately high and adverse when compared to the effect upon the baseline general population. Based on the NRC staff's analysis for any given action, if an EJ population is identified within the demographic region and linkage between that population and a potential disproportionately high and adverse health or environmental effects is established, then an EJ analysis is required. The NRC will perform any EJ analysis as part of the project-specific NEPA analysis prepared for the proposed action.

3.13.2 Environmental Justice Impacts

3.13.2.1 Environmental Consequences of Construction and Operation

The NRC staff has determined that potential EJ impacts during construction or operations of an ANR cannot be determined without the consideration of meaningful project-specific factors, and therefore are a Category 2 issue. Project-specific factors include the presence, geographic location, and size of specific minority or low-income populations; impact pathways derived from the plant design, layout, or site characteristics; or other community characteristics affecting specific minorities or low-income populations. In performing its EJ analysis, the NRC staff will be guided by the NRC's "Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions," which was published in the *Federal Register* on

August 24, 2004 (69 FR 52040-TN1009), and is hereby incorporated by reference into this GEIS.

3.14 Fuel Cycle

3.14.1 Baseline Conditions and PPE/SPE Values and Assumptions

3.14.1.1 Uranium Fuel Cycle Environmental Data

As discussed in Section 3.12.1.1, Uranium Fuel Cycle, of the License Renewal GEIS NRC 2013-TN2654), the NRC evaluated the environmental impacts that would be associated with operating uranium fuel cycle facilities other than reactors in two NRC documents: WASH-1248 (AEC 1974-TN23) and NUREG-0116 (NRC 1976-TN292). The types of facilities and their environmental impacts considered in these two documents include:

- uranium mining – facilities in which the uranium ore is mined;
- uranium milling – facilities in which the uranium ore is refined to produce uranium concentrates in the form of triuranium octaoxide (U_3O_8);
- UF_6 production – facilities in which the uranium concentrates are converted to UF_6;
- isotopic enrichment – facilities in which the isotopic ratio of the uranium-235 (U-235) isotope in natural uranium is increased to meet the requirements of LWRs;
- fuel fabrication – facilities in which the enriched UF_6 is converted to uranium dioxide (UO_2) and made into sintered UO_2 pellets. The pellets are subsequently encapsulated in fuel rods, and the rods are assembled into fuel assemblies ready to be inserted into the reactors;
- reprocessing – facilities that disassemble the spent fuel assemblies, chop up the fuel rods into small sections, chemically dissolve the spent fuel out of sectioned fuel rod pieces, and chemically separate the uranium in spent fuel from the plutonium for reuse and other radionuclides (primarily fission products and actinides); and
- disposal – facilities in which the radioactive wastes generated at all fuel cycle facilities, including the reactors, are buried. Spent nuclear fuel (SNF) that is removed from the reactors and not reprocessed was also assumed to be disposed of at a geologic repository.

In addition to impacts occurring at the above facilities, the impacts associated with the transportation of radioactive materials among these facilities, including the transportation of wastes to disposal facilities, were evaluated. The results were summarized in a table and promulgated as Table S–3 in 10 CFR 51.51(b) (TN250). The analysis in WASH-1248 is based on the principal environmental considerations for each component of the nuclear fuel cycle, and the aggregate considerations, normalized to the annual fuel requirement of a 1,000 MWe (3,000 MWt) model LWR are summarized for the nuclear fuel cycle in Table S–3 (AEC 1974-TN23). This normalization is called the “annual model LWR fuel requirement” throughout WASH-1248 (AEC 1974-TN23).

Figure 3-4 displays the uranium fuel cycle for the majority of pathways. Table S–3 addresses their environmental impacts related to the uranium fuel cycle, but this does not include mixed oxide fuel, as shown in the figure. Additional details about the nuclear fuel cycle are provided in Section 1.1, Uranium Fuel Cycle, of a Pacific Northwest National Laboratory (PNNL) report prepared for the NRC (Napier 2020-TN6443). The assumption applied for Table S–3 regarding plutonium recovered from recycling was that the recovered plutonium would be placed into storage for future use (see Figure S-1 of WASH-1248 [AEC 1974-TN23]).

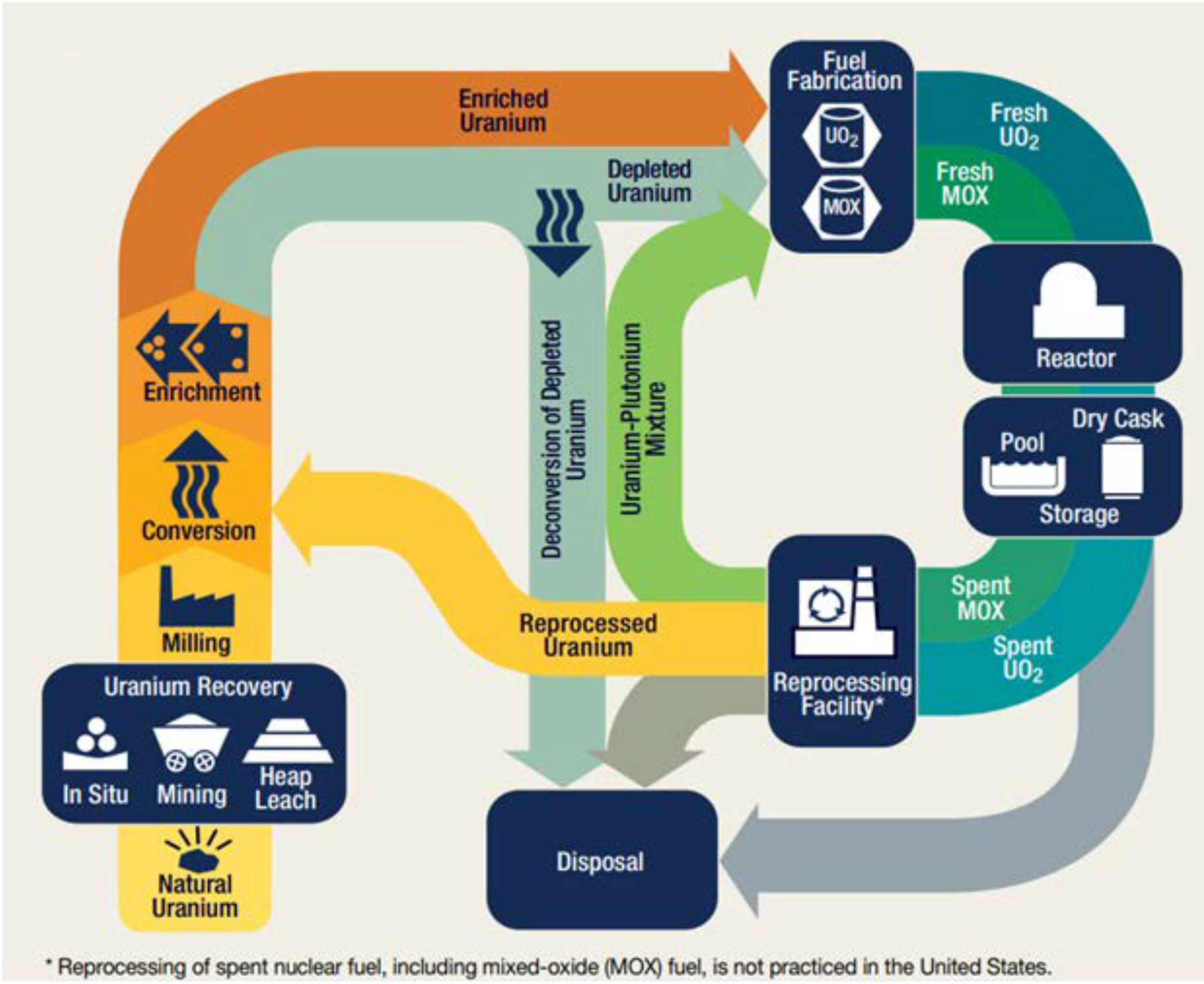

Figure 3-4 Options of the Current Fuel Cycle which Includes the Table S–3 Uranium Fuel Cycle (NRC 2019-TN6652)

The 1996 version of the License Renewal GEIS (NRC 1996-TN288) found the once-through, low-enriched uranium (LEU) fuel cycle to be a Category 1 issue with environmental findings of SMALL. This result was codified into regulations and the findings are provided in 10 CFR Part 51 (TN250), Appendix B, Table B-1, *Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants*. Section 4.12.1.1 of the License Renewal GEIS (NRC 2013-TN2654) reassessed the environmental effects listed in Table S–3 and concluded that no new information has been identified that would alter the conclusion in the 1996 version of the License Renewal GEIS. The analyses provided in Section 4.12.1.1 to the License Renewal GEIS are incorporated by reference into this analysis. There are potential fuel cycle options regarding fast spectrum MSRs, as described by Holcomb et al. (e.g., LWR-derived TRU burner) (Holcomb et al. 2011-TN6943), but they are not considered in this GEIS because of the continuing development of the related technology bases.

3.14.1.2 Other Fissile Fuel Cycles

Fuel cycles based on fissile or fertile materials other than uranium are possible, such as a thorium fuel cycle in which thorium is irradiated to create fissile uranium-233 (U-233). This fuel cycle thus would start with mining of thorium, rather than uranium, and would require irradiation of the thorium in a reactor using U-235–based fuel to generate the necessary U-233. Thorium is a commercially available material already mined and processed for use in a variety of commercial products, such as an alloying element in magnesium and in the manufacturing of lenses for cameras and scientific instruments (RSC 2020-TN6442). Because this fuel cycle requires neutron transmutation of thorium-232 (Th-232) to U-233 (typically considered to be from fission of U-235 but could also be from fission of plutonium-239 [Pu-239]), it can be considered to be partially part of the uranium cycle of Figure 3-4 and partially a separate cycle. The processes associated with thorium mining, milling, fuel fabrication, reactor use, storage, reprocessing, and waste disposal should be similar to, but distinct from, those for the uranium fuel cycle. Enrichment of thorium is unnecessary; however, irradiated thorium requires processing to obtain the U-233 necessary to this fuel cycle (WNA 2017-TN6668). Thus, a thorium fuel cycle should only significantly differ from uranium in that conversion of uranium to a gas (UF_6) and subsequent enrichment processes are omitted after initial thorium fuel cycle startup; however, reprocessing would be an additional step currently not seen in the once-through uranium fuel cycle. The NRC staff assumes that the thorium fuel cycle will not be significantly different than the uranium fuel cycle, therefore the uranium fuel cycle impacts should bound the thorium fuel cycle impacts.

3.14.1.3 Fusion Fuel Cycle

Because of the unique nature of the various fusion reactions, only one involves the use of a radioactive isotope, namely the deuterium-tritium (D-T) fusion reaction in which the key nuclear fuel is radioactive tritium (Dolan 1982-TN6780), a material regulated by the NRC. Therefore, for a fusion device using the D-T fusion reaction, an external source for tritium must be secured (for example, tritium recovered from Canada Deuterium Uranium (CANDU) heavy-water fission reactors in Canada (Pearson et al. 2018-TN6781) or produced by the fusion device where the 14.1 MeV neutron from the D-T reaction is absorbed by a surrounding blanket containing enriched lithium-6 (Li-6) to produce, or breed, tritium. Because the only radioactive products left over from any of the fusion reactions could only be from activated structural material due to 14.1 MeV neutron interactions if D-T fuel is used, no spent fuel impacts are associated with fusion reactors. Fusion radioactive waste would be similar to the radioactive structures and components remaining after a fission reactor ceases operation. However, there should be less material to dispose of in a radioactive waste disposal site because there would be no long half-life TRU contamination.

3.14.1.4 Nuclear Fuel Cycle Regulatory Requirements for ANRs

As provided in 10 CFR 51.51(a) (TN250), the environmental data of Table S–3 only apply to construction permit (CP), operating license (OL), ESP, or COL applications for light-water-cooled nuclear power reactors. However, as required in 10 CFR 51.50(b)(3) and 51.50(c) for other than light-water-cooled nuclear power reactors (i.e., non-LWRs), an ER for an ESP or a COL shall contain the basis for evaluating the contribution of the environmental effects of fuel cycle activities for the nuclear power reactor. Any ANR SNF container (i.e., a storage cask or a transportation container or cask) or an independent spent fuel storage installation (ISFSI) and dry transfer system (DTS) facilities for ANR SNF must satisfy the regulatory requirements of 10 CFR Part 71 (TN301), *Packaging and Transportation of Radioactive Material*, 10 CFR

Part 72 (TN4884), *Licensing Requirements for the Independent Storage of Spent Fuel, High-Level Radioactive Waste, and Reactor-related Greater Than Class C Waste*, and 10 CFR Part 73 (TN423), *Physical Protection of Plants and Materials.* Any fuel cycle facility must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882), *Domestic Licensing of Source Material,* and 10 CFR Part 70 (TN4883), *Domestic Licensing of Special Nuclear Material*. Any fuel cycle reprocessing must meet the regulatory requirements of 10 CFR Part 50 (TN249), *Domestic Licensing of Production and Utilization Facilities*.

3.14.1.5 Changes in the Nuclear Fuel Cycle since WASH-1248

Many of the nuclear fuel cycle facilities and processes assessed for Table S–3 still exist today. However, some have undergone several industrial developments and technological advances that have significantly reduced their environmental effects. As discussed in NUREG-2226, the Clinch River ESP FEIS (NRC 2019-TN6136), recent changes in the uranium fuel cycle may have some bearing on environmental impacts. As discussed below, the staff is confident that the contemporary normalized uranium fuel cycle impacts for LWRs are less than those identified in Table S–3. This assertion is true in light of the following recent uranium fuel cycle trends in the United States:

- Increasing use of in situ leach uranium mining, which does not produce mine tailings and would lower the release of radon gas. A discussion of this subject is provided in Section 3.14.2.1.
- Transitioning of U.S. uranium enrichment technology from gaseous diffusion to gas centrifugation. The latter process uses only a fraction of the electrical energy per separation unit compared to gaseous diffusion and U.S. gaseous-diffusion plants that relied on electricity derived mainly from the burning of coal. A discussion of this subject is provided in Section 3.14.2.3.
- Current LWRs are using nuclear fuel more efficiently because of higher levels of fuel burnup. Thus, less uranium fuel per year of reactor operation is required than in the past to generate the same amount of electricity (an increase in the time for refueling (from 12 months to 18 months or greater) as applied for Table S–3).

The values in Table S–3 were calculated from industry averages for the performance of each type of facility or operation within the fuel cycle. Recognizing that this approach meant that there would be a range of reasonable values for each estimate, the staff chose the assumptions or factors to be applied so that the calculated values would not be underestimated. This approach was intended to make sure that the actual environmental impacts would be less than the quantities shown in Table S–3 for all LWR nuclear power plants within the widest range of operating conditions. The staff recognizes that many of the fuel cycle parameters and interactions vary in small ways from the estimates in Table S–3 and concludes that these variations would have no impacts on the Table S–3 calculations. For example, to determine the quantity of fuel required for a year’s operation of a nuclear power plant in Table S–3, the staff defined the reference reactor as a 1,000 MW LWR operating at 80 percent capacity with a 12-month fuel-reloading cycle and an average fuel burnup of 33,000 megawatt-day(s) per metric ton of uranium (MWd/MTU). The current LWR fleet is operating with an average factor approximately 95 percent capacity for peak fuel rod burnup of up to 62,000 MWd/MTU with refueling occurring at approximately 2-year intervals (NRC 2019-TN6136).

The Table S–3 analysis from the 1970s was also based on most of the electricity generated in the United States being produced in plants that burn fossil fuels and coal composing the bulk of fossil-fuel utilization (AEC 1974-TN23). However, today the energy sources for utility-scale electrical generation are very diverse with (DOE/EIA 2020-TN6782):

- only 23 percent from coal;
- 38 percent from natural gas, for which air emissions are much less than those from coal;
- 20 percent from nuclear power plants;
- 17 percent from renewables (10 percent from non-hydroelectric renewables and 7 percent from hydroelectric); and
- 1 percent from petroleum and other sources.

Therefore, environmental impacts related to air emissions, associated pollutants, and water/thermal impacts from today's electrical generation contribution to the nuclear fuel cycle are clearly less and are bounded by the coal-electrical generation data assessed by WASH-1248 (AEC 1974-TN23) and found in Table S–3. This trend of decreasing reliance on fossil fuels for electrical generation will continue, spurred by actions to combat climate change (DOE/EIA 2020-TN6653). Additional information concerning GHG emission from the fuel cycle is discussed in Section 3.3.2.2.2.

Based on several of the items discussed above, the 2013 revision of the License Renewal GEIS states:

> It was concluded that even though certain fuel cycle operations and fuel management practices have changed over the years, the assumptions and methodology used in preparing Table S–3 were conservative enough that the impacts described by the use of Table S–3 would still be bounding.

With Table S–3 still bounding for particular parts of the LWR nuclear fuel cycle, the following sections provide a brief background on the components of the nuclear fuel cycle and discuss their current situation with respect to Table S–3 regarding the advanced nuclear fuel cycle since the publication of the 2013 revision to the License Renewal GEIS (NRC 2013-TN2654).

3.14.1.6 PPE Assumptions

As discussed above, a review of past LWR projects has revealed a number of trends, which the staff assumes will continue for the ANR fuel cycle. Therefore, the following assumptions are made regarding these trends for establishing the PPE for the various ANR fuel cycle components and are discussed in Section 3.14.2, Fuel Cycle Impacts:

- increasing use of in situ leach uranium mining,
- transitioning of U.S. uranium enrichment technology from gaseous diffusion to gas centrifugation for enrichment levels of up to 20 percent,
- using fuel more efficiently in the current LWRs due to higher levels of fuel burnup,
- discharging of fewer spent fuel assemblies per reactor-year, and
- relying less on coal-fired electrical generation plants.

In addition, the following are not part of the above-listed current once-through uranium fuel cycle trends, but could be applicable to ANR fuel cycles:

- The reprocessing capacity would be up to 900 MTU/yr based on analysis in WASH-1248 (AEC 1974-TN23).
- Uranium fuel cycle impacts will bound the thorium fuel cycle impacts.

The PPE also assumes that the regulatory requirements of 10 CFR Part 40 (TN4882), *Domestic Licensing of Source Material*; 10 CFR Part 50 (TN249), *Domestic Licensing of Production and Utilization Facilities*; 10 CFR Part 70 (TN4883), *Domestic Licensing of Special Nuclear Material*; 10 CFR Part 71 (TN301), *Packaging and Transportation of Radioactive Material*; 10 CFR Part 72 (TN4884), *Licensing Requirements for the Independent Storage of Spent Fuel, High-Level Radioactive Waste, and Reactor-related Greater Than Class C Waste*; and 10 CFR Part 73 (TN423), *Physical Protection of Plants and Materials,* are also met.

3.14.2 Fuel Cycle Impacts

The NRC must still evaluate nuclear fuel cycle impacts of the non-LWR fuels to meet its obligations under NEPA, as has been done for UO_2 fuels for LWRs. The NRC has generically evaluated the environmental effects of the nuclear fuel cycle[31] for LWRs that use uranium fuel. The results of the evaluation are presented in 10 CFR 51.51 (TN250), Table S–3, Table of Uranium Fuel Cycle Environmental Data. However, the environmental data of Table S–3 can only be applied to LWRs that use UO_2 fuel. ANR developers are expected to predominately still use enriched uranium fuel with close to 20 percent by weight enrichment, also known as high-assay low-enriched uranium or HALEU. Several of the potential non-LWR designs are expected to deploy non-UO_2 fuels (e.g., uranium metal, uranium carbide, uranium in a molten salt, etc.) or rely on up recycled fissile material. Some ANR developers intend to build on a thorium/U-233 fuel cycle. To the extent practicable, this section assesses the nuclear fuel cycle for ANRs for the expected environmental effects compared to the environmental data provided in Table S–3 where possible.

The NRC staff identified six environmental issues for analysis of fuel cycle impacts associated with an ANR:

- uranium recovery,
- uranium conversion,
- enrichment,
- fuel fabrication,
- reprocessing, and
- storage and disposal of radiological wastes.

3.14.2.1 Uranium Recovery

As indicated on the NRC's public website, uranium recovery focuses on extracting (or mining) natural uranium ore from the Earth and concentrating (or milling) that ore (NRC 2020-TN6444). These recovery operations produce a product, called "yellowcake," which is then transported to a fuel cycle facility. There, the yellowcake is transformed into fuel for nuclear power reactors.

[31] In the United States, all currently operating commercial plants are LWRs that use uranium for fuel. Therefore, in this section the term "uranium fuel cycle" is used to describe the current use of nuclear fuel where the principal fissile material is U-235. The term "nuclear fuel cycle" includes the use of other fissile nuclides, such as U-233 applied in a thorium-based fuel cycle.

In addition to yellowcake, uranium recovery operations generate waste products, called byproduct materials, that contain low levels of radioactivity.

For mining activities, the regulatory responsibility depends on the extraction method that the given facility uses. Specifically, conventional mining (where uranium ore is removed from deep underground shafts or shallow open pits) is regulated by the Office of Surface Mining, the U.S. Department of the Interior, and the individual States in which the mines are located. By contrast, the NRC regulates in situ recovery (formerly known as in situ leach recovery), where the uranium ore is chemically altered underground before being pumped to the surface for further processing. Currently, the NRC regulates active uranium recovery operations in New Mexico and Nebraska, but does not directly regulate the active uranium recovery operations in Wyoming, Texas, Colorado, and Utah, because they are Agreement States, meaning that they have entered into strict agreements with the NRC to exercise regulatory authority over this type of material (NRC 2020-TN6444).

The NRC has provided information about the past and current practices for uranium recovery on the NRC's public website (NRC 2020-TN6827). The table provided on the public website compares the features of the three main types of uranium recovery facilities, namely conventional uranium mills, heap leach/ion-exchange facilities, and in situ recovery facilities.

In general, the primary industrial hazards associated with uranium milling are the occupational hazards found in any metal milling operation that uses chemical extraction, as well as the chemical toxicity of the uranium itself (NRC 2020-TN6444). Because the uranium produced at these facilities is not enriched, there is no criticality hazard and little fire or explosive hazard. Radiological hazards are also low at these facilities because uranium has little penetrating radiation and only moderate non-penetrating radiation. The primary radiological hazard is attributable to the presence of radium in the waste byproduct material (known as "mill tailings").

To facilitate the agency's review of in situ recovery applications, in May 2009 the NRC staff published the *Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities* (NUREG-1910; NRC 2009-TN2559), which addresses common environmental issues associated with the building, operating, and decommissioning of facilities, as well as the groundwater restoration at such in situ recovery facilities, if they are located in particular regions of the western United States (NRC 2020-TN6828). In addressing environmental issues common to the in situ recovery process, the NRC staff applied the *Generic Environmental Impact Statement for In Situ Leach Uranium Milling Facilities* (In Situ Recovery GEIS) as the starting point for its project-specific environmental review of license applications for new in situ recovery facilities. Completed project-specific environmental reviews of new in situ recovery facilities can be found at https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1910/ (NRC 2020-TN6829). The analysis of the In Situ Recovery GEIS is incorporated by reference.

The analyses for Table S–3 regarding uranium recovery were predicated on active uranium mining, heap leaching, and large industrial milling facilities (see Appendix C of the In Situ Recovery GEIS [NRC 2020-TN6828]). There are no active heap leaching sites and only one active underground uranium mining site in the U.S. during 2019 (DOE/EIA 2020-TN6655). As indicated in the In Situ Recovery GEIS, in situ recovery has removed many of the causes of harmful uranium recovery impacts because this process does not directly remove the uranium ore from a site, transport the uranium ore to a large milling facility, and process large volumes of uranium ore that produce tailing piles and leachate ponds and the associated release of radon gas. Thus, the in situ recovery process avoids many of the environmental impacts of these past uranium recovery processing steps. Therefore, the environmental impacts for in situ recovery are expected to be less than those listed in Table S–3 for uranium recovery facilities and the impacts would be SMALL. This is a Category 1 issue. The staff relied on the following PPE assumptions to reach this conclusion:

- Table S–3 is expected to bound the impacts for ANR fuels, because of uranium fuel cycle changes since WASH-1248 (AEC 1974-TN23), including:
  - Increasing use of in situ leach uranium mining has lower environmental impacts than traditional mining and milling methods.
  - Current LWRs are using nuclear fuel more efficiently due to higher levels of fuel burnup resulting in less demand for mining and milling activities.
  - Less reliance on coal-fired electrical generation plants resulting in less gaseous effluent releases from electrical generation sources supporting mining and milling activities.
- Must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882) Domestic Licensing of Source Material and 10 CFR Part 71 (TN301), Packaging and Transportation of Radioactive Material

3.14.2.2 Uranium Conversion

The processing involved in converting U_3O_8, (also called “yellowcake”) into UF_6 for ease of use in uranium enrichment facilities remains the same as that analyzed for Table S–3. The only UF_6 conversion facility in the United States—the Metropolis Works uranium conversion facility operated by Honeywell International Inc.—is in Metropolis, Illinois (NRC 2020-TN6837), and is currently in “idle-ready” status. However, Honeywell plans to restart production in 2023 at the Metropolis Works uranium conversion facility with preparations beginning in 2021 (Ruch 2021-TN6962). Honeywell believes they will be ready to support HALEU demand in the future (ConverDyn 2020-TN6657).

The NRC staff assumes that environmental and process control improvements along with new or amended Federal or State environmental regulations since the publication of WASH-1248 in 1974 would reduce operating uranium conversion facility environmental impacts, maintaining them within those listed in Table S–3. For example, the RCRA (42 U.S.C. §§ 6901 *et seq*.; TN1281) was passed into law in 1976 (EPA 2020-TN6963). Additionally, Honeywell has completed treatment upgrades to the environmental protection facility to provide enhancements to meet new fluoride discharge limits (NRC 2019-TN6964). Therefore, NRC staff assumes Table S–3 will still bound the environmental impacts of a uranium conversion facility operating today and would be SMALL. This is a Category 1 issue. The staff relied on the following PPE assumptions to reach this conclusion:

- Table S–3 is expected to bound the impacts for ANR fuels, because of uranium fuel cycle changes since WASH-1248 (AEC 1974-TN23), including:
  - Current LWRs are using nuclear fuel more efficiently due to higher levels of fuel burnup resulting in less demand for conversion activities.
  - Less reliance on coal-fired electrical generation plants resulting in fewer gaseous effluent releases from electrical generation sources supporting conversion activities.
- Must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882) *Domestic Licensing of Source Material* and 10 CFR Part 71 (TN301), *Packaging and Transportation of Radioactive Material*, and 10 CFR Part 73 (TN423), *Physical Protection of Plants and Materials.*

3.14.2.3 Enrichment

The uranium enrichment process has undergone significant changes since the analysis of Table S–3 provided in WASH-1248 (AEC 1974-TN23) and NUREG-0116 (NRC 1976-TN292). That analysis was based on gaseous-diffusion enrichment, which had large energy requirements and the electricity needed to run the process was produced by coal-electrical generation plants that featured large air emissions and other environmental conditions, as noted in Table S–3.

Gaseous-diffusion enrichment was the first commercial process used in the United States to enrich uranium. The enrichment facilities used massive amounts of electricity and as the centrifuge enrichment technology matured the existing gaseous-diffusion plants became obsolete (NRC 2020-TN6836). Worldwide they have all been replaced by second-generation technology, i.e., centrifuge enrichment technology, which requires far less electric power to produce equivalent amounts of separated uranium. The two gaseous-diffusion plants under NRC purview in the United States have ceased operations and are in the process of being decommissioned, namely the facilities at Paducah, Kentucky, and Portsmouth, Ohio (NRC 2020-TN6836). Deconversion plants now operating at the Portsmouth and Paducah sites are converting depleted UF_6 tails to depleted UO_2, a more stable form for possible reuse or disposal (DOE 2020-TN6659).

There is a significant difference in energy use between gaseous-diffusion and centrifuge enrichment technologies. Separative work unit, or SWU, is the standard measure of the effort required to separate isotopes of uranium (U-235 and uranium-238 [U-238]) during an enrichment process and is independent of the enrichment process (either gaseous or centrifuge). Using a SWU calculator (UxC 2020-TN6660) to obtain 2,200 lb (1,000 kg) of 4 percent by weight enriched uranium, assuming 0.25 percent by weight of U-235 in the tails, from a related amount of natural uranium requires 5,832 SWUs, and to obtain 2,200 lb (1,000 kg) of 20 percent by weight enriched uranium (HALEU) requires 41,579 SWUs. The gaseous-diffusion process consumes about 2,500 kWh per SWU, while modern gas centrifuge plants require only about 50 kWh per SWU (WNA 2020-TN6661). Thus, a centrifuge enrichment facility would consume approximately 2,100,000 kWh to reach 20 percent by weight uranium enrichment, while a gaseous-diffusion plant would need approximately 14,600,000 kWh to reach the 4 percent by weight uranium enrichment analyzed in WASH-1248 (AEC 1974-TN23) and assessed in Table S–3. Therefore, for the enrichment of uranium, Table S–3 would bound the environmental impacts from a centrifuge enrichment facility to produce HALEU and the impact would be SMALL. This is a Category 1 issue. The staff relied on the following PPE assumptions to reach this conclusion:

- Table S–3 is expected to bound the impacts for ANR fuels, because of uranium fuel cycle changes since WASH-1248 (AEC 1974-TN23), including:
  - Transitioning of U.S. uranium enrichment technology from gaseous diffusion to gas centrifugation which requires less electrical usage per SWU.
  - Current LWRs are using nuclear fuel more efficiently due to higher levels of fuel burnup resulting in less demand for enrichment activities.
  - Less reliance on coal-fired electrical generation plants resulting in fewer gaseous effluent releases from electrical generation sources supporting enrichment activities.
- Must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882) *Domestic Licensing of Source Material*, 10 CFR Part 70 (TN4883), *Domestic Licensing of Special Nuclear Material*,

10 CFR Part 71 (TN301), *Packaging and Transportation of Radioactive Material*, and 10 CFR Part 73 (TN423), *Physical Protection of Plants and Materials.*

3.14.2.4 Fuel Fabrication

Fuel fabrication facilities will need to be licensed, constructed, and operated to produce the necessary ANR fuel types. The NRC currently regulates several different types of nuclear fuel fabrication operations. For commercial nuclear power plant fuel, three fuel fabrication plants processing LEU (up to 5 percent by weight enrichment of U-235) are currently licensed by the NRC (2020-TN6835):

- Global Nuclear Fuel-Americas in Wilmington, North Carolina;
- Westinghouse Columbia Fuel Fabrication Facility in Columbia, South Carolina; and
- Framatome, Inc., in Richland, Washington.

Two other fuel fabrication plants licensed by the NRC produce nuclear fuel for the U.S. Navy and can downblend highly enriched uranium (HEU) with other uranium to create LEU reactor fuel for commercial nuclear power plants. These are the Nuclear Fuel Services (NFS) plant in Erwin, Tennessee, and the BWXT Nuclear Operations Group plant in Lynchburg, Virginia. All five of the abovementioned fuel fabrication facilities were in operation at the time of the WASH-1248 study, as were five other fuel fabrication facilities (AEC 1974-TN23).

In Appendix E of WASH-1248 (AEC 1974-TN23), a model fuel fabrication plant that had a capacity of 3 MTU per day and operated 300 days per year was used to assess environmental impacts. The model plant lifetime was taken to be 20 years. WASH-1248 also assumed that the electricity used in fuel fabrication facilities came from coal power plants; some natural gas was used for process heat and other external resources involved land use and water. At the time of WASH-1248, fuel fabrication facilities applied a wet process method for UF_6 to UO_2 conversion, which involves the use of ammonium hydroxide to form an intermediate ammonium diuranate (ADU) compound prior to final conversion to UO_2.

While WASH-1248 notes that a dry conversion process (DCP) was under development at that time, several of the above mentioned fuel fabrication facilities now apply a dry process (AEC 1974-TN23). The ADU process was recognized as creating greater waste management problems than the dry process. The Global Nuclear Fuel-Americas facility converted to DCP in 1997 (NRC 2009-TN6663) and the Framatome facility converted in 1998 (NRC 2009-TN6664). The BWXT facility currently only packages customer-provided uranium fuel material into fuel assemblies (NRC 2003-TN6665). The NFS facility could provide a variety of nuclear fuel services such as converting HEU into LEU or HALEU for use in commercial nuclear power plants (NRC 2011-TN6666). Only the Westinghouse Columbia Fuel Fabrication Facility currently applies the ADU process for final conversion to commercial nuclear fuel (NRC 2019-TN6472). Available capacity information for the three commercial nuclear fuel fabricators is provided in Table 3-8. Note that the rod and assembly capacity number may not be similar to the conversion and pelletizing capacity because UO_2 pellets could be provided from an outside source and the fuel fabricator is only inserting these outside source fuel pellets into cladding pins and then combining them into fuel assemblies.

Table 3-8 LWR Fuel Fabrication Capacity

Fabricator	Location	Conversion		Pelletizing		Rod/Assembly	
		MTU/yr (a)	MTU/d (b)	MTU/yr (a)	MTU/d (b)	MTU/yr (a)	MTU/d (b)
Framatome Inc	Richland, WA	1,200	3.4	1,200	3.4	1,200	3.4
Global Nuclear Fuel – Americas	Wilmington, NC	1,200	3.4	1,000	2.9	1,000	2.9
Westinghouse	Columbia, SC	1,600	4.6	1,594	4.6	2,154	6.2

(a) WNA 2020-TN6667.
(b) The metric tons of uranium per day (MTU/d) value is based on a current fuel fabrication facility operating schedule of 350 days per year as opposed to the 300 days assumed in WASH-1248 (AEC 1974-TN23).

WASH-1248 states that most of the airborne chemical effluents result from the combustion of fossil fuels to produce electricity to operate the fabrication plant (AEC 1974-TN23). As previously described, a large percentage of electricity production today is from generation sources other than coal. Thus, existing and any new fuel fabrication facilities would have lower air emissions than those assessed in WASH-1248. The level of environmental impacts for other aspects of fuel fabrication, as presented in Appendix E of WASH-1248, are provided in Table 3-9.

Table 3-9 WASH-1248 Fuel Fabrication Environmental Impacts (AEC 1974-TN23)

Environmental Impact	Value	WASH-1248 Comments
Site Size (ac)	A few acres up to a few thousand acres	Less than 5 percent of that committed by the rest of the fuel cycle
Building Size (ft^2)	100,000	
Annual Water Consumption (gal)	5,200,000	About 0.05 percent of that used by the model LWR evaluated by WASH-1248
Power Required (MW and MWh)	6 MWe and 1,700 MWe-hr	About 0.5 percent of the electricity of the enrichment plant evaluated by WASH-1248
Annual Natural Gas Usage for Process Heat (ft^3)	3,600,000	About 4 percent of that consumed by the total nuclear fuel cycle
Liquid Waste Stream Volume (gpd)	25,000	Combined with about 425,000 gpd of process cooling water in the holding ponds prior to release offsite
Annual Solid Waste Volume (MT)	680	Calcium fluoride precipitate from the liquid waste stream for retaining on site (11 yd^3 [8.4 m^3])
Annual Gaseous Airborne Activity Released (Ci)	0.005	Less than 0.1 percent of the applicable 10 CFR Part 20 (TN283) limit
Annual Liquid Activity Released (mCi)	40	Less than 10 percent of 10 CFR Part 20 (TN283) limits for release to an unrestricted area
Annual Solid Activity for Disposal (mCi)	25	Activity shipped per annual fuel requirement

The establishment of commercial ANR fuel fabrication process lines has yet to occur (at the time of publishing this GEIS). It is expected that the majority of ANR fuel will use HALEU, but it might not be in the form of UO_2 sintered pellets. ANR fuel forms could be TRi-structural ISOtropic (TRISO) fuel, uranium metal, uranium compound in a molten salt, or in another yet unidentified form. In addition, there is the potential for an ANR, likely a MSRs design, to be designed with a thorium-based fuel cycle using fissile U-233 (WNA 2017-TN6668).

3.14.2.4.1 TRISO Fuel Fabrication

As described in the previously mentioned PNNL report (Napier 2020-TN6443), TRISO fuel is composed of fuel particles or seeds less than 1 mm in diameter. Each has a kernel (ca. 0.5 mm) of uranium oxycarbide (or UO_2), and the uranium is likely to be enriched up to 20 percent by weight of U-235. This kernel is surrounded by layers of carbon and silicon carbide, giving a containment for fission products that is expected to be stable up to very high temperatures (up to 1,600°C (Napier 2020-TN6443). There are two ways in which these particles can be arranged: either in blocks—hexagonal "prisms" of graphite; or in billiard ball-sized pebbles of graphite encased in silicon carbide, each with about 15,000 fuel particles and 0.32 oz (9 g) of uranium. Either way, the moderator is graphite. A description of a TRISO fuel fabrication process is also provided in PNNL-29367 and includes the related environmental emissions (Napier 2020-TN6443).

In the United States, BWXT is making HALEU TRISO fuel on an engineering scale, funded by DOE, and in October 2019 the company announced a planned expansion to commercial scale within 3 years (WNA 2020-TN6667). As presented in a DOE categorical exclusion document supporting this work (DOE 2020-TN6735), HEU material would be shipped from the Y-12 National Security Complex in Oak Ridge, Tennessee, to the BWXT facility in Erwin, Tennessee, for conversion from HEU metal to HEU oxide. BWXT would then ship the HEU oxide to the BWXT fuel fabrication plant in Lynchburg, Virginia, for downblending and TRISO fabrication. BWXT was tasked with producing 220 lb (100 kg) of TRISO HALEU fuel. In November 2020, BWXT announced it had completed its TRISO nuclear fuel line restart project and is actively producing fuel at its Lynchburg facility (BWXT 2020-TN6756). Test samples of the BWXT TRISO fuel have been irradiated and examined at the Idaho National Laboratory (INL) Advanced Test Reactor (Nagley 2020-TN6739). The production of this TRISO fuel is being conducted under existing NRC special nuclear material (SNM) licenses and associated environmental assessments (EAs). For the BWXT Lynchburg facility, the license renewal EA, issued in 2006 for a 20-year period under Materials License SNM-42, concluded the BWXT operations would not result in a significant impact on the environment where airborne and liquid effluent releases along with public and occupational doses are below regulatory limits (71 FR 16348-TN6785). Therefore, this EA covers the environmental impact of producing 220 lb (100 kg) of TRISO HALEU fuel under DOE funding.

A potential new fuel fabricator for TRISO is X-Energy LLC (X-Energy 2020-TN6736). X-Energy has also been producing TRISO fuel on an engineering scale and announced irradiation testing in May 2020 to be performed at the Massachusetts Institute of Technology (MIT) Nuclear Reactor Laboratory's 6 MW MIT reactor (MITR) (WNN 2020-TN6740). X-Energy has developed a pilot TRISO fuel fabrication process and presented an overview of this process to the NRC and during a national HALEU webinar (Pappano 2018-TN6738, Pappano 2020-TN6737).

A direct comparison of existing ADU and DCP fabrication and industry-level TRISO fuel fabrication processes cannot be made at this time. The BWXT TRISO work is being conducted under an existing NRC SNM license but production quantity is limited. Based on the available public information, once the UF_6 feedstock is converted to a solid form, the X-Energy TRISO-X process and NRC's experience with BWXT TRISO fuel fabrication licensing both have similar steps that feature environmental impacts comparable to or less than those of the ADU (the fuel fabrication process associated with Table S–3) and the current DCP fuel fabrication processes (Pappano 2020-TN6737).

3.14.2.4.2 Metallic Uranium Fuel Fabrication

It is anticipated that several ANR designs, such as microreactors and liquid sodium-cooled reactors, could use a form of metal uranium alloy fuel. Such a fuel type has been employed in a variety of research and test reactors. Supplies of metallic HALEU could become available to commercial developers, at least initially, from DOE's surplus HEU stockpiles. One initial source of metallic uranium is recycled material from the Experimental Breeder Reactor-II (EBR-II) at INL, but it could also be provided by DOE if surplus HEU from the U.S. government's nuclear weapons program is made available for commercial nuclear fuels. The uranium material from EBR-II, up to 10 MT, will be melted into ingots and could be cast into reactor components (DOE 2019-TN6757). INL has developed the Hybrid Zirconium Extraction (ZIRCEX) process, which is used to remove cladding from the fuel, thereby allowing downblending of metallic HEU into HALEU casting (INL 2019-TN6758). The first castings for an ANR were made in late 2019 (Morning Consult 2019-TN6759). INL is also prepared to further refine the former EBR-II fuel into appropriate fuel forms for ANR fuel developers (Todd 2020-TN6760).

For the case where the initial supply of metallic uranium fuel for an ANR is supplied from DOE's surplus HEU stock, all of the environmental impacts prior to fuel fabrication already occurred during U.S. government processes years ago. HALEU fuel could use processed spent EBR-II fuel (DOE/EA-2087; DOE 2019-TN6757) or, potentially, future spent Navy fuel processed at DOE-controlled facilities, which would have their own NEPA assessment of impacts. Thus, any environmental impacts from the processing of metallic fuel from DOE sources for ANRs related to past mining, milling, enrichment, and conversion have been accounted for in the WASH-1248 analysis (AEC 1974-TN23) and are provided in Table S–3. If the HALEU feedstock is taken from unprocessed irradiated fuel (i.e., EBR-II or spent Navy fuel), then there will be an environmental impact associated with reprocessing the irradiated fuel, likely similar to the impacts associated with previously processed irradiated EBR-II fuel, as described in DOE/EA-2087 (DOE 2019-TN6757). Thus, future commercial production of metallic HALEU fuel would have environmental impacts similar to those previously discussed for all steps prior to fuel fabrication.

An overall fuel fabrication process is presented in Section 1.1 of the PNNL report entitled *Metal Fuel Fabrication Safety and Hazards* (LaHaye and Burkes 2019-TN6961). The metal fuel fabrication steps, as provided by LaHaye and Burkes (2019-TN6961), are as follows:

1. Feedstock must be prepared from ore. This includes dissolution, purification, and chemical conversion to the desired chemical state for the next step. Feedstock can also be prepared from used fuel through reprocessing. Enrichment will typically take place between purification and conversion to the final chemical state for reduction but is outside the scope of this effort. (These steps are addressed previously in this section of this GEIS.)
2. Feedstock must then be reduced to metal. This is traditionally achieved by bomb/metallothermic reduction, but other means can also be employed to convert feedstock to metal.
3. The metal is alloyed with the desired alloying agent(s) to create a binary, ternary, or other alloy.
4. The alloy is cast to form a fuel billet.

5. The fuel billet is machined and/or thermomechanically processed to get it into a desired form.

6. The formed fuel billet is clad and collected into fuel assemblies.

Each of the above metal fuel fabrication process steps is described in detail in subsequent sections by LaHaye and Burkes (2019-TN6961) and is incorporated by reference.

For assessing the environmental impacts of metal fuel fabrication, the level of impacts is likely to vary with the source of metal fuel feedstock. If the fuel material is being supplied directly from the enrichment facility or was from downblended HEU, the only radiological hazard would be from the uranium itself. Such a feedstock source should also not need any further purification. For recycled or reprocessed used fuel, the purification to remove fission products and TRU elements could be an initial step in the metal fuel fabrication facility. The effectiveness of this purification process in removing the highly radioactive non-fuel nuclides could affect the kind of processing protections (e.g., remote operations in a highly shielded hot cell versus a glovebox) necessary in the subsequent fabrication steps.

Outside of the expected radiological impacts, the effluent releases and wastes streams from the above process steps are not expected to be significantly different than those of most metal fabrication facilities. As described by the European Bank for Reconstruction and Development (EBRD Undated-TN6941) and by LaHaye and Burkes (2019-TN6961), there are likely to be a number of waste streams from metal fabrication. Air emissions from volatile chemicals, fumes, and dust/particulates would be generated from various process steps involving melting, degreasing, cleaning, welding, and grinding operations. Solid waste in the form of chips and scrap metal could be generated from machining, milling, and thermomechanical treatments. Wastewater could also be generated containing various chemical wastes due to the mentioned degreasing, cleaning, treatments, and grinding operations.

The NRC staff assumes a metal fuel fabrication facility would have the appropriate process controls (e.g., glove boxes and hot cells as appropriate), ventilation filters (e.g., high-efficiency particulate air [HEPA] and charcoal filter beds), and monitoring to minimize the amount of waste generated and associated environmental impacts. Environmental impacts could be bounded by current fuel fabrication processes. However, there could be noticeable waste streams from casting and from stabilizing uranium scraps (LaHaye and Burkes 2019-TN6961). Therefore, due to the lack of environmental impact information for ANR metal fuel fabrication, the NRC staff cannot readily assess an environmental impact for such fuel fabrication in relationship to WASH-1248 and Table S–3.

3.14.2.4.3 Nuclear Fuel in Molten-Salt Reactors

The ANR classified as a MSRs is one where a molten salt is used as the working fluid for heat, transferring the energy from the nuclear core to an industrial process, such as electrical generation or industrial heat processes. The nuclear fuel could be in a form described above in the MSR's own fuel channel. There are also proposed MSR designs in which the nuclear fuel will be mixed in the molten salt and the reactor will be specifically designed so that the reactor vessel's configuration is such that the nuclear core physics support criticality (i.e., a liquid-fuel MSR). As indicated by the WNA, "in the normal or basic MSR concept, the fuel is a molten mixture of lithium and beryllium fluoride salts with dissolved LEU (U-235 or U-233) fluorides (UF_4)" (WNA 2021-TN7072). As further indicated by the WNA, "chloride salts have some attractive features compared with fluorides, in particular the actinide trichlorides form lower melting point solutions and have higher solubility for actinides so can contain significant amounts of transuranic elements" (WNA 2021-TN7072). The type of nuclear fuel could be based on any of the fissile isotopes in the form of HALEU U-235, a mixture of uranium and plutonium (TRU mixture with U-235, Pu-239, and U-238 in a fast neutron spectrum), or thorium-based U-233. A number of MSR developers are examining a variety of molten-salt types (Flanagan 2017-TN6742). Discussions of nuclear fuel salts likely to be employed in MSRs (chloride- and fluoride-based salts) and the general characteristics of reactors that would use those types of salts are provided in Chapter 2 of McFarlane et al. (2019-TN6741).

Two prior productions of liquid-fuel MSRs could be used as an indication of the fuel preparation impacts for this type of nuclear fuel (McFarlane et al. 2019-TN6741): the Aircraft Reactor Experiment (ARE) in 1954, and the Molten-Salt Reactor Experiment (MSRE). McFarlane et al. (2019-TN6741) provide a description of the processing of the ARE fuel in Section 2.2.1 of their report, Fuel Loading at ARE:

> At the ARE, Na_2UF_6 was added to an initially barren mixture of sodium and zirconium fluorides. The procedure to add the ARE fuel involved the successive connection of numerous small concentrate containers to an intermediate transfer pot. The pot was then connected to the fuel system, which injected the concentrate into the pump tank above the liquid level. Since the ARE was not optimized for breeding, its fuel salt contained a higher concentration of uranium. The ARE final fuel mixture consisted of 53.09 mole percent NaF, 40.73 mole percent ZrF_4, and 6.18 mole percent UF_4, with ^{235}U enriched to 93.4 weight percent. The ARE fuel salt ^{235}U concentration was increased 8.8 percent over the course of operations (from 0.383 g/cc to 0.416 g/cc) as operational power was increased.

McFarlane et al. (2019-TN6741) provide the following description of the MSRE fuel in Section 2.2.2 of their report, Fuel Loading at MSRE:

> The MSRE reactor fuel mixture nominally consisted of 65 ^7LiF, 29.1 BeF_2, 5 ZrF_4, and 0.9 UF_4 (mole percent). At MSRE, ^7LiF-UF_4 (73-27 mole %) was separately synthesized and incrementally dissolved into barren carrier salt to start and maintain nuclear operation. Both the MSRE coolant and the flush salt were a binary mixture of 66 mole percent LiF in BeF_2. Initial operation employed 33 weight percent enriched uranium. The operational fuel salt volume was roughly 2,067 liters. All of the lithium used was assayed to be at least 99.99 percent ^7Li. In 1968, the uranium was removed from the fuel salt and replaced with nearly pure ^{233}U. The last few refueling capsules in 1969 contained PuF_3 (94 weight percent ^{239}Pu).

McFarlane et al. (2019-TN6741) discuss the processes for synthesizing the carrier salt and related chemical hazards in Chapter 3 of their report. In addition, it is expected there would be onsite processing to add fissile material and to remove certain fission products to maintain MSR operations. While these processes would be like other industrial hazards associated with producing chloride- and fluoride-based compounds, they were not part of the analysis in WASH-1248 (AEC 1974-TN23) and are not addressed in Table S–3.

An additional consideration for the liquid-fuel MSRs is that the fission products dissolved in the fuel salt could be continuously removed in an adjacent online reprocessing loop and replaced with fissile uranium, plutonium and other actinides, or, potentially, fertile Th-232 or U-238 (WNA 2021-TN7072). Because this is a series of actions that would occur during operations, it is not a fuel fabrication process. For this situation, once the MSR begins operation, only the manufacturing of the chemical form of the fissile material being produced to be compatible with the respective chemistry of the molten salt to be delivered to the MSR is part of the fuel preparation process. Potential waste processing and waste forms associated with MSRs are documented by Riley et al. (2018-TN6942).

If the MSR design has a separate fuel channel from the molten-salt coolant then NRC staff assumes the fuel fabrication environmental impacts as described above to be similar to the nuclear fuel form being employed in the reactor design (i.e., oxides, TRISO, and metal). However, due to the lack of environmental impact information about generating liquid-fuel molten salt, the NRC staff cannot readily assess an environmental impact of such fuel fabrication in relationship to WASH-1248 (AEC 1974-TN23) and Table S–3.

3.14.2.4.4 Fuel Fabrication Conclusions

For the assessment of environmental impacts, Table S–3 is expected to bound the impacts for ANRs that rely on uranium oxycarbide/UO_2 fuels if such fuel fabrication is applying the existing processes of the NRC-licensed fuel fabrication facilities resulting in SMALL impacts. If not, the impacts from ANR fuel fabrication would need to be bounded by the values provided in Appendix E of WASH-1248 (AEC 1974-TN23), as listed in Table 3-9. Based on the assumption of meeting these values, fuel fabrication is a Category 1 issue. The staff relied on the following PPE assumptions to reach this conclusion:

- Table S–3 is expected to bound the impacts for ANR fuels, because of uranium fuel cycle changes since WASH-1248 (AEC 1974-TN23), including:
  - Current LWRs are using nuclear fuel more efficiently due to higher levels of fuel burnup resulting in fewer discharged fuel assemblies to be fabricated each year and due to longer time periods between refueling
  - Less reliance on coal-fired electrical generation plants resulting in less gaseous effluent releases from electrical generation sources supporting fabrication
- Must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882) *Domestic Licensing of Source Material*, 10 CFR Part 70 (TN4883), *Domestic Licensing of Special Nuclear Material*, 10 CFR Part 71 (TN301), *Packaging and Transportation of Radioactive Material*, and 10 CFR Part 73 (TN423), *Physical Protection of Plants and Materials.*

Any ANR fuel fabrication that cannot be bounded by WASH-1248 (AEC 1974-TN23), namely metallic fuel and liquid-fuel MSRs, requires a discussion of the anticipated ANR fuel fabrication process and environmental impacts in the project-specific application. ANR applications in these cases must include enough information to support the staff’s review for reaching an environmental finding. The information needs identified in the PNNL report (Napier 2020-TN6443) should be provided in the ANR application.

3.14.2.5 Reprocessing

As discussed in Section 1.6.1 of SECY-2011-0163 (NRC 2011-TN6830), the NRC staff considers reprocessing to be defined as the separation of SNF into its constituent components of isotopes of uranium, fission products, and TRU nuclides by aqueous and nonaqueous chemical processing of irradiated fuel for the purpose of recovering reusable fuel material. This definition encompasses the types of materials that would be produced in reprocessing and the various methods of separation that have been proposed. Reprocessing of SNF could occur for some types of ANR fuels (e.g., fissile material circulating in the molten-salt coolant or an ANR designed to use reprocessed SNF) and could be internal to the operation of the ANR at the site or could be conducted externally at a remote reprocessing facility. Therefore, the environmental impacts of reprocessing ANR fuel are addressed in this section.

At the time WASH-1248 was published, only U.S. government reprocessing facilities were in operation and applying the plutonium uranium reduction extraction (PUREX) process.[32] There were no operational commercial SNF reprocessing facilities. Three U.S. commercial reprocessing facilities were anticipated to be operational later in the 1970s (AEC 1974-TN23). Thus, WASH-1248 and related reports in support of Table S–3 evaluated the environmental impacts of PUREX reprocessing as being maximized for either of the two fuel cycles: uranium only and full recycle. Based on a court decision, the Commission directed the staff to prepare a supplement to WASH-1248 to establish a basis for identifying environmental impacts associated with fuel reprocessing and waste management activities that are attributable to the licensing of a model LWR. These environmental impacts were documented in NUREG-0116, *Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle* (NRC 1976-TN292). However, no U.S. commercial SNF reprocessing facilities are in operation today, and there are no licensing actions to construct and operate such a nuclear facility at the time of this ANR GEIS.

WASH-1248 Table F-1 provides a summary of environmental considerations for irradiated fuel reprocessing normalized to the model LWR annual fuel requirement (AEC 1974-TN23). The table is based on the collective operation of the three anticipated reprocessing facilities, normalized to an annual capacity of 900 MTU/yr, to serve as the selected model reprocessing plant. This capacity is equivalent to the annual fuel requirements of approximately 26 model LWRs at 1,000 MWe each, or 3.46×10^{-2} MTU/yr-MWe.

The level of impacts of reprocessing in WASH-1248 (AEC 1974-TN23) correspond to approximately a quarter of the current nuclear operating fleet. This amount of reprocessing capability could support a large number of ANRs. Thus, it is likely that the capacity of an offsite reprocessing process related to one ANR would be significantly under 900 MTU/yr. Therefore, this is a Category 1 issue based on the bounding assumption that the reprocessing capacity for the ANR, if pursued as an integral part of its fuel cycle, would be less than 900 MTU/yr, and that the contents of Table S–3 would bound the environmental impacts.

Table 2-10 in the *Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle* (NUREG-0116) provides a summary of the impacts of reprocessing and waste management per reference reactor-year (RRY) for a 1,000 MWe reactor (assumed to be operating at 80 percent of its maximum capacity for 1 year) (NRC 1976-TN292). Based on the best available information applied in NUREG-0116, the impacts as summarized in Table 2.10 of this NUREG are slightly different from those in WASH-1248 (AEC 1974-TN23). When these impacts are included in the total impacts of the uranium fuel cycle attributable to a single reactor (see the new Total column in Table 2.10 of NUREG-0116), the total values are not substantially different from those in WASH-1248; the difference in values is not sufficient to affect the NRC staff's impact determination in this GEIS.

Under the Integral Fast Reactor program (ANL 2017-TN6832), a form of pyroprocessing (ANL 2016-TN6831), a pyrochemical/electrochemical reprocessing (PER) method, was

[32] PUREX involves the dissolution of irradiated nuclear fuel in nitric acid, followed by separation of the uranium, plutonium, and fission products by solvent extraction using a mixture of tributyl phosphate in an organic diluent.

developed and tested using the EBR-II fuel and facilities. Pyroprocessing is a nonaqueous reprocessing process in which spent fuel is subjected to high temperatures (typically over 600°C [equivalent])] to facilitate physical or chemical processes for the purpose of separating and recovering fissile and fertile materials (NRC 2011-TN6830). PER is a pyroprocessing operation involving selective reduction and oxidation in molten salts or metals to recover nuclear fuel materials, and management of the resulting waste (NRC 2011-TN6830). However, the Integral Fast Reactor program was cancelled, and further development of PER has been limited since then (Frank et al. 2015-TN6833). Renewed interest in applying PER for reprocessing ANR fuel has been expressed, so the environmental impacts of a potential PER method are considered in this GEIS. In support of the treatment of sodium-bonded SNF, DOE has evaluated several methods of reprocessing including a PUREX-based and a PER-based treatment (DOE 2000-TN6834). As provided in Table S-4 of DOE/EIS-0306 (DOE 2000-TN6834), the PER environmental impacts were shown to be less than those associated with a PUREX treatment process with one exception where there is a small difference in the volume of high-level waste generated (18 m^3 for PER vs. 5.6 m^3 for PUREX) (DOE 2000-TN6834).

The NRC staff finds the above conclusions provided in NUREG-0116 support the conclusions in WASH-1248 resulting in SMALL impacts. Additionally, for the same mass of spent fuel processed as in the PUREX process described in WASH-1248 (AEC 1974-TN23) and NUREG-0116 (NRC 1976-TN292), these environmental impacts should bound or be similar to a PER-based treatment process. This is a Category 1 issue. The staff relied on the following PPE assumptions to reach this conclusion:

- Table S–3 is expected to bound the impacts for ANR fuels, because of uranium fuel cycle changes since WASH-1248 (AEC 1974-TN23), including:
  - Current LWRs are using nuclear fuel more efficiently due to higher levels of fuel burnup resulting in fewer discharged fuel assemblies to be reprocessed each year
  - Less reliance on coal-fired electrical generation plants resulting in less gaseous effluent releases from electrical generation sources supporting reprocessing
- Reprocessing capacity up to 900 MTU/yr
- Must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882) "Domestic Licensing of Source Material," 10 CFR Part 50 (TN249), "Domestic Licensing of Production and Utilization Facilities,"10 CFR Part 70 (TN4883), "Domestic Licensing of Special Nuclear Material," 10 CFR Part 71 (TN301)," Packaging and Transportation of Radioactive Material," 10 CFR Part 72 (TN4884)," Licensing Requirements for the Independent Storage of Spent Fuel, High-Level Radioactive Waste, and Reactor-related Greater Than Class C Waste," and 10 CFR Part 73 (TN423), "Physical Protection of Plants and Materials."

3.14.2.6 Storage and Disposal of Radiological Wastes

As with LWRs, the NRC must analyze the environmental impacts of the generation of radioactive wastes by an ANR and their safe storage and ultimate disposal. Appendix G of WASH-1248 presents the analysis of the environmental impacts of managing radioactive wastes from the nuclear fuel cycle activities (AEC 1974-TN23). The analysis is for radioactive wastes that can be categorized as HLWs and other than high-level, or LLRWs. HLWs, generated at fuel reprocessing plants, contain fission products separated from fissile material recovered from irradiated fuel. LLRWs result from operations involving UF_6 production, fuel fabrication, and fuel reprocessing. These include all wastes, regardless of concentration or specific activity, that are not designated as HLWs.

While WASH-1248 states the LLRW, which is generated during fuel cycle operations, is variable and difficult to estimate, the total waste volume is estimated to be approximately 14,000 ft^3 (396 m^3) (AEC 1974-TN23). This analysis also assumes that, with no further compaction of the waste, the final volume of packages containing the waste could approximate 20,000 ft^3 (566 m^3) per annual model LWR fuel requirement. As discussed in Section 3.15, Transportation of Fuel and Waste, in this GEIS, this is a fraction of the annual LLRW from all U.S. sources shipped to the four Agreement State-licensed LLRW disposal facilities.

The analysis in WASH-1248 (AEC 1974-TN23) was based on lower burnup levels than are currently allowed for the current fleet of LWRs. The higher burnup levels result in greater utilization of the uranium fuel along with corresponding greater efficiency in extracting energy from the fuel. This has also resulted in extended time between refueling and the removal of fewer fuel assemblies per reactor-year.

WASH-1248, while recognizing that a HLW disposal facility, which includes disposal of SNF, did not yet exist, did state that the U.S. Atomic Energy Commission (AEC) was proceeding on a program to design, construct, and operate a surface (or near-surface) facility in which the solidified commercial HLW in sealed canisters would be stored (AEC 1974-TN23). However, this program was never completed. Rather, in the late 1970s, the NRC reexamined an underlying assumption used in licensing reactors up to that time, namely that a repository could be secured for the ultimate disposal of spent fuel generated by nuclear reactors, and that spent fuel could be safely stored in the interim (NRC 2014-TN4117). This analysis was later codified into NRC regulations under 10 CFR 51.23 (TN250), "Temporary storage of spent fuel after cessation of reactor operation – Generic determination of no significant environmental impact" (49 FR 34658-TN3370), or the Waste Confidence decision.

3.14.2.6.1 Waste Confidence and the Evaluation of Continued Storage

The complete history of the Waste Confidence decision is provided in Section 1.1, History of Waste Confidence, of NUREG-2157, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel* (NRC 2014-TN4117) and is incorporated by reference. As a result of legal actions involving the unknown timing of an operational geologic repository for the permanent disposal of SNF, the NRC developed and published NUREG-2157 and revised 10 CFR 51.23 (TN250), which became "Environmental impacts of continued storage of SNF beyond the licensed life for operation of a reactor" (79 FR 56238-TN4104).

NUREG-2157 analyzes the environmental impacts of continued storage of spent fuel (NRC 2014-TN4117). In it, the NRC analyzed the direct, indirect, and cumulative effects of continued storage for three timeframes:

- short-term – 60 years beyond licensed life for reactor operations;
- long-term – 100 years beyond the short-term storage timeframe; and
- indefinite – indefinite storage and handling of spent fuel.

These timeframes are discussed in more detail in Section 1.8.2 of NUREG-2157 (NRC 2014-TN4117). The locations of the storage sites related to these impacts were assessed for at-reactor storage, away-from-reactor storage, and cumulative impacts when added to other past, present, and reasonably foreseeable activities. The analyses contained in NUREG-2157 provide the regulatory basis for the revisions to 10 CFR 51.23 (TN250), in which 10 CFR 51.23(a) states:

> The Commission has generically determined that the environmental impacts of continued storage of SNF beyond the licensed life for operation of a reactor are those impacts identified in NUREG–2157, “Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel.”

The impact levels determined in NUREG-2157 of at-reactor storage, away-from-reactor storage, and cumulative impacts of continued storage when added to other past, present, and reasonably foreseeable activities are summarized in Table 6-4 of NUREG-2157 (NRC 2014-TN4117). The impact levels are denoted as SMALL, MODERATE, and LARGE as a measure of their expected adverse environmental impacts. Most impacts were found to be SMALL and SMALL to MODERATE. For some resource areas, the impact determination language is specific to the authorizing regulation, Executive Order, or guidance. Impact determinations that include a range of impacts reflect uncertainty related to both geographic variability and the temporal scale of the analysis. As a result, based on analyses performed in NUREG-2157, the NRC assumes that further project-specific analysis would be unlikely to result in impact conclusions with different ranges. The analyses of NUREG-2157 were codified into 10 CFR 51.23 (79 FR 56238-TN4104).

Many of the assumptions provided in Section 1.8.3, Analysis Assumptions, and subsequent analysis in NUREG-2157 are independent of the fuel type because they involve onsite impacts related to the siting, operating, and maintenance of the ISFSI and DTS facilities over all timeframes during continued storage (NRC 2014-TN4117). For example, the waste management resource area involves radioactive and chemical wastes generated by the operation of the ISFSI itself and does not directly involve the SNF in the storage casks. Only a select few topics considered in NUREG-2157 have a connection with the SNF itself and how it could result in offsite environmental impacts, namely related to “Transportation,” “Public and Occupational Health,” “Postulated Accidents,” and “Potential Acts of Terrorism.”

For the transportation of SNF and for public and occupational health, the staff concluded in NUREG-2157 that the radiological doses would be expected to continue to remain below the regulatory dose limits during continued storage and all of the related activities would have small environmental impacts (NRC 2014-TN4117). The staff reached this conclusion in Sections 4.16 and 4.17 of NUREG-2157 because the operations during continued storage would have a smaller workforce, lower volume of traffic and shipment activities, and continued storage represents a fraction of the activities occurring during reactor operations, as previously analyzed in the License Renewal GEIS (NRC 2013-TN2654) and in other NRC studies.

Regarding the analysis of postulated accidents in NUREG-2157 (NRC 2014-TN4117), any SNF must be safely stored and decay heat must be appropriately removed once the SNF is removed from the reactor. This includes the protection from and the mitigation of severe accidents, or beyond-design-basis accidents, which are accidents that may challenge safety systems at a level higher than that for which they were designed.

The concerns about severe accidents within an ISFSI, whether involving at-reactor or away-from-reactor storage, were analyzed in NUREG-2157 (NRC 2014-TN4117). The lowest consequences events with any radiological release involved dropping a cask. The highest consequences were associated with an impact on the storage cask followed by a fire, such as could occur after an aircraft impact. In all cases, the staff determined the likelihood of the event would be very low and the environmental risk of an accident would be small. The consequences described for cask drops at an ISFSI also provided some insight into the consequences of severe accidents in a DTS. Compliance with NRC regulations for spent fuel handling and storage would likely make the risk of severe accidents in a DTS small. In addition, the consequences of any severe accident in a DTS would likely be comparable to or less than that for the cask drop accident described above. This resulted in the staff concluding in NUREG-2157 that the likely impacts from activities in a DTS also would be small.

An assessment of the risks that could potentially result from acts of terrorism or radiological sabotage was also provided in NUREG-2157 (NRC 2014-TN4117). The assessment was based, in part, on the analysis provided in the licensing of the Diablo Canyon ISFSI and accounted for the security and protective measures required by NRC regulations (see Section 4.19 of NUREG-2157). The staff determined that the potential for theft or diversion of LWR spent fuel from the ISFSI with the intent of using the contained SNM for nuclear explosives is not considered credible because of the following:

- the inherent protection afforded by the massive reinforced concrete storage module and the steel storage canister;
- the unattractive form of the contained SNM, which is not readily separable from the radioactive fission products; and
- the immediate hazard posed by the high radiation levels of the spent fuel to persons not provided with radiation protection.

The staff concluded in NUREG-2157 (NRC 2014-TN4117) that for acts of terrorism, even though the environmental consequences of a successful attack could be large, the very low probability of a successful attack ensures that the environmental risk would be small for operational ISFSIs and DTSs during continued storage.

Finally, the Commission, in the Continued Storage rulemaking, reclassified the offsite radiological impacts of SNF and HLW disposal as a Category 1 issue; no impact level was assigned and the finding column entry was revised to address the existing radiation standards (79 FR 56238-TN4104). Thus, the Commission has concluded that the impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR Part 54 (TN4878) should be eliminated (see Table B-1 in 10 CFR Part 51 [TN250]).

3.14.2.6.2 Continued Storage of Spent ANR Fuel

ANRs were not part of the analysis of NUREG-2157 (NRC 2014-TN4117), as noted in Section 1.8.6, Issues Eliminated from Review in this GEIS. This is likely due to information provided in a report to Congress in August 2012 (NRC 2012-TN6670), which stated:

> Spent nuclear fuel storage regulations in 10 CFR Part 72 are generally broad enough to address new types of fuel associated with advanced reactor designs. However, minor modifications may be necessary to address new design features from any new class of cask storage technologies associated with advanced reactor fuels. The NRC would need to evaluate the adequacy of new storage cask designs for onsite storage of advanced LWR and non-LWR fuel designs and any other radioactive components not previously reviewed as part of the current LWR technology. The NRC would consider how cask designs may be affected by different discharge and loading operations, since discharged fuel may not be housed in traditional spent fuel pools. Other challenges may involve

stacking spent fuel for non-LWRs during refueling operations, as well as detecting, segregating, and processing damaged fuel.

Thus, with only limited information about ANR SNFs concerning high-temperature gas-cooled reactors or liquid metal fast reactors, NUREG-2157 designated SNF from ANRs as being out of scope (NRC 2014-TN4117).

The same requirements for the shipment of spent fuel to and storage at an offsite ISFSI with respect to NRC and the U.S. Department of Transportation (DOT) regulations would apply to ANR SNF. Thus, the analysis of NUREG-2157 (NRC 2014-TN4117) for the safe handling, storage, and management of SNF could also apply to any type of ANR SNF, regardless of its chemical form, and is incorporated here by reference. Several assumptions can be made simply because any such SNF container (i.e., a storage cask or a transportation container or cask) or an ISFSI and DTS facilities for ANR SNF must satisfy the regulatory requirements of 10 CFR Part 71 (TN301), "Packaging and Transportation of Radioactive Material," 10 CFR Part 72 (TN4884), "Licensing Requirements for the Independent Storage of Spent Fuel, High-Level Radioactive Waste, and Reactor-related Greater Than Class C Waste," and 10 CFR Part 73 (TN423), "Physical Protection of Plants and Materials."

Any ANR spent fuel storage or shipping containers must demonstrate that ANR fuels can always be safely managed (see 10 CFR Part 71 Subpart E (TN301), *Package Approval Standards*, for shipping containers and 10 CFR Part 72 Subpart L (TN4884), *Approval of Spent Fuel Storage Casks, for spent fuel storage casks*).

Radionuclide inventories and thermal loading limits should not be a significant departure from the performance of currently certified spent fuel shipping and storage containers. For example, the radionuclide inventory and related container shielding for any type of ANR SNF must meet the regulatory requirements of 10 CFR 71.47 (TN301), *External radiation standards for all packages* and 10 CFR 72.236 (TN4884), *Specific requirements for spent fuel storage cask approval and fabrication*.

If ANR SNF is not encased in a zirconium alloy, then the highly exothermic chemical reaction called a runaway zirconium oxidation reaction or autocatalytic ignition as assessed in NUREG-2157 (NRC 2014-TN4117) is not possible. Metallic fuels could be encased in a type of stainless steel (e.g., stainless steel [SS] 316, HT9, and D9) rather than a zirconium alloy cladding (FRWG 2018-TN6696). TRISO fuels are encapsulated in ceramic and carbon-based materials, and "are structurally more resistant to neutron irradiation, corrosion, oxidation, and high temperatures (the factors that most impact fuel performance) than traditional reactor fuels" (DOE 2019-TN6786). Several suitable non-zirconium alloys may exist, including high-temperature nickel-based alloys and modified Hastelloy N variants, for showing acceptable compatibility in MSRs (Busby et al. 2019-TN6695).

In addition, any shipping or storage container for SNF, including SNF from ANRs, would have to satisfy the regulatory requirements of 10 CFR 71.55 (TN301), "General requirements for fissile material packages," and 10 CFR 72.236 (TN4884), "Specific requirements for spent fuel storage cask approval and fabrication," which include the following:

- Confine fuel to a known volume.
- Ensure compliance with criticality safety.
- Meet specific structural testing requirements.

- Permit normal handling and retrieval.

Because the ISFSI infrastructure and the required physical protection is no different for LWR SNF than for ANR SNF, the same considerations provided in NUREG-2157 (NRC 2014-TN4117) of a very low probability of an accident or of a successful terrorist attack with the resulting small environmental risk would apply during continued storage of ANR SNF. The one difference identified in NUREG-2157 was that for non-LWR SNF, the period of self-protection from acts of terrorism may be shorter than that of LWR SNF, depending on the burnup level and the isotopic composition of the SNM (i.e., the attractiveness of the material for diversion).

Therefore, if the ANR SNF conforms with the above analysis for this Category 1 issue, then the analysis of NUREG-2157 (NRC 2014-TN4117) would bound the environmental impacts and impacts would be SMALL. The staff relied on the following PPE assumptions to reach this conclusion:

- Table S–3 is expected to bound the impacts for ANR fuels, because of uranium fuel cycle changes since WASH-1248 (AEC 1974-TN23), including:
  - Current LWRs are using nuclear fuel more efficiently due to higher levels of fuel burnup resulting in fewer discharged fuel assemblies to be stored and disposed.
  - Less reliance on coal-fired electrical generation plants resulting in less gaseous effluent releases from electrical generation sources supporting storage and disposal.
- Waste and spent fuel inventories, as well as their associated certified spent fuel shipping and storage containers, are not significantly different from what has been considered for LWR evaluations in NUREG-2157 (NRC 2014-TN4117)
- Must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882) *Domestic Licensing of Source Material*, 10 CFR Part 70 (TN4883), *Domestic Licensing of Special Nuclear Material*, 10 CFR Part 71 (TN301), *Packaging and Transportation of Radioactive Material*, 10 CFR Part 72 (TN4884), *Licensing Requirements for the Independent Storage of Spent Fuel, High-Level Radioactive Waste, and Reactor-related Greater Than Class C Waste*, and 10 CFR Part 73 (TN423), *Physical Protection of Plants and Materials.*

However, if conditions, such as fuel stability within the uranium spent fuel (ORNL 1970-TN6754, ORNL 1998-TN6755) and the site conditions for construction and operation of an ISFSI including fuel transfers, go beyond what is in NUREG-2157, then a project-specific analysis would be necessary to demonstrate continued safe storage (ORNL 1970-TN6754, ORNL 1998-TN6755).

Disposal of ANR SNF in a deep geological repository would need to demonstrate compliance with radiation standards that are expected to be comparable, if not the same, as the existing radiation standards in Table B-1 in 10 CFR Part 51 (TN250) (e.g., a dose limit of 0.15 mSv [15 mrem]). Therefore, the offsite radiological impacts of ANR SNF could be expected to be classified as a Category 1 issue with no impact level assigned.

3.14.3 Staff Conclusions about the Environmental Impacts of an ANR Fuel Cycle

It is important to acknowledge that the determinations arrived in this GEIS are based on the staff's current understanding of the proposed plans and designs for the activities associated with ANR fuel and facilities. The staff reviewed the general literature containing information about expected ANR (LWR and non-LWR) fuel cycles. The review examined expected uranium and uranium-plutonium fuel forms (oxide, metal, TRISO, salt). The staff review examined available information about uranium extraction, uranium conversion, uranium enrichment, fuel processing/fabrication, nuclear material transportation, irradiated fuel processing, spent fuel management, and radioactive waste management as it is related to expected ANR systems. The NRC staff assumes that the thorium fuel cycle will not be significantly different from the uranium fuel cycle, therefore the uranium fuel cycle impacts should bound the thorium fuel cycle impacts.

Based on its review of the available, general information, the staff believes that ANR fuel cycles will have SMALL environmental impacts (i.e., impacts that are less than or comparable to those of current LWRs and those discussed in Table S–3), particularly for once-through fuel cycle options. The lower fuel cycle impacts are the result of improved fuel cycle technologies (reduced environmental impact), improved reactor technologies, and waste and spent fuel inventories that are not significantly different from what has been considered for LWR evaluations (e.g., as in Continued Storage Rulemaking) with respect to hazardous radionuclides.

An ANR applicant would have to demonstrate in its ER that the impacts of its fuel cycle fall within the values and assumptions of the PPE for the Category 1 issues above (see Section 1.4.1 of this GEIS). The NRC staff expects the ANR applicants to describe their planned fuel cycle designs, plans, and activities. The applicant's analysis needs to discuss and analyze any new processes (ones not considered in GEIS) that will be part of their fuel cycle.

3.15 Transportation of Fuel and Waste

3.15.1 Baseline Conditions and PPE/SPE Values and Assumptions

The NRC has generically evaluated the environmental effects of the transportation of fuel and waste to and from LWRs in 10 CFR 51.52 Table S-4, Environmental effects of transportation of fuel and waste (TN250). However, the environmental data in Table S-4 is only applicable to LWRs that use uranium oxide, or UO_2, fuel that meets specific criteria in 10 CFR 51.52(a) as expanded in Addendum 1 of NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Addendum to Main Report* (NRC 1999-TN289) and as discussed in Revision 1 of NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (NRC 2013-TN2654). ANR developers are expected to use uranium fuel with enrichment levels of up to 20 percent enrichment, known as HALEU (high-assay low-enriched uranium). In addition, as discussed in Section 3.14 of this GEIS, several of the potential non-LWR designs are expected to deploy non-UO_2 fuels (e.g., uranium metal, uranium carbide, uranium in a molten salt, etc.) or deploy ANRs based on a Th-232/U-233 fuel cycle. While Table S-4 does not apply to ANRs and non-UO_2 fuels, the transportation of fuel and waste is a connected action under NEPA regulations, guidance, and case law. Therefore, the NRC must still evaluate transportation impacts for the non-LWR fuel and waste to meet its obligations under NEPA as has been done for large LWR UO_2 fuels. This section addresses both the radiological and nonradiological environmental impacts from incident-free and accident conditions resulting from (1) shipment of unirradiated fuel to the ANR site, (2) shipment of LLRW and mixed waste to offsite disposal facilities, and (3) shipment of spent fuel to an interim storage facility or a permanent geologic repository. Air emissions from the transportation of fuel and waste, specifically for greenhouse gases or GHGs, are discussed in Section 3.3 of this GEIS.

3.15.1.1 Table S-4 on the Transportation of Fuel and Waste

The NRC performed a generic analysis of the environmental effects of the transportation of fuel and waste to and from LWRs in the *Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants*, WASH-1238 (AEC 1972-TN22) and in a supplement to WASH-1238, NUREG-75/038 (NRC 1975-TN216), and found the impact to be small. These documents provided the basis for Table S-4 in 10 CFR 51.52 (TN250) that summarizes the environmental impacts of transportation of fuel and waste to and from one LWR of 3,000 to 5,000 MW(t) (1,000 to 1,500 MW(e)). Impacts are provided for normal conditions of transport and accidents in transport for a reference 1,100 MW(e) LWR.[33] Dose to transportation workers during normal transportation operations was estimated to result in a collective dose of 4 person-rem per RRY. The combined dose to the public along the route and the dose to onlookers were estimated to result in a collective dose of 3 person-rem per RRY.

Based on public comments on the 1996 version of NUREG-1437 (NRC 1996-TN288), the NRC reevaluated the transportation issues and the adequacy of Table S-4 for license renewal application reviews. In 1999, the NRC issued an addendum to the 1996 License Renewal GEIS (NRC 1999-TN289) in which the agency evaluated the applicability of Table S-4 to future license renewal proceedings, given that the spent fuel is likely to be shipped to a single repository (as opposed to several destinations, as originally assumed in the preparation of Table S-4) and given that shipments of spent fuel are likely to involve more highly enriched fresh fuel (more than 4 percent as assumed in Table S-4) and higher-burnup spent fuel (higher than 33,000 MWd/MTU as assumed in Table S-4). In the addendum, the NRC evaluated the impacts of transporting the spent fuel from reactor sites to the candidate repository at Yucca Mountain and the impacts of shipping more highly enriched fresh fuel and higher-burnup spent fuel. On the basis of the evaluations, the NRC concluded that the values given in Table S-4 would still be bounding, as long as the (1) enrichment of the fresh fuel was 5 percent or less, (2) burnup of the spent fuel was 62,000 MWd/MTU or less, and (3) higher-burnup spent fuel (higher than 33,000 MWd/MTU) was cooled for at least 5 years before being shipped offsite. A later study found that the impacts presented in Table S-4 would bound the potential environmental impacts that would be associated with transportation of SNF with up to 75,000 MWd/MTU burnup, provided that the fuel is cooled for at least 5 years before shipment (Ramsdell et al. 2001-TN4545).

3.15.1.2 Additional NRC Studies of the Risk from the Transportation of SNF

Since the publication of WASH-1238 (AEC 1972-TN22) and NUREG-75/038 (NRC 1975-TN216), the NRC has undertaken four studies regarding the risk from the transportation of SNF. Each study improved upon the assumptions and analysis techniques from the prior study for assessing these risks.

In September 1977, the NRC published NUREG-0170, *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes*, which assessed the adequacy of the regulations in 10 CFR Part 71 (TN301), then entitled *Packaging and Transportation of Radioactive Waste* (NRC 1977-TN417, NRC 1977-TN6497). In that assessment, the measure of safety was the risk associated with radiation doses to the public under routine and accident transport conditions, and the risk was found to be acceptable. Since that time, there have been

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[33] Note that the basis for Table S-4 is a 1,100 MW(e) LWR at an 80 percent capacity factor (AEC 1972-TN22; NRC 1975-TN216).

two affirmations of this conclusion for SNF transportation, each using improved tools and information.

A 1987 study applied actual accident statistics to projected spent fuel transportation (Fischer et al. 1987-TN4105). This study, known as the "Modal Study," recognized that accidents could be described in terms of the strains they produced in transportation packages (for impacts) and the increase in package temperature (for fires). Like NUREG-0170 (NRC 1977-TN417, NRC 1977-TN6497), the 1987 study based risk estimates on models because the limited number of accidents that had occurred involving spent fuel shipments was not sufficient to support projections or predictions. The Modal Study's refinement of modeling techniques and use of accident frequency data resulted in smaller assessed risks than had been projected in NUREG-0170.

In 2000, a study of two generic truck packages and two generic rail packages analyzed the package structures and response to accidents by using computer modeling techniques (Sprung et al. 2000-TN222). The study used semi-trailer truck and rail accident statistics for general freight shipments because, even though more than 1,000 spent fuel shipments had been completed in the United States by the year 2000 and many thousands more had been completed safely internationally, there had been too few accidents involving spent fuel shipments to provide statistically valid accident rates. Sprung et al. 2000 (TN222) used improved technology to analyze the ability of containers to withstand an accident. This study concluded that the risk from the increased number of spent fuel shipments that could occur in the first half of this century would be even smaller than originally estimated in NUREG-0170 (NRC 1977-TN417, NRC 1977-TN6497).

NUREG-2125, published in January 2014, presented the results of a fourth investigation into the safety of SNF transportation (NRC 2014-TN3231). The selected routes included the origins and destinations analyzed in NUREG/CR-6672 (Sprung et al. 2000-TN222), thereby permitting the results of the studies to be compared. This investigation showed that the risk from the radiation emitted from the packages is a small fraction of naturally occurring background radiation and the risk from accidental release of radioactive material is several orders of magnitude less. Because there have been only minor changes to the radioactive material transportation regulations in NUREG-0170 (NRC 1977-TN417, NRC 1977-TN6497) and NUREG-2125, the calculated dose from the external radiation from the package under routine transport conditions is similar to what was found in earlier studies. The improved analysis tools and techniques, improved data availability, and a reduction in uncertainty have made the estimate of accident risk from the release of radioactive material in NUREG-2125 approximately five orders of magnitude less than what was estimated in NUREG-0170. The results from NUREG-2125 (NRC 2014-TN3231) demonstrate that NRC regulations continue to provide adequate protection of public health and safety during the transportation of SNF.

For the assessment of the potential generic impacts of transporting SNF in this GEIS, NUREG-2125 (NRC 2014-TN3231) is examined for environmental impacts because it is the most recent study that applies the latest knowledge and analytical tools.

3.15.1.3 Additional NRC Information Sources

Several NRC EISs regarding the construction and operation of new reactors contain an analysis of the potential environmental impacts due to the transportation of LWR fuel and waste. These transportation assessments were performed by the new reactor applicants to meet the regulatory requirements of 10 CFR 51.52 (TN250). The NRC staff then reviewed the applicant's analyses and made a final assessment of the impacts, normalized with respect to power level and the amount of radioactive material per shipment, to allow for comparison to the results presented in Table S-4 of 10 CFR 51.52. While 10 CFR 51.52 applies only to LWRs, these assessments may help inform the staff's assessment in this GEIS because of the similarities in transportation modes (e.g., packaging, routing, and distances) and the quantities of radioactive material per shipment.

In addition to the new reactor EISs, the NRC has published two draft EISs regarding the proposed licensing of two interim storage facilities (NRC 2020-TN6498, NRC 2020-TN6499). The transportation assessments of these draft EISs will also be examined for informing the transportation assessments in this GEIS.

3.15.1.4 U.S. Department of Energy Transportation Risk Assessments

The DOE routinely ships radioactive material between their various national laboratories and other nuclear facilities. Examples of these shipments include shipments of LLRW and transuranic wastes to DOE disposal sites at the Nevada Test Site and the Waste Isolation Pilot Plant (WIPP), respectively. Some DOE LLRW has also been shipped to commercial disposal sites. DOE has also transported SNF as part of various national programs, such as shipments of research quantities of commercial SNF to the INL (INL 2020-TN6500). Hence, DOE developed a transportation risk assessment handbook to provide a methodology for DOE staff and DOE contractors to apply when conducting necessary NEPA analysis related to DOE programs involving shipments of radioactive material (DOE 2002-TN1236). The methodology presented in the DOE handbook is the preferred analytical method for assessing the environmental impacts of the transportation of fuel and waste.

DOE has also published a number of reports that include transportation risk assessments as a component of their NEPA analysis in support of a number of DOE program decisions. A majority of these are for specific situations and for a limited number of radioactive material shipments. There are two transportation risk assessments that are more comprehensive with respect to potentially large shipping campaigns. The first of these two assessments is the transportation analysis in support of the licensing of the Yucca Mountain geologic repository (DOE 2002-TN1236). The second study is a series of reports (Monette et al. 1995-TN6505, Monette et al. 1995-TN6506; Biwer et al. 1996-TN6502; Monette et al. 1996-TN6501, Monette et al. 1996-TN6503) concerning the transportation of radioactive wastes as part of the production of the DOE Waste Management Programmatic Environmental Impact Statement (DOE 1997-TN6752). Information from these assessments will be used in this evaluation of the environmental impacts of non-LWR waste shipments.

3.15.1.5 Issues for the Transportation of Non-LWR Fuel and Wastes

There is limited information regarding the transportation of several forms of non-LWR fuel due to the expected higher enrichment levels (i.e., HALEU fuel) and the physical form of the non-LWR fuel being shipped. This limited information has been identified in several reports and conference/seminar/workshop presentations and principally involves suitable transportation packages to support the economic use of HALEU materials (Jarrell 2018-TN6508; Eidelpes et al. 2019-TN6507; Reardon et al. 2019-TN6952).

Principal issues involve the lack of certified transport packages for unirradiated and irradiated HALEU fuel and radioactive waste. Items being considered for non-LWR fuel and waste transport packages include the following:

- non-LWR fresh fuel shipments likely to be similar to those for LWRs (except for molten salt);
- processing operations and transportation for MSRs and sodium fast reactors (SFRs) are significantly different than for the current reactor fleet; and
- uncertainty in the post irradiation forms for transport and storage.

Another potential departure from current transportation practices for LWR unirradiated, or fresh, fuel and SNF is the fuel loading in one transport package. Currently, multiple shipments must be made to fuel the LWR core and to remove the SNF from the LWR site. There are non-LWR developers whose relatively small size of the reactor core may lead them to consider transporting the entire and completely assembled reactor core or reactor vessel with the core to and from the reactor site. These are all factors that must be considered in this evaluation to determine if the environmental impacts from the transportation of non-LWR fuel and waste can be generically addressed.

Another aspect of ANRs not previously analyzed by the NRC for their environmental impacts from the transportation of fuels and wastes involves the potential for such impacts from a fusion reactor. Because one of the expected forms of fusion fuel is related to radioactive tritium (see Section 3.14 for more information about a fusion fuel cycle), there could be the need for shipments of tritium from a commercial source to a fusion facility. For example, DOE has shipped tritium in support of defense programs in Type B quantities (greater than or equal to 40 TBq) in the Bulk Tritium Shipping Package (BTSP), UC-609, or H1616 packages (DOE 2015-TN6787); the NAC International Inc.-Legal Weight Truck (NAC-LWT) package is certified by the NRC to transport tritium in the form of tritium-producing burnable absorber rods (NRC 2020-TN6797); and the 3605D package is approved by the DOT for import/export shipments of tritium (DOT 2018-TN6798; NRC 2020-TN6797). In addition, there would be some volume of LLRW generated within a fusion facility to be shipped to a licensed disposal facility. This LLRW would be from the operations of the fusion reactor, such as equipment maintenance, and from the management of the tritium fuel. The LLRW could include contaminated tools, contaminated anti-contamination clothing, and activated replaced parts or small components from the 14.1 MeV neutron that deuterium-tritium fusion generates.

3.15.1.6 Development of the Transportation Plant Parameter Envelope

The effects of incident-free and accident transportation are proportional to the total shipment distance associated with the unirradiated fuel, radioactive waste, or irradiated fuel, i.e., as the number of shipments and the shipping distance increase, the effects from transporting the unirradiated fuel, radioactive waste, or irradiated fuel also increase. For this reason, the total shipment distance was used as the metric for the transportation PPE. The total shipment distance is quantified in terms of the annual one-way shipment distance or the annual round-trip shipment distance.

The annual one-way shipment distance is calculated using the formula:

Annual One-Way Shipment Distance (km) = Annual Number of Normalized Shipments x One-Way Shipping Distance (km)

The annual round-trip shipment distance is calculated using the formula:

Annual Round-Trip Shipment Distance (km) = 2 x Annual Number of Normalized Shipments x One-Way Shipping Distance (km)

In order to develop the transportation PPE, NRC staff examined WASH-1238 and past new reactor EISs to determine the total shipment distances evaluated in these EISs for unirradiated fuel, radioactive waste, or irradiated fuel. The NRC staff also identified factors that could affect the relationship between the effects of incident-free and accident transportation and the total shipment distance.

Factors identified by the NRC staff included:

- The use of different versions of RADTRAN to estimate the effects of transporting unirradiated fuel, radioactive waste, and irradiated fuel: The radiation doses and risks discussed in Sections 3.15.1.7, 3.15.1.8, and 3.15.1.9 below were estimated using the RADTRAN computer code. RADTRAN has changed over time, with Version 5 (Neuhauser et al. 2000-TN6990; Neuhauser and Kanipe 2003-TN6989) being used in EISs published in the period 2006-2008, Version 5.6 (Weiner et al. 2008-TN302) being used in EISs published in the period 2011-2016, and Version 6 being the current version (Weiner et al. 2013-TN3390, Weiner et al. 2014-TN3389). A specific example of how RADTRAN has changed over time is in how it estimates long-term doses after a transportation accident, where RADTRAN 5 and 5.6 estimated a 50-year long-term dose from transportation accidents, while RADTRAN 6 no longer provides 50-year long-term dose estimates (see page 66 and equation 75 in Weiner et al. 2014-TN3389).
- The use of different census data to estimate the effects of transporting unirradiated fuel, radioactive waste, and irradiated fuel: The radiation doses and risks discussed in Sections 3.15.1.7, 3.15.1.8, and 3.15.1.9 below were estimated using 2000 census and 2010 census data; earlier EISs used 2000 census data and later EISs used 2010 census data to estimate transportation impacts. The use of different census data can affect the estimates of the effects of transporting unirradiated fuel, radioactive waste, and irradiated fuel for a transportation route, even if the route remains the same.
- The use of different sources of transportation accident, injury, and fatality rate data to estimate the effects of transporting unirradiated fuel, radioactive waste, and irradiated fuel: In general, the radiological and nonradiological effects discussed in Sections 3.15.1.7, 3.15.1.8, and 3.15.1.9 below were estimated using state-level accident, injury, and fatality rate data from Saricks and Tompkins (1999-TN81). However, other sources of transportation accident, injury, and fatality rate data have been used (e.g., DOT 2013-TN3930). The use of different accident, injury, and fatality rate data can affect the estimates of the effects of transporting unirradiated fuel, radioactive waste, and irradiated fuel.
- The number of exposed persons along different transportation routes: Lower transportation effects would be estimated for routes through more sparsely populated areas (rural) than for routes through more highly populated areas (urban and suburban), where higher transportation effects would be estimated. The fraction of a route that is urban, suburban, and rural will vary for the same destination depending on the originating site's location and on the states traversed by a transportation route.
- Differences in the accident, injury, and fatality rates in the various states traversed by a transportation route: The transportation accident effects discussed in Sections 3.15.1.7, 3.15.1.8, and 3.15.1.9 below were typically estimated using state-level accident, injury, and fatality rate data (see Saricks and Tompkins 1999-TN81). These rates differ by state, which can yield higher or lower estimates of effects depending on the states traversed by a transportation route.
- Differences in parameters such as source-to-receptor distances, shielding factors, transportation cask dimensions, etc., used to estimate the effects of transporting

unirradiated fuel, radioactive waste, and irradiated fuel: The radiological effects discussed in Sections 3.15.1.7, 3.15.1.8, and 3.15.1.9 below were estimated using specific values of parameters deemed appropriate at the time of the analysis, such as source-to-receptor distances, shielding factors, and transportation cask dimensions. These specific parameter values would affect the calculated values in the tables below.

- Differences in the radionuclide inventory contained in a transportation cask due to the irradiated fuel having higher or lower burnup: The radiological effects associated with transportation accidents involving irradiated fuel discussed in Section 3.15.1.9 were estimated using a transportation cask with a capacity of 0.5 MTU. However, the burnup associated with the irradiated fuel would be reactor-specific. The burnup affects the radionuclide inventory, which in turn affects the estimates of the estimated radiation doses from transportation accidents involving irradiated fuel.
- Use of an updated stop model for unirradiated fuel shipments: The transportation effects in the North Anna (NRC 2006-TN7), Clinton (NRC 2006-TN672), and Grand Gulf (NRC 2006-TN674) EISs were estimated using a stop model with a population density of 64,300 people/km^2 in a 3.3 to 33 ft (1 to 10 m) annular ring around the vehicle. In addition, the exposure time was estimated to be 4.5 hours and no shielding was assumed. In later EISs, transportation effects were estimated using the updated stop model described by Griego et al. (1996-TN69).

NRC staff found that these factors do not affect the use of the total shipment distance as the metric for the transportation PPE but account for the variations in the calculated values in the subsequent tables.

3.15.1.7 Transportation of Unirradiated ANR Fuel

Unirradiated nuclear fuel assemblies, or fresh fuel elements, are transported to the nuclear reactor in protective outer packages designed to prevent damage to the fuel elements in transit (Rhoads 1977-TN6572). Typically, one pressurized water reactor (PWR) or two boiling water reactor (BWR) fuel elements are placed in a protective overpack designed to protect the valuable fuel element from damage during transport (NRC 2019-TN6511, NRC 2019-TN6512, NRC 2019-TN6513). These overpacks are usually shipped to the nuclear reactor site by truck. Ten containers of PWR fuel (Table B-2 of WEC 2019-TN6510) each containing one assembly or six containers of BWR fuel each containing two assemblies are typically placed on a standard truck semi-trailer with a current maximum Federal gross vehicle weight limit of 80,000 pounds (DOT 2015-TN6753).[34] The overpack dimensions appear to be the limiting factor for the number of overpacks in one shipment and not the maximum Federal gross vehicle weight limit.

The necessary NRC-certified transport packages for unirradiated ANR fuel at HALEU enrichment levels are being developed (Jarrell 2018-TN6508; Eidelpes et al. 2019-TN6507; Jarrell and Eidelpes 2020-TN6694). For example, in Section 4, Review and Application of Existing Packaging Designs, in the paper by Eidelpes et al. (2019-TN6507), the authors note that two promising packaging designs were identified that could be adapted for HALEU transportation, and could be readily transported by truck. These are the Transnuclear (TN) Americas Long Cask (TN-LC) (NRC 2017-TN6684) and the NAC International Optimal Modular Universal Shipping for low-activity contents (OPTIMUS™-L) packaging. In addition, review of the NRC-certified transport packages listed on DOE’s Radioactive Material Packaging

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[34] 10 CFR 51.52 (TN250) Table S–4 includes a condition that the truck shipments not exceed 73,000 lb as governed by Federal or State gross vehicle weight restrictions.

(RAMPAC) website reveals a small number of transportation packages that are currently certified for shipping HALEU material, such as the VP-55 package (Hennebach and Langston 2020-TN6693; NRC 2020-TN6686). The VP-55 package is also certified for various forms of unirradiated TRISO fuel in the form of uranium kernels and TRISO particles, which may be loose or mixed in a graphite matrix and pressed into compacts of various fuel forms (e.g., annular cylinders, planks, right circular cylinders, spheres, etc.).

There are also DOE-certified transport packages that potentially could be applied for shipping HALEU fuel (Jarrell 2018-TN6508). The higher enriched material approved for such certified packages could be in the form of UF_6, TRISO, and research reactor plate fuel. Given the nature of liquid-fueled MSRs where the HALEU material is mixed with the chloride- or fluoride-based molten salt, it should be expected that the HALEU material would be shipped from the enrichment site to the ANR site in the form of UF_6 (McFarlane et al. 2019-TN6741).

3.15.1.7.1 Normal Conditions

Normal conditions, sometimes referred to as “incident-free” transportation, are transportation activities during which shipments reach their destination without releasing any radioactive material to the environment (i.e., not being involved in a vehicular accident). Impacts from these shipments would be from the low levels of radiation that penetrate the shielding provided by unirradiated fuel shipping containers. In the case of unirradiated fuel, the radiation would be from the natural decay of the uranium isotopes. Past studies have determined the largest impacts would occur for shipments made by trucks due to a larger number of shipments that would occur versus rail shipments, and these impacts would also have a larger exposure population due to existing travel densities on U.S. roadways.

The number of unirradiated fuel shipments for WASH-1238 (AEC 1972-TN22) and new reactor LWR licensing actions are provided in Table 3-10. This table is broken down by shipments for an initial core loading, the number of annual shipments to support core reloading, and the total number of shipments over the lifetime of the operating license (assumed to be 40 years). For example, the Advanced Passive 1000 (AP1000) fuel shipments would have approximately seven PWR overpacks for each truck shipment.[35] This results in a mass loading of approximately 3.8 MTU per truck shipment. It is anticipated that for an MSR, unirradiated fuel would be shipped in the form of UF_6. For low-enriched UF_6, a standard truck loading is six Type 30B cylinders per truck (USEC 1999-TN6515) for approximately 9.3 MTU per truck. To have the equivalent MTU as the PWR unirradiated fuel shipment would require about three Type 30B cylinders per truck. Assuming equal uranium requirements, this would reduce the number of unirradiated fuel shipments required for an MSR by about 50 percent compared to a large LWR.

The radiological impacts provided in WASH-1238 (AEC 1972-TN22) and the previous new reactor EISs, as shown in Table 3-11, were based on annual exposures from the expected number of shipments over a year as normalized to 1,100 MW(e) (or 880 MW(e) net electrical output). Another factor to consider when extending this analysis to ANRs is the assumption applied in WASH-1238 and in the staff’s analysis of new reactor unirradiated fuel shipments that the radiation dose rate at 3.3 ft (1 m) from the transport vehicle is about 0.1 mrem/hr. This assumption should also be reasonable for ANRs because the HALEU materials would still be low-dose-rate uranium radionuclides and would likely be packaged similarly to those described in WASH-1238 (i.e., inside a metal container that provides little radiation shielding).

[35] There are 157 fuel assemblies per core loading and 23 initial core loading shipments; therefore, 157/23 ≈ 6.8 rounded to 7 fuel assemblies per shipment.

Table 3-10 Number of Truck Shipments and One-Way Shipping Distances for Unirradiated Fuel

Site Name	Number of Shipments Per Site				
	Initial Core	Total Reload[(a)]	Total[(a)]	Normalized Annual Shipments[(b)]	One-Way Shipping Distance (km)
WASH-1238 (NRC 2006-TN7)	18	234	252	6.3	3,200
North Anna Power Station Unit 3 ESP (NRC 2006-TN7)	51	780	831	18.2	3,200
Clinton Exelon ESP (NRC 2006-TN672)	51	780	831	18.2	3,200
Grand Gulf ESP (NRC 2006-TN674)	51	780	831	18.2	3,200
Vogtle Units 3 and 4 ESP (NRC 2008-TN673)	23	210	233	5	3,200
Calvert Cliffs Unit 3 COL (NRC 2011-TN1980)	–	–	298	4.4	3,200
South Texas Units 3 and 4 COL (NRC 2011-TN1722)	–	–	372	6.6	3,200
Virgil C. Summer Units 2 and 3 COL (NRC 2011-TN1723)	–	–	233	5	3,200
Levy Units 1 and 2 COL (NRC 2012-TN1976)	23	210	233	5	1,166
Comanche Peak Units 3 and 4 COL (NRC 2011-TN6437)	–	–	100	1.5	3,200
Enrico Fermi Unit 3 COL (NRC 2013-TN6436)	38	323	361	5.3	3,600
William States Lee Units 1 and 2 COL (NRC 2013-TN6435)	23	234	257	6.1	3,200
PSEG ESP (NRC 2015-TN6438)	45	300	345	4.9	4,400
Turkey Point Units 6 and 7 COL (NRC 2016-TN6434)	–	–	209	5	3,200
Bell Bend COL (NRC and USACE 2016-TN6562)	–	–	298	4.3	4,247
Clinch River ESP (NRC 2019-TN6136)	36	456	492	15	3,944

(a) Total shipments of unirradiated fuel over a 40-year plant lifetime.
(b) Normalized to Reference LWR (880 MW(e) net).

Table 3-11 Radiological Impacts Under Normal Conditions of Transporting Unirradiated Fuel from WASH-1238 and New Reactor Sites

Site Name	Annual Total One-Way Shipment Distance[a] (km)	Population Impacts (person-rem/yr)[b]		
		Workers	Public Onlookers	Public Along Route
WASH-1238 (NRC 2006-TN7)	20,160	0.011	0.042	0.0010
North Anna Power Station Unit 3 ESP (NRC 2006-TN7)	58,240	0.031	0.12	0.0029
Clinton Exelon ESP (NRC 2006-TN672)	58,240	0.031	0.12	0.0029
Grand Gulf ESP (NRC 2006-TN674)	58,240	0.031	0.12	0.0029
Vogtle Units 3 and 4 ESP (NRC 2008-TN673)	16,000	0.0085	0.015	0.00021
Calvert Cliffs Unit 3 COL (NRC 2011-TN1980)	14,080	0.0076	0.016	0.00023
South Texas Units 3 and 4 COL (NRC 2011-TN1722)	21,120	0.011	0.024	0.00033
Virgil C. Summer Units 2 and 3 COL (NRC 2011-TN1723)	16,000	0.0085	0.018	0.00025
Levy Units 1 and 2 COL (NRC 2012-TN1976)	5,830	0.0031	0.0076	0.00029
Comanche Peak Units 3 and 4 COL (NRC 2011-TN6437)	4,800	0.0041	0.0071	0.000043
Enrico Fermi Unit 3 COL (NRC 2013-TN6436)	19,080	0.010	0.018	0.00018
William States Lee Units 1 and 2 COL (NRC 2013-TN6435)	19,520	0.012	0.021	0.00029
PSEG ESP (NRC 2015-TN6438)	21,560	0.0071	0.016	0.00047
Turkey Point Units 6 and 7 COL (NRC 2016-TN6434)	16,000	0.0090	0.018	0.00025
Bell Bend COL (NRC and USACE 2016-TN6562)	18,262	0.0098	0.038	0.00067
Clinch River ESP (NRC 2019-TN6136)	59,160	0.0078	0.044	0.0012
Maximum Estimate	59,160	0.031	0.12	0.0029

(a) The total shipment distance is based on the number of annual shipments multiplied by the shipping distance.
(b) Normalized to Reference LWR (880 MW(e) net).(a). Normalized to Reference LWR (880 MW(e) net).

The one-way distances should also be bounding for unirradiated HALEU fuel shipments because the existing fuel fabrication facility locations would still be expected to fabricate HALEU fuel. Additionally, the distances from enrichment facilities to an MSR site for HALEU UF_6 shipments should also be within these one-way distances.

3.15.1.7.2 Transportation Accidents

Accident risks are a combination of accident frequency and consequence. Accident frequencies for transportation of unirradiated fuel are expected to be lower than those used in the analysis in WASH-1238 (AEC 1972-TN22). This is based on the NRC staff evaluations in previous new reactor EISs where the NRC staff identified the trends in improvements in highway safety and security, and an overall reduction in traffic accident, injury, and fatality rates since WASH-1238 was published. Although packages for all types of ANR unirradiated fuel have not been designed or certified by the NRC, these packages must comply with the packaging requirements contained in 10 CFR Part 71 (TN301) and, for this reason, the impacts of radiological accidents during transport of unirradiated fuel to an ANR are expected to be smaller than those listed in Table S-4 in 10 CFR 51.52 (TN250).

Nonradiological impacts are the human health impacts projected to result from traffic accidents involving shipments of unirradiated fuel to the ANR site (i.e., the analysis does not consider the radiological or hazardous characteristics of the cargo). Nonradiological impacts include the projected number of traffic accidents, injuries, and fatalities that could result from shipments of unirradiated fuel to the site and return shipments of empty containers from the site. The methodology for determining the nonradiological impacts can be found in any of the new reactor EISs, such as in Section 6.2.1.3, Nonradiological Impacts of Transportation Accidents, of the Clinch River ESP Final EIS (NRC 2019-TN6136). This methodology is incorporated by reference in this GEIS. The nonradiological impacts for unirradiated fuel shipment accidents from WASH-1238 (AEC 1972-TN22) and the new reactor EISs are provided in Table 3-12.

3.15.1.7.3 Summary of PPE Values for Transport of Unirradiated ANR Fuel

Based on the above information, Table 3-11 and Table 3-12 present the PPE for transport of unirradiated ANR fuel. This PPE consists of two components:

- The maximum annual one-way shipment distance (36,760 mi [59,160 km]) presented below in Table 3-11. The annual shipments associated with the one-way shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor from WASH-1238.
- The maximum annual round-trip shipment distance (73,520 mi [118,320 km]) presented below in Table 3-12. The annual shipments associated with the round-trip shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor from WASH-1238.

The PPE applies to situations where the enrichment of the unirradiated ANR fuel is 20 percent or less, based on the unlimited A_2 value in Table A-1 in 10 CFR Part 71 for unirradiated uranium enriched to 20 percent or less (10 CFR Part 71-TN301). This PPE does not apply to situations in which an ANR applicant proposes to ship the unirradiated ANR fuel by air, ship, or barge; or in which an ANR applicant proposes that an unirradiated ANR fuel transportation package be approved using the provisions of 10 CFR 71.12, 10 CFR 71.41(c), or 10 CFR 71.41(d), such as might be applied for when shipping a complete unirradiated ANR core.

Table 3-12 Nonradiological Impacts of Transporting Unirradiated Fuel

Site Name	Annual Total Round-Trip Shipment Distance[a] (km)	Accidents per Year[b]	Injuries per Year[b]	Fatalities per Year[b]
WASH-1238 (NRC 2006-TN7)	40,320	–[c]	–[c]	–[c]
North Anna Power Station Unit 3 ESP (NRC 2006-TN7)	116,480	–[c]	–[c]	–[c]
Clinton Exelon ESP (NRC 2006-TN672)	116,480	–[c]	–[c]	–[c]
Grand Gulf ESP (NRC 2006-TN674)	116,480	–[c]	–[c]	–[c]
Vogtle Units 3 and 4 ESP (NRC 2008-TN673)	32,000	0.0090	0.0061	0.00029
Calvert Cliffs Unit 3 COL (NRC 2011-TN1980)	28,160	0.013	0.0066	0.00041
South Texas Units 3 and 4 COL (NRC 2011-TN1722)	42,240	0.020	0.0098	0.00061
Virgil C. Summer Units 2 and 3 COL (NRC 2011-TN1723)	32,000	0.015	0.0074	0.00046
Levy Units 1 and 2 COL (NRC 2012-TN1976)	11,660	0.0069	0.0038	0.00031
Comanche Peak Units 3 and 4 COL (NRC 2011-TN6437)	9,600	0.0026	0.0013	0.000087
Enrico Fermi Unit 3 COL (NRC 2013-TN6436)	38,160	0.018	0.0089	0.00055
William States Lee Units 1 and 2 COL (NRC 2013-TN6435)	39,040	0.018	0.0090	0.00056
PSEG ESP (NRC 2015-TN6438)	43,120	0.024	0.012	0.00072
Turkey Point Units 6 and 7 COL (NRC 2016-TN6434)	32,000	0.015	0.0074	0.00046
Bell Bend COL (NRC and USACE 2016-TN6562)	36,524	0.14	0.0086	0.00030
Clinch River ESP (NRC 2019-TN6136)	118,320	0.069	0.035	0.0018
Maximum Estimate	118,320	0.14	0.035	0.0018

(a) The total shipment distance is based on the number of annual shipments multiplied by the round-trip shipping distance. The round-trip distance is used because nonradiological vehicle accident impacts could occur on the return trip.
(b) Normalized to Reference LWR (880 MW(e) net).
(c) Not analyzed.

3.15.1.8 Transportation of Radioactive Waste from ANRs

As discussed in Section 3.10 of this GEIS, radioactive waste can consist of a variety of materials with radioactivity levels from just above background radiation levels found in nature to very high radioactivity in certain cases. While SNF is also radioactive waste, it is classified as high-level radioactive waste, or HLW, and will be discussed in Section 3.15.1.8. This section assesses the LLRW generated at an ANR site that would be stored onsite, either until it has decayed away and can be disposed of as ordinary trash, or until amounts are large enough for shipment to a LLRW disposal site in packages authorized by the DOT (e.g., Type A packages) or approved by the NRC (e.g., Type B transport packages).

The characteristics of radioactive waste from ANRs are expected to be the same as those of the radioactive waste generated by the current LWR fleet. Because of the design, size, and the nature of the potential operations at an ANR, the amount of LLRW likely to be generated annually by an ANR could be noticeably less than that generated by the current LWRs.

The staff has assessed LLRW shipment impacts as part of the environmental review of new reactor ESP and COL applications relative to the annual LLRW shipments shown in Table 3-13. As noted on the NRC website for LLRW disposal (NRC 2020-TN6516), there are four existing commercial LLRW disposal facilities in the United States that accept various classes of LLRW.[36] All are in Agreement States. The Low-Level Radioactive Waste Policy Amendments Act of 1985 (Public Law 99–240, 99 Stat. 1842; TN6517) gave the States responsibility for the disposal of their LLRW. The Act encouraged the States to enter into compacts that would allow them to dispose of waste at a common disposal facility. Two LLRW disposal facilities only accept wastes from within their Compact. Two other LLRW disposal facilities could accept LLRW regardless of the location of the LLRW generator. One LLRW disposal site will accept Class A LLRW and another LLRW disposal site will accept Class A, B, and C LLRW. Energy*Solutions* Clive Operations, located in Clive, Utah, accepts waste from all regions of the United States. Clive is licensed by the State of Utah for Class A waste only (NRC 2017-TN6518). Waste Control Specialists (WCS), LLC, located near Andrews, Texas, accepts waste from the Texas Compact generators and outside generators with permission from the Compact. WCS is licensed by the State of Texas to dispose of Class A, B, and C waste. For the new reactor LLRW transportation impacts, the staff selected the Energy*Solutions* or the WCS LLRW disposal facility if the location was not in a Compact with one of the other two LLRW disposal facilities.

The DOE's Manifest Information Management System (MIMS) is a database used to monitor the management of commercial LLRW in the United States (DOE 2020-TN6669). The LLRW information in MIMS is derived from manifests for waste shipments to one closed and four operating commercial LLRW disposal facilities. MIMS information for the most recent five years for available data (i.e., 2015 to 2019) was compiled for the four commercial LLRW disposal facilities by the different classes of LLRW. Table 3-14 provides the breakdown to each LLRW disposal facility by volume and Table 3-15 does so by activity.

[36] The classes of LLRW are defined under 10 CFR 61.55, "Waste classification" (10 CFR Part 61-TN252).

Table 3-13 Summary of Radioactive Waste Shipments and One-Way Shipping Distances

Site Name	Annual Waste Generation per Unit (m^3/yr-unit)	Number of Radioactive Waste Shipments[(a)]	One-Way Shipping Distance (km)
WASH-1238 (NRC 2006-TN7)	108	46	–[(b)]
North Anna Power Station Unit 3 ESP (NRC 2006-TN7)	168	51	–[(b)]
Clinton Exelon ESP (NRC 2006-TN672)	168	51	–[(b)]
Grand Gulf ESP (NRC 2006-TN674)	168	51	–[(b)]
Vogtle Units 3 and 4 ESP (NRC 2008-TN673)	56	21	800
Calvert Cliffs COL (NRC 2011-TN1980)	208	9	800
South Texas Units 3 and 4 COL (NRC 2011-TN1722)	99	31	800
Virgil C. Summer Units 2 and 3 COL (NRC 2011-TN1723)	56	21	800
Levy Units 1 and 2 COL (NRC 2012-TN1976)	56	21	800
Comanche Peak Units 3 and 4 COL (NRC 2011-TN6437)	433	109	800
Enrico Fermi Unit 3 COL (NRC 2013-TN6436)	449	114	800
William States Lee Units 1 and 2 COL (NRC 2013-TN6435)	56	21	800
PSEG ESP (NRC 2015-TN6438)	432.7	105.4	1110
Turkey Point Units 6 and 7 COL (NRC 2016-TN6434)	56	23	800
Bell Bend COL (NRC and USACE 2016-TN6562)	208	52	800
Clinch River ESP (NRC 2019-TN6136)	142	75	1954.3

(a) The number of shipments was calculated assuming the average waste shipment capacity of 82.6 ft^3 (2.34 m^3) per shipment applied in WASH-1238 (AEC 1972-TN22) (3,810 ft^3/yr [108 m^3/yr] divided by 46 shipments/year yields 82.6 ft^3 [2.34 m^3] per shipment). The number of shipments was also normalized to 880 MW(e).

(b) Not analyzed.

Table 3-14 Low-Level Radioactive Waste by Volume

Year	Class A Volume (m^3)	Class B Volume (m^3)	Class C Volume (m^3)	Total Volume (m^3)
		Barnwell		
2019	246.5	39.3	19.1	305.0
2018	293.4	41.1	19.7	354.2
2017	325.2	33.5	23.8	382.6
2016	128.2	54.4	17.8	200.4
2015	220.1	44.1	15.8	280.0
Median	246.5	41.1	19.1	305.0
		Energy*Solutions*		
2019	118,516.6	0.0	0.0	118,516.6
2018	142,926.6	0.0	0.0	142,926.6
2017	142,007.0	0.0	0.0	142,007.0
2016	45,589.0	0.0	0.0	45,589.0
2015	34,922.3	0.0	0.0	34,922.3
Median	118,516.6	0.0	0.0	118,516.6
		Richland		
2019	493.1	0.0	0.0	592.3
2018	381.0	3.4	0.0	432.8
2017	314.9	3.4	0.1	393.9
2016	479.9	3.4	11.6	600.8
2015	699.7	0.4	0.6	775.9
Median	479.9	3.4	0.1	592.3
		Waste Control Specialists		
2019	756.6	104.2	49.7	910.4
2018	191.9	205.5	75.1	472.5
2017	144.3	133.8	48.5	326.6
2016	156.1	137.7	66.8	360.5
2015	366.3	273.3	53.7	693.3
Median	191.9	137.7	53.7	472.5
		Annual Total		
2019	120,012.8	143.5	68.8	120,324.3
2018	143,792.8	250.0	94.9	144,186.1
2017	142,791.4	170.8	72.4	143,110.1
2016	46,353.1	195.5	96.1	46,750.8
2015	36,208.4	317.8	70.2	36,671.5
Median	120,012.8	195.5	72.4	120,324.3

Source: DOE 2020-TN6669. Original units were cubic feet. Cubic feet were converted to cubic meters by multiplying by 0.0283 m^3/ft^3.

Table 3-15 Low-Level Radioactive Waste by Activity

Year	Activity Class A (curies)	Activity Class B (curies)	Activity Class C (curies)	Total Activity (curies)
		Barnwell		
2019	251.90	3,315.23	26,986.16	30,553.29
2018	301.45	977.64	157.36	1,436.45
2017	219.09	637.42	399.58	1,256.09
2016	72.55	587.42	76.58	736.55
2015	162.49	594.71	8,860.88	9,618.09
Median	219.09	637.42	399.58	1,436.45
		Energy*Solutions*		
2019	9,553.56	0.00	0.00	9,553.56
2018	11,426.33	0.00	0.00	11,426.33
2017	11,986.52	0.00	0.00	11,986.52
2016	11,632.51	0.00	0.00	11,632.51
2015	13,300.38	0.00	0.00	13,300.38
Median	11,632.51	0.00	0.00	11,632.51
		Richland		
2019	658.32	0.00	0.00	669.66
2018	1,190.35	164.48	0.00	1,359.77
2017	63.00	7,752.74	562.90	9,825.65
2016	219.07	7,673.09	67,555.10	75,742.88
2015	361.79	358.00	2.71	738.85
Median	361.79	358.00	2.71	1,359.77
		Waste Control Specialists		
2019	723.33	4,935.57	88,333.14	93,992.05
2018	91.41	9,537.20	200,489.96	210,118.58
2017	156.85	4,439.65	29,514.14	34,110.65
2016	492.16	4,886.19	110,835.49	116,213.84
2015	1,404.82	6,648.10	35,146.49	43,199.41
Median	492.16	4,935.57	88,333.14	93,992.05
		Annual Total		
2019	11,187.11	8,250.80	115,319.30	134,768.56
2018	13,009.54	10,679.32	200,647.32	224,341.13
2017	12,425.46	12,829.81	30,476.62	57,178.91
2016	12,416.29	13,146.70	178,467.17	204,325.78
2015	15,229.48	7,600.81	44,010.08	66,856.73
Median	10,679.32	115,319.30	134,757.21	134,768.56

Source: DOE 2020-TN6669

As can be seen in a comparison of annual waste volumes in Table 3-13 and Table 3-14, all of the LWR waste streams are a small fraction of the median annual total volumes for the last 5 years of data. The annual curie content of the LLRW from ANRs is also expected to be small fraction of the median annual total as provided in Table 3-15.

3.15.1.8.1 Summary of PPE Values for Transport of Radioactive Waste from ANRs

In NUREG-0170, *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes* (NRC 1977-TN417, NRC 1977-TN6497), the NRC evaluated the shipment of radioactive material, including shipments of unirradiated fuel, SNF, and radioactive waste to and from nuclear power plants. The NRC concluded in NUREG-0170 that the average radiation dose to the population at risk from normal transportation is a small fraction of the limits recommended for members of the general public from all sources of radiation other than natural and medical sources and is a small fraction of the natural background dose. In addition, the NRC determined that the radiological risk from accidents in transportation is small, amounting to about 0.5 percent of the normal transportation risk on an annual basis. The NRC also determined in NUREG-0170 that the environmental impacts of normal transportation of radioactive materials and the risks attendant to accidents involving radioactive material shipments are sufficiently small to allow continued shipments by all modes. The doses from radioactive waste accidents were negligible when compared to the doses from accidents involving spent fuel shipments.

Previous LWR ESP and COL environmental analyses of the nonradiological impacts from accidents involving the transportation of LLRW (injuries and death from physical collisions involving truck LLRW shipments) have shown the risks to be low and the environmental impact finding was SMALL. The results from these environmental analyses are shown in Table 3-16. There is uncertainty as to the design of ANRs and how that relates to the generation of LLRW; most designs are expected to generate lower volumes of LLRW than LWRs due to their having less complex SSCs (systems, structures, and components). This should result in a much lower number of annual LLRW shipments but will depend on the capacity of the onsite radiological waste storage building.

Based on the above information, Table 3-16 presents the PPE for transport of radioactive waste from ANRs. This PPE consists of one component:

- The maximum annual round-trip shipment distance (182,152 mi [293,145 km]) presented below in Table 3-16. The annual shipments associated with the round-trip shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor and a shipment volume of 82.6 ft^3(2.34 m^3) per shipment from WASH-1238.

This PPE does not apply to situations where an ANR applicant proposes shipping the ANR radioactive waste by air, ship, or barge; or where an ANR applicant proposes that an ANR radioactive waste transportation package be approved using the provisions of 10 CFR 71.12, 10 CFR 71.41(c), or 10 CFR 71.41(d) (10 CFR Part 71-TN301).

Table 3-16 Annual Nonradiological Impacts of Transporting Waste from the Site

Site Name	Annual Total Round-Trip Shipment Distance[a,b] (km)	Accidents per Year[b]	Injuries per Year[b]	Fatalities per Year[b]
WASH-1238 (NRC 2006-TN7)	–[c]	–[c]	–[c]	–[c]
North Anna Power Station Unit 3 ESP (NRC 2006-TN7)	–[c]	–[c]	–[c]	–[c]
Clinton Exelon ESP (NRC 2006-TN672)	–[c]	–[c]	–[c]	–[c]
Grand Gulf ESP (NRC 2006-TN674)	–[c]	–[c]	–[c]	–[c]
Vogtle Units 3 and 4 ESP (NRC 2008-TN673)	33,600	0.0095	0.0065	0.00031
Calvert Cliffs COL (NRC 2011-TN1980)	14,400	0.0067	0.0033	0.00021
South Texas Units 3 and 4 COL (NRC 2011-TN1722)	49,600	0.023	0.011	0.00072
Virgil C. Summer Units 2 and 3 COL (NRC 2011-TN1723)	33,600	0.016	0.0078	0.00049
Levy Units 1 and 2 COL (NRC 2012-TN1976)	33,600	0.016	0.0078	0.00049
Comanche Peak Units 3 and 4 COL (NRC 2011-TN6437)	174,400	0.077	0.040	0.0026
Enrico Fermi Unit 3 COL (NRC 2013-TN6436)	182,400	0.085	0.042	0.0026
William States Lee Units 1 and 2 COL (NRC 2013-TN6435)	33,600	0.016	0.0078	0.00049
PSEG ESP (NRC 2015-TN6438)	233,988	0.17	0.097	0.0060
Turkey Point Units 6 and 7 COL (NRC 2016-TN6434)	36,800	0.017	0.0085	0.00053
Bell Bend COL (NRC and USACE 2016-TN6562)	83,200	0.076	0.0045	0.00016
Clinch River ESP (NRC 2019-TN6136)	293,145	0.17	0.11	0.0049
Maximum Estimate	293,145	0.17	0.11	0.0060

(a) The total shipment distance is based on the number of annual shipments multiplied by the round-trip shipping distance. The round-trip distance is used because nonradiological vehicle accident impacts could occur on the return trip.

(b) In determining the round-trip shipment-km, accidents per year, injuries per year, and fatalities per year, the number of shipments was calculated assuming the average waste shipment capacity of 82.6 ft^3 (2.34 m^3) per shipment applied in WASH-1238 (AEC 1972-TN22) (3,810 ft^3/yr [108 m^3/yr] divided by 46 shipments/year yields 82.6 ft^3 (2.34 m^3) per shipment). The number of shipments was also normalized to 880 MW(e).

(c) Not analyzed.

3.15.1.9 Transportation of SNF from ANRs

This section discusses the radiological and nonradiological environmental impacts from the potential shipments of SNF for normal operating, or incident-free conditions and transportation accidents. For the previous new reactor EISs, the staff performed an independent analysis of the environmental impacts of transporting spent fuel from the proposed and alternative sites to a spent fuel disposal repository. The staff has also performed an independent analysis for the transportation of SNF to two Consolidated Interim Storage Facilities (CISFs) for SNF and HLW, as published in two draft EISs (NRC 2020-TN6498, NRC 2020-TN6499).

For the purposes of these new reactor transportation analyses, the NRC staff considered the proposed Yucca Mountain site in Nevada as a surrogate destination. The NRC has not made a licensing decision about the DOE application for the proposed geologic repository at Yucca Mountain. However, the NRC staff considers an estimate of the impacts of the transportation of spent fuel to a possible repository in Nevada to be a reasonable bounding estimate of the transportation impacts on a spent fuel interim storage or disposal facility because of the distances involved and the representativeness of the distribution of members of the public in urban, suburban, and rural areas (i.e., population distributions) along the shipping routes. In addition, as noted in Section 3.15.1.3, Additional NRC Information Sources, the new reactor transportation analyses using truck shipments of 0.5 MTU were normalized with respect to power level and shipment quantities to allow a comparison to the results presented in Table S-4 of 10 CFR 51.52 (TN250). The results of the new reactor transportation analyses for SNF as normalized for comparison to Table S-4 are provided in Table 3-17, Table 3-18, and Table 3-19, for incident-free SNF impacts, radiological accident SNF impacts, and nonradiological accident SNF impacts, respectively.

For the licensing action of the Private Fuel Storage Facility (PFSF) ISFSI, the staff analyzed the human health impacts from the transportation of SNF in NUREG-1714, (NRC 2001-TN6514). Section 5.7, Human Health Impacts of SNF Transportation, discusses the radiological and nonradiological human health impacts associated with transportation of SNF from nuclear power plants to the PFSF. For cross-country transportation to the proposed PFSF, only shipments by rail are analyzed because Private Fuel Storage planned to receive only rail transportation packages under its NRC license with the potential for short travel distances by heavy-haul trucks or by barges when necessary. Based on the results of the transportation analysis, the staff found that annual and cumulative radiological impacts of transporting SNF to the proposed PFSF would be small. Also, the analytical results for transportation of SNF to and from the proposed PFSF are consistent with earlier analyses of SNF risks reported in NUREG-0170 (NRC 1977-TN417, NRC 1977-TN6497).

In the CISF draft EISs, the staff estimated the potential radiological impacts on workers and the public from the proposed rail transportation of SNF from nuclear power plants and ISFSIs to the proposed CISF based on prior NRC transportation risk estimates in NUREG-2125, *Spent Fuel Transportation Risk Assessment* (NRC 2014-TN3231). In the NUREG-2125 analysis, the staff performed a transportation risk assessment to calculate worker and public doses and risks from the transportation of SNF along various representative national routes under incident-free and accident conditions. In that analysis, the staff calculated occupational doses for groups of workers, including rail crew, escorts in transit, and railyard workers, as well as crew and escorts at stops. Because the resulting dose estimates provided in NUREG-2125 were presented for single shipments and for each kilometer traveled and for each hour of transportation, the staff scaled the results by these variables (e.g., number of shipments, distance, and time) to generate estimates that were applicable to the proposed CISF projects. The staff selected a representative route that was bounding for the proposed shipments of SNF to the proposed CISF and scaled the calculated doses to match the number of proposed shipments and, as applicable, the shipment distance and time.

3.15.1.9.1 Differences between Truck and Rail Transportation Modes

Several differences between the truck and rail transportation modes should be considered when selecting the transportation mode for assessing the impacts of transporting ANR SNF. First, there is a significant difference in the MTU load that can be carried by each. Truck shipments are likely not to contain more than approximately 2 MTU (e.g., 4 PWR SNF assemblies) where 0.5 MTU has been applied in previous staff analyses for a comparison to Table S-4. Rail transportation packages could contain upwards of approximately 18.5 MTU (e.g., 37 PWR SNF assemblies) (NRC 2020-TN6683, NRC 2018-TN6685). Thus, for a set MTU quantity of ANR SNF, fewer numbers of shipments are necessary for the rail mode.

The rail mode would likely involve less radiation exposure to members of the public because people traveling on roads would be next to truck shipments and there is generally a buffer zone on each side of the rail right-of-way going through residential neighborhoods. There are also access limitations for the shipment of SNF by rail. It is not certain that all ANR sites would have rail access. Thus, some portion of the transportation route may have to be performed using heavy-haul trucks for rail shipments. Such heavy-haul truck shipments are expected to be heavily monitored and controlled resulting in low to negligible impacts on members of the public.

Therefore, it is expected that truck shipments would have larger incident-free impacts than rail shipments due to the larger number of shipments (e.g., as much as 37 times—0.5 MTU versus 18.5 MTU) and due to the greater potential for radiation exposure to members of the public. In addition, 49 CFR 397.101 (49 CFR Part 397-TN6621) requires that placarded radioactive material shipments made by truck are operated on routes that minimize radiological risks. Similarly, 49 CFR 172.820 requires that rail routes for highway-route–controlled quantities of radioactive material consider factors that would also serve to minimize radiological risks (see 49 CFR Part 172-TN6616, Appendix D).

When considering impacts from transportation accidents, both rail and truck packages have a very low probability of a radioactive release. As stated in the summary for Chapter 3, Cask Response to Impact Accidents, of NUREG-2125 (NRC 2014-TN3231):

> Detailed FE [finite element] analyses performed for two spent fuel transportation rail casks indicate that casks are very robust structures capable of withstanding almost all impact accidents without release of radioactive material. In fact, when spent fuel is transported within an inner welded canister or in a truck cask, no impacts result in release. Even the rail cask without an inner welded canister can withstand impacts much more severe than the regulatory impact without releasing any material.

And with respect to truck packages:

> Assessment of previous analyses performed for spent fuel truck transportation casks, including impacts onto flat rigid targets, into cylindrical rigid targets, by locomotives, and by falling bridge structures, indicate that truck casks will not release their contents in any impact accidents.

Chapter 5, Transportation Accidents, of NUREG-2125 (NRC 2014-TN3231) concluded the overall collective dose risks are very small to negligible for the two types of extra-regulatory accidents (accidents involving a release of radioactive material and loss-of-lead-shielding accidents).

For transportation accidents involving severe fires, NUREG/CR-7209 (Fort et al. 2017-TN6692) evaluated four severe roadway and railway fires for their potential impact on spent fuel transportation packages. The analyses found that NRC regulations and packaging standards provide a high degree of protection of public health and safety against releases of radioactive material in real-world transportation accidents involving fires.

3.15.1.9.2 Summary of PPE Values for Transport of Irradiated ANR Fuel

Based on the above information, Table 3-17 and Table 3-19 present the PPE for transport of irradiated ANR fuel. This PPE consists of two components:

- The maximum annual one-way shipment distance (314,037 mi [505,393 km]) presented below in Table 3-17. The annual shipments associated with the one-way shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor and a shipment capacity of 0.5 MTU/shipment from WASH-1238.
- The maximum annual round-trip shipment distance (628,073 mi [1,010,786 km]) presented below in Table 3-19. The annual shipments associated with the round-trip shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor and a shipment capacity of 0.5 MTU/shipment from WASH-1238.

Based on the radiological accident impacts presented below in Table 3-18, an additional component is established for the PPE:

- A maximum peak rod burnup of 62 GWd/MTU for UO_2 fuel and peak pellet burnup of 133 GWd/MTU for TRISO fuel.

This PPE does not apply to situations where an ANR applicant proposes shipping the irradiated ANR fuel by air, ship, or barge; or where an ANR applicant proposes that an irradiated ANR fuel transportation package be approved using the provisions of 10 CFR 71.12, 10 CFR 71.41(c), or 10 CFR 71.41(d) (10 CFR Part 71-TN301), such as might be applied for when shipping an entire irradiated ANR core. In addition, the irradiated ANR fuel must be shipped in a transportation package that meets all of the applicable NRC regulations.

Table 3-17 Incident-Free Radiological Impacts for Shipping SNF to the Yucca Mountain Site

Site Name	Annual Shipments[(a)]	Shipping Distance (km)	Annual Total One-Way Shipment Distance[(a)] (km)	Population Impacts (person-rem/yr)[(b)]		
				Workers	Public Onlookers	Public Along Route
North Anna Power Station Unit 3 ESP (NRC 2006-TN7)	90	4,410	396,900	9.2	32	0.82
Clinton Exelon ESP (NRC 2006-TN672)	90	3,076	276,840	6.4	22	0.41
Grand Gulf ESP (NRC 2006-TN674)	90	3,718	334,620	7.8	25	0.62
Vogtle Units 3 and 4 ESP (NRC 2008-TN673)	40	4,091	163,640	7.3	13	0.38
Calvert Cliffs Unit 3 COL (NRC 2011-TN1980)	46	4,568	210,128	9.4	19	0.53
South Texas Units 3 and 4 COL (NRC 2011-TN1722)	60	2,922	175,320	8.0	17	0.37
Virgil C. Summer Units 2 and 3 COL (NRC 2011-TN1723)	46	4,096	188,416	7.4	15	0.35
Levy Units 1 and 2 COL (NRC 2012-TN1976)	40	4,520	180,800	8.2	20	0.42
Comanche Peak Units 3 and 4 COL (NRC 2011-TN6437)	9.5	2,568	24,396	2.0	0.37	0.11
Enrico Fermi Unit 3 COL (NRC 2013-TN6436)	40.3	3,481	140,284	6.4	13	0.25
William States Lee Units 1 and 2 COL (NRC 2013-TN6435)	39	4,041	157,599	7.5	13	0.37
PSEG ESP (NRC 2015-TN6438)	54.5	4,470	243,615	11	23	0.63
Turkey Point Units 6 and 7 COL (NRC 2016-TN6434)	60	4,977	298,620	9.9	18	0.59
Bell Bend COL (NRC and USACE 2016-TN6562)	44	4,090	179,960	4.3	14	0.35
Clinch River ESP (NRC 2019-TN6136)	137	3,689	505,393	2.8	50	0.97
Maximum Estimate			505,393	11	50	0.97

(a) The total shipment distance is based on the number of annual shipments multiplied by the shipping distance.
(b) Normalized to Reference LWR (880 MW(e) net).

Table 3-18 Radiological Accident Impacts for Shipping SNF to the Yucca Mountain Site

Site Name	Annual Shipments[(a)]	Shipping Distance (km)	Annual Total One-Way Shipment Distance[(a)] (km)	Population Impacts (person-rem/yr)[(b)]	Burnup (GWd/MTU)
North Anna Power Station Unit 3 ESP (NRC 2006-TN7)	90	4,410	396,900	5.00E-04[(c)]	62 (LWRs)[(d)] 133 (TRISO)
Clinton Exelon ESP (NRC 2006-TN672)	90	3,076	276,840	2.30E-04[(c)]	62 (LWRs)[(d)] 133 (TRISO)
Grand Gulf ESP (NRC 2006-TN674)	90	3,718	334,620	4.10E-04[(c)]	62 (LWRs)[(d)] 133 (TRISO)
Vogtle Units 3 and 4 ESP (NRC 2008-TN673)	40	4,091	163,640	2.20E-05	62 (LWR)[(d)]
Calvert Cliffs Unit 3 COL (NRC 2011-TN1980)	46	4,568	210,128	8.40E-05	52 (LWR)
South Texas Units 3 and 4 COL (NRC 2011-TN1722)	60	2,922	175,320	1.50E-04	32.3 (LWR)
Virgil C. Summer Units 2 and 3 COL (NRC 2011-TN1723)	46	4,096	188,416	1.80E-05	50.5 (LWR)
Levy Units 1 and 2 COL (NRC 2012-TN1976)	40	4,520	180,800	9.20E-05	62 (LWR)[(d)]
Comanche Peak Units 3 and 4 COL (NRC 2011-TN6437)	9.5	2,568	24,396	5.90E-05	46.2 (LWR)
Enrico Fermi Unit 3 COL (NRC 2013-TN6436)	40.3	3,481	140,284	3.10E-06	46 (LWR)
William States Lee Units 1 and 2 COL (NRC 2013-TN6435)	39	4,041	157,599	7.10E-05	62 (LWR)
PSEG ESP (NRC 2015-TN6438)	54.5	4,470	243,615	2.00E-04	54.2 (LWR)
Turkey Point Units 6 and 7 COL (NRC 2016-TN6434)	60	4,977	298,620	5.20E-05	50.5 (LWR)
Bell Bend COL (NRC and USACE 2016-TN6562)	44	4,090	179,960	1.28E-04	52 (LWR)
Clinch River ESP (NRC 2019-TN6136)	137	3,689	505,393	7.50E-06	51 (LWR)
Maximum Estimate			505,393	5.00E-4	62 (LWRs)[(d)] 133 (TRISO)

(a) The total shipment distance is based on the number of annual shipments multiplied by the shipping distance.
(b) Normalized to Reference LWR (880 MW(e) net).
(c) Maximum population impact if multiple reactor types evaluated.
(d) Peak rod burnup.

Table 3-19 Nonradiological Accident Impacts for Shipping SNF to the Yucca Mountain Site

Site Name	Annual Shipments[a]	Shipping Distance (km)	Annual Total Round-Trip Shipment Distance (km)[a]	Accidents per Year[b]	Injuries per Year[b]	Fatalities per Year[b]
North Anna Power Station Unit 3 ESP (NRC 2006-TN7)	90	4,410	793,800	–[c]	–[c]	–[c]
Clinton Exelon ESP (NRC 2006-TN672)	90	3,076	553,680	–[c]	–[c]	–[c]
Grand Gulf ESP (NRC 2006-TN674)	90	3,718	669,240	–[c]	–[c]	–[c]
Vogtle Units 3 and 4 ESP (NRC 2008-TN673)	40	4,091	327,280	0.081	0.067	0.0036
Calvert Cliffs Unit 3 COL (NRC 2011-TN1980)	46	4,568	420,256	0.16	0.099	0.0076
South Texas Units 3 and 4 COL (NRC 2011-TN1722)	60	2,922	350,640	0.20	0.13	0.0062
Virgil C. Summer Units 2 and 3 COL (NRC 2011-TN1723)	46	4,096	376,832	0.11	0.071	0.0056
Levy Units 1 and 2 COL (NRC 2012-TN1976)	40	4,520	361,600	0.15	0.087	0.0062
Comanche Peak Units 3 and 4 COL (NRC 2011-TN6437)	9.5	2,568	48,792	0.011	0.062	0.0042
Enrico Fermi Unit 3 COL (NRC 2013-TN6436)	40.3	3,481	280,569	0.15	0.068	0.0046
William States Lee Units 1 and 2 COL (NRC 2013-TN6435)	39	4,041	315,198	0.11	0.072	0.0056
PSEG ESP (NRC 2015-TN6438)	54.5	4,470	487,230	0.28	0.13	0.0080
Turkey Point Units 6 and 7 COL (NRC 2016-TN6434)	60	4,977	597,240	0.15	0.098	0.0068
Bell Bend COL (NRC and USACE 2016-TN6562)	44	4,090	359,920	0.33	0.019	0.00067
Clinch River ESP (NRC 2019-TN6136)	137	3,689	1,010,786	0.32	0.21	0.016
Maximum Estimate			1,010,786	0.33	0.21	0.016

(a) The total shipment distance is based on the number of annual shipments multiplied by the round-trip shipping distance. The round-trip distance is used because nonradiological vehicle accident impacts could occur on the return trip.
(b) Normalized to Reference LWR (880 MW(e) net).
(c) Not analyzed.

3.15.2 Transportation Impacts

The NRC staff identified the following three environmental issues associated with the radiological and nonradiological environmental impacts from incident-free transportation and transportation accident conditions:

- shipment of unirradiated fuel to the ANR site,
- shipment of LLRW and mixed waste to offsite disposal facilities, and
- shipment of SNF to an interim storage facility or a permanent geologic repository.

This assessment will draw upon previous analyses for their assumptions, shipment parameters, and routing information and provide a basis that an ANR applicant could apply for bounding the potential environmental impacts for their non-LWR fuel and waste, given there is a certain amount of uncertainty in transport packaging and processing.

A couple of notable conditions in this analysis can be accepted without specific ANR design information. First, it is likely that ANR developers will use HALEU fuel with resulting longer refueling cycling times than the 2-year refueling frequencies of LWRs that were assessed in the new reactor EISs. Thus, the number of shipments of fresh fuel to the ANR site and the potential number of SNF shipments from the ANR site could be significantly less than previously assessed for new reactor LWRs. The previous analyses, whether they used existing certified transport packages or not, were based on a specific quantity of nuclear fuel in each shipment. For example, WASH-1238 (AEC 1972-TN22) assumed a 0.5 MTU per SNF truck shipment. Thus, this is another shipment parameter that could be applied as a bounding value for ANR fuel shipments.

Second, there are a number of unknowns or questions related to several aspects of ANR, or non-LWR, fuel shipments. Prior transportation risk assessments were reviewed for their applicability to support resolution of ANR fuel transportation issues. In addition, PNNL has prepared a report for the NRC regarding ANR transportation analysis (Maheras 2020-TN6509). While Section 6.2 in NRC RG 4.2 (NRC 2022-TN7081) provides detailed guidance for how to estimate transportation-related impacts for LWRs, the PNNL report provides additional guidance for estimating transportation-related impacts for non-LWRs in the following areas:

- applicability of NRC and DOT regulations to the shipment of non-LWR fuel and waste;
- absence of certified packages for shipping the unirradiated fuel, spent fuel, and radioactive waste associated with non-LWRs;
- external dose rates associated with the shipment of non-LWR unirradiated fuel, spent fuel, and radioactive waste;
- transportation routing for non-LWR shipments;
- chemical and physical forms associated with the non-LWR unirradiated fuel, spent fuel, and radioactive waste;
- number of shipments associated with unirradiated fuel, spent fuel, and radioactive waste shipments;
- radionuclide inventory per shipment for non-LWR unirradiated fuel, spent fuel, and radioactive waste;

- conditional probabilities and release fractions associated with transportation accidents involving non-LWR fuel and waste shipments; and
- comparison of transportation risk assessment results to various criteria.

In addition to the PNNL report (Maheras 2020-TN6509), other transportation analysis documents are discussed for their usefulness to support the environmental conclusions in Section 3.15.1.

3.15.2.1 Transportation of Unirradiated ANR Fuel

The staff's evaluation of the transport of unirradiated ANR fuel focused on incident-free radiological impacts and the nonradiological impacts of transportation accidents. This is a Category 1 issue. If the values and assumptions of the PPE that the transport of unirradiated ANR fuel will fit within the bounds outlined in Table 3-11 and Table 3-12 in Section 3.15.1.7.1 are met, the impacts can be generically determined to be SMALL and the maximum transportation estimates are as listed in Table 3-11 and Table 3-12. The staff relied on the following PPE values and assumptions to reach this conclusion:

- The maximum annual one-way shipment distance (36,760 mi [59,160 km]) presented in Table 3-11. The annual shipments associated with the one-way shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor from WASH-1238 (AEC 1972-TN22).
- The maximum annual round-trip shipment distance (73,520 mi [118,320 km]) presented in Table 3-12. The annual shipments associated with the round-trip shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor from WASH-1238.

This requires that the unirradiated ANR fuel shipments be normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor from WASH-1238. The PPE applies to situations where the enrichment of the unirradiated ANR fuel is 20 percent or less, based on the unlimited A_2 value in Table A-1 in 10 CFR Part 71 (TN301) for unirradiated uranium enriched to 20 percent or less. In addition, the PPE does not apply to situations in which an ANR applicant proposes shipping the unirradiated ANR fuel by air, ship, or barge; or in which an ANR applicant proposes that an unirradiated ANR fuel transportation package be approved using the provisions of 10 CFR 71.12, 10 CFR 71.41(c), or 10 CFR 71.41(d) (10 CFR Part 71-TN301). If these assumptions are not met, a project-specific transportation impact analysis must be performed as part of the ANR application.

Some ANR designs are anticipated to ship a fully loaded but unirradiated reactor core from a manufacturing facility to an appropriately licensed ANR site. In the case of shipping an ANR core and its unirradiated contents or any other ANR unirradiated fuel, in which any of the above conditions are not met, then a project-specific transportation impact analysis must be performed as part of the ANR application.

3.15.2.2 Transportation of Radioactive Waste from ANRs

The staff's evaluation of the transport of radioactive waste from ANRs focused on the nonradiological impacts of transportation accidents. This is a Category 1 issue. If the values and assumptions of the PPE that the transport of radioactive waste from an ANR will fit within the bounds outlined in Table 3-16 in Section 3.15.1.8.1 are met, the impacts can be generically determined to be SMALL and the maximum transportation estimates are as listed in Table 3-16. The staff relied on the following PPE value and assumptions to reach this conclusion:

- The maximum annual round-trip shipment distance (182,152 mi [293,145 km]) presented in Table 3-16. The annual shipments associated with the round-trip shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor and a shipment volume of 2.34 m^3/shipment from WASH-1238 (AEC 1972-TN22).

This requires that the radioactive waste shipments from ANRs be normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor and a shipment volume of 2.34 m^3/shipment from WASH-1238 (AEC 1972-TN22). In addition, the PPE does not apply to situations in which an ANR applicant proposes shipping the ANR radioactive waste by air, ship, or barge; or in which an ANR applicant proposes that an ANR radioactive waste transportation package be approved using the provisions of 10 CFR 71.12, 10 CFR 71.41(c), or 10 CFR 71.41(d) (10 CFR Part 71-TN301). If these assumptions are not met, a project-specific transportation impact analysis must be performed as part of the ANR application.

3.15.2.3 Transportation of Irradiated Fuel from ANRs

The staff's evaluation of the transport of irradiated ANR fuel focused on incident-free radiological impacts and the radiological and nonradiological impacts of transportation accidents. This is a Category 1 issue. If the values and assumptions of the PPE that the transport of irradiated ANR fuel will fit within the bounds outlined in Table 3-17 and Table 3-19 are met, the impacts can be generically determined to be SMALL and the maximum transportation estimates are as listed in Table 3-17, Table 3-18, and Table 3-19. The staff relied on the following PPE values and assumptions to reach this conclusion:

- The maximum annual one-way shipment distance (314,037 mi [505,393 km]) presented in Table 3-17. The annual shipments associated with the one-way shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor and a shipment capacity of 0.5 MTU/shipment from WASH-1238.
- The maximum annual round-trip shipment distance (628,073 mi [1,010,786 km]) presented in Table 3-19. The annual shipments associated with the round-trip shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor and a shipment capacity of 0.5 MTU/shipment from WASH-1238.
- A maximum peak rod burnup of 62 GWd/MTU for UO_2 fuel and peak pellet burnup of 133 GWd/MTU for TRISO fuel (see Table 3-18).

This requires that the irradiated fuel shipments from ANRs be normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor and a shipment capacity of 0.5 MTU/shipment from WASH-1238. The PPE also does not apply to situations in which an ANR applicant proposes shipping the irradiated ANR fuel by air, ship, or barge; or in which an ANR applicant proposes that an ANR irradiated fuel transportation package be approved using the provisions of 10 CFR 71.12, 10 CFR 71.41(c), or 10 CFR 71.41(d) (10 CFR Part 71-TN301). In addition, the irradiated ANR fuel must be shipped in a transportation package that meets all of the applicable NRC regulations. If these assumptions are not met, a project-specific transportation impact analysis must be performed as part of the ANR application.

It is recommended that the transportation analysis be performed in manner to the practicable extent possible to apply impact results from previous NRC or DOE analysis. The basis for applying these prior results must be justified to show that the ANR SNF characteristics fit within the parameters and assumptions applied in the prior transportation analysis, such as was done for the two CISF DEIS transportation analyses (NRC 2020-TN6498, NRC 2020-TN6499).

3.16 Decommissioning

3.16.1 Baseline Conditions and PPE/SPE Values and Assumptions

At the end of the operating life of a power reactor, NRC regulations require that the nuclear facility undergo decommissioning. The NRC defines decommissioning as the safe removal of a facility from service and the reduction of residual radioactivity to a level that permits termination of the NRC license. The regulations governing decommissioning of power reactors are found in 10 CFR 50.75 (TN249), 10 CFR 50.82 (TN249), and 10 CFR 52.110 (TN251). The radiological criteria for termination of the NRC license are in 10 CFR Part 20 (TN283), Subpart E. The requirements for the minimization of contamination and generation of radioactive waste for facility design and procedures for operation are addressed in 10 CFR 20.1406 (TN283).

If an ANR applicant submits an application for an operating license or a COL, or applies for a license to construct a new nuclear power plant, there is a requirement in 10 CFR 50.33 (TN249) to provide a report (discussed in 10 CFR 50.75 [TN249], and 10 CFR 52.77 refers back to 10 CFR 50.33) that contains a certification indicating how reasonable assurance will be provided that funds will be available to complete decommissioning of the facility. In addition, the regulations for termination of the license in10 CFR 50.82(a)(4)(i) (TN249) and 10 CFR 52.110(d)(1) (TN251) require the licensee to submit a post-shutdown decommissioning activity report (PSDAR) to the NRC and a copy to the affected State(s) either before or not later than 2 years after permanent cessation of operations.

The PSDAR must include a description of the licensee's planned decommissioning activities, a schedule for the accomplishment of significant milestones, and an estimate of all expected costs for radiological decommissioning (this does not include site restoration). The PSDAR is sometimes referred to as the licensee's decommissioning plan that provides the decommissioning strategy for the reactor. The PSDAR must contain, among other things, a discussion that provides the reasons for concluding that the environmental impacts associated with project-specific decommissioning activities will be bounded by appropriate previously issued EISs.

The PSDAR should also document the results of the licensee's evaluation of the environmental impacts associated with project-specific decommissioning activities. The evaluation should include a comparison of the project-specific environmental impacts of the proposed decommissioning to the impacts identified in previously issued environmental statements, that is, NUREG-0586, Supplement 1, *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities Regarding the Decommissioning of Nuclear Power Reactors* (the Decommissioning GEIS) (NRC 2002-TN665), NUREG-1496, Volume 1, *Generic Environmental Impact Statement in Support of Rulemaking on Radiological Criteria for License Termination of NRC-Licensed Nuclear Facilities* (NRC 1997-TN5455), and any previous project-specific environmental NEPA licensing documents. The NRC will determine whether the licensee's PSDAR contains the information required by the regulation. If the NRC determines that the information provided by the licensee in the PSDAR does not comply with the regulatory requirements, it will inform the licensee in writing of the additional information required by the regulations and request a response. NRC must find the PSDAR acceptable, but the staff does not approve it through a licensing action. The licensee is required to provide updates to the NRC for review if there are any significant changes to the PSDAR.

The licensee is required to submit a License Termination Plan application with its final status survey strategy to the NRC at least 2 years before they intend to terminate the license. Before the completion of decommissioning, the licensee conducts a final status survey to demonstrate compliance with criteria established in the License Termination Plan; the License Termination Plan is sometimes referred to in layman's terms as the approved decommissioning plan for power reactors. The NRC may verify the survey by one or more of the following: a quality assurance/quality control review, side-by-side or split sampling of a radiological survey of selected areas, and independent confirmatory surveys. When the NRC confirms that the criteria in the License Termination Plan and all other NRC regulatory requirements have been met, the NRC either terminates or amends the license, depending on the licensee's decision to use the licensed area.

The NRC staff assumes that decommissioning of an NRC-licensed fusion facility would also have to satisfy the above-noted regulatory requirements. There are potential Category 1 decommissioning environmental impacts after permanent cessation of fusion energy operations that have undergone the D-T fusion reaction and to a lesser extent, the deuterium-deuterium (D-D) fusion reaction. In particular, impacts due to the significant neutron activation in structural material from D-T fusion are like those identified for LWR decommissioning involving neutron-activated material decommissioning and disposal. Explicitly, the 14.1 MeV neutron from D-T fusion reactions produce significant neutron activation in any stainless-steel structures. While the D-D fusion reaction could produce a 2.5 MeV neutron in half of its reactions, this lower energy neutron is more easily shielded. The resulting activated material from both the D-T and D-D fusion reactions would likely only be in the concrete shielded cell that contained the fusion device, much like the containment building for a fission reactor. It is expected that the dismantling and disposal of a D-T or a D-D fusion device would have environmental impacts similar to the decommissioning impacts for a similar sized fission reactor. The decommissioning of a fusion device using any of the other fusion fuels would not have residual radioactivity or neutron-activated material and would address decommissioning like any other non-nuclear industrial facility. Therefore, the decommissioning of fusion reactors that have undergone D-T and/or D-D fusion reactions are the only type of fusion reactors that do have environmental impacts (categorized as Category 1), but they are expected to be like those for fission reactors.

The Decommissioning GEIS (NRC 2002-TN665) makes the following assumptions:

- Doses to the public would be well below applicable regulatory standards regardless of which decommissioning method considered in the Decommissioning GEIS is used.
- Occupational doses would be well below applicable regulatory standards during the license term.
- The quantities of Class C or GTCC wastes generated would be comparable to or less than the amounts of solid waste generated by reactors licensed before 2002.
- The air quality impacts of decommissioning are expected to be negligible.
- Measures are readily available to avoid potential significant water quality impacts from erosion or spills. The liquid radioactive waste system design includes features, such as pipe chases and tank collection basins, to limit release of radioactive material to the environment.

These features will minimize the amount of radioactive material in potential spills and leakage that would have to be addressed at decommissioning.

- The ecological impacts of decommissioning are expected to be negligible.
- The socioeconomic impacts should be neither detectable nor destabilizing.
- The Decommissioning GEIS does not address situations such as a liquid-fuel MSR processing the molten salt to remove fission products, high-level waste, and transuranic waste and the subsequent impacts on decommissioning activities due to residual material within the equipment or of the facility.

3.16.2 Decommissioning Impacts

This section addresses the potential environmental impacts of the decommissioning of the ANR facility and the management of SNF that may remain at the ANR site until it is removed and the license is terminated. The continued storage of spent fuel during the period of time past permanent cessation of reactor operations is discussed in Section 3.14.2.6, Storage and Disposal of Radiological Wastes.

The NRC staff evaluated the environmental impacts during the decommissioning of nuclear power reactors as residual radioactivity at the site is reduced to levels that allow for termination of the NRC license. This evaluation was documented in the Decommissioning GEIS (NUREG-0586, Supplement 1; NRC 2002-TN665). NUREG-0586, Supplement 1, is incorporated here by reference. The License Renewal GEIS (NUREG-1437 Revision 1, Section 4.12.2 [NRC 2013-TN2654]) references the Decommissioning GEIS and describes the impacts associated with decommissioning existing LWRs (a nuclear facility with a large footprint). This section describes and discusses the environmental consequences of terminating nuclear power plant operations and decommissioning, but the only impacts attributable to the proposed action (license renewal) are the effects of an additional 20 years of operations on the impacts of decommissioning. The majority of the impacts associated with plant operations would cease with reactor shutdown; however, some impacts would remain unchanged, while others would continue at reduced or altered levels. Some new impacts might also result directly from terminating nuclear power plant operations. Section 4.12.2.1, Termination of Operations and Decommissioning of Existing Nuclear Power Plants, of the License Renewal GEIS discusses the various impacts by resource area; some could be quantified as having small impacts, such as radiological impacts, while others could have higher impacts, such as socioeconomics (NRC 2013-TN2654). The License Renewal GEIS concluded the following:

> The effects of license renewal on impacts of terminating nuclear power plant operations and decommissioning are considered a single environmental issue. Because the impacts are expected to be SMALL at all plants and for all environmental resources, it is considered a Category 1 issue.

The License Renewal GEIS discussion above informs the impacts expected for decommissioning an ANR and are incorporated here by reference.

At the initial licensing stage, ANR applicants are not required to submit information regarding the specific method chosen for decommissioning or the schedule, but financial planning is required per 10 CFR 50.75 “Reporting and recordkeeping for decommissioning planning” and 10 CFR 50.82(a)(8) “Termination of license” (10 CFR Part 50-TN249). However, an ANR applicant should provide a discussion in the application’s ER that demonstrates whether the environmental impacts of decommissioning discussed in NUREG-0586, Supplement 1 (NRC 2002-TN665) would bound those for the ANR design.

The NRC staff's evaluation of the environmental impacts of decommissioning presented in NUREG-0586, Supplement 1, considered environmental issues for LWRs and three permanently shutdown facilities that included a fast breeder reactor and two high-temperature gas-cooled reactors (NRC 2002-TN665). The Decommissioning GEIS identified whether the environmental issues were considered generic to all decommissioning sites or project-specific. If the issue was considered generic, then it was assigned a significance level of either SMALL, MODERATE, or LARGE. For the environmental issues assessed in the Decommissioning GEIS, most impacts were considered generic and SMALL for all plants, regardless of the activities and identified variables. The two issues that were determined to require a project-specific review were EJ and threatened and endangered species. Four issues in the Decommissioning GEIS were considered to be conditionally project-specific:

- land use involving offsite areas to support decommissioning activities,
- aquatic ecology for activities beyond the licensed operational area,
- terrestrial ecology for activities beyond the licensed operational area, and
- historic and cultural for activities within and beyond the licensed operational area with no current (i.e., at the time of decommissioning) historic and cultural resource surveys and aboveground resources that are 50 years of age and have not been evaluated for NRHP eligibility.[37]

The staff believes these impacts, as discussed in Decommissioning GEIS (NRC 2002-TN665), are bounding for large LWRs deployed after 2002. The expected methods and processes for decommissioning an ANR are expected to be similar to existing decommissioning methods and processes for large LWRs. The staff assumes the decommissioning of ANRs would likely have no greater impacts than large LWR decommissioning impacts given that the two project-specific and four conditionally project-specific issues above can be evaluated and addressed, if needed, at the time of either early decommissioning (PSDAR) or later (during License Termination Plan review). Therefore, the licensee would verify that the decommissioning activities meet the requirements of 10 CFR 50.82(a)(6)(i) through 10 CFR 50.82(a)(6)(iii) or seek appropriate regulatory approval, if needed. In addition, 10 CFR 50.82 (TN249) or 10 CFR 52.110 (TN251), as applicable, provide that a licensee shall not perform any decommissioning activities that result in significant environmental impacts not bounded by previously issued environmental review documents, such as the Decommissioning GEIS.

The Decommissioning GEIS (NRC 2002-TN665) does not specifically address the GHG footprint of decommissioning activities. However, it does list the decommissioning activities and states that the decommissioning workforce would be expected to be smaller than the operational workforce, and that the decontamination and demolition activities could take up to 10 years to complete. Finally, it discusses Safe Storage (also called the SAFSTOR decommissioning option), in which decontamination and dismantlement are delayed for a number of years (within a cumulative time period of a 50-year timeframe [6–10 years is equivalent to 50 years for SAFSTOR]). Equipment and vehicles used during decommissioning

[37] In some cases, the nuclear power plant itself may be considered a historic property for its design or engineering. Ultimately, historic and cultural resources at each site can be quite different and must be assessed at a project-specific level and in consultation with SHPOs, Tribal representatives, and other interested parties.

and SAFSTOR activities would emit GHGs, principally CO_2. Combining the PPE values for GHG emissions for these stages listed in Table 3-1 in Section 3.3.1, 74,000 MT CO_2(e) would be emitted during a 10-year decommissioning period and 40-year SAFSTOR period of two 1,000 MW reactors, or less than 1,500 MT CO_2(e)/yr on average. For comparison, in 2019, total gross annual U.S. GHG emissions were 6,577.2 MMT of CO_2(e), of which 5,410.8 MMT CO_2(e) were from the energy sector (EPA 2021-TN6965). Estimated annual GHGs emissions from equipment used during decommissioning are about 0.00003 percent of the 2019 GHG emissions from the U.S. energy sector.

As noted in Section 3.3.2, the staff has determined that the contribution of plant life-cycle GHG emissions to national emissions is a Category 1 issue. The staff concludes that, as long as the PPE assumptions associated with GHG emissions are met, the GHG impacts from decommissioning an ANR can also be generically determined to be SMALL. The generic analysis for GHG emissions for decommissioning can be relied on without applying any mitigation measures.

Assuming that the decommissioning of an ANR is similar to current decommissioning practices, the impacts from decommissioning should be within the bounds described in the Decommissioning GEIS (NRC 2002-TN665). Based on the above information, the Decommissioning GEIS can be incorporated here by reference for ANR decommissioning and the impacts would be SMALL. This would be a Category 1 issue. The staff relied on the following PPE assumptions to reach this conclusion:

- The ANR would be within the bounds of the Decommissioning GEIS (NRC 2002-TN665) based on the following assumptions:
  - Doses to the public would be well below applicable regulatory standards regardless of which decommissioning method considered in the Decommissioning GEIS is used.
  - Occupational doses would be well below applicable regulatory standards during the license term.
  - The quantities of Class C or GTCC wastes generated would be comparable to or less than the amounts of solid waste generated by reactors licensed before 2002.
  - The air quality impacts of decommissioning would be negligible.
  - Measures would be readily available to avoid potential significant water quality impacts from erosion or spills. The liquid radioactive waste system design would include features to limit release of radioactive material to the environment, such as pipe chases and tank collection basins. These features would minimize the amount of radioactive material in spills and leakage that would have to be addressed at decommissioning.
  - The ecological impacts of decommissioning would be negligible.
  - The socioeconomic impacts would be neither detectable nor destabilizing.

4.0 SUMMARY OF FINDINGS

Table 4-1 summarizes the findings of this Generic Environmental Impact Statement (GEIS), for which 121 environmental issues were analyzed. The table identifies issues as Category 1, Category 2, or N/A. A Category 1 designation means that the U.S. Nuclear Regulatory Commission (NRC) has determined that a generic analysis of environmental impacts is possible, provided that relevant values and assumptions in the plant parameter envelope (PPE) and site parameter envelope (SPE) are met. Issues for which the impacts are beneficial are also designated as Category 1. A Category 2 designation means that NRC has determined that a meaningful generic analysis of environmental impacts is not possible without consideration of project-specific information. The two N/A issues relate to exposure to electromagnetic fields (EMFs) and do not have a national scientific agreement regarding adverse health effects (i.e., Uncertain impacts).

For Category 1 issues involving adverse impacts, the NRC staff will evaluate the applicant's Environmental Report (ER) as part of the staff's determination of whether the proposed reactor project meets the PPE and SPE for the issue. In its project-specific supplemental environmental impact statement (SEIS), the NRC will set forth its analysis and determination about whether the project meets the PPE and SPE for the issue and will identify whether the NRC staff considered any additional information not provided in the applicant's ER. If the NRC staff finds that the project meets the PPE and SPE for that Category 1 issue, then the environmental impact will be considered SMALL for that issue. The NRC defines SMALL impacts as impacts that are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that the impacts that do not exceed permissible levels in the Commission's regulations are considered SMALL.

For Category 2 issues, this GEIS does not include either PPE or SPE values or assumptions because a meaningful generic analysis of Category 2 issues is not possible. The applicant will be required to provide a project-specific analysis for each Category 2 issue in its ER. The project-specific analysis for a Category 2 issue may lead to a conclusion of SMALL, MODERATE, or LARGE impacts. Because the NRC staff cannot reach a conclusion regarding the impacts for these issues, the impacts are stated as being "Undetermined" in Table 4-1.

For the N/A (Uncertain) issues, the staff will continue to monitor research initiatives to evaluate the potential human health effects of EMFs. If the NRC finds that the appropriate Federal health agencies have reached a general agreement on the potential human health effects of exposure to EMFs, the NRC will determine what to require of all ANR license applicants.

Assumptions including mitigation measures were considered in the analysis of each environmental issue and are discussed in the appropriate sections of Chapter 3 and are summarized in Table 4-1. The staff's generic conclusion for a Category 1 issue may rely on one or more of the values and assumptions for a parameter. However, the Category 1 issue may not use all of the values and assumptions for the parameter. To determine which values and assumptions are applicable to an individual Category 1 issue, the reader should review the resource-specific evaluation section in Chapter 3.

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Table 4-1 Summary of Findings and Mitigation[38]

Issue	Section	Category	Finding	Plant Parameter Envelope/Site Parameter Envelope Values and Assumptions
Land Use				
Construction				
Onsite Land Use	3.1.2.1.1	1	SMALL	• The proposed project, including any associated land uses, complies with applicable U.S. Nuclear Regulatory Commission (NRC) siting regulations such as Title 10 of the *Code of Federal Regulations* (10 CFR) Part 100 (TN282). • The site size is 100 ac (40.5 ha) or less. • The permanent footprint of disturbance includes 30 ac (12 ha) or less of vegetated lands, and the temporary footprint of disturbance includes no more than an additional 20 ac (8.1 ha) or less of vegetated lands. • The proposed project complies with the site's zoning and is consistent with any relevant land use plans or comprehensive plans. • The site would not be situated closer than 0.5 mi (0.8 km) to existing residential areas or 1.0 mi (1.6 km) to sensitive land uses such as Federal, State, or local parks; wildlife refuges; conservation lands; Wild and Scenic Rivers; or Natural Heritage Rivers. • The site does not have a history of past industrial use capable of leaving a legacy of contamination requiring cleanup to protect human health and the environment. • The total wetland loss from use of the site, including use of any offsite rights-of-way (ROWs), would be no more than 0.5 ac (0.2 ha). • Best management practices (BMPs) for erosion, sediment control, and stormwater management would be used. • Compliance with any mitigation measures established through zoning ordinances, local building permits, site use permits, or other land use authorizations.
Offsite Land Use	3.1.2.1.2	1	SMALL	• New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length. • No new offsite ROW would be situated closer than 0.5 mi (0.8 km) to existing residential areas or sensitive land uses such as Federal, State, or local parks; wildlife refuges; conservation lands; Wild and Scenic Rivers; or Natural Heritage Rivers. • No existing ROWs in residential areas would be used or widened to accommodate project features. • No ROW has a history of past industrial use capable of leaving a legacy of contamination requiring cleanup to protect human health and the environment. • The total wetland loss from use of the entire project, including use of the site and any offsite ROWs, would be no more than 0.5 ac (0.2 ha). • BMPs for erosion, sediment control, and stormwater management would be used. • Compliance with any mitigation measures established through zoning ordinances, local building permits, site use permits, or other land use authorizations.
Impacts to Prime and Unique Farmland	3.1.2.1.3	1	SMALL	• The site size is 100 ac (40.5 ha) or less. • The site does not contain any prime or unique farmland or other farmland of statewide or local importance; or the site does not abut any agricultural land and is not situated in a predominantly agricultural landscape.
Coastal Zone and Compliance with the Coastal Zone Management Act (16 U.S.C. §§ 1451 *et seq.*; TN1243)	3.1.2.1.4	1	SMALL	• The site is not situated in any designated coastal zone, or the applicant can demonstrate that the affected state(s) have or will issue a consistency determination or other indication that the project complies with the Coastal Zone Management Act.
Operation				
Onsite Land Use	3.1.2.2.1	1	SMALL	• The proposed project, including any associated land uses, complies with applicable NRC siting regulations such as 10 CFR Part 100. • The site size is 100 ac (40.5 ha) or less. • If needed, cooling towers would be mechanical draft, not natural draft; less than 100 ft (30.5 m) in height; and equipped with drift eliminators. • Any makeup water for the cooling towers would be fresh water (less than 1 ppt salinity). • BMPs for erosion, sediment control, and stormwater management would be used.
Offsite Land Use	3.1.2.2.2	1	SMALL	• New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length. • BMPs for erosion, sediment control, and stormwater management would be used (wherever land is disturbed during the course of ROW management).
Visual Resources				
Construction				
Visual Impacts in Site and Vicinity	3.2.2.1.1	1	SMALL	• The site size is 100 ac (40.5 ha) or less. • The site would not be situated closer than 0.5 mi (0.8 km) to existing residential areas or 1 mi (1.6 km) to sensitive land uses such as Federal, State, or local parks; wildlife refuges; conservation lands; Wild and Scenic Rivers; or Natural Heritage Rivers.

[38] For Category 2 issues, the impacts are stated as "Undetermined" because the NRC staff cannot reach a generic conclusion regarding the impacts for these issues.

Issue	Section	Category	Finding	Plant Parameter Envelope/Site Parameter Envelope Values and Assumptions
				• The maximum proposed building and structure height is no more than 50 ft (15.2 m), except that the maximum height is 200 ft (61 m) for proposed meteorological towers and 100 ft (30.5 m) for transmission line poles/towers and mechanical draft cooling towers. • The proposed project structures would not be visible from Federal or State parks or wilderness areas designated as Class 1 under Section 162 of the Clean Air Act (42 U.S.C. § 7472; TN6954); or as a Wild and Scenic River, a Natural Heritage River, or a river of similar State designation.
Visual Impacts from Transmission Lines	3.2.2.1.2	1	SMALL	• New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length. • No transmission line structures (poles or towers) would be over 100 ft (30.5 m) in height. • The new offsite ROWs would not be situated closer than 1 mi (1.6 km) to existing residential areas or sensitive land uses such as Federal, State, or local parks; wildlife refuges; conservation lands; Wild and Scenic Rivers; or Natural Heritage Rivers. • Any proposed new structures on offsite ROWs would not be visible from Federal or State parks or wilderness areas designated as Class 1 under Section 162 of the Clean Air Act (42 U.S.C. § 7472; TN6954); or as a Wild and Scenic River, a Natural Heritage River, or a river of similar State designation.
Operation				
Visual Impacts During Operations	3.2.2.2.1	1	SMALL	• The site would not be situated closer than 1 mi (1.6 km) to existing residential areas or sensitive land uses such as Federal, State, or local parks; wildlife refuges; conservation lands; Wild and Scenic Rivers; or Natural Heritage Rivers. • The maximum proposed building and structure height would be no more than 50 ft (15.2 m), except that the maximum height would be 200 ft (61 m) for proposed meteorological towers and 100 ft (30.5 m) for proposed transmission line poles/towers and proposed mechanical draft cooling towers. • The proposed project structures would not be visible from Federal or State parks or wilderness areas designated as Class 1 under Section 162 of the Clean Air Act (42 U.S.C. § 7472; TN6954); or as a Wild and Scenic River, a Natural Heritage River, or a river of similar State designation. • If needed, cooling towers would be mechanical draft, not natural draft; less than 100 ft (30.5 m) in height; and equipped with drift eliminators. • Any makeup water for the cooling towers would be fresh water (less than 1 ppt salinity).
Meteorology and Air Quality				
Construction				
Emissions of Criteria Pollutants and Dust During Construction	3.3.2.1.1	1	SMALL	• The site size is 100 ac (40.5 ha) or less. • The permanent footprint of disturbance is 30 ac (12 ha) or less of vegetated lands and the temporary footprint of disturbance is an additional 20 ac (8.1 ha) or less of vegetated land. • New offsite ROWs for transmission lines, pipelines, or access roads would be no longer than 1 mi (1.6 km) and have a maximum ROW width of 100 ft (30.5 m). • Criteria pollutants emitted from vehicles and standby power equipment during construction are less than Clean Air Act *de minimis* levels set by the U.S. Environmental Protection Agency (EPA) if the site is located in a nonattainment or maintenance area, or the site is located in an attainment area. • The site is not located within 1 mi (1.6 km) of a mandatory Class I Federal area where visibility is an important value. • The level of service (LOS) determination for affected roadways does not change. • Mitigation necessary to rely on the generic analysis includes implementation of BMPs for dust control. • Compliance with air permits under State and Federal laws that address the impact of air emissions during construction.
Greenhouse Gas Emissions During Construction	3.3.2.1.2	1	SMALL	• Greenhouse gases emitted by equipment and vehicles during the 97-year advanced nuclear reactor (ANR) greenhouse gas (GHG) life-cycle period would be equal to or less than 2,534,000 metric tons (MT) of carbon dioxide equivalent (CO_2(e)). Appendix H of this Generic Environmental Impact Statement (GEIS) contains the staff's methodology for developing this value, which includes emissions from building, operating, and decommissioning. As long as this total value is met, the impacts for the life-cycle of the project and the individual phases of the project are determined to be SMALL.
Operation				
Emissions of Criteria and Hazardous Air Pollutants during Operation	3.3.2.2.1	1	SMALL	• Criteria pollutants emitted from vehicles and standby power equipment during operations are less than Clean Air Act *de minimis* levels set by the EPA if located in a nonattainment or maintenance area. • The site is not located within 1 mi (1.6 km) of a mandatory Class I Federal area where visibility is an important value. • The LOS determination for affected roadways does not change. • The generic analysis can be relied on without applying any mitigation measures. • Compliance with air permits under State and Federal laws that address the impact of air emissions. • Hazardous air pollutant (HAP) emissions will be within regulatory limits.
Greenhouse Gas Emissions During Operation	3.3.2.2.2	1	SMALL	• Greenhouse gases emitted by equipment and vehicles during the 97-year ANR GHG life-cycle period would be equal to or less than 2,534,000 MT of CO_2(e). Appendix H of this GEIS contains the staff's methodology for developing this value, which includes emissions from building, operating, and decommissioning. As long as this total value is met, the impacts for the life-cycle of the project and the individual phases of the project are determined to be SMALL.
Cooling-System Emissions	3.3.2.2.3	1	SMALL	• If needed, cooling towers would be mechanical draft, not natural draft. • Cooling towers would be equipped with drift eliminators.

Issue	Section	Category	Finding	Plant Parameter Envelope/Site Parameter Envelope Values and Assumptions
				• The site is not located within 1 mi (1.6 km) of a mandatory Class I Federal area where visibility is an important value. • Mechanical draft cooling towers would be less than 100 ft (30.5 m) tall. • Makeup water would be fresh (with a salinity less than 1 ppt). • Operation of cooling towers is assumed to be subject to State permitting requirements. • HAP emissions would be within regulatory limits. • No existing residential areas within 0.5 mi (0.8 km) of the site.
Emissions of Ozone and Nitrogen Oxides during Transmission Line Operation	3.3.2.2.4	1	SMALL	• The transmission line voltage would be no higher than 1,200 kV.
Water Resources				
Construction				
Surface Water Use Conflicts during Construction	3.4.2.1.1	1	SMALL	Total Plant Water Demand • Less than or equal to a daily average of 6,000 gpm (0.379 m^3/s). If water is obtained from a flowing water body, then the following plant parameter envelope/site parameter envelope (PPE/SPE) parameter and the associated assumptions also apply: • Average plant water withdrawals do not reduce discharge from the flowing water body by more than 3 percent of the 95 percent exceedance daily flow and do not prevent the maintenance of applicable instream flow requirements. • The 95 percent exceedance flow accounts for existing and planned future withdrawals. • Water availability is demonstrated by the ability to obtain a withdrawal permit issued by State, regional, or tribal governing authorities. • Water rights for the withdrawal amount are obtainable, if needed. If water is obtained from a non-flowing water body, then the following PPE/SPE values and assumptions also apply: • Water availability of the Great Lakes, the Gulf of Mexico, oceans, estuaries, and intertidal zones exceeds the amount of water required by the plant. • Water availability is demonstrated by the ability to obtain a withdrawal permit issued by State, regional, or tribal governing authorities. • Water rights for the withdrawal amount are obtainable, if needed. • The Coastal Zone Management Act consistency determination is obtainable, if applicable, for the non-flowing water body.
Groundwater Use Conflicts due to Excavation Dewatering	3.4.2.1.2	1	SMALL	• The long-term dewatering withdrawal rate is less than or equal to 50 gpm (0.003 m^3/s) (the initial rate may be larger). • Dewatering results in negligible groundwater level drawdown at the site boundary.
Groundwater Use Conflicts due to Construction-Related Groundwater Withdrawals	3.4.2.1.3	1	SMALL	• Groundwater withdrawal for all plant uses (excluding dewatering) is less than or equal to 50 gpm (0.003 m^3/s). • Withdrawal results in no more than 1 ft (0.3 m) of groundwater level drawdown at the site boundary. • Withdrawals are not derived from an EPA-designated Sole Source Aquifer (SSA), or from any aquifer designated by a State, tribe, or regional authority to have special protections to limit drawdown. • Withdrawals meet any applicable State or local permit requirements.
Water Quality Degradation due to Construction-Related Discharges	3.4.2.1.4	1	SMALL	• The permanent footprint of disturbance includes 30 ac (12 ha) or less of vegetated lands, and the temporary footprint of disturbance includes no more than an additional 20 ac (8.1 ha) or less of vegetated lands. • Adherence to requirements in National Pollutant Discharge Elimination System (NPDES) permits issued by the EPA or State permitting program, and any other applicable permits. • The long-term groundwater dewatering withdrawal rate is less than or equal to 50 gpm (0.003 m^3/s). • Dewatering discharge has minimal effects on the quality of the receiving water body (e.g., as demonstrated by conformance with NPDES permit requirements). • There are no planned discharges to the subsurface (by infiltration or injection), including stormwater discharge.
Water Quality Degradation due to Inadvertent Spills during Construction	3.4.2.1.5	1	SMALL	• The site size is 100 ac (40.5 ha) or less. • The permanent footprint of disturbance includes 30 ac (12 ha) or less of vegetated lands, and the temporary footprint of disturbance includes no more than an additional 20 ac (8.1 ha) or less of vegetated lands. • Applicable requirements and guidance on spill prevention and control are followed, including relevant BMPs and Integrated Pollution Prevention Plans (IPPPs).
Water Quality Degradation due to Groundwater Withdrawal	3.4.2.1.6	1	SMALL	Groundwater Withdrawal for Excavation or Foundation Dewatering • The long-term dewatering withdrawal rate is less than or equal to 50 gpm (0.003 m^3/s) (the initial rate may be larger). • Dewatering results in negligible groundwater level drawdown at the site boundary. Groundwater Withdrawal for Plant Uses • Groundwater withdrawal for all plant uses (excluding dewatering) is less than or equal to 50 gpm (0.003 m^3/s). • Withdrawal results in no more than 1 ft (0.3 m) of groundwater level drawdown at the site boundary.

Issue	Section	Category	Finding	Plant Parameter Envelope/Site Parameter Envelope Values and Assumptions
				• Withdrawals are not derived from an EPA-designated SSA, or from any aquifer designated by a State, tribe, or regional authority to have special protections to limit drawdown. • Withdrawals meet any applicable State or local permit requirements.
Water Quality Degradation due to Offshore or In-Water Construction Activities	3.4.2.1.7	1	SMALL	• In-water structures (including intake and discharge structures) are constructed in compliance with provisions of the Clean Water Act (CWA) Section 404 (33 U.S.C. § 1344; TN1019) and Section 10 of the Rivers and Harbors Appropriation Act of 1899 (33 U.S.C. §§ 401 *et seq.*; TN660). • Adverse effects of building activities controlled and localized using BMPs such as installation of turbidity curtains or installation of cofferdams. • Construction duration would be less than 7 years.
Water Use Conflict Due to Plant Municipal Water Demand	3.4.2.1.8	1	SMALL	• The amount available from municipal water systems exceeds the amount of municipal water required by the plant (gpm). • Municipal Water Availability accounts for all existing and planned future uses. • An agreement or permit for the usage amount can be obtained from the municipality.
Degradation of Water Quality from Plant Effluent Discharges to Municipal Systems	3.4.2.1.9	1	SMALL	• Municipal Systems' Available Capacity to Receive and Treat Plant Effluent accounts for all existing and reasonably foreseeable future discharges. • Agreement to discharge to a municipal treatment system is obtainable.
Operation				
Surface Water Use Conflicts during Operation due to Water Withdrawal from Flowing Waterbodies	3.4.2.2.1	1	SMALL	• Total plant water demand is less than or equal to a daily average of 6,000 gpm (0.379 m^3/s). • Average plant water withdrawals do not reduce discharge from the flowing water body by more than 3 percent of the 95 percent exceedance daily flow and do not prevent the maintenance of applicable instream flow requirements. • The 95 percent exceedance flow accounts for existing and planned future withdrawals. • Water availability is demonstrated by the ability to obtain a withdrawal permit issued by State, regional, or tribal governing authorities. • Water rights for the withdrawal amount are obtainable, if needed.
Surface Water Use Conflicts during Operation due to Water Withdrawal from Non-flowing Waterbodies	3.4.2.2.2	1	SMALL	• Total plant water demand is less than or equal to a daily average of 6,000 gpm (0.379 m^3/s). • Water availability of the Great Lakes, the Gulf of Mexico, oceans, estuaries, and intertidal zones exceeds the amount of water required by the plant. • Water availability is demonstrated by the ability to obtain a withdrawal permit issued by State, regional, or tribal governing authorities. • Water rights for the withdrawal amount are obtainable, if needed. • Coastal Zone Management Act of 1972 (16 U.S.C. §§ 1451 *et seq.*; TN1243) consistency determination is obtainable, if applicable.
Groundwater Use Conflicts Due to Building Foundation Dewatering	3.4.2.2.3	1	SMALL	• The long-term dewatering withdrawal rate is less than or equal to 50 gpm (0.003 m^3/s) (the initial rate may be larger). • Dewatering results in negligible groundwater level drawdown at the site boundary.
Groundwater Use Conflicts Due to Groundwater Withdrawals for Plant Uses	3.4.2.2.4	1	SMALL	• Groundwater withdrawal for all plant uses (excluding dewatering) is less than or equal to 50 gpm (0.003 m^3/s). • Withdrawal results in no more than 1 ft (0.3 m) of groundwater level drawdown at the site boundary. • Withdrawals are not derived from an EPA-designated SSA, or from any aquifer designated by a State, tribe, or regional authority to have special protections to limit drawdown. • Withdrawals meet any applicable State or local permit requirements.
Surface Water Quality Degradation Due to Physical Effects from Operation of Intake and Discharge Structures	3.4.2.2.5	1	SMALL	• Total plant water demand is less than or equal to a daily average of 6,000 gpm (0.379 m^3/s). • Adhere to best available technology requirements of CWA 316(b) (33 U.S.C. § 1326-TN4823). • Operated in compliance with CWA Section 316 (b) and 40 CFR 125.83, including compliance with monitoring and recordkeeping requirements in 40 CFR 125.87 and 40 CFR 125.88, respectively (40 CFR Part 125-TN254). • Best available technologies are employed in the design and operation of intake and discharge structures to minimize alterations due to scouring, sediment transport, increased turbidity, and erosion. • Adherence to requirements in NPDES permits issued by the EPA or a given state. If water is obtained from a flowing water body, then the following PPE/SPE value also applies: • The average rate of plant withdrawal does not exceed 3 percent of the 95 percent exceedance daily flow for the water body. If water is obtained from a non-flowing water body, then the following PPE/SPE values and assumptions also apply: • Water availability of the Great Lakes, the Gulf of Mexico, oceans, estuaries, and intertidal zones exceeds the amount of water required by the plant.
Surface Water Quality Degradation Due to Changes in Salinity Gradients Resulting from Withdrawals	3.4.2.2.6	1	SMALL	• Total plant water demand is less than or equal to a daily average of 6,000 gpm (0.379 m^3/s). If water is obtained from a flowing water body, then the following PPE/SPE values and assumptions also apply: • Average plant water withdrawals do not reduce discharge from the flowing water body by more than 3 percent of the 95 percent exceedance daily flow and do not prevent the maintenance of applicable instream flow requirements. • The 95 percent exceedance flow accounts for existing and planned future withdrawals. • Water availability is demonstrated by the ability to obtain a withdrawal permit issued by State, regional, or tribal governing authorities. • Water rights for the withdrawal amount are obtainable, if needed.

Issue	Section	Category	Finding	Plant Parameter Envelope/Site Parameter Envelope Values and Assumptions
				• If withdrawals are from an estuary or intertidal zone, then changes to salinity gradients are within the normal tidal or seasonal movements that characterize the water body. If water is obtained from a non-flowing water body, then the following PPE/SPE values and assumptions also apply: • Water availability of the Great Lakes, the Gulf of Mexico, oceans, estuaries, and intertidal zones exceeds the amount of water required by the plant. • Water availability is demonstrated by the ability to obtain a withdrawal permit issued by State, regional, or tribal governing authorities. • Water rights for the withdrawal amount are obtainable, if needed. • If withdrawals are from an estuary or intertidal zone, then changes to salinity gradients are within the normal tidal or seasonal movements that characterize the water body.
Surface Water Quality Degradation Due to Chemical and Thermal Discharges	3.4.2.2.7	2	Undetermined	The staff determined that a generic analysis to determine operational impacts on surface water quality due to chemical and thermal discharges was not possible because (1) some States may impose effluent constituent limitations more stringent that those required by the EPA, (2) limitations imposed on effluent constituents may vary among States, and (3) the establishment of a mixing zone may be required. Because all of these issues related to degradation of surface water quality from chemical and thermal discharges require consideration of project-specific information, a project-specific assessment should be performed in the SEIS.
Groundwater Quality Degradation Due to Plant Discharges	3.4.2.2.8	1	SMALL	• The plant is outside the recharge area for any EPA-designated SSA, or any aquifer designated to have special protections by a State, tribal, or regional authority. • The plant is outside the wellhead protection area or designated contributing area for any public water supply well. • There are no planned discharges to the subsurface (by infiltration or injection).
Water Quality Degradation due to Inadvertent Spills and Leaks during Operation	3.4.2.2.9	1	SMALL	• Applicable requirements and guidance on spill prevention and control are followed, including relevant BMPs and IPPPs. • There are no planned discharges to the subsurface (by infiltration or injection), including stormwater discharge. • A groundwater protection program conforming to NEI 07-07 (NEI 2019-TN6775) is established and followed. • The site size is 100 ac (40.5 ha) or less. • Use of BMPs for soil erosion, sediment control, and stormwater management. • Adherence to requirements in NPDES permits issued by the EPA or a given State, and any other applicable permits.
Water Quality Degradation due to Groundwater Withdrawals	3.4.2.2.10	1	SMALL	• The long-term dewatering withdrawal rate is less than or equal to 50 gpm (0.003 m^3/s) (the initial rate may be larger). • Dewatering results in negligible groundwater level drawdown at the site boundary. • Groundwater withdrawal for all plant uses (excluding dewatering) is less than or equal to 50 gpm (0.003 m^3/s). • Withdrawal results in no more than 1 ft (0.3 m) of groundwater level drawdown at the site boundary. • Withdrawals are not derived from an EPA-designated SSA, or from any aquifer designated by a State, tribe, or regional authority to have special protections to limit drawdown. • Withdrawals meet any applicable State or local permit requirements.
Water Use Conflict from Plant Municipal Water Demand	3.4.2.2.11	1	SMALL	• Usage amount is within the existing capacity of the system(s), accounting for all existing and planned future uses. • An agreement or permit for the usage amount can be obtained from the municipality.
Degradation of Water Quality from Plant Effluent Discharges to Municipal Systems	3.4.2.2.12	1	SMALL	• Municipal Systems' Available Capacity to Receive and Treat Plant Effluent accounts for all existing and reasonably foreseeable future discharges. • Agreement to discharge to a municipal treatment system is obtainable.
Terrestrial Ecology				
Construction				
Permanent and Temporary Loss, Conversion, Fragmentation, and Degradation of Habitats	3.5.2.1.1	1	SMALL	• The permanent footprint of disturbance would include 30 ac (12 ha) or less of vegetated lands, and the temporary footprint of disturbance would include no more than an additional 20 ac (8.1 ha) or less of vegetated lands. • Temporarily disturbed lands would be revegetated using regionally indigenous vegetation once the lands are no longer needed to support building activities. • New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length. • The footprint of disturbance (permanent and temporary) would contain no ecologically sensitive features such as floodplains, shorelines, riparian vegetation, late-successional vegetation, land specifically designated for conservation, or habitat known to be potentially suitable for one or more Federal or State threatened or endangered species. • Total wetland impacts from use of the site and any offsite ROWs would be no more than 0.5 ac (0.2 ha). • Applicants would demonstrate an effort to minimize fragmentation of terrestrial habitats by using existing ROWs, or widening existing ROWs, to the extent practicable. • BMPs would be used for erosion, sediment control, and stormwater management.
Permanent and Temporary Loss and Degradation of Wetlands	3.5.2.1.2	1	SMALL	• Applicant would provide a delineation of potentially impacted wetlands, including wetlands not under CWA jurisdiction. • Total wetland impacts from use of the site and any offsite ROWs would be no more than 0.5 ac (0.2 ha).

Issue	Section	Category	Finding	Plant Parameter Envelope/Site Parameter Envelope Values and Assumptions
				• If activities regulated under the CWA are performed, those activities would receive approval under one or more nationwide permit (NWP) (33 CFR Part 330) or other general permits recognized by the U.S. Army Corps of Engineers (USACE). • Temporary groundwater withdrawals for excavation or foundation dewatering would not exceed a long-term rate of 50 gpm (0.003 m^3/s). • Applicants would be able to demonstrate that the temporary groundwater withdrawals would not substantially alter the hydrology of wetlands connected to the same groundwater resource. • Any required state or local permits for wetland impacts would be obtained. • Any mitigation measures indicated in the NWPs or other permits would be implemented. • BMPs would be used for erosion, sediment control, and stormwater management.
Effects of Building Noise on Wildlife	3.5.2.1.3	1	SMALL	• Noise generation would not exceed 85 dBA 50 ft (15.2 m) from the source.
Effects of Vehicular Collisions on Wildlife	3.5.2.1.4	1	SMALL	• The site size would be 100 ac (40.5 ha) or less. • The permanent footprint of disturbance would include 30 ac (12 ha) or less of vegetated lands, and the temporary footprint of disturbance would include no more than an additional 20 ac (8.1 ha) or less of vegetated lands. • There would be no decreases in the Level of Service (LOS) designation for affected roadways. • The licensee would communicate with Federal and State wildlife agencies and implement mitigation actions recommended by those agencies to reduce potential for vehicular injury to wildlife.
Bird Collisions and Injury from Structures and Transmission Lines	3.5.2.1.5	1	SMALL	• The site size would be 100 ac (40.5 ha) or less. • New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length. • No transmission line structures (poles or towers) would be more than 100 ft (30.5 m) in height. • Licensees would implement common mitigation measures such as those provided by the American Bird Conservancy (ABC 2015-TN6763) for buildings, by the U.S. Fish and Wildlife Service (FWS) for towers (FWS 2013-TN6764), and by the Avian Power Line Interaction Committee (APLIC) for transmission lines (APLIC 2012-TN6779).
Important Species and Habitats – Resources Regulated under the Endangered Species Act of 1973 (ESA; 16 U.S.C. §§ 1531 *et seq*; TN1010)	3.5.2.1.6.1	2	Undetermined	The NRC staff is unable to determine the significance of potential impacts without consideration of project-specific factors, including the specific species and habitats affected and the types of ecological changes potentially resulting from each specific licensing action.
Important Species and Habitats – Other Important Species and Habitats	3.5.2.1.6.2	1	SMALL	• Applicants would communicate with State natural resource or conservation agencies regarding wildlife and plants and implement mitigation recommendations of those agencies.
Operation				
Permanent and Temporary Loss or Disturbance of Habitats	3.5.2.2.1	1	SMALL	• Temporarily disturbed lands would be revegetated using regionally indigenous vegetation once the lands are no longer needed to support building activities. • The total wetland loss from site disturbance over the operational life of the plant would be no more than 0.5 ac (0.2 ha). • Any State or local permits for wetland impacts would be obtained. • Any mitigation measures indicated in the NWPs or other wetland permits would be implemented. • BMPs would be used for erosion, sediment control, and stormwater management.
Effects of Operational Noise on Wildlife	3.5.2.2.2	1	SMALL	• Noise generation would not exceed 85 dBA 50 ft (15.2 m) from the source. • There would be no decreases in the LOS designation for affected roadways. • The licensee would communicate with Federal and State wildlife agencies and implement mitigation actions recommended by those agencies to reduce potential for vehicular injury to wildlife.
Effects of Vehicular Collisions on Wildlife	3.5.2.2.2	1	SMALL	• Noise generation would not exceed 85 dBA 50 ft (15.2 m) from the source. • There would be no decreases in the LOS designation for affected roadways. • The licensee would communicate with Federal and State wildlife agencies and implement mitigation actions recommended by those agencies to reduce potential for vehicular injury to wildlife.
Exposure of Terrestrial Organisms to Radionuclides	3.5.2.2.3	1	SMALL	• Applicants would demonstrate in their application that any radiological nonhuman biota doses would be below International Atomic Energy Agency (IAEA 1992-TN712) and National Council on Radiation Protection and Measurements (NCRP 1991-TN729) guidelines.
Cooling-Tower Operational Impacts on Vegetation	3.5.2.2.4	1	SMALL	• If needed, cooling towers would be mechanical draft, not natural draft; less than 100 ft (30.5 m) in height; and equipped with drift eliminators. • Any makeup water for the cooling towers would be fresh water (less than 1 ppt salinity).
Bird Collisions and Injury from Structures and Transmission Lines	3.5.2.2.5	1	SMALL	• The site size would be 100 ac (40.5 ha) or less. • New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length. • No transmission line structures (poles or towers) would be more than 100 ft (30.5 m) in height. • Licensees would implement common mitigation measures such as those provided by the American Bird Conservancy (ABC 2015-TN6763) for buildings, by FWS (2013-TN6764) for towers, and by APLIC for transmission lines (APLIC 2012-TN6779).

Issue	Section	Category	Finding	Plant Parameter Envelope/Site Parameter Envelope Values and Assumptions
Bird Electrocutions from Transmission Lines	3.5.2.2.6	1	SMALL	• New offsite ROWs for transmission lines, pipelines, or access roads would be no more than 100 ft (30.5 m) in width and total no more than 1 mi (1.6 km) in length. • Common mitigation measures, such as those recommended by APLIC (2006-TN794), would be implemented.
Water Use Conflicts with Terrestrial Resources	3.5.2.2.7	1	SMALL	• Total plant water demand would be less than or equal to a daily average of 6,000 gpm (0.379 m^3/s). • If water is withdrawn from flowing water bodies, average plant water withdrawals would not reduce flow by more than 3 percent of the 95 percent exceedance daily flow and would not prevent maintenance of applicable instream flow requirements. • Any water withdrawals would be in compliance with any EPA or State permitting requirements. • Applicants would be able to demonstrate that hydroperiod changes are within historical or seasonal fluctuations.
Effects of Transmission Line ROW Management on Terrestrial Resources	3.5.2.2.8	1	SMALL	• Vegetation in transmission line ROWs would be managed following a plan consisting of integrated vegetation management practices. • All ROW maintenance work would be performed in compliance with all applicable laws and regulations. • Herbicides would be applied by licensed applicators, and only if in compliance with applicable manufacturer label instructions.
Effects of Electromagnetic Fields on Flora and Fauna	3.5.2.2.9	1	SMALL	• Based on the literature review in the License Renewal GEIS, the staff determined that this is a Category 1 issue and impacts would be SMALL regardless of the length, location, or size of the transmission lines. The staff did not recommend any mitigation in the License Renewal GEIS (NRC 2013-TN2654); hence, none is needed here. The staff did not rely on any PPE and SPE values or assumptions in reaching this conclusion.
Important Species and Habitats – Resources Regulated under the ESA of 1973	3.5.2.2.10.1	2	Undetermined	The NRC staff is unable to determine the significance of potential impacts without consideration of project-specific factors, including the specific species and habitats affected and the types of ecological changes potentially resulting from each specific licensing action.
Important Species and Habitats – Other Important Species and Habitats	3.5.2.2.10.2	1	SMALL	• Applicants would communicate with State natural resource or conservation agencies regarding wildlife and plants and implement mitigation recommendations of those agencies.
Aquatic Ecology				
Construction				
Runoff and sedimentation from construction areas	3.6.2.1.1	1	SMALL	• BMPs would be used for erosion and sediment control. • Temporarily disturbed lands would be revegetated using regionally indigenous vegetation once the lands are no longer needed to support building activities.
Dredging and filling aquatic habitats to build intake and discharge structures	3.6.2.1.2	1	SMALL	• Applicant would obtain approval, if required, under NWP 7 in 33 CFR Part 330. • Applicant would implement any mitigation required under NWP 7 in 33 CFR Part 330. • Applicant would minimize any temporarily disturbed shoreline and riparian lands needed to build the intake and discharge structures and restore those areas with regionally indigenous vegetation suited to those landscape settings once the disturbances are no longer needed. • BMPs would be used for erosion and sediment control.
Building transmission lines, pipelines, and access roads across surface waterbodies	3.6.2.1.3	1	SMALL	• If activities regulated under the CWA are performed, they would receive approval under one or more NWPs (33 CFR Part 330-TN4318) or other general permits recognized by the USACE. • Pipelines would be extended under (or over) surface through directional drilling without physically disturbing shorelines or bottom substrate. • Access roads would span streams and other surface waterbodies with a bridge or ford, and any fords would include placement and maintenance of matting to minimize physical disturbance of shorelines and bottom substrates. • No access roads would be extended across stream channels over 10 ft (3 m) in width (at ordinary high water). • Any bridges or fords would be removed once no longer needed, and any exposed soils or substrate would be revegetated using regionally indigenous vegetation appropriate to the landscape setting. • Any mitigation measures indicated in the NWPs or other permits would be implemented. • BMPs would be used for erosion and sediment control.
Important Species and Habitats – Resources Regulated under the ESA and Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. §§ 1801 *et seq.*; TN1061)	3.6.2.1.4.1	2	Undetermined	The NRC staff is unable to determine the significance of potential impacts without consideration of project-specific factors, including the specific species and habitats affected and the types of ecological changes potentially resulting from each specific licensing action. Furthermore, the ESA and Magnuson-Stevens Fishery Conservation and Management Act require consultations for each licensing action that may affect regulated resources.
Important species and habitats – Other Important Species and Habitats	3.6.2.1.4.2	1	SMALL	• Applicants would communicate with State natural resource or conservation agencies regarding aquatic fish, wildlife, and plants and implement mitigation recommendations of those agencies.
Operation				
Stormwater runoff	3.6.2.2.1	1	SMALL	• Preparation, approval by applicable regulatory agencies, and implementation of a stormwater management plan. • Obtaining and compliance with any required permits for the storage and use of hazardous materials issued by Federal and State agencies under Resource Conservation and Recovery Act (RCRA). • BMPs would be used for stormwater management.
Exposure of aquatic organisms to radionuclides	3.6.2.2.2	1	SMALL	• Applicants would demonstrate in their application that any radiological nonhuman biota doses would be below IAEA (1992-TN712) and NCRP (1991-TN729) guidelines.

Issue	Section	Category	Finding	Plant Parameter Envelope/Site Parameter Envelope Values and Assumptions
Effects of refurbishment on aquatic biota	3.6.2.2.3	1	SMALL	• BMPs would be used for erosion, sediment control, and stormwater management. • Exposed soils would be restored as soon as possible with regionally indigenous vegetation.
Effects of maintenance dredging on aquatic biota	3.6.2.2.4	1	SMALL	• If activities regulated under the CWA are performed, those activities would receive approval under one or more NWPs (33 CFR Part 330), or other general permits recognized by the USACE. • Any mitigation measures indicated in the NWPs or other permits would be implemented. • BMPs would be used for erosion and sediment control.
Impacts of transmission line ROW management on aquatic resources	3.6.2.2.5	1	SMALL	• Vegetation in transmission line ROWs would be managed following a plan consisting of integrated vegetation management practices. • All ROW maintenance work would be performed in compliance with all applicable laws and regulations. • Herbicides would be applied by licensed applicators, and only if in compliance with applicable manufacturer label instructions. • BMPs would be used for erosion and sediment control.
Impingement and entrainment of aquatic organisms	3.6.2.2.6	1	SMALL	• Intakes would comply with regulatory requirements established by EPA in 40 CFR 125.84 (TN254) to be protective of fish and shellfish. • Best available control technology would be employed in the design of intakes to minimize entrainment and impingement, such as use of screens and intake rates recognized to minimize effects.
Thermal impacts on aquatic biota	3.6.2.2.7	2	Undetermined	Staff would have to first review the discharge plume analysis (as described in Section 3.4) and the aquatic biota potentially present before being able to reach a conclusion regarding the possible significance of impacts to that biota.
Other effects of cooling-water discharges on aquatic biota	3.6.2.2.8	2	Undetermined	Staff would have to first review the discharge plume analysis (as described in Section 3.4) and the aquatic biota potentially present before being able to reach a conclusion regarding the possible significance of impacts to that biota.
Water use conflicts with aquatic resources	3.6.2.2.9	1	SMALL	• If needed, cooling towers would be mechanical draft, not natural draft; less than 100 ft (30.5 m) in height; and equipped with drift eliminators. • Any makeup water for the cooling towers would be fresh water (less than 1 ppt salinity). • Total plant water demand would be less than or equal to a daily average of 6,000 gpm (0.379 m^3/s). • If water is withdrawn from flowing waterbodies, average plant water withdrawals would not reduce flow by more than 3 percent of the 95 percent exceedance daily flow, and would not prevent maintenance of applicable instream flow requirements. • Any water withdrawals would be in compliance with any EPA or State permitting requirements. • Applicants would be able to demonstrate that hydroperiod changes are within historical or seasonal fluctuations.
Important Species and Habitats – Resources Regulated under the ESA and Magnuson-Stevens Fishery Conservation and Management Act	3.6.2.2.10.1	2	Undetermined	The NRC staff is unable to determine the significance of potential impacts without consideration of project-specific factors, including the specific species and habitats affected and the types of ecological changes potentially resulting from each specific licensing action. Furthermore, the ESA and Magnuson-Stevens Fishery Conservation and Management Act require consultations for each licensing action that may affect regulated resources.
Important species and habitats – Other Important Species and Habitats	3.6.2.2.10.2	1	SMALL	• Applicants would communicate with State natural resource or conservation agencies regarding aquatic fish, wildlife, and plants and implement mitigation recommendations of those agencies.
Historic and Cultural Resources				
Construction				
Construction impacts on historic and cultural resources	3.7.2	2	Undetermined	Impacts on historic and cultural resources are analyzed on a project-specific basis. The NRC will perform National Environmental Policy Act (NEPA) and National Historic Preservation Act (NHPA) Section 106 analysis, in accordance with 36 CFR Part 800, in its preparation of the supplemental environmental impact statement (SEIS). The NHPA Section 106 analysis includes consultation with the State and Tribal Historic Preservation Officers, American Indian Tribes, and other interested parties.
Operation				
Operation impacts on historic and cultural resources	3.7.2	2	Undetermined	Impacts on historic and cultural resources are analyzed on a project-specific basis. The NRC will perform NEPA and NHPA Section 106 analysis, in accordance with 36 CFR Part 800, in its preparation of the SEIS. The NHPA Section 106 analysis includes consultation with the State and Tribal Historic Preservation Officers, American Indian Tribes, and other interested parties.
Environmental Hazards – Radiological Environment				
Construction				
Radiological dose to construction workers	3.8.1.2.1	1	SMALL	• For protection against radiation, the applicant must meet the regulatory requirements of: - 10 CFR 20.1101 Radiation Protection Programs (10 CFR Part 20-TN283) if issued a license - 10 CFR 20.1201 Occupational dose limits for adults - 10 CFR 20.1301 Dose limits for individual members of the public - Appendix B of 10 CFR Part 20 *Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage* • Applicable NRC radiation protection regulations, such as: − 10 CFR 50.34a (10 CFR Part 50-TN249) Design objectives for equipment to control releases of radioactive material in effluents—nuclear power reactors − 10 CFR 50.36a Technical specifications on effluents from nuclear power reactors - Application contains sufficient technical information for the staff to complete the detailed technical safety review.

Issue	Section	Category	Finding	Plant Parameter Envelope/Site Parameter Envelope Values and Assumptions
				- Application will be found to be in compliance by the staff with the above regulations through a radiation protection program and an effluent release monitoring program.
Operation				
Occupational doses to workers	3.8.1.2.2.1	1	SMALL	• For protection against radiation, the applicant must meet the regulatory requirements of: − 10 CFR 20.1101 Radiation Protection Programs (10 CFR Part 20-TN283) if issued a license − 10 CFR 20.1201 Occupational dose limits for adults − Appendix B of 10 CFR Part 20 *Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage* • Applicable radiation protection regulations, such as: − 10 CFR 50.34a (10 CFR Part 50-TN249) Design objectives for equipment to control releases of radioactive material in effluents—nuclear power reactors − 10 CFR 50.36a Technical specifications on effluents from nuclear power reactors • Application contains sufficient technical information for the staff to complete the detailed technical safety review • Application will be found to be in compliance by the staff with the above regulations through a radiation protection program and an effluent release monitoring program.
Maximally exposed individual annual doses	3.8.1.2.2.2	1	SMALL	• For protection against radiation, the applicant must meet the regulatory requirements of: − 10 CFR 20.1101 Radiation Protection Programs (10 CFR Part 20-TN283) if issued a license − 10 CFR 20.1301 Dose limits for individual members of the public − Appendix B of 10 CFR Part 20 *Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage* • Applicable radiation protection regulations, such as: − 10 CFR 50.34a (10 CFR Part 50-TN249) Design objectives for equipment to control releases of radioactive material in effluents—nuclear power reactors − 10 CFR 50.36a Technical specifications on effluents from nuclear power reactors • Application contains sufficient technical information for the staff to complete the detailed technical safety review • Application will be found to be in compliance by the staff with the above regulations through a radiation protection program and an effluent release monitoring program
Total population annual doses	3.8.1.2.2.3	1	SMALL	• For protection against radiation, the applicant must meet the regulatory requirements of: − 10 CFR 20.1101 Radiation Protection Programs (10 CFR Part 20-TN283) if issued a license − 10 CFR 20.1301 Dose limits for individual members of the public − Appendix B of 10 CFR Part 20 *Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage* • Applicable radiation protection regulations, such as: − 10 CFR 50.34a (10 CFR Part 50-TN249) Design objectives for equipment to control releases of radioactive material in effluents—nuclear power reactors − 10 CFR 50.36a Technical specifications on effluents from nuclear power reactors • Application contains sufficient technical information for the staff to complete the detailed technical safety review • Application will be found to be in compliance by the staff with the above regulations through a radiation protection program and an effluent release monitoring program.
Nonhuman biota doses	3.8.1.2.2.4	1	SMALL	• Applicants would demonstrate in their application that any radiological nonhuman biota doses would be below IAEA (1992-TN712) and NCRP (1991-TN729) guidelines.
Environmental Hazards – Nonradiological Environment				
Construction				
Building impacts of chemical, biological, and physical nonradiological hazards	3.8.2.2.1.1	1	SMALL	• The applicant must adhere to all applicable Federal, State, local or Tribal regulatory limits and permit conditions for chemical hazards, biological hazards, and physical hazards. • The applicant will follow nonradiological public and occupational health BMPs and mitigation measures, as appropriate.
Building impacts of electromagnetic fields (EMFs)	3.8.2.2.1.2	N/A	Uncertain	Studies of 60 Hz EMFs have not uncovered consistent evidence linking harmful effects with field exposures. Because the state of the science is currently inadequate, no generic conclusion on human health impacts is possible. If, in the future, the Commission finds that a general agreement has been reached by appropriate Federal health agencies that there are adverse health effects from EMFs, the Commission will require applicants to submit project-specific reviews of these health effects as part of their application. Until such time, applicants are not required to submit information about this issue.
Operation				
Operation impacts of chemical, biological, and physical nonradiological hazards	3.8.2.2.2.1	1	SMALL	• The applicant must adhere to all applicable Federal, State, local or Tribal regulatory limits and permit conditions for chemical hazards, biological hazards, and physical hazards. • The applicant will follow nonradiological public and occupational health BMPs and mitigation measures, as appropriate.

Issue	Section	Category	Finding	Plant Parameter Envelope/Site Parameter Envelope Values and Assumptions
Operation impacts of EMFs	3.8.2.2.2.2	N/A	Uncertain	Studies of 60 Hz EMFs have not uncovered consistent evidence linking harmful effects with field exposures. Because the state of the science is currently inadequate, no generic conclusion on human health impacts is possible. If, in the future, the Commission finds that a general agreement has been reached by appropriate Federal health agencies that there are adverse health effects from EMFs, the Commission will require applicants to submit project-specific reviews of these health effects as part of their application. Until such time, applicants are not required to submit information about this issue.
Noise				
Construction				
Construction-related noise	3.9.2.1	1	SMALL	• The noise level would be no more than 65 dBA at site boundary, unless a relevant State or local noise abatement law or ordinance sets a different threshold, which would then be the presumptive threshold for PPE purposes. • If an applicant cannot meet the 65 dBA threshold through mitigation, then the applicant must obtain a various or exception with the relevant State or local regulator. • The project would implement BMPs, including such as modeling, foliage planting, construction of noise buffers, and the timing of construction and/or operation activities.
Operation				
Operation-related noise	3.9.2.2	1	SMALL	• The noise level would be no more than 65 dBA at site boundary, unless a relevant State or local noise abatement law or ordinance sets a different threshold, which would then be the presumptive threshold for PPE purposes. • If an applicant cannot meet the 65 dBA threshold through mitigation, then the applicant must obtain a various or exception with the relevant State or local regulator. • The project would implement BMPs, including such as modeling, foliage planting, construction of noise buffers, and the timing of construction and/or operation activities.
Waste Management – Radiological Environment				
Operation				
Low-level radioactive waste (LLRW)	3.10.1.2.1	1	SMALL	• Applicants must meet the regulatory requirements of 10 CFR Part 20 (TN283) (e.g., 20.1406 and Subpart K), 10 CFR Part 61 (TN252), 10 CFR Part 71 (TN301), and 10 CFR Part 72 (TN4884). • Quantities of low-level radioactive waste (LLRW) generated at an ANR would be less than the quantities of LLRW generated at existing nuclear power plants, which generate an average of 21,200 ft^3 (600 m^3) and 2,000 Ci (7.4×10^{13} Bq) per year for boiling water reactors and half that amount for pressurized water reactors (NRC 2013-TN2654).
Onsite spent nuclear fuel management	3.10.1.2.2	1	SMALL	• Compliance with 10 CFR Part 72 (TN4884)
Mixed waste	3.10.1.2.3	1	SMALL	• (RCRA Small-Quantity Generator (EPA 2020-TN6590) for Mixed Waste.
Waste Management – Nonradiological Environment				
Construction				
Construction nonradiological waste	3.10.2.2.1	1	SMALL	• The applicant must meet all the applicable permit conditions, regulations, and BMPs related to solid, liquid, and gaseous waste management. • For hazardous waste generation, applicants must meet conformity with hazard waste quantity generation levels in accordance with RCRA. • For sanitary waste, applicants must dispose of sanitary waste in a permitted process. • For mitigation measures, the applicant would perform mitigation measures to the extent practicable, such as recycling, process improvements, or the use of a less hazardous substance.
Operation				
Operation nonradiological waste	3.10.2.2.2	1	SMALL	• The applicant must meet all the applicable permit conditions, regulations, and BMPs related to solid, liquid, and gaseous waste management. • For hazardous waste generation, applicants must meet conformity with hazard waste quantity generation levels in accordance with RCRA. • For sanitary waste, applicants must dispose of sanitary waste in a permitted process. • For mitigation measures, the applicant would perform mitigation measures to the extent practicable, such as recycling, process improvements, or the use of a less hazardous substance.
Postulated Accidents				
Operation				
Design Basis Accidents Involving Radiological Releases	3.11.2.1	1	SMALL	• For the exclusion area boundary, the maximum total effective dose equivalent (TEDE) for any 2-hour period during the radioactivity release should be calculated. • For the low-population zone, the TEDE should be calculated for the duration of the accident release (i.e., 30 days, or other duration as justified). The above calculations should demonstrate that the design basis accident doses satisfy the dose criteria given in regulations related to the application (e.g., 10 CFR 50.34(a)(1) [TN249], 10 CFR 52.17(a)(1) and 10 CFR 52.79(a)(1) [10 CFR Part 52-TN251]), standard review plans (e.g., standard review plan [SRP] criteria, Table 1 in SRP Section 15.0.3 of NUREG-0800 [NRC 2007/2019-TN6221]), and Regulatory Guides (RGs), (e.g., RG 1.183 [NRC 2000-TN517]), as applicable.

Issue	Section	Category	Finding	Plant Parameter Envelope/Site Parameter Envelope Values and Assumptions
Accidents Involving Releases of Hazardous Chemicals	3.11.2.2	1	SMALL	• ANR inventory of a regulated substance is less than its Threshold Quantity (TQ). TQs are found in 40 CFR 68.130, Tables 1, 2, 3, and 4 (TN5494); and • ANR inventory of an extremely hazardous substance (EHS) is less than its Threshold Planning Quantity (TPQ). TPQs are found in 40 CFR Part 355, Appendices A and B (TN5493).
Severe Accidents	3.11.2.3	2	Undetermined	Based on the analysis in the Final Safety Analysis Report/Preliminary Safety Analysis Report regarding severe accidents, if an ANR design has severe accident progressions with radiological or hazardous chemical releases, then an environmental risk evaluation must be performed.
Severe Accident Mitigation Design Alternatives	3.11.2.4	1	SMALL	If a cost-screening analysis determines that the maximum benefit for avoiding an accident is so small that a severe accident mitigation design alternative (SAMDA) analysis is not justified based on a minimum cost to design an appropriate SAMDA.
Acts of Terrorism	3.11.2.5	1	SMALL	The environmental impacts of acts of terrorism and sabotage only need to be addressed if an ANR facility is subject to the jurisdiction of the U.S. Court of Appeals for the Ninth Circuit.
Socioeconomics				
Construction				
Community Services and Infrastructure	3.12.1.1.1	1	SMALL	• The housing vacancy rate in the affected economic region does not change by more than 5 percent, or at least 5 percent of the housing stock remains available after accounting for in-migrating construction workers. • Student:teacher ratios in the affected economic region do not exceed locally mandated levels after including the school age children of the in-migrating worker families.
Transportation Systems and Traffic	3.12.1.1.2	1	SMALL	The LOS determination for affected roadways does not change. Mitigation measures may include implementation of traffic flow management, management of shift-change timing, and encouragement of ride-sharing and use of public transportation options, such that LOS values can be maintained with the increased volumes.
Economic Impacts	3.12.1.1.3	1	Beneficial	The economic impacts of construction and operation of an ANR are expected to be beneficial; therefore, this is a Category 1 issue. If, during the project-specific environmental review, the NRC staff determines a detailed analysis of economic costs and benefits is needed for analysis of the range of alternatives considered or relevant to mitigation, the staff may require further information from the applicant.
Tax Revenue Impacts	3.12.1.1.4	1	Beneficial	The tax revenue impacts of construction and operation of an ANR are expected to be beneficial; therefore, this is a Category 1 issue. If, during the project-specific environmental review, the NRC staff determines a detailed analysis of tax revenue costs and benefits is needed for analysis of the range of alternatives considered or relevant to mitigation, the staff may require further information from the applicant.
Operation				
Community Services and Infrastructure	3.12.1.2.1	1	SMALL	• The housing vacancy rate in the affected economic region does not change by more than 5 percent, or at least 5 percent of the housing stock remains available after accounting for in-migrating construction workers. • Student:teacher ratios in the affected economic region do not exceed locally mandated levels after including the school age children of the in-migrating worker families.
Transportation Systems and Traffic	3.12.1.2.2	1	SMALL	The LOS determination for affected roadways does not change. Mitigation measures may include implementation of traffic flow management, management of shift-change timing, and encouragement of ride-sharing and use of public transportation options, such that LOS values can be maintained with the increased volumes.
Economic Impacts	3.12.1.2.3	1	Beneficial	The economic impacts of construction and operation of an ANR are expected to be beneficial; therefore, this is a Category 1 issue. If, during the project-specific environmental review, the NRC staff determines a detailed analysis of economic costs and benefits is needed for analysis of the range of alternatives considered or relevant to mitigation, the staff may require further information from the applicant.
Tax Revenue Impacts	3.12.1.2.4	1	Beneficial	The tax revenue impacts of construction and operation of an ANR are expected to be beneficial; therefore, this is a Category 1 issue. If, during the project-specific environmental review, the NRC staff determines a detailed analysis of tax revenue costs and benefits is needed for analysis of the range of alternatives considered or relevant to mitigation, the staff may require further information from the applicant.
Environmental Justice				
Construction				
Construction Environmental Justice Impacts	3.13.2.1	2	Undetermined	Project-specific analysis would be necessary, including analysis of the presence and size of specific minority or low-income populations, impact pathways derived from the plant design, layout, or site characteristics, or other community characteristics affecting specific minority or low-income populations. In performing its environmental justice analysis, the NRC staff will be guided by the NRC's "Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions," which was published in the *Federal Register* on August 24, 2004 (69 FR 52040-TN1009).
Operation				
Operation Environmental Justice Impacts	3.13.2.1	2	Undetermined	Project-specific analysis would be necessary, including analysis of the presence and size of specific minority or low-income populations, impact pathways derived from the plant design, layout, or site characteristics, or other community characteristics affecting specific minority or low-income populations. In performing its environmental justice analysis, the NRC staff will be guided by the NRC's "Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions," which was published in the *Federal Register* on August 24, 2004 (69 FR 52040-TN1009).

Issue	Section	Category	Finding	Plant Parameter Envelope/Site Parameter Envelope Values and Assumptions
Fuel Cycle				
Operation				
Uranium Recovery	3.14.2.1	1	SMALL	• Table S–3 as codified in 10 CFR 51.51 is expected to bound the impacts for ANR fuels, because of uranium fuel cycle changes since WASH-1248 (AEC 1974-TN23), including: − Increasing use of in situ leach uranium mining has lower environmental impacts than traditional mining and milling methods. − Current light-water reactors are using nuclear fuel more efficiently due to higher levels of fuel burnup resulting in less demand for mining and milling activities. − Less reliance on coal-fired electrical generation plants is resulting in less gaseous effluent releases from electrical generation sources supporting mining and milling activities. • Must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882) *Domestic Licensing of Source Material* and 10 CFR Part 71 (TN301), *Packaging and Transportation of Radioactive Material*.
Uranium Conversion	3.14.2.2	1	SMALL	• Table S–3 is expected to bound the impacts for ANR fuels because of uranium fuel cycle changes since WASH-1248 (AEC 1974-TN23), including: − Current light-water reactors (LWRs) are using nuclear fuel more efficiently due to higher levels of fuel burnup resulting in less demand for conversion activities. − Less reliance on coal-fired electrical generation plants is resulting in less gaseous effluent releases from electrical generation sources supporting conversion activities. • Must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882) *Domestic Licensing of Source Material* and 10 CFR Part 71 (TN301), *Packaging and Transportation of Radioactive Material*, and 10 CFR Part 73 (TN423), *Physical Protection of Plants and Materials*.
Enrichment	3.14.2.3	1	SMALL	• Table S–3 is expected to bound the impacts for ANR fuels, because of uranium fuel cycle changes since WASH-1248 (AEC 1974-TN23), including: • Transitioning of U.S. uranium enrichment technology from gaseous diffusion to gas centrifugation, which requires less electrical usage per separative work unit. • Current LWRs are using nuclear fuel more efficiently due to higher levels of fuel burnup resulting in less demand for enrichment activities. • Less reliance on coal-fired electrical generation plants is resulting in less gaseous effluent releases from electrical generation sources supporting enrichment activities. • Must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882) *Domestic Licensing of Source Material*, 10 CFR Part 70 (TN4883), *Domestic Licensing of Special Nuclear Material*, 10 CFR Part 71 (TN301), *Packaging and Transportation of Radioactive Material*, and 10 CFR Part 73 (TN423), *Physical Protection of Plants and Materials*.
Fuel Fabrication[(a)]	3.14.2.4	1	SMALL	• Table S–3 is expected to bound the impacts for ANR fuels, because of uranium fuel cycle changes since WASH-1248 (AEC 1974-TN23), including: − Current LWRs are using nuclear fuel more efficiently due to higher levels of fuel burnup resulting in fewer discharged fuel assemblies to be fabricated each year and due to longer time periods between refueling − Less reliance on coal-fired electrical generation plants is resulting in less gaseous effluent releases from electrical generation sources supporting fabrication. • Must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882) *Domestic Licensing of Source Material*, 10 CFR Part 70 (TN4883), *Domestic Licensing of Special Nuclear Material*, 10 CFR Part 71 (TN301), *Packaging and Transportation of Radioactive Material*, and 10 CFR Part 73 (TN423), *Physical Protection of Plants and Materials*.
Reprocessing	3.14.2.5	1	SMALL	• Table S–3 is expected to bound the impacts for ANR fuels, because of uranium fuel cycle changes since WASH-1248 (AEC 1974-TN23), including: − Current LWRs are using nuclear fuel more efficiently due to higher levels of fuel burnup resulting in fewer discharged fuel assemblies to be reprocessed each year. − Less reliance on coal-fired electrical generation plants is resulting in less gaseous effluent releases from electrical generation sources supporting reprocessing. • Reprocessing capacity up to 900 MTU/yr • Must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882) *Domestic Licensing of Source Material*, 10 CFR Part 50 (TN249) *Domestic Licensing of Production and Utilization Facilities*,10 CFR Part 70 (TN4883), *Domestic Licensing of Special Nuclear Material*, 10 CFR Part 71 (TN301), *Packaging and Transportation of Radioactive Material*, 10 CFR Part 72 (TN4884), *Licensing Requirements for the Independent Storage of Spent Fuel, High-Level Radioactive Waste, and Reactor-related Greater Than Class C Waste*, and 10 CFR Part 73 (TN423), *Physical Protection of Plants and Materials*.
Storage and Disposal of Radiological Wastes	3.14.2.6	1	SMALL	• Table S–3 is expected to bound the impacts for ANR fuels, because of uranium fuel cycle changes since WASH-1248 (AEC 1974-TN23), including: − Current LWRs are using nuclear fuel more efficiently due to higher levels of fuel burnup resulting in fewer discharged fuel assemblies to be stored and disposed. − Less reliance on coal-fired electrical generation plants is resulting in less gaseous effluent releases from electrical generation sources supporting storage and disposal.

Issue	Section	Category	Finding	Plant Parameter Envelope/Site Parameter Envelope Values and Assumptions
				• Waste and spent fuel inventories, as well as their associated certified spent fuel shipping and storage containers, are not significantly different from what has been considered for LWR evaluations in NUREG-2157 (NRC 2014-TN4117). • Must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882) *Domestic Licensing of Source Material*, 10 CFR Part 70 (TN4883), *Domestic Licensing of Special Nuclear Material*, 10 CFR Part 71 (TN301), *Packaging and Transportation of Radioactive Material*, 10 CFR Part 72 (TN4884), *Licensing Requirements for the Independent Storage of Spent Fuel, High-Level Radioactive Waste, and Reactor-related Greater Than Class C Waste*, and 10 CFR Part 73 (TN423), *Physical Protection of Plants and Materials.*
Transportation of Fuel and Waste				
Operation				
Transportation of Unirradiated ANR Fuel	3.15.2.1	1	SMALL	• The maximum annual one-way shipment distance (36,760 mi [59,160 km]) presented in Table 3-11. The annual shipments associated with the one-way shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor from WASH-1238 (AEC 1972-TN22). • The maximum annual round-trip shipment distance (73,520 mi [118,320 km]) presented in Table 3-12. The annual shipments associated with the round-trip shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor from WASH-1238 (AEC 1972-TN22).
Transportation of Radioactive Waste from ANRs	3.15.2.2	1	SMALL	• The maximum annual round-trip shipment distance (182,152 mi [293,145 km]) presented in Table 3-16. The annual shipments associated with the round-trip shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor and a shipment volume of 2.34 m^3/shipment from WASH-1238 (AEC 1972-TN22).
Transportation of Irradiated Fuel from ANRs	3.15.2.3	1	SMALL	• The maximum annual one-way shipment distance (314,037 mi [505,393 km]) presented in Table 3-17. The annual shipments associated with the one-way shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor and a shipment capacity of 0.5 MTU/shipment from WASH-1238 (AEC 1972-TN22). • The maximum annual round-trip shipment distance (628,073 mi [1,010,786 km]) presented in Table 3-19. The annual shipments associated with the round-trip shipment distance have been normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor and a shipment capacity of 0.5 MTU/shipment from WASH-1238 (AEC 1972-TN22). • A maximum peak rod burnup of 62 GWd/MTU for UO_2 fuel and peak pellet burnup of 133 GWd/MTU for TRi-structural ISOtropic (TRISO) fuel (see Table 3-18).
Decommissioning				
Decommissioning	3.16.2	1	SMALL	The ANR would be within the bounds of the Decommissioning GEIS (NRC 2002-TN665) based on the following assumptions: • Doses to the public would be well below applicable regulatory standards regardless of which decommissioning method considered in Decommissioning GEIS is used. • Occupational doses would be well below applicable regulatory standards during the license term. • The quantities of Class C or greater than Class C wastes generated would be comparable to or less than the amounts of solid waste generated by reactors licensed before 2002. • The air quality impacts of decommissioning are expected to be negligible. • Measures are readily available to avoid potential significant water quality impacts from erosion or spills. The liquid radioactive waste system design includes features to limit release of radioactive material to the environment, such as pipe chases and tank collection basins. These features will minimize the amount of radioactive material in spills and leakage that would have to be addressed at decommissioning. • The ecological impacts of decommissioning are expected to be negligible. • The socioeconomic impacts should be neither detectable nor destabilizing.
Issues Applying Across All Resources				
Climate Change	1.4.3.2.2	2	Undetermined	The effects of climate change are location-specific and cannot, therefore, be evaluated generically. For example, while climate change may cause many areas to receive less than average annual precipitation, other areas may see an increase in average annual precipitation. Therefore, applicants and staff would address the effects of climate change in the environmental documents for ANR licensing.
Cumulative Impacts	1.4.2.2.2	2	Undetermined	Applications must individually consider the cumulative impacts from past, present, and reasonably foreseeable future actions known to occur at specific sites for proposed ANRs, and briefly present those considerations in supplemental NEPA documentation. The staff would explain whether these individualized evaluations of potential cumulative impacts alter any of the generic analyses and conclusions relied upon for Category 1 issues. The individualized cumulative impact analyses may also identify opportunities where staff might rely upon the generic analyses for some Category 1 issues for which certain of the PPE or SPE values and assumptions might be exceeded.
Non-Resource Related Issues				
Purpose and Need	1.4.3.2.3	2	Undetermined	Must be described in the Environmental Report associated with a given application.
Need for Power	1.4.3.2.3	2	Undetermined	Must be described in the Environmental Report associated with a given application.
Site Alternatives	1.4.3.2.3	2	Undetermined	Must be described in the Environmental Report associated with a given application.
Energy Alternatives	1.4.3.2.3	2	Undetermined	Must be described in the Environmental Report associated with a given application.
System Design Alternatives	1.4.3.2.3	2	Undetermined	Must be described in the Environmental Report associated with a given application.
(b) **Fuel fabrication impacts for metal fuel and liquid-fueled molten salt are not included in the staff's generic analysis**				

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4.1 Unavoidable Adverse Environmental Impacts and Irreversible and Irretrievable Commitments of Resources

Unavoidable adverse environmental impacts are those potential impacts of the NRC proposed action that cannot be avoided and for which no practical means of mitigation are available. The term "irreversible and irretrievable commitments of resources" refers to environmental resources that would be irreparably changed by the activities authorized by the NRC, where the environmental resources could not be restored at some later time to the resource's state before the relevant activities.

Because the issuance of the advanced nuclear reactor (ANR) GEIS would itself have no impacts and would not approve or license the construction and/or operation of any new reactor, there would be no unavoidable adverse environmental impacts or any irreversible or irretrievable commitments of resources from development of the ANR GEIS.

Any project-specific SEIS developed for a proposed ANR tiering to this GEIS would be required to analyze the impacts associated with building, operating, and decommissioning such a facility. The unavoidable adverse environmental impacts associated with the granting of the license would include impacts of construction, preconstruction, operating, and decommissioning and would be described in the project-specific SEIS.

The irreversible and irretrievable commitments of resources during construction of the proposed ANR generally would be similar to those of any major construction project and would be dependent on the size and scale of the proposed reactor. The NRC would prepare the project-specific SEIS, issue the requisite record of decision in accordance with 10 CFR 51.102 (TN250), and assuming approval of the project, describe any such irreversible and irretrievable commitments of resources in the SEIS before the issuance of any license, permit, or other authorization to construct or operate an ANR.

The NRC staff expects that the use of construction materials in the quantities associated with those expected for ANRs tiering to this GEIS, while irreversible and irretrievable, would be of small consequence with respect to the availability of such resources. The main resource that would be irreversibly and irretrievably committed during operation of any new nuclear unit would be the fuel. If uranium is the fuel, the availability of uranium ore and existing stockpiles of highly enriched uranium in the United States and Russia that could be processed into fuel is sufficient (OECD/NEA and IAEA 2008-TN3992) so that the irreversible and irretrievable commitment of this resource would be negligible. The irreversible and irretrievable commitment of resources would not be the same for all nuclear power plants and would depend on the specific characteristics of the power plant (e.g., thorium fuel cycle, or other resource characteristic) and its resource needs.

4.2 Relationship between Short-Term Use of the Environment and Long-Term Productivity

NEPA Section 102(2)(C)(iv) (42 U.S.C. § 4332(C)(iv); TN4880) requires that an EIS include information about the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity.

Because the issuance of the ANR GEIS would not approve or license the construction and/or operation of any new reactor, this GEIS itself would not result in either short-term or long-term impacts. However, a project-specific SEIS tiering to this GEIS would consider the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity.

Nuclear power plant building, operating, and decommissioning would necessitate short-term use of the environment and commitments of resources. Certain resources (e.g., land and energy) will be committed indefinitely or permanently. Short-term use of the environment can affect long-term productivity of the ecosystem if that use alters the ability of the ecosystem to reestablish an equilibrium that is comparable to that of its original condition.

Air emissions from power plant operations would introduce small amounts of radiological and nonradiological constituents to the region around the plant site. Over time, these emissions could result in increased concentrations and exposure, but are not expected to affect air quality or radiation exposure to the extent that public health and long-term productivity of the environment would be impaired. Continued employment, expenditures, and tax revenues generated during power plant operations would directly benefit local, regional, and State economies during the short term. Local governments investing project-generated tax revenues into infrastructure and other required services could enhance economic productivity over the long term. The management and disposal of spent nuclear fuel, low-level waste, hazardous waste, and nonhazardous waste would require an increase in energy and would consume space at treatment, storage, or disposal facilities. Regardless of the location, the use of land to meet waste disposal needs would reduce the long-term productivity of the land. Power plant facilities would be committed to power production over the short term. After decommissioning these facilities and restoring the power plant site, the land would become available for other productive uses. The nature of the relationship between short-term use of the environment and long-term productivity would vary among plants and would depend on the specific characteristics of each plant and its interaction with the environment. This relationship is reactor-specific and would be analyzed in a project-specific SEIS.

4.3 No-Action Alternative Conclusion

Under the No-Action Alternative the NRC would not issue this GEIS. There are no environmental impacts associated with not issuing this GEIS. In this context, the No-Action Alternative would accomplish none of the benefits intended by this GEIS process, which would include (1) reducing the time and resources for the applicant's preparation of the ER, (2) reducing the time and resources for the NRC staff's preparation of the EIS, and (3) focusing the effort of applicant, NRC staff, and decision-makers on issues that involve a potential for significant environmental impacts.

Selection of the No-Action Alternative would likely lead to the same magnitude and level of environmental impacts associated with the licensing of ANRs; these impacts would be addressed in project-specific EISs rather than in supplemental analyses tiering to the ANR GEIS. Mitigation measures associated with these projects would be developed on a case-by-case basis rather than comprehensively, as in this GEIS, potentially leading to increased inconsistency and potential greater impacts.

4.4 Cost Benefit

Section 102(B) of NEPA requires that all Federal agencies "identify and develop methods and procedures, in consultation with the Council on Environmental Quality established by Title II of this Act, which will ensure that currently unquantified environmental amenities and values may be given appropriate consideration in decision-making along with economic and technical considerations" (42 U.S.C. § 4332(B); TN4880).

However, neither NEPA nor the government-wide NEPA-implementing regulations of the Council on Environmental Quality require the benefits and costs of a proposed action be quantified in dollars or any other common metric. The intent of this section is not to identify and quantify all of the potential societal benefits of the proposed activities and compare them to the potential costs of the proposed activities. Instead, this section focuses on only the benefits and costs of such magnitude or importance that their inclusion in this analysis can inform the decision-making process. This section summarizes the pertinent analytical conclusions reached in earlier chapters of this GEIS.

The proposed action of proceeding with this GEIS is expected to improve the efficiency of the environmental review process and avoid duplication of effort, compared to the No-Action Alternative of developing individual project-specific EISs for ANR applications. The issues identified as Category 1 in this GEIS have been analyzed and resolved generically; therefore, the resources needed for subsequent staff reviews of environmental issues in individual ANR applications would be reduced. In addition, by analyzing Category 1 issues generically, this GEIS would also enhance consistency across environmental reviews, thereby increasing efficiency and streamlining the environmental review process. Use of this GEIS would allow NRC staff and decision-makers to focus on issues that involve a potential for significant environmental impacts. Project-specific environmental reviews would be able to incorporate the ANR GEIS findings by reference, thereby streamlining the review processes.

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APPENDIX A

CONTRIBUTORS TO THE ENVIRONMENTAL IMPACT STATEMENT

APPENDIX A

CONTRIBUTORS TO THE ENVIRONMENTAL IMPACT STATEMENT

Members of the U.S. Nuclear Regulatory Commission prepared this Generic Environmental Impact Statement with assistance and support from Pacific Northwest National Laboratory and a commercial contractor. The table below identifies each contributor's name, affiliation, and function or expertise.

Name	Affiliation	Review Area/Expertise
U.S. Nuclear Regulatory Commission		
Jack Cushing[39]	Office of Nuclear Material Safety and Safeguards	Project Management, Historic and Cultural Resources, Cumulative Impacts
Laura Willingham	Office of Nuclear Material Safety and Safeguards	Project Management, Meteorology and Air Quality, Climate Change
Dan Barnhurst	Office of Nuclear Material Safety and Safeguards	Surface Water and Groundwater Resources, Project Management
Jennifer Davis	Office of Nuclear Material Safety and Safeguards	Historic and Cultural Resources
Peyton Doub	Office of Nuclear Material Safety and Safeguards	Land Use, Terrestrial Ecology, Aquatic Ecology, Visual Resources, Alternatives, Executive Summary
Dan Mussatti	Office of Nuclear Material Safety and Safeguards	Visual Resources, Noise, Socioeconomics, Environmental Justice, Need for Project
Donald Palmrose	Office of Nuclear Material Safety and Safeguards	Radiological Environment, Accidents, Radiological Waste Management, Fuel Cycle, Transportation of Fuel and Waste, Decommissioning, Continued Storage
Pacific Northwest National Laboratory[40]		
Bo Saulsbury		Project Management, Need for Project
Dave Goodman		Project Management, Land Use, Visual Resources, Noise, Alternatives Analysis, Cumulative Impacts
Terri Miley		Comment Response
Bruce McDowell		Air Quality
Rajiv Prasad		Surface Water Resources
Philip Meyer		Groundwater Resources
Jim Becker		Terrestrial Ecology
Stephanie Liss		Aquatic Ecology
Ann Miracle		Aquatic Ecology

[39] Retired from the U.S. Nuclear Regulatory Commission in May 2021.

[40] Pacific Northwest National Laboratory is managed for the U.S. Department of Energy by Battelle Memorial Institute.

Name	Affiliation	Review Area/Expertise
Ellen Kennedy		Historic and Cultural Resources
Dave Anderson		Socioeconomics, Environmental Justice
Kim Leigh		Nonradiological Environment
Caitlin Condon		Radiological Environment, Waste Management, Fuel Cycle, Decommissioning
Steve Maheras		Accidents, Transportation of Fuel and Waste, Continued Storage
AJK NEPA Tech		
Andrew Kugler		Project Management, Plant and Site Parameter Envelopes, Alternatives

APPENDIX B

OUTREACH

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APPENDIX B

OUTREACH

This appendix provides a description of outreach activities and the Federal, State, and Tribal agencies and groups that the U.S. Nuclear Regulatory Commission (NRC) contacted during the preparation of this *Generic Environmental Impact Statement for Advanced Nuclear Reactors* (ANR GEIS). The NRC did not identify any cooperating agencies for the environmental review or receive any formal requests for cooperating agency status. The NRC staff conducted extensive outreach during preparation of the draft ANR GEIS and rule.

B.1 Exploratory Process

On November 15, 2019, the NRC staff issued the following *Federal Register* Notices (FRN) (84 FR 62559-TN6470, 84 FR 67299-TN7085, and 84 FR 68194-TN7084) announcing an exploratory process and soliciting comments to determine the possibility of developing a GEIS for licensing advanced nuclear reactors. The exploratory process included two public meetings, a comprehensive public workshop attended by multiple stakeholders, and a site visit to the Idaho National Laboratory, a location that is being contemplated for advanced nuclear reactors (NRC 2019-TN7087, NRC 2019-TN7086, NRC 2020-TN7088).

B.2 Public Meetings and Webinars

On May 28, 2020 from 1:00 p.m. to 4:00 p.m. the NRC staff held a webinar with the public as part of the scoping process to gather information necessary to prepare an ANR GEIS for advanced nuclear reactors (85 FR 24040-TN6458).

B.3 Obtaining Comments

The staff collected comments from the public three ways during the public comment period associated with the initial scoping process, held from April 30, 2020 to June 30, 2020 (85 FR 24040-TN6458).

- **Federal Rulemaking website:** The public submitted comments to the NRC staff through the Federal Rulemaking website at https://www.regulations.gov using Docket ID NRC-2020-0101.
- **AdvancedReactors-GEIS Email:** The NRC staff used an email account, AdvancedReactors-GEIS@nrc.gov, to receive comments from the public during the initial scoping process for the ANR GEIS.
- **Mail:** The NRC staff requested that comments be sent by mail, if desired, to Office of Administration, Mail Stop TWFN-7-A60M, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

B.4 Distribution of the Scoping Summary Report

The NRC staff summarized the comments received during the scoping process and the staff's related responses in a report titled, *Environmental Impact Statement Scoping Process Summary*

Report: The Advanced Nuclear Reactor Generic Environmental Impact Statement Public Scoping Period (NRC 2020-TN6593). This scoping report was issued in September 2020.

B.5 NRC Website

Throughout the development of the ANR GEIS and the rulemaking process, the NRC maintained a webpage at: https://www.nrc.gov/reactors/new-reactors/advanced/details.html#advRxGEIS (NRC 2021-TN7099). The NRC regularly updated the website, which contained a description of the purpose of the ANR GEIS and rulemaking, the history of the ANR GEIS development and rulemaking, and the schedule for the ANR GEIS and rule. The website also provided an overview of key communications between the staff and Commission (SECY-20-0020 [NRC 2020-TN6493] and SRM-SECY-20-0020 [NRC 2020-TN6492]) and the public. In addition there is a website for the rulemaking effort associated with the ANR GEIS at https://www.nrc.gov/reading-rm/doc-collections/rulemaking-ruleforum/active/ruledetails.html?id=1139 (NRC 2021-TN7103). This website provides the public with rulemaking information such as the schedule, the NRC docket ID, and the rulemaking project manager information along with other information.

B.6 Advanced Reactor Stakeholder Meetings

On at least nine occasions, the NRC staff has taken part in the periodic Advanced Reactor Stakeholder Meetings to provide an overview of the ANR GEIS development and answer questions. All meetings were open to the public and associated slides may be found at https://www.nrc.gov/reactors/new-reactors/advanced/details.html#stakeholder (NRC 2021-TN7099).

B.7 Tribal Contact

The NRC staff contacted Federally recognized Tribes via a State and Tribal Correspondence letter regarding scoping for the ANR GEIS (NRC 2020-TN7095). The staff distributed the scoping summary report to Tribes via LYRIS distribution through the NRC Tribal liaison branch (NRC 2020-TN7094, NRC 2020-TN7093, NRC 2020-TN7092, NRC 2020-TN7091, NRC 2020-TN7090, NRC 2020-TN7089). Another State and Tribal Correspondence letter was sent to invite Tribes to attend the July 15, 2021 Advanced Reactors Stakeholder meeting (NRC 2021-TN7096).

B.8 Other Federal Agencies

On April 1, 2020, the NRC reached out to the Advisory Council on Historic Preservation and the U.S. Environmental Protection Agency via email to notify them of the NRC's intent to conduct a scoping process for the ANR GEIS and to inform the agencies that the NRC would issue a *Federal Register* Notice (NRC 2021-TN7097, NRC 2021-TN7098).

B.9 References

84 FR 62559. November 15, 2019. "Agency Action Regarding the Exploratory Process for the Development of an Advanced Nuclear Reactor Generic Environmental Impact Statement." *Federal Register*, Nuclear Regulatory Commission. TN6470.

84 FR 67299. December 9, 2019. "Agency Action Regarding the Exploratory Process for the Development of an Advanced Nuclear Reactor; Generic Environmental Impact Statement." *Federal Register*, Nuclear Regulatory Commission. TN7085.

84 FR 68194. December 13, 2019. "Agency Action Regarding the Exploratory Process for the Development of an Advanced Nuclear Reactor; Generic Environmental Impact Statement; Correction." *Federal Register*, Nuclear Regulatory Commission. TN7084.

85 FR 24040. April 30, 2020. "Notice To Conduct Scoping and Prepare an Advanced Nuclear Reactor Generic Environmental Impact Statement." *Federal Register*, Nuclear Regulatory Commission. TN6458.

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NRC (U.S. Nuclear Regulatory Commission). 2020. Email from L. Willingham to the Hopi Tribe, dated November 17, 2020, regarding "U.S. Nuclear Regulatory Commission - Advanced Reactor Generic Environmental Impact Statement Scoping Summary Report." Washington, D.C. ADAMS Accession No. ML21224A293. TN7091.

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NRC (U.S. Nuclear Regulatory Commission). 2020. Email from L. Willingham to the Navajo Nation, dated November 17, 2020, regarding "U.S. Nuclear Regulatory Commission - Advanced Reactor Generic Environmental Impact Statement Scoping Summary Report." Washington, D.C. ADAMS Accession No. ML21224A292. TN7092.

NRC (U.S. Nuclear Regulatory Commission). 2020. Email from L. Willingham to the San Manuel Band of Mission Indians, dated November 17, 2020, regarding "U.S. Nuclear Regulatory Commission - Advanced Reactor Generic Environmental Impact Statement Scoping Summary Report." Washington, D.C. ADAMS Accession No. ML21224A291. TN7093.

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NRC (U.S. Nuclear Regulatory Commission). 2020. Letter from L.Y. Cuadrado to All Agreement and Non-Agreement States, State Liaison Officers, and All Federally Recognized Indian Tribes, dated April 30,2020, regarding "Notification of the Intent to Conduct a Scoping Process and Prepare a Generic Environmental Impact Statement for Advanced Nuclear Reactors." Washington, D.C. ADAMS Accession No. ML20114E140. TN7095.

NRC (U.S. Nuclear Regulatory Commission). 2020. Memorandum from A.L. Vietti-Cook to M.M. Doane, dated September 21, 2020, regarding Staff Requirements - SECY-20-0020 - Results of Exploratory Process for Developing a Generic Environmental Impact Statement for the Construction and Operation of Advanced Nuclear Reactors." SRM-SECY-20-0020, Washington, D.C. ADAMS Accession No. ML20265A112. TN6492.

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NRC (U.S. Nuclear Regulatory Commission). 2021. "Advanced Reactors Details." Washington, D.C. ADAMS Accession No. ML21232A543. TN7099.

NRC (U.S. Nuclear Regulatory Commission). 2021. Email from NRC to ACHP, dated April 1, 2021. regarding "NRC Preparing an Advance Nuclear Reactor Generic Environmental Impact Statement (GEIS)." Washington, D.C. ADAMS Accession No. ML21219A001. TN7097.

NRC (U.S. Nuclear Regulatory Commission). 2021. Email from NRC to EPA, dated April 1, 2021. regarding "NRC Preparing an Advance Nuclear Reactor Generic Environmental Impact Statement (GEIS)." Washington, D.C. ADAMS Accession No. ML21218A186. TN7098.

NRC (U.S. Nuclear Regulatory Commission). 2021. Letter from M. Arribas-Colon to All Agreement States, Connecticut, Indiana, Non-Agreement States, State Liaison Officers, and Federally Recognized Indian Tribes, dated July 12, 2021, regarding "Opportunity to Observe the U.S. Nuclear Regulatory Commission Periodic Advanced Reactor Stakeholder Meeting (STC-21-044)." Washington, D.C. ADAMS Accession No. ML21190A285. TN7096.

NRC (U.S. Nuclear Regulatory Commission). 2021. "Planned Rulemaking Activities - Rule." Washington, D.C. ADAMS Accession No. ML21232A497. TN7103.

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APPENDIX C

CHRONOLOGY OF NRC STAFF ENVIRONMENTAL REVIEW CORRESPONDENCE RELATED TO THE ADVANCED NUCLEAR REACTOR GENERIC ENVIRONMENTAL IMPACT STATEMENT

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APPENDIX C

CHRONOLOGY OF NRC STAFF ENVIRONMENTAL REVIEW CORRESPONDENCE RELATED TO THE ADVANCED NUCLEAR REACTOR GENERIC ENVIRONMENTAL IMPACT STATEMENT

This appendix contains a chronological listing of correspondence between the U.S. Nuclear Regulatory Commission (NRC) staff and external parties as part of its development of the Advanced Nuclear Reactor Generic Environmental Impact Statement (ANR GEIS).

All documents, with the exception of those containing proprietary information, are available electronically in the NRC's Library, which is found on the Internet at the following Web address: http://www.nrc.gov/reading-rm.html. From this site, the public can gain access to the NRC's Agencywide Documents Access and Management System (ADAMS), which provides text and image files of the NRC's public documents. The ADAMS accession number for each document is included below. If you need assistance in accessing or searching in ADAMS, contact the Public Document Room staff at 1-800-397-4209.

October 31, 2019	Public Meeting Announcement: Meeting to Discuss the Environmental Information Needed to Develop a Generic Environmental Impact Statement for Advanced Nuclear Reactors (Accession No. ML19304B011).
November 15, 2019	*Federal Register* Notice Announcing an Exploratory Process and Soliciting Comments on a Possible ANR GEIS (84 FR 62559) (Accession No. ML19302G126).
December 9, 2019	*Federal Register* Notice Announcing an Exploratory Process and Soliciting Comments on a Possible ANR GEIS – Comment Extension (84 FR 67299) (Accession No. ML19331A106).
December 10, 2019	Meeting Summary of November 15 and 20, 2019 Public Meetings to Discuss Exploratory Process for Developing an ANR GEIS (Accession No. ML19337C862).
December 13, 2019	*Federal Register* Notice Announcing an Exploratory Process and Soliciting Comments on a Possible ANR GEIS – Comment Extension Correction (84 FR 68194) (Accession No. ML21258A342).
December 13, 2019	Public Meeting Announcement: Workshop to Discuss the Environmental Information needed to Develop a Generic Environmental Impact Statement for Advanced Nuclear Reactors (Accession No. ML19347A733).
January 8, 2020	Exploratory Workshop for Developing an Advanced Reactor GEIS (Accession No. ML20007E666).

February 28, 2020	SECY-20-0020, Results of Exploratory Process for Developing a GEIS for the Construction and Operation of Advanced Nuclear Reactors (Package Accession No. ML20052D175).
April 1, 2020	Scoping e-mail to NRC, from J. Eddins, Advisory Council on Historic Preservation, Regarding Preparation of a GEIS for Advanced Reactors (Accession No. ML21219A001).
April 1, 2020	Scoping e-mail to M. Roundtree, Environmental Protection Agency, from NRC, Regarding Preparation of an Advance Nuclear Reactor GEIS (Accession No. ML21218A186).
April 30, 2020	*Federal Register* Notice Providing Notice of Intent to Conduct Scoping and Prepare an ANR GEIS (85 FR 24040) (Accession No. ML20111A308).
April 30, 2020	Notification to All Agreement and Non-Agreement States, State Liaison Officers, and All Federally Recognized Indian Tribes, Regarding Notice of Intent to Conduct Scoping and Prepare an ANR GEIS (STC-20-036) (Accession No. ML20114E140).
April 30, 2020	Public Meeting Notice to Discuss the Scope of the GEIS for ANRs (Accession No. ML20148M245).
May 14, 2020	E-mail to NRC, from K. Jensen, The Yocha Dehe Wintun Nation, Regarding the Generic EIS for Small Scale ANR (Accession No. ML21220A000).
May 14, 2020	E-mail to L. Bill, The Yocha Dehe Wintun Nation, from NRC, Regarding Yocha Dehe Wintun Nation Notification Response (Accession No. ML21220A001).
May 27, 2020	E-mail to M. Bremer, The Pueblo de San Ildefonso Tribe, from NRC, Regarding the Generic EIS for ANR (Accession No. ML21220A003).
June 3, 2020	E-mail from A. McCleary, The San Manuel Band of Mission Indians, Regarding Attending the Scoping Meeting (Accession No. ML21223A341).
June 10, 2020	Letter to D. True, Nuclear Energy Institute, from NRC, Regarding the Nuclear Energy Institute's March 5, 2020 letter "Recommendations for Streamlining Environmental Reviews for Advanced Reactors" (Accession No. ML20147A540).
July 2, 2020	NRC Memorandum: Scoping Meeting Summary (Package Accession No. ML20161A339).
July 23, 2020	Letter to NRC, from Senators J. Barrasso, M. Braun, and M. Crapo, Regarding the ANR GEIS (Accession No. ML20206K923).

August 19, 2020	E-mail to D. Hunter, The Miami Tribe of Oklahoma, from NRC, Regarding Notification of Intent to Review and update the Generic EIS (Accession No. ML20233A558).
August 27, 2020	Letter to Senator J. Barrasso, from NRC, Regarding the Senator's July 23, 2020 letter on the ANR GEIS (Accession No. ML20225A074).
September 21, 2020	Staff Requirements Memorandum (SRM) 20-0020, Results of Exploratory Process for Developing a GEIS for the Construction and Operation of ANRs (Accession No. ML20265A112).
September 22, 2020	E-mail to Mr. Koyiyumptewa, The Hopi Tribe, from NRC, Regarding the Hopi Tribe Response to the NRC's April 30, 2020 letter (Accession No. ML21223A408).
September 25, 2020	ANR GEIS Scoping Summary Report (Package Accession No. ML20260H180).
November 17, 2020	Email to T. Martin, The Shoshone Bannock Tribe, from NRC, Regarding the ANR GEIS Scoping Summary Report (Accession No. ML21216A202).
November 17, 2020	E-mail to A. McCleary, The San Manuel Band of Mission Indians, transmitting the ANR GEIS Scoping Summary Report (Accession No. ML21224A291).
November 17, 2020	E-mail to Mr. Karr, Navajo Nation, Department of Justice, transmitting the ANR GEIS Scoping Summary Report (Accession No. ML21224A292).
November 17, 2020	E-mail to Mr. Koyiyumptewa, The Hopi Tribe, transmitting the ANR GEIS Scoping Summary Report (Accession No. ML21224A293).
November 17, 2020	E-mail to D. Hunter, The Miami Tribe of Oklahoma, transmitting the ANR GEIS Scoping Summary Report (Accession No. ML21224A296).
November 17, 2020	E-mail from Joan Olmstead, NRC, transmitting the Scoping summary report to Tribal and State Liaison Contacts (Accession No. ML21224A280).
November 17, 2020	Email from Danielle Aikins, Clarks Point Village Council, to Joan Olmstead, NRC, Auto Response: RE: Scoping Summary Report for the ANR GEIS (Accession No. ML21228A167).
November 17, 2020	Email from Cynthia Peterson, Yakutat Tlingit Tribe, to NRC, Joan Olmstead, Auto Response: RE: Scoping Summary Report for the ANR GEIS (Accession No. ML21228A163).
November 17, 2020	Email from Arthur Blazer, Mescalero Apache Tribe, to Joan Olmstead, NRC, Automatic Reply: Scoping Summary Report for the ANR GEIS (Accession No. ML21228A170).

November 17, 2020	Email from Jack Cushing, NRC, to Shaun Dinubilo, Squaxin Island Tribe, RE: Scoping Summary Report for the ANR GEIS (Accession No. ML21228A175).
November 17, 2020	Email from Jack Cushing, NRC, to Governor Talachy, Pueblo of Pojoaque Responding to Questions on the ANR GEIS (Accession No. ML21228A176).
November 17, 2020	Email from Arnold Cooper, Squaxin Island Tribe, to Joan Olmstead, NRC, Automatic Reply: Scoping Summary Report for the ANR GEIS (Accession No. ML21228A171).
November 20, 2020	Email from Joan Olmstead, NRC, to Laura Willingham et al., NRC, forwarding email from John Rodwan, Pine Creek Indian Reservation, RE: Scoping Summary Report for the ANR GEIS (Accession No. ML21228A177).
July 12, 2021	State and Tribal Correspondence Letter to All Agreement States, Connecticut, Indiana, Non-agreement States, State Liaison Officers, Federally Recognized Indian Tribes, from María Arribas-Colon, NRC, Subject: Opportunity to Observe the U.S. NRC Periodic Advanced Reactor Stakeholder Meeting (STC-21-044) (Accession No. ML21190A285).
August 31, 2021	Slides for the September 1, 2021 Department of Energy Nuclear Energy Tribal Working Group Meeting (Accession No. ML21253A250).

APPENDIX D

DISTRIBUTION LIST

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APPENDIX D

DISTRIBUTION LIST

The U.S. Nuclear Regulatory Commission (NRC) is providing copies of the Generic Environmental Impact Statement for Advanced Nuclear Reactors (ANR GEIS) to the organizations and individuals listed below. In addition, the NRC will issue a State and Tribal Correspondence letter to notify all Federally recognized Tribes and State liaison contacts. The NRC will also send the ANR GEIS to over 3,000 private citizens that provided scoping comments during the scoping period held for the ANR GEIS from April to June 2020. The NRC will provide copies to other interested organizations and individuals upon request.

Name	Affiliation	Review Area/Expertise
Federal Agencies		
John Eddins	Advisory Council on Historic Preservation	jeddins@achp.gov
Amy Klein	U.S. Army Corps of Engineers	Amy.S.Klein@usace.army.mil
Marthea Rountree	U.S. Environmental Protection Agency	Rountree.Marthea@epa.gov
Other Organizations and Individuals		
Bud Albright	U.S. Nuclear Industry Council	bud.albright@usnic.org
Peter Hastings	Kairos	hastings@kairospower.com
Edwin Lyman	Union of Concerned Scientist	ELyman@ucsusa.org
Nicholas McMurray	ClearPath	mcmurray@clearpath.org
Marcus Nichol	Nuclear Energy Institute	mrn@nei.org
Caleb Ward	U.S. Nuclear Industry Council	caleb.ward@usnic.org

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APPENDIX E

COMMENTS ON THE ANR GEIS

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APPENDIX E

COMMENTS ON THE ANR GEIS

E.1 Public Scoping

On April 30, 2020, the U.S. Nuclear Regulatory Commission (NRC) issued, for public comment, a Notice of Intent to prepare an advanced nuclear reactor (ANR) generic environmental impact statement (GEIS) and to conduct a scoping process to gather the information necessary to prepare such a GEIS for small-scale ANRs (85 FR 24040-TN6458). The NRC held a webinar on May 28, 2020, to receive comments from the public on the scope of this GEIS (NRC 2020-TN6459).

The NRC received a number of comments about the scope of this GEIS both during the May 28, 2020 webinar and throughout the scoping comment period. The NRC staff and its contractor reviewed the transcript from the webinar and all written materials received during the public comment period. All comments were considered. The NRC staff issued a summary of the scoping comments, and the staff's responses to those comments, on September 25, 2020 (NRC 2020-TN6593).

In accordance with 10 CFR 51.29(b) (TN250), this scoping summary report has been made publicly available at the NRC Public Document Room, located at One White Flint North, 11555 Rockville Pike, Rockville, Maryland 20852, or from the Agencywide Documents Access and Management System (ADAMS). The ADAMS Public Electronic Reading Room is accessible through the NRC's public website, www.nrc.gov. The Accession Number for the scoping summary report is ML20269A317.

E.2 Comments on the Draft GEIS

(Reserved for future use.)

E.3 References

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." TN250.

85 FR 24040. April 30, 2020. "Notice To Conduct Scoping and Prepare an Advanced Nuclear Reactor Generic Environmental Impact Statement." *Federal Register*, Nuclear Regulatory Commission. TN6458.

NRC (U.S. Nuclear Regulatory Commission). 2020. *Scoping Summary Report for the Advanced Nuclear Reactor Generic Environmental Impact Statement Public Scoping Period*. Washington, D.C. ADAMS Accession No. ML20269A317. TN6593.

NRC (U.S. Nuclear Regulatory Commission). 2020. *Summary of Public Scoping Meeting Conducted for the Advanced Reactor Generic Environmental Impact Statement, May 28, 2020*. Washington, D.C. ADAMS Package Accession No. ML20161A339. TN6459.

APPENDIX F

LAWS, REGULATIONS, AND OTHER AUTHORIZATIONS

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APPENDIX F

LAWS, REGULATIONS, AND OTHER AUTHORIZATIONS

F.1 Introduction

This appendix presents a brief discussion of Federal and State laws, regulations, and other requirements that may affect the application for and issuance of a license for an advanced nuclear reactor (ANR). The Federal and State laws, regulations, and other requirements listed herein are designed to protect the environment and address the following topics: land and water use, air quality, aquatic resources, terrestrial resources, radiological impacts, waste management, chemical impacts, and socioeconomic conditions. Title 10 of the *Code of Federal Regulations* (10 CFR) 51.45(d) (TN250), "Status of compliance," states:

> The environmental report shall list all Federal permits, licenses, approvals, and other entitlements which must be obtained in connection with the proposed action and shall describe the status of compliance with these requirements. The environmental report shall also include a discussion of the status of compliance with applicable environmental quality standards and requirements including, but not limited to, applicable zoning and land-use regulations, and thermal and other water pollution limitations or requirements which have been imposed by Federal, State, regional, and local agencies having responsibility for environmental protection. The discussion of alternatives in the report shall include a discussion of whether the alternatives will comply with such applicable environmental quality standards and requirements.

The U.S. Nuclear Regulatory Commission (NRC) uses compliance with other laws and regulations designed to protect the environment in the assessment of environmental impacts in its environmental impact statement (EIS).

This appendix is intended to provide a basic overview to assist the applicant in identifying environmental and natural resources laws that may affect the ANR licensing process. The descriptions of the laws, regulations, Executive Orders, and other directives are general in nature and are not intended to provide a comprehensive analysis or explanation of any of the items listed. In addition, the list itself is not intended to be comprehensive, and an applicant for an ANR license is reminded that a variety of additional Federal, State, or local requirements may apply to their application.

Section F.2 identifies Federal laws and regulations that may be applicable to the ANR licensing process. Section F.3 discusses relevant environmental Executive Orders, and Section F.4 identifies applicable NRC regulations. Section F.5 discusses State laws, regulations, and agreements, and Section F.6 discusses emergency management and response laws, regulations, and Executive Orders. Section F.7 discusses laws that contain requirements for consultation with agencies and federally recognized American Indian Nations.

F.2 Federal Laws and Regulations

The Federal laws and regulations that are identified and briefly discussed in this section are presented in alphabetical order.

American Indian Religious Freedom Act of 1978 (42 United States Code [U.S.C.] § 1996; TN5281) – The American Indian Religious Freedom Act protects Native Americans' rights of freedom to believe, express, and exercise traditional religions.

Antiquities Act of 1906, as amended (54 U.S.C. §§ 320301–320303 and 18 U.S.C. § 1866(b); TN6602) – The Antiquities Act protects historic and prehistoric ruins, monuments, and antiquities, including paleontological resources, on federally controlled lands from appropriation, excavation, injury, and destruction without permission.

Archeological and Historic Preservation Act of 1974, as amended (54 U.S.C. §§ 312501 *et seq.*; TN4844) – The Archeological and Historic Preservation Act establishes procedures for preserving historical and archaeological resources. Analysis of environmental compliance included assessing the energy alternatives for possible impacts on prehistoric, historic, and traditional cultural resources.

Archaeological Resources Protection Act of 1979, as amended (54 U.S.C. §§ 302101 *et seq.*; TN1687) – The Archaeological Resources Protection Act requires a permit for any excavation or removal of archaeological resources from Federal or American Indian lands. Excavations must be undertaken for the purpose of furthering archaeological knowledge in the public interest, and resources removed are to remain the property of the United States. Consent must be obtained from the American Indian Tribe or the Federal agency that has authority over the land, on which a resource is located, before issuance of a permit. The permit must contain terms and conditions requested by the Tribe or Federal agency.

Atomic Energy Act of 1954 (42 U.S.C. §§ 2011 *et seq.*; TN663) – The 1954 Atomic Energy Act (AEA), as amended, and the Energy Reorganization Act of 1974 (42 U.S.C. § 5801 *et seq.*; TN4466) gives the NRC the licensing and regulatory authority for nuclear energy uses within the commercial sector. It gives the NRC responsibility for licensing and regulating commercial uses of atomic energy and allows the NRC to establish dose and concentration limits for protection of workers and the public for activities under NRC jurisdiction. The NRC implements its responsibilities under the AEA through regulations set forth in 10 CFR.

Bald and Golden Eagle Protection Act of 1940, as amended (16 U.S.C. §§ 668–668d; TN1447) – The Bald and Golden Eagle Protection Act makes it unlawful to take, pursue, molest, or disturb bald and golden eagles, their nests, or their eggs anywhere in the United States. The U.S. Fish and Wildlife Service (FWS) may issue take permits to individuals, government agencies, or other organizations to authorize limited, non-purposeful disturbance of eagles, in the course of conducting lawful activities such as operating utilities or conducting scientific research.

Clean Air Act of 1970, as amended (42 U.S.C. §§ 7401 *et seq.;* TN1141) – The Clean Air Act (CAA) is intended to "protect and enhance the quality of the nation's air resources so as to promote the public health and welfare and the productive capacity of its population." The CAA establishes regulations to ensure maintenance of air quality standards and authorizes individual States to manage permits. Section 118 of the CAA requires each Federal agency, with jurisdiction over properties or facilities engaged in any activity that might result in the discharge of air pollutants, to comply with all Federal, State, interstate, and local requirements with regard to the control and abatement of air pollution. Section 109 of the CAA directs the U.S. Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards (NAAQSs) for criteria pollutants. The EPA has identified and set NAAQSs for the following criteria pollutants: particulate matter, sulfur dioxide, carbon monoxide, ozone, nitrogen dioxide, and lead. Section 111 of the CAA requires establishment of national performance standards for new or modified stationary sources of atmospheric pollutants. Section 160 of the CAA requires that specific emission increases must be evaluated prior to permit approval in order to prevent significant deterioration of air quality. Section 112 requires specific standards for release of hazardous air pollutants (including radionuclides). These standards are implemented through plans developed by each State and approved by the EPA. The CAA requires sources to meet standards and obtain permits to satisfy those standards. Nuclear power plants may be required to comply with the CAA Title V, Sections 501–507, for sources subject to new source performance standards or sources subject to National Emission Standards for Hazardous Air Pollutants. Emissions of air pollutants are regulated by the EPA in 40 CFR Parts 50 to 99 (TN5264).

Clean Water Act (33 U.S.C. §§ 1251 *et seq.*; TN662) – The Clean Water Act (CWA; formerly the Federal Water Pollution Control Act) was enacted to "restore and maintain the chemical, physical, and biological integrity of the Nation's water." The Act requires all branches of the Federal government, with jurisdiction over properties or facilities engaged in any activity that might result in a discharge or runoff of pollutants to surface waters, to comply with Federal, State, interstate, and local requirements.

As authorized by the CWA, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. The NPDES program requires that all facilities that discharge pollutants from any point source into waters of the United States obtain an NPDES permit. An NPDES permit is developed with two levels of controls: technology-based limits and water quality-based limits. NPDES permit terms may not exceed 5 years, and the applicant must reapply at least 180 days prior to the permit expiration date. A nuclear power plant may also participate in the NPDES General Permit for Industrial Stormwater due to stormwater runoff from industrial or commercial facilities to waters of the United States. The EPA is authorized under the CWA to directly implement the NPDES program; however, the EPA has authorized many States to implement all or parts of the national program. Section 401 of the CWA requires States to certify that the permitted discharge would comply with all limitations necessary to meet established State water quality standards, treatment standards, or schedule of compliance.

The U.S. Army Corps of Engineers (USACE) is the lead agency for enforcement of CWA wetland requirements (33 CFR Part 320-TN424). Under Section 401 of the CWA, the EPA or a delegated State agency has the authority to review and approve, condition, or deny all permits or licenses that might result in a discharge to waters of the State, including wetlands. CWA Section 401 [33 U.S.C. 1341(a)(1)] states: "No license or permit shall be granted until the certification required by this section has been obtained or has been waived as provided in the preceding sentence. No license or permit shall be granted if certification has been denied by the State, interstate agency, or the Administrator, as the case may be." Therefore, the NRC cannot issue its license without a 401 certification or an NRC determination that a waiver has occurred, in accordance with 40 CFR 121.9(c) (TN6718). In accordance with 10 CFR 50.54(aa) (TN249), conditions in the 401 Certification become a condition of the NRC's license.

A Section 404 permit would need to be obtained from the USACE before implementing any action, such as earthmoving activities and certain erosion controls, which could disturb wetlands. Federal and State permits/certifications are obtained using the same form and permit applications for activities affecting waterways, and wetlands are reviewed by the USACE in consultation with the FWS, the Soil Conservation Service, the EPA, and the delegated State agency.

Coastal Zone Management Act of 1972, as amended (16 U.S.C. §§ 1451 *et seq*.; TN1243) – Congress enacted the Coastal Zone Management Act in 1972 to address the increasing pressures of over-development upon the nation's coastal resources. The National Oceanic and Atmospheric Administration administers the Act. The Coastal Zone Management Act encourages States to preserve, protect, develop, and, where possible, restore or enhance valuable natural coastal resources such as wetlands, floodplains, estuaries, beaches, dunes, barrier islands, and coral reefs, as well as the fish and wildlife using those habitats. Participation by States is voluntary. To encourage States to participate, the Coastal Zone Management Act makes Federal financial assistance available to any coastal State or territory, including those on the Great Lakes, that are willing to develop and implement a comprehensive coastal management program.

Comprehensive Environmental Response, Compensation, and Liability Act as amended by the Superfund Amendments and Reauthorization Act (42 U.S.C. §§ 9601 *et seq.;* TN6592) – The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) includes an emergency response program to respond to a release of a hazardous substance to the environment. Releases of source, byproduct, or special nuclear material from a nuclear incident are excluded from CERCLA requirements if the releases are subject to the financial protection requirements of the AEA. CERCLA is intended to provide a response to, and cleanup of, environmental problems that are not covered adequately by the permit programs of the many other environmental laws, including the CAA; CWA; Safe Drinking Water Act (SDWA); Marine Protection, Research, and Sanctuaries Act (33 U.S.C. §§ 1401 *et seq.*; TN6637); Resource Conservation and Recovery Act (RCRA); and AEA. Under Section 120 of CERCLA, each department, agency, and instrumentality (e.g., a municipality) of the United States is subject to, and must comply with, CERCLA in the same manner as any nongovernmental entity (except for requirements for bonding, insurance, financial responsibility, or applicable time period). Under CERCLA, the EPA would have the authority to regulate hazardous substances at a facility in the event of a release or a "substantial threat of a release" of those materials. Releases greater than reportable quantities would be reported to the National Response Center. Assessment of alternatives for environmental compliance includes consideration of whether hazardous substances, in reportable quantity amounts, could be present at power plants during the license term.

Emergency Planning and Community Right-to-Know Act of 1986 (42 U.S.C. §§ 11001 *et seq*.; TN6603) (also known as "SARA Title III") – The Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA), which is the major amendment to CERCLA (42 U.S.C. § 9601; TN6592), establishes the requirements for Federal, State, and local governments, American Indian Tribes, and industry regarding emergency planning and "Community Right-to-Know" reporting on hazardous and toxic chemicals. The "Community Right-to-Know" provisions increase the public's knowledge and access to information about chemicals at individual facilities, their uses, and releases into the environment. States and communities working with facilities can use the information to improve chemical safety and protect public health and the environment. This Act requires emergency planning and notice to communities and government agencies concerning the presence and release of specific chemicals. The EPA implements this Act under regulations found in 40 CFR Part 355 (TN5493), Part 370 (TN6612), and Part 372 (TN6613).

Endangered Species Act of 1973 (16 U.S.C. § 1531–1544; TN1010) – The Endangered Species Act (ESA) was enacted to prevent the further decline of endangered and threatened species and to restore those species and their critical habitats. Section 7 of the Act requires

Federal agencies to consult with the FWS or the National Marine Fisheries Service (NMFS) for Federal actions that may affect listed species or designated critical habitats.

Environmental Standards for Uranium Fuel Cycle (40 CFR Part 190, Subpart B; TN739) – These regulations establish maximum doses to the body or organs of members of the public as a result of normal operational releases from uranium fuel cycle activities, including uranium enrichment. These regulations were promulgated by the EPA under the authority of the AEA, as amended, and have been incorporated by reference in the NRC regulations in 10 CFR 20.1301(e) (TN283).

Federal Insecticide, Fungicide, and Rodenticide Act, as amended (7 U.S.C. §§ 136 *et seq*.; TN4535) – The Federal Insecticide, Fungicide, and Rodenticide Act, as amended, by the Federal Environmental Pesticide Control Act and subsequent amendments, requires the registration of all new pesticides with the EPA before they are used in the United States. Manufacturers are required to develop toxicity data for their pesticide products. Toxicity data may be used to determine permissible discharge concentrations for an NPDES permit.

Fish and Wildlife Conservation Act of 1980 (16 U.S.C. §§ 2901 *et seq*.; TN6604) – The Fish and Wildlife Conservation Act provides Federal technical and financial assistance to States for the development of conservation plans and programs for nongame fish and wildlife. Fish and Wildlife Conservation Act conservation plans identify significant problems that may adversely affect nongame fish and wildlife species and their habitats and appropriate conservation actions to protect the identified species. The Act also encourages Federal agencies to conserve and promote the conservation of nongame fish and wildlife and their habitats.

Fish and Wildlife Coordination Act of 1934, as amended (16 U.S.C. §§ 661–666e; TN4467) – The Fish and Wildlife Coordination Act requires Federal agencies that construct, license, or permit water resource development projects to consult with the FWS (or NMFS, when applicable) and State wildlife resource agencies for any project that involves an impoundment of more than 10 ac (4 ha), diversion, channel deepening, or other waterbody modification regarding the impacts of that action to fish and wildlife and any mitigative measures to reduce adverse impacts.

Fixing America's Surface Transportation Act (42 U.S.C. §§ 4370m *et seq*.; TN6392) – Title 41 of the Fixing America's Surface Transportation Act (FAST-41) established new coordination and oversight procedures for infrastructure projects being reviewed by Federal agencies. FAST-41 is intended to accomplish the following:

- Increase predictability
  - through the publication of project-specific permitting timetables and
  - clear processes to modify permitting timetables and resolve issues.
- Increase transparency and accountability over the
  - Federal environmental review and
  - authorization process.
- Improve early coordination of agencies' schedules and synchronization of environmental reviews and authorizations.

FAST-41 established the Federal Permitting Improvement Steering Council, which is composed of agency representatives from various Federal agencies.

To be eligible for FAST-41, a proposal must meet the definition of a "covered project" under the statute. A covered project is one that: (1) is subject to the National Environmental Policy Act (NEPA); (2) is likely to require a total investment of more than $200,000,000; and (3) does not qualify for abbreviated authorization or environmental review processes under any applicable law. A covered project can also be one that is subject to NEPA and is of the size and complexity which, in the opinion of Federal Permitting Improvement Steering Council, make the project likely to benefit from enhanced oversight and coordination, including a project likely to require (1) authorization from or environmental review involving more than two Federal agencies; or (2) the preparation of an EIS under NEPA."

Hazardous Materials Transportation Act, as amended (49 U.S.C. §§ 5101 *et seq.*; TN6605) – The Hazardous Materials Transportation Act regulates the transportation of hazardous material (including radioactive material) in and between States. According to the Act, States may regulate the transport of hazardous material as long as their regulation is consistent with the Act or the U.S. Department of Transportation regulations provided in 49 CFR Parts 171 through 177 (TN5466). Other regulations regarding packaging for transportation of radionuclides are contained in 49 CFR Part 173, Subpart I (TN298).

Low-Level Radioactive Waste Policy Act of 1980, as amended (42 U.S.C. §§ 2021b *et seq.*; TN6606) – The Low-Level Radioactive Waste Policy Act amended the AEA to improve the procedures for the implementation of compacts providing for the establishment and operation of regional low-level radioactive waste disposal facilities. It also allows for Congress to grant consent for certain interstate compacts. The amended Act sets forth the responsibilities for disposal of low-level waste by States or interstate compacts. The Act states the amount of waste that certain low-level waste recipients can receive over a set time period. The amount of low-level radioactive waste generated from both pressurized and boiling water reactor types is allocated over a transition period until a local waste facility is operational.

Magnuson-Stevens Fishery Conservation and Management Act, as amended (16 U.S.C. §§ 1801–1884; TN1061) – The Magnuson-Stevens Fishery Conservation and Management Act governs marine fisheries management in U.S. Federal waters. The Act created eight regional fishery management councils and includes measures to rebuild overfished fisheries, protect essential fish habitat, and reduce bycatch. Under Section 305 of the Act, Federal agencies are required to consult with NMFS for any Federal actions that may adversely affect essential fish habitat.

Marine Mammal Protection Act of 1972 (16 U.S.C. §§ 1361 *et seq.;* TN4478) – The Marine Mammal Protection Act (MMPA) was enacted to protect and manage marine mammals and their products (e.g., the use of hides and meat). The primary authority for implementing the Act belongs to the FWS and NMFS. The FWS manages walruses, polar bears, sea otters, dugongs, marine otters, and the West Indian, Amazonian, and West African manatees. The NMFS manages whales, porpoises, seals, and sea lions. The two agencies may issue permits under MMPA Section 104 (16 U.S.C. § 1374) to persons, including Federal agencies, that authorize the taking or importing of specific species of marine mammals.

After the Secretary of the Interior or the Secretary of Commerce approves a State's program, the State can take over responsibility for managing one or more marine mammals. The MMPA also established a Marine Mammal Commission whose duties include reviewing laws and international conventions related to marine mammals, studying the condition of these mammals, and recommending steps to Federal officials (e.g., listing a species as endangered) that should be taken to protect marine mammals. Federal agencies are directed by MMPA Section 205

(16 U.S.C. § 1405) to cooperate with the Commission by permitting it to use their facilities or services.

Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§ 703 *et seq*.; TN3331) – The Migratory Bird Treaty Act is intended to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia. The Act stipulates that, except as permitted by regulations, it is unlawful at any time, by any means, or in any manner to pursue, hunt, take, capture, or kill any migratory bird.

National Environmental Policy Act of 1969, as amended (42 U.S.C. §§ 4321 *et seq*.; TN661) – NEPA requires Federal agencies to integrate environmental values into their decision-making process by considering the environmental impacts of proposed Federal actions and reasonable alternatives to those actions. NEPA establishes policy, sets goals (in Section 101), and provides means (in Section 102) for carrying out the policy. Section 102(2) contains action-forcing provisions to ensure that Federal agencies follow the letter and spirit of the Act. For major Federal actions that significantly affect the quality of the human environment, Section 102(2)(C) of NEPA requires Federal agencies to prepare a detailed statement that includes the environmental impacts of the proposed action and other specified information. This generic environmental impact statement (GEIS) has been prepared in accordance with NEPA requirements and NRC regulations (10 CFR Part 51-TN250) for implementing NEPA to ensure compliance with Section 102(2).

National Historic Preservation Act of 1966, as amended (54 U.S.C. §§ 300101 *et seq*.; TN4157) – The National Historic Preservation Act (NHPA) was enacted to create a national historic preservation program, including the National Register of Historic Places and the Advisory Council on Historic Preservation. Section 106 of the Act requires Federal agencies to take into account the effects of their undertakings on historic properties. The Advisory Council on Historic Preservation regulations implementing Section 106 of the Act are found in 36 CFR Part 800 (TN513). The regulations call for public involvement in the Section 106 consultation process, including American Indian Tribes and other interested members of the public, as applicable.

Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. § 3001; TN1686) – The Native American Graves Protection and Repatriation Act establishes provisions for the treatment of inadvertent discoveries of American Indian remains and cultural objects. When discoveries are made during ground-disturbing activities, the activity in the area must immediately stop, and reasonable protective efforts, proper notifications, and appropriate disposition of the discovered items must be pursued.

Noise Control Act of 1972 (42 U.S.C. §§ 4901 *et seq.;* TN4294) – The Noise Control Act delegates the responsibility of noise control to State and local governments. Commercial facilities are required to comply with Federal, State, interstate, and local requirements regarding noise control. Section 4 of the Noise Control Act directs Federal agencies to carry out programs in their jurisdictions "to the fullest extent within their authority" and in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health and welfare.

Nuclear Energy Innovation and Modernization Act of 2019 (NEIMA, Public Law 115-439; TN6469) – NEIMA's purpose is to establish transparency and accountability measures on the NRC's budget and fee recovery programs as well as to require the Commission to develop the regulatory framework necessary to enable the licensing of ANRs. The Act enables the licensing of ANRs by, among other things, requiring the Commission to develop and implement risk-informed, performance-based licensing policies and guidance. The Act also defines the term "advanced nuclear reactor." The Act authorizes appropriations sums necessary for the Commission to carry out the requirements of Section 103 of NEIMA.

Nuclear Regulatory Commission License Termination Rule (10 CFR Part 20, Subpart E; TN283) – The AEA assigns NRC the responsibility for licensing and regulating commercial uses of atomic energy. When a licensed facility has completed its mission, the facility must meet standards for cleanup in order to terminate its license. The License Termination Rule establishes that the NRC will consider a site acceptable for unrestricted use if (1) the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent to an average member of the critical group that does not exceed 25 mrem per year, including that from groundwater sources of drinking water, and (2) the residual radioactivity has been reduced to levels that are as low as reasonably achievable. The critical group is the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances.

The License Termination Rule also provides for land-use restrictions or other types of institutional controls to allow for the termination of NRC licenses and the release of sites under restricted conditions if decommissioning criteria for unrestricted use cannot be met. Plus, the License Termination Rule establishes alternate criteria for license termination if the licensee provides assurance that public health and safety would continue to be protected, and that it is unlikely that the dose from all manufactured sources combined, other than medical, would be more than 100 mrem per year.

Nuclear Waste Policy Act of 1982 (42 U.S.C. §§ 10101 *et seq.*; TN740) – The Nuclear Waste Policy Act provides for the research and development of repositories for the disposal of high-level radioactive waste, spent nuclear fuel, and low-level radioactive waste. Title I includes the provisions for the disposal and storage of high-level radioactive waste and spent nuclear fuel. Subtitle A of Title I delineates the requirements for site characterization and construction of the repository and the participation of States and other local governments in the selection process. Subtitles B, C, and D of Title I deal with the specific issues for interim storage, monitored retrievable storage, and low-level radioactive waste.

Occupational Safety and Health Act of 1970 (29 U.S.C. §§ 651 *et seq.*; TN4453) – The Occupational Safety and Health Act establishes standards to enhance safe and healthy working conditions in places of employment throughout the United States. The Act is administered and enforced by the Occupational Safety and Health Administration (OSHA), a U.S. Department of Labor agency. Employers who fail to comply with OSHA standards can be penalized by the Federal government. The Act allows States to develop and enforce OSHA standards if such programs have been approved by the Secretary of Labor.

Pollution Prevention Act of 1990 (42 U.S.C. §§ 13101 *et seq.*; TN6607) – The Pollution Prevention Act establishes a national policy for waste management and pollution control that focuses first on source reduction, then on environmental issues, safe recycling, treatment, and disposal.

Resource Conservation and Recovery Act as amended by the Hazardous and Solid Waste Amendments (42 U.S.C. §§ 6901 *et seq.*; TN1281) – The RCRA requires the EPA to define and identify hazardous waste; establish standards for its transportation, treatment, storage, and disposal; and require permits for persons engaged in hazardous waste activities. Section 3006 (42 U.S.C. § 6926) allows States to establish and administer these permit programs with EPA approval. EPA regulations implementing the RCRA are found in 40 CFR Parts 239 through 283 (TN6618). Regulations imposed on a generator or on a treatment, storage, and/or disposal facility vary according to the type and quantity of material or waste generated, treated, stored, and/or disposed. The method of treatment, storage, and/or disposal also affects the extent and complexity of the requirements.

Rivers and Harbors Act of 1899, Section 10 (33 U.S.C. § 403) – The Rivers and Harbors Act of 1899 (33 U.S.C. §§ 401 *et seq.*) requires USACE authorization in order to protect navigable waters in the development of harbors and other construction and excavation. Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. § 403) prohibits the unauthorized obstruction or alteration of any navigable water of the United States. That section provides that the construction of any structure in or over any navigable water of the United States, or the accomplishment of any other work affecting the course, location, condition, or physical capacity of such waters is unlawful unless the work has been authorized by the Secretary of the Army through the USACE. Activities requiring Section 10 permits include structures (e.g., piers, wharfs, breakwaters, bulkheads, jetties, weirs, transmission lines) and work such as dredging or disposal of dredged material, or excavation, filling, or other modifications to the navigable waters of the United States.

Safe Drinking Water Act of 1974 (42 U.S.C. §§ 300(f) *et seq.*; TN1337) – The SDWA was enacted to protect the quality of public water supplies and sources of drinking water and establishes minimum national standards for public water supply systems in the form of maximum contaminant levels for pollutants, including radionuclides. Other programs established by the SDWA include the Sole Source Aquifer Program, the Wellhead Protection Program, and the Underground Injection Control Program. In addition, the Act provides underground sources of drinking water with protection from contaminated releases and spills.

If a nuclear power plant is located within an area designated as being a Sole Source Aquifer pursuant to Section 1424(e) of the SDWA, the supplemental EIS would be subject to EPA review. If the EPA review raises concerns that plant operations are not protective of groundwater quality, specific mitigation recommendations or additional pollution prevention requirements may be required.

Toxic Substances Control Act (15 U.S.C. §§ 2601 *et seq.*; TN4454) – The Toxic Substances Control Act (TSCA) regulates the manufacture, processing, distribution, and use of certain chemicals not regulated by RCRA or other statutes, including asbestos-containing material and polychlorinated biphenyls. Any TSCA-regulated waste removed from structures (e.g., polychlorinated biphenyls-contaminated capacitors or asbestos) or discovered during the implementation phase (e.g., contaminated media) would be managed in compliance with TSCA requirements in 40 CFR Part 761 (TN6610).

F.3 Environmental Executive Orders

Executive Orders establish policies and requirements for Federal agencies. Executive Orders do not have the force of law or regulation. Generally, Executive Orders are applicable to most Federal agencies, although they may or may not be binding upon independent regulatory agencies such as the NRC.

Executive Order 11514, *Protection and Enhancement of Environmental Quality* (35 FR 4247-TN6608) – This Order (regulated by 40 CFR Parts 1500 through 1508; TN6611) requires Federal agencies to continually monitor and control their activities to (1) protect and enhance the quality of the environment, and (2) develop procedures to ensure the fullest practicable provision of timely public information and understanding of the Federal plans and programs that may have potential environmental impacts so that the views of interested parties can be obtained.

Executive Order 11593, *Protection and Enhancement of the Cultural Environment* (36 FR 8921-TN6609) – This Order directs Federal agencies to locate, inventory, and nominate qualified properties under their jurisdiction or control to the National Register of Historic Places.

Executive Order 11988, *Floodplain Management* (42 FR 26951-TN270) – This Order requires Federal agencies to avoid direct or indirect support of floodplain development whenever there is a practicable alternative. A Federal agency is required to evaluate the potential effects of any actions it may take in a floodplain. Federal agencies are also required to encourage and provide appropriate guidance to applicants to evaluate the effects of their proposals on floodplains prior to submitting applications for Federal licenses, permits, loans, or grants.

Executive Order 11990, *Protection of Wetlands* (42 FR 26961-TN269) – This Order requires Federal agencies to avoid any short- or long-term adverse impacts on wetlands, whenever there is a practicable alternative and to provide opportunity for early public review of any plans or proposals for new construction in wetlands. Federal agencies are required to evaluate the potential effects of any actions they may take on wetlands when carrying out their responsibilities (e.g., planning, regulating, and licensing activities). However, this Executive Order does not apply to the issuance by Federal agencies of permits, licenses, or allocations to private parties for activities involving wetlands on non-Federal property.

Executive Order 12088, *Federal Compliance with Pollution Control Standards* (43 FR 47707-TN6623), as amended by Executive Order 12580, *Superfund Implementation* (52 FR 2923-TN6624) – This Order directs Federal agencies to comply with applicable administrative and procedural pollution controls standards established by, but not limited to, the CAA, the Noise Control Act, the CWA, the SDWA, the TSCA, and the RCRA.

Executive Order 12148, *Federal Emergency Management* (44 FR 43239-TN6614) – This Order transfers functions and responsibilities associated with Federal emergency management to the Director of the Federal Emergency Management Agency. The Order assigns the Director the responsibility to establish Federal policies for, and to coordinate all civil defense and civil emergency planning, management, mitigation, and assistance functions of, Executive agencies.

Executive Order 12580, *Superfund Implementation* (52 FR 2923-TN6624), as amended by Executive Order 13308 (68 FR 37691-TN6625) – This Order delegates to the heads of Executive Departments and agencies the responsibility of undertaking remedial actions for releases or threatened releases that are not on the National Priorities List, and removal actions, other than emergencies, where the release is from any facility under the jurisdiction or control of Executive Departments and agencies.

Executive Order 12656, *Assignment of Emergency Preparedness Responsibilities* (53 FR 47491-TN6626) – This Order assigns emergency preparedness responsibilities to Federal departments and agencies.

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (59 FR 7629-TN1450) – This Order calls for Federal agencies to address environmental justice in minority populations and low-income populations, and directs Federal agencies to identify and address, as appropriate, disproportionately high and adverse health or environmental effects of their programs, policies, and activities on minority and low-income populations. In response to this Executive Order, the NRC has issued a final policy statement on the "Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions" (69 FR 52040-TN1009) and environmental justice procedures to be followed in NEPA documents.

Executive Order 13007, *Indian Sacred Sites* (61 FR 26771-TN6629) – This Order directs Federal agencies, to the extent permitted by law and not inconsistent with agency missions, to avoid adverse effects on sacred sites and to provide access to those sites to Native Americans for religious practices. The Order directs agencies to plan projects and provide protection of and access to sacred sites to the extent compatible with the project.

Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks* (62 FR 19885-TN6630), as amended by Executive Order 13229 (66 FR 52013-TN6631), as amended by Executive Order 13296 (68 FR 19931-TN6632) – This Order requires Federal Executive branch agencies to make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children and to ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health or safety risks.

Executive Order 13112, *Invasive Species* (64 FR 6183-TN4477) – This Order directs Federal agencies to act to prevent the introduction of or to monitor and control, invasive (non-native) species, to provide for restoration of native species, to conduct research, to promote educational activities, and to exercise care in taking actions that could promote the introduction or spread of invasive species. During the implementation phase, rehabilitation of disturbed areas would be accomplished by reseeding or revegetating areas with native plants and trees.

Executive Order 13123, *Greening the Government through Efficient Energy Management* (64 FR 30851-TN6634) – This Order sets goals for agencies to reduce greenhouse gas emissions from facility energy use, reduce energy consumption per gross square foot of facilities, reduce energy consumption per gross square foot or unit of production, expand use of renewable energy, reduce the use of petroleum within facilities, reduce source energy use, and reduce water consumption and associated energy use.

Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments* (65 FR 67249-TN4846) – This Order directs Federal agencies to establish regular and meaningful consultation and collaboration with tribal governments in the development of Federal policies that have tribal implications, to strengthen U.S. government-to-government relationships with American Indian Tribes, and to reduce the imposition of unfunded mandates on tribal governments. On January 9, 2017, the NRC published its Tribal Policy Statement, which describes best practices and principles in conducting the agency's government-to-government interactions with American Indian and Alaska Native tribes (82 FR 2402-TN5500).

Executive Order 13990, *Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis* (86 FR 7037-TN7028) – This Order lays out a broad policy related to science, public health, environmental protection, environmental justice, and associated job creation. The Order directs Federal agency heads to "immediately" review actions taken during the Trump Administration “that are or may be inconsistent with, or present obstacles to,” this policy and to develop and submit to certain Administration officials lists of planned agency actions to rectify the identified issues. The Order also establishes an Interagency Working Group on the Social Cost of Greenhouse Gases and revokes or temporarily suspends a number of prior Orders and other White House issuances related to environmental, infrastructure, and energy issues that were issued by President Trump.

Executive Order 14008, *Tackling the Climate Crisis at Home and Abroad* (86 FR 7619-TN7027) – This Order addresses a number of areas related to climate change, including making climate change issues central to U.S. foreign policy and national security and pursuing various government-wide domestic initiatives. The aspects of the Order with the most direct applicability to the NRC are the provisions addressing the sustainability and climate-related resilience of a Federal agency’s own operations. For example, the NRC will submit a draft action plan describing steps the agency can take with regard to its facilities and operations to bolster adaptation and increase resilience to the impacts of climate change and will also release publicly progress reports as updates on the agency’s implementation efforts.

F.4 U.S. Nuclear Regulatory Commission Regulations and Guidance

The AEA, as amended, allows the NRC to issue licenses for commercial power reactors to operate up to 40 years. This license is based on adherence of the licensee to the NRC’s regulations that are set forth in Chapter 1 of Title 10 of the CFR.

The ANR license process includes two reviews: an environmental review and a safety review. The reviews are based on the regulations published in 10 CFR Part 51 (TN250) for the environmental review and 10 CFR Part 50 (TN249) or Part 52 (TN251) for the safety review. These regulations prescribe the format and content of license applications, as well as the methods and criteria used by NRC staff in evaluating these applications.

Future environmental reviews will rely upon the following regulations and guidance:

- *Code of Federal Regulations* – The scope of the environmental review is based on the regulations provided in 10 CFR Part 51 (TN250), “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions.”
- *Preparation of Environmental Reports for Nuclear Power Stations* (Regulatory Guide 4.2; NRC 2022-TN7081) – This document outlines the format and content to be used by the applicant to discuss the environmental aspects of its license application. It also defines the information and analyses the applicant must include in its Environmental Report submitted as part of the application.
- *Standard Review Plan for Environmental Reviews for Nuclear Power Plants* (NUREG-1555) – This document provides guidance to the staff in implementing provisions of 10 CFR Part 51 (TN250), “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions,” related to new site/plant applications.
- “Interim Staff Guidance Environmental Considerations Associated with Micro-reactors” (COL-ISG-029; NRC 2020-TN6710) – This document provides supplemental guidance to assist the NRC staff in determining the scope and scale of environmental reviews of microreactor applications.

- *Generic Environmental Impact Statement for Advanced Nuclear Reactors (GEIS)* (NUREG-2249; NRC 2021-TN7080) – This document discusses the environmental impacts from ANR licensing that are common to all or most nuclear power facilities. The ANR GEIS allows the applicant and the NRC to focus on environmental issues specific to each site seeking a renewed operating license. The staff's review results in a project-specific supplement to the ANR GEIS for each plant site.

F.5 State Laws, Regulations, and Other Requirements

The AEA authorizes States to establish programs to assume NRC regulatory authority for certain activities (the NRC's Agreement State Program). The New York State Department of Labor and Department of Environmental Conservation, for example, have established requirements under this Agreement State Program. New York State Department of Labor has jurisdiction in New York over commercial and industrial uses of radioactive material. Under the New York Agreement State Program, New York State Department of Labor and Department of Environmental Conservation has jurisdiction over discharges of radioactive material to the environment, including releases to the air and water, and the disposal of radioactive wastes in the ground. In addition, States have enacted their own laws to protect public health and safety, and the environment. State laws may supplement or implement various Federal laws for protection of air, water quality, and groundwater. State laws may also address solid waste management programs, locally rare or endangered species, and historic and cultural resources.

In addition, the CWA allows for primary enforcement and administration through State agencies, provided the State program (1) is at least as stringent as the Federal program and (2) conforms to the CWA. The primary CWA mechanism for controlling water pollution is the requirement that direct dischargers obtain an NPDES permit or, in the case of States in which the authority has been delegated from the EPA, a State permit.

One important difference between Federal regulations and certain State regulations is the definition of "waters" regulated by the State. Certain State regulations may include underground waters, while the CWA only regulates the navigable waters of the United States. For example, a State permit is required under New York State law for all discharges to both surface waters and groundwater.

F.6 State Environmental Requirements

Certain environmental requirements, including some discussed earlier, may have been delegated to State authorities for implementation, enforcement, or oversight. Table F-1 provides a list of representative State environmental requirements that may affect ANR applications for nuclear power plants.

Table F-1 State Environmental Requirements

Law/Regulation	Requirements
Air Quality Protection	
Title V Permit Rules	Establishes the policies and procedures by which a State will administer the Title V permit program under the CAA. Requires Title V sources to apply for and obtain a Title V permit prior to operation of the source facility.
Permits to Install New Sources of Pollution	Requires a permit prior to the installation of a new source of air pollutants or the modification of an air contaminant source. Discusses exemptions and conditions under which approval will be granted. Also requires an impact analysis to determine if the air contaminant source will cause or contribute to violations of the NAAQSs.
Air Permits to Operate and Variances	Requires a permit prior to the operation or use of any air contaminant source in violation of any applicable air pollution control law, unless a variance has been applied for and obtained from the State agency.
Accidental Release Prevention Program	Requires the owner or operator of a stationary source, that has more than a Threshold Quantity of a regulated substance, to comply with all the provisions of the rule, including creating a hazard assessment, risk management plan, a prevention program, and an emergency response program.
General Conformity Rules	Rules on "general conformity" are mandated by the CAA to ensure that Federal actions do not contribute to air quality violations within the State. Discusses which Federal actions are subject to the conformity requirements, the procedures for conformity analysis, public participation/consultation, and the final conformity determination.
Water Resources Protection	
National Pollutant Discharge Elimination System Permits	Requires a permit prior to the discharge of pollutants from any point source into waters of the United States. Each permit holder must comply with authorized discharge levels, monitoring requirements, and other appropriate requirements in the permit.
Permits to Install New Sources of Pollution	Requires a permit prior to the installation of a new source of water pollutants or the modification of any pollutant discharge source.
Water Quality Standards	Establishes water quality standards for surface waters in the State, including beneficial use designations, numeric water quality criteria, and the anti-degradation waterbody classification system. Water quality standards are enforced through the NPDES permit.
Section 401 Water Quality Certifications	Requires a Section 401 water quality certification and payment of applicable fees before the issuance of any Federal permit or license to conduct any activity that may result in discharges to waters of the State.
Public Water Systems Licenses to Operate	Requires a public water system license prior to operating or maintaining a public water system.
Design, Construction, Installation, and Upgrading for Underground Storage Tank Systems	Establishes performance standards and upgrading requirements for underground storage tanks containing petroleum (e.g., diesel fuel) or other regulated substances. Requires an installation or upgrading permit for each location where such installation or upgrading is to occur prior to beginning either an installation or upgrading of a tank or piping comprising an underground storage tank system.

Table F-1 (contd)

Law/Regulation	Requirements
Registration of Underground Storage Tank System	Establishes annual registration requirements for underground storage tanks containing petroleum or other regulated substances.
Flammable and Combustible Liquids	Requires a permit to install, remove, repair, or alter a stationary tank for the storage of flammable or combustible liquids or modify or replace any line or dispensing device.
Waste Management and Pollution Prevention	
Generator Standards	Requires any person who generates waste to determine if that waste is hazardous. Requires a generator identification number from the EPA or State agency prior to treatment, storage, disposal, transport, or offer for transport of hazardous waste.
Licensing Requirements for Solid Waste, Construction, and Demolition Debris Facilities	Requires an annual license for any municipal solid waste landfill, industrial solid waste landfill, residual solid waste landfill, compost facility, transfer facility, infectious waste treatment facility, or solid waste incineration facility prior to operation. New facilities must obtain a permit to install, prior to construction. Also, requires a license to establish, modify, operate, or maintain a construction and demolition debris facility.
Radiation Generator and Broker Reporting Requirements	Requires completion of a low-level radioactive waste generator report within 60 days of beginning to generate low-level waste. Also requires each generator to submit an annual report about the state of low-level waste activities in their facility and pay applicable fees.
Hazardous Waste Management System Permits	Requires operation permits for any new or existing hazardous waste facility.
Emergency Planning and Response	
Hazardous Chemical Reporting	Requires the submission of Safety Data Sheets (previously referred to as Material Safety Data Sheets)[(a)] and an annual Emergency and Hazardous Chemical Inventory to local emergency response officials for any hazardous chemicals that are produced, used, or stored at the facility in an amount that equals or exceeds the Threshold Quantity.
Emergency Planning Requirements of Subject Facilities	Requires any facility that has an extremely hazardous substance present in an amount equal to, or exceeding the Threshold Planning Quantity, to notify the emergency response commission and the local emergency planning committee within 60 days after onsite storage begins. Also requires the designation of a facility representative who will participate in the local emergency planning process as a facility emergency coordinator.
Toxic Chemical Release Reporting	Establishes reporting requirements and a schedule for each toxic chemical known to be manufactured (including imported), processed, or otherwise used in excess of an applicable Threshold Quantity. Applies only to facilities of a certain classification.
Biotic Resources Protection	
State Endangered Plant Species Protection	Establishes criteria for identifying threatened or endangered species of native plants and prohibits injuring or removing endangered species without permission.

Table F-1 (contd)

Law/Regulation	Requirements
State Endangered Fish and Wildlife Species Protection	Establishes and requires periodic updates to a State list of endangered fish and wildlife species.
Permits for Impacts on Isolated Wetlands	Requires a general or individual isolated wetland permit prior to engaging in an activity that involves the filling of an isolated wetland.
Cultural Resources Protection	
State Registry of Archaeological Landmarks	Establishes a State registry of archaeological landmarks. Prohibits any person from excavating or destroying such land, or from removing skeletal remains or artifacts from any land, placed on the registry without first notifying the State Historic Preservation Office.
Survey and Salvage; Discoveries; Preservation	Directs State departments, agencies, and political subdivisions to cooperate in the preservation of archaeological and historic sites and the recovery of scientific information from such sites. Also, requires State agencies and contractors performing work on public improvements to cooperate with archaeological and historic survey and salvage efforts and to notify the State historic preservation office about archaeological discoveries.

(a) In 2012, the Hazard Communication Standard (29 CFR 1910.1200(g) [TN654]) was revised to require Safety Data Sheets replace Material Safety Data Sheets.

F.7 Operating Permits and Other Requirements

Several operating permit applications may be prepared and submitted, and regulatory approval and/or permits would be received, prior to license approval by the NRC. Table F-2 lists representative Federal, State, and local permits.

Table F-2 Federal, State, and Local Permits and Other Requirements

License, Permit, or Other Required Approval	Responsible Agency	Authority	Relevance and Status
Air Quality Protection			
Title V Operating Permit: Required for sources that are not exempt and are major sources, affected sources subject to the Acid Rain Program, sources subject to new source performance standards, or sources subject to National Emission Standards for Hazardous Air Pollutants.	EPA or State agency	CAA, Title V, Sections 501–507 (U.S.C., Title 42, §§ 7661–7661f [42 U.S.C. §§ 7661–7661f; TN1141])	Nuclear power plants are subject to 40 CFR Part 61, Subpart H (TN3289), "National Emissions Standards for Emissions of Radionuclides," which is included in the terms and conditions of the Title V Operating Permit.

Table F-2 (contd)

License, Permit, or Other Required Approval	Responsible Agency	Authority	Relevance and Status
Risk Management Plan: Required for any stationary source that has a regulated substance (e.g., chlorine, hydrogen fluoride, nitric acid) in any process (including storage) in a quantity that is over the threshold level.	EPA or State agency	CAA, Title 1, Section 112(R)(7) (42 U.S.C. § 7412-TN7014)	These regulated substances stored in quantities that exceed the threshold levels would require a risk management plan.
CAA Conformity Determination: Required for each criteria pollutant (i.e., sulfur dioxide, particulate matter, carbon monoxide, ozone, nitrogen dioxide, and lead) where the total of direct and indirect emissions in a nonattainment or maintenance area caused by a Federal action would equal or exceed threshold rates.	EPA or State agency	CAA, Title 1, Section 176(c) (42 U.S.C. § 7506-TN4856)	CAA conformity determination would be required at nuclear power plants located in nonattainment areas with NAAQSs for criteria pollutants or maintenance areas for any criteria pollutant that would be emitted as a result of ANR licensing.
Water Resources Protection			
NPDES Permit: Construction Site Stormwater: Required before making point source discharges of stormwater from a construction project that disturbs more than 5 ac (2 ha) of land.	EPA or State agency	CWA (33 U.S.C. §§ 1251 *et seq.*; TN662); 40 CFR Part 122 (TN2769)	Any plant refurbishment involving construction of more than 5 ac (2 ha) of land would require a Stormwater Pollution Prevention Plan and construction site stormwater discharge permit.
NPDES Permit: Industrial Facility Stormwater: Required before making point source discharges of stormwater from an industrial site.	EPA or State agency	CWA (33 U.S.C. §§ 1251 *et seq.*; TN662); 40 CFR Part 122 (TN2769)	Stormwater would be discharged from the nuclear power plants during operations. Stormwater would discharge through existing outfalls covered by a permit.
NPDES Permit: Process Water Discharge: Required before making point source discharges of industrial process wastewater.	EPA or State agency	CWA (33 U.S.C. §§ 1251 *et seq.;* TN662); 40 CFR Part 122 (TN2769)	Process industrial wastewater would be discharged through existing outfalls covered by the permit.
Spill Prevention Control and Countermeasures Plan: Required for any facility that could discharge diesel fuel in harmful quantities into navigable waters or onto adjoining shorelines.	EPA or State agency	CWA (33 U.S.C. §§ 1251 *et seq.*; TN662); 40 CFR Part 112 (TN1041)	A Spill Prevention Control and Countermeasures Plan is required at nuclear power plants storing large volumes of diesel fuel and/or other petroleum products.

Table F-2 (contd)

License, Permit, or Other Required Approval	Responsible Agency	Authority	Relevance and Status
CWA Section 401 Water Quality Certification: Required to be submitted to the agency responsible for issuing any Federal license or permit to conduct an activity that may result in a discharge of pollutants into waters of a State.	EPA or State agency	CWA, Section 401 (33 U.S.C. § 1341-TN4764); Chapters 119 and 6111	Certification for operation of a nuclear power plant may require a Federal license or permit (e.g., a CWA Section 404 Permit).
New Underground Storage Tanks System Registration: Required within 30 days of bringing a new underground storage tank system into service.	EPA or State agency	RCRA, as amended, Subtitle I (42 U.S.C. §§ 6991a–6991i; TN1281); 40 CFR 280.22 (TN6619)	Required if new underground storage tank systems would be installed at a nuclear power plant.
Aboveground Storage Tank: A permit is required to install, remove, repair, or alter any stationary tank for the storage of flammable or combustible liquids.	State Fire Marshal		Required if new aboveground diesel fuel storage tanks would be installed at a nuclear power plant.
Waste Management and Pollution Prevention			
Registration and Hazardous Waste Generator Identification Number: Required before a person who generates over 220 lb (100 kg) per calendar month of hazardous waste ships the hazardous waste offsite.	EPA or State agency	RCRA, as amended (42 U.S.C. §§ 6901 *et seq.*; TN1281), Subtitle C	Generators of hazardous waste must notify the EPA that the wastes exist and require management in compliance with RCRA.
Hazardous Waste Facility Permit: Required if hazardous waste will undergo nonexempt treatment by the generator, be stored onsite for longer than 90 days by the generator of 2,205 lb (1,000 kg) or more of hazardous waste per month, be stored onsite for longer than 180 days by the generator of between 220 and 2,205 lb (100 and 1,000 kg) of hazardous waste per month, disposed of onsite, or be received from offsite for treatment or disposal.	EPA or State agency	RCRA, as amended (42 U.S.C. §§ 6901 *et seq.*; TN1281), Subtitle C	Hazardous wastes are usually not disposed of onsite at nuclear power plants. Hazardous wastes generated onsite are not generally stored for more than 90 days. However, should a nuclear power plant store waste onsite for greater than 90 days for characterization, profiling, or scheduling for treatment or disposal, a Hazardous Waste Facility Permit would be required.

Table F-2 (contd)

License, Permit, or Other Required Approval	Responsible Agency	Authority	Relevance and Status
Emergency Planning and Response			
List of Safety Data Sheets (previously referred to as Material Safety Data Sheets).[(a)] Submission of a list of Safety Data Sheets is required for hazardous chemicals (as defined in 29 CFR Part 1910-TN654) that are stored onsite in excess of their threshold quantities.	State and local emergency planning agencies	EPCRA, Section 311 (42 U.S.C. § 11021; TN6603); 40 CFR 370.20 (TN6612)	Nuclear power plant operators are required to submit a list of Material Safety Data Sheets to State and local emergency planning agencies.
Annual Hazardous Chemical Inventory Report: The report must be submitted when hazardous chemicals have been stored at a facility during the preceding year in amounts that exceed threshold quantities.	State and local emergency response agencies; local fire department	EPCRA, Section 312 (42 U.S.C. § 11022; TN6603); 40 CFR 370.25 (TN6612)	If hazardous chemicals have been stored at a nuclear power plant during the preceding year in amounts that exceed threshold quantities, then plant operators would be required to submit an annual Hazardous Chemical Inventory Report.
List of Safety Data Sheets[(a)]: Submission of a list of Safety Data Sheets is required for hazardous chemicals (as defined in 29 CFR Part 1910-TN654) that are stored onsite in excess of their threshold quantities.	State and local emergency planning agencies	EPCRA, Section 311 (42 U.S.C. § 11021; TN6603); 40 CFR 370.20 (TN6612)	Nuclear power plant operators are required to submit a list of Material Safety Data Sheets to State and local emergency planning agencies.
Annual Hazardous Chemical Inventory Report: The report must be submitted when hazardous chemicals have been stored at a facility during the preceding year in amounts that exceed threshold quantities.	State and local emergency response agencies; local fire department	EPCRA, Section 312 (42 U.S.C. § 11022; TN6603); 40 CFR 370.25 (TN6612)	If hazardous chemicals have been stored at a nuclear power plant during the preceding year in amounts that exceed threshold quantities, then plant operators would be required to submit an annual Hazardous Chemical Inventory Report.
Annual Hazardous Chemical Inventory Report: The report must be submitted when hazardous chemicals have been stored at a facility during the preceding year in amounts that exceed threshold quantities.	State and local emergency response agencies; local fire department	EPCRA, Section 312 (42 U.S.C. § 11022; TN6603); 40 CFR 370.25 (TN6612)	If hazardous chemicals have been stored at a nuclear power plant during the preceding year in amounts that exceed threshold quantities, then plant operators would be required to submit an annual Hazardous Chemical Inventory Report.

Table F-2 (contd)

License, Permit, or Other Required Approval	Responsible Agency	Authority	Relevance and Status
Notification of Onsite Storage of an Extremely Hazardous Substance: Submission of the notification is required within 60 days after onsite storage begins of an extremely hazardous substance in a quantity greater than the Threshold Planning Quantity.	State and local emergency response agencies	EPCRA, Section 304 (42 U.S.C. § 11004; TN6603); 40 CFR 355.30 (TN5493)	If an extremely hazardous substance will be stored at a nuclear power plant in a quantity greater than the Threshold Planning Quantity, plant operators would prepare and submit the Notification of Onsite Storage of an Extremely Hazardous Substance.
Annual Toxics Release Inventory Report: Required for facilities that have 10 or more full-time employees and are assigned certain Standard Industrial Classification Codes.	EPA or State agency	EPCRA, Section 313 (42 U.S.C. § 11023; TN6603); 40 CFR Part 372 (TN6613)	If required, nuclear power plant operators would prepare and submit a Toxics Release Inventory Report to the EPA.
Transportation of Radioactive Wastes and Conversion Products Packaging, Labeling, and Routing Requirements for Radioactive Materials: Required for packages containing radioactive materials that will be shipped by truck or rail.	U.S. Department of Transportation	Hazardous Materials Transportation Act (49 U.S.C. §§ 5101 *et seq.*; TN6605); AEA, as amended (42 U.S.C. §§ 2011 *et seq.*; TN663); 49 CFR Part 172 (TN6616), Part 173 (TN298), Part 174 (TN6622), Part 177 (TN6620), and Part 397 (TN6621)	When shipments of radioactive materials are made, nuclear power plant operators would comply with U.S. Department of Transportation packaging, labeling, and routing requirements.
Biotic Resource Protection			
Threatened and Endangered Species Consultation: Required between the responsible Federal agencies and FWS and/or NMFS to ensure that the project is not likely to: (1) jeopardize the continued existence of any species listed at the Federal or State level as endangered or threatened, or (2) result in destruction of critical habitat of such species.	FWS and NMFS	ESA of 1973, as amended (16 U.S.C. §§ 1531 *et seq.*; TN1010)	For actions that may affect listed species or designated critical habitat, the NRC would consult with the FWS and/or NMFS under Section 7 of the ESA.

Table F-2 (contd)

License, Permit, or Other Required Approval	Responsible Agency	Authority	Relevance and Status
Essential Fish Habitat Consultation: Required between the responsible Federal agency and NMFS to ensure that Federal actions authorized, funded, or undertaken do not adversely affect essential fish habitat.	NMFS	Magnuson-Stevens Fishery Conservation and Management Act, as amended (16 U.S.C. §§ 1801–1884; TN1061)	For actions that may adversely affect essential fish habitat, the NRC would consult with NMFS in accordance with 50 CFR Part 600, Subpart J (TN1342).
CWA Section 404 (Dredge and Fill) Permit: Required to place dredged or fill material into waters of the United States, including areas designated as wetlands, unless such placement is exempt or authorized by a nationwide permit or a regional permit; a notice must be filed if a nationwide or regional permit applies.	USACE	CWA (33 U.S.C. §§ 1251 *et seq.*; TN662); 33 CFR Part 323 (TN4827) and Part 330 (TN4318)	Dredging or placement of fill material into wetlands within the jurisdiction of the USACE at a nuclear power plant would require a Section 404 permit.
Cultural Resources Protection			
Archaeological and Historical Resources Consultation: Required before a Federal agency approves a project in an area where archaeological or historic resources might be located.	State Historic Preservation Officer and/or Tribal Historic Preservation Officer	NHPA of 1966, as amended (54 U.S.C. §§ 300101 *et seq.*; TN4157); Archeological and Historical Preservation Act of 1974 (54 U.S.C. §§ 312501 *et seq.*; TN4844); Antiquities Act of 1906 (54 U.S.C. §§ 320301–320303 and 18 U.S.C. § 1866(b); TN6602); Archaeological Resources Protection Act of 1979, as amended (16 U.S.C. §§ 470aa–mm; TN1687)	The NRC would consult with the State and/or Tribal Historic Preservation Officers and representative American Indian Tribes regarding the impacts of licensing and ANR and the results of archaeological and architectural surveys of nuclear power plant sites.

(a) In 2012, the Hazard Communication Standard (29 CFR 1910.1200(g) [TN654]) was revised to require Safety Data Sheets replace Material Safety Data Sheets.

F.8 Emergency Management and Response Laws, Regulations, and Executive Orders

This section discusses the response laws, regulations, and Executive Orders that address the protection of public health and worker safety and require the establishment of emergency plans. These laws, regulations, and Executive Orders relate to the operation of nuclear power plants. To make things easier for readers, certain items are repeated from previous sections in this appendix.

F.9 Federal Emergency Management Response Laws

Emergency Planning and Community Right-to-Know Act of 1986 (42 U.S.C. §§ 11001 *et seq.*; TN6603) (also known as "SARA Title III") – EPCRA, which is the major amendment to CERCLA (42 U.S.C. § 9601; TN6592), establishes the requirements for Federal, State, and local governments, American Indian Tribes, and industry regarding emergency planning and "Community Right-to-Know" reporting on hazardous and toxic chemicals. The "Community Right-to-Know" provisions increase the public's knowledge and access to information about chemicals at individual facilities, their uses, and releases into the environment. States and communities working with facilities can use the information to improve chemical safety and protect public health and the environment. This Act requires emergency planning and notice to communities and government agencies concerning the presence and release of specific chemicals. The EPA implements this Act under regulations found in 40 CFR Part 355 (TN5493), Part 370 (TN6612), and Part 372 (TN6613).

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 U.S.C. § 9604(l); TN6592 (also known as "Superfund") – This Act provides authority for Federal and State governments to respond directly to hazardous substance incidents. The Act requires reporting of spills, including radioactive spills, to the National Response Center.

Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 (42 U.S.C. § 5121; TN6638) – This Act, as amended, provides an orderly, continuing means of providing Federal government assistance to State and local governments in managing their responsibilities to alleviate suffering and damage resulting from disasters. The President, in response to a State governor's request, may declare an "emergency" or "major disaster" to provide Federal assistance under this Act. The President, in Executive Order 12148 (44 FR 43239-TN6614), delegated all functions except those in Sections 301, 401, and 409 to the Director of the Federal Emergency Management Agency. The Act provides for the appointment of a Federal coordinating officer who will operate in the designated area with a State coordinating officer for the purpose of coordinating State and local disaster assistance efforts with those of the Federal government.

Justice Assistance Act of 1984 (42 U.S.C. § 3701–3799; TN6639) – This Act establishes emergency Federal law enforcement assistance to State and local governments in responding to a law enforcement emergency. The Act defines the term "law enforcement emergency" as an uncommon situation that requires law enforcement, that is or threatens to become of serious or epidemic proportions, and with respect to which State and local resources are inadequate to protect the lives and property of citizens or to enforce the criminal law. Emergencies that are not of an ongoing or chronic nature (for example, the Mount St. Helens volcanic eruption) are eligible for Federal law enforcement assistance including funds, equipment, training, intelligence information, and personnel.

Price-Anderson Act (42 U.S.C. § 2210; TN4522) – The Price-Anderson Act provides insurance protection to victims of a nuclear accident. The main purpose of the Act is to partially indemnify the nuclear industry against liability claims arising from nuclear incidents, while still ensuring compensation coverage for the general public. The Act establishes a no-fault insurance-type system in which the first $12.6 billion (as of 2011) is industry-funded as described in the Act (any claims above the $12.6 billion would be covered by the Federal government).

The Act requires NRC licensees and U.S. Department of Energy contractors to enter into agreements of indemnification to cover personal injury and property damage to those harmed by a nuclear or radiological incident, including the costs of incident response or precautionary evacuation, costs of investigating and defending claims, and settling suits for such damages.

F.10 Federal Emergency Management and Response Regulations

Quantities of Radioactive Materials Requiring Consideration of the Need for an Emergency Plan for Responding to a Release (10 CFR 30.72, Schedule C; TN4881) – This section of the regulations provides a list that is the basis for both the public and private sector to determine whether the radiological materials they handle must have an emergency response plan for unscheduled releases.

Occupational Safety and Health Administration Emergency Response, Hazardous Waste Operations, and Worker Right-to-Know (29 CFR Part 1910; TN654) – This regulation establishes OSHA requirements for employee safety in a variety of working environments. It addresses employee emergency and fire prevention plans (Section 1910.38), hazardous waste operations and emergency response (Section 1920.120), and hazards communication (Section 1910.1200) to make employees aware of the dangers they face from hazardous materials in their workplace. These regulations do not directly apply to Federal agencies. However, Section 19 of the Occupational Safety and Health Act (29 U.S.C. § 668) requires all Federal agencies to have occupational safety programs "consistent" with Occupational Safety and Health Act standards.

Emergency Management and Assistance (44 CFR Section 1.1; TN6615) – This regulation contains the policies and procedures for the Federal Emergency Management Act, National Flood Insurance Program, Federal Crime Insurance Program, Fire Prevention and Control Program, Disaster Assistance Program, and Preparedness Program, including radiological planning and preparedness.

Hazardous Materials Tables and Communications, Emergency Response Information Requirements (49 CFR Part 172; TN6616) – This regulation defines the regulatory requirements for marking, labeling, placarding, and documenting hazardous material shipments. The regulation also specifies the requirements for providing hazardous material information and training.

F.11 Emergency Management and Response Executive Orders

Executive Order 12148, *Federal Emergency Management* (44 FR 43239-TN6614) – This Order transfers functions and responsibilities associated with Federal emergency management to the Director of the Federal Emergency Management Agency. The Order assigns the Director the responsibility to establish Federal policies and to coordinate all civil defense and civil emergency planning for the management, mitigation, and assistance functions of Executive agencies.

Executive Order 12656, *Assignment of Emergency Preparedness Responsibilities* (53 FR 47491-TN6626) – This Order assigns emergency preparedness responsibilities to Federal departments and agencies.

Executive Order 12938, *Proliferation of Weapons of Mass Destruction* (59 FR 59099-TN6640) – This Order states that the proliferation of nuclear, biological, and chemical weapons (“weapons of mass destruction”) and the means of delivering such weapons constitutes an unusual and extraordinary threat to the national security, foreign policy, and economy of the United States, and that a national emergency would be declared to deal with that threat.

F.12 Consultations with Agencies and Federally Recognized American Indian Nations

Certain laws, such as the ESA (16 U.S.C. §§ 1531 *et seq.*; TN1010), the Fish and Wildlife Coordination Act (16 U.S.C. §§ 661 *et seq.*; TN4467), and the NHPA (54 U.S.C. §§ 300101 *et seq.*; TN4157), require consultation and coordination by the NRC with other governmental entities, including other Federal, State, and local agencies and federally recognized American Indian Tribes. These consultations must occur on a timely basis and are generally required before any land disturbance can begin. Most of these consultations are related to biotic resources, historic properties, cultural resources, and recognizes NRC’s Federal trust responsibility to American Indian Tribes. The biotic resource consultations generally pertain to the potential for activities to disturb sensitive species or habitats. Cultural resource consultations relate to the potential for disruption of important cultural resources and archaeological sites. Consultations with American Indian Tribes are conducted on a government-to-government basis.

F.13 References

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation." TN283.

10 CFR Part 30. *Code of Federal Regulations*, Title 10, *Energy*, Part 30, "Rules of General Applicability to Domestic Licensing of Byproduct Material." TN4881.

10 CFR Part 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, "Domestic Licensing of Production and Utilization Facilities." TN249.

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." TN250.

10 CFR Part 52. *Code of Federal Regulations*, Title 10, *Energy*, Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." TN251.

29 CFR Part 1910. *Code of Federal Regulations*, Title 29, *Labor*, Part 1910, "Occupational Safety and Health Standards." TN654.

33 CFR Part 320. *Code of Federal Regulations*, Title 33, *Navigation and Navigable Waters*, Part 320, "General Regulatory Policies." Washington, D.C. TN424.

33 CFR Part 323. *Code of Federal Regulations*, Title 33, *Navigation and Navigable Waters,* Part 323, "Permits for Discharge of Dredged or Fill Material into Waters of the United States." TN4827.

33 CFR Part 330. *Code of Federal Regulations*, Title 33, *Navigation and Navigable Waters*, Part 330, "Nationwide Permit Program." TN4318.

36 CFR Part 800. *Code of Federal Regulations*, Title 36, *Parks, Forests, and Public Property*, Part 800, "Protection of Historic Properties." TN513.

40 CFR Part 61. *Code of Federal Regulations,* Title 40, *Protection of Environment,* Part 61, "National Emission Standards for Hazardous Air Pollutants." TN3289.

40 CFR Part 112. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 112, "Oil Pollution Prevention." Washington, D.C. TN1041.

40 CFR Part 121. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 121, "State Certification of Activities Requiring a Federal License or Permit." TN6718.

40 CFR Part 122. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 122, "EPA Administered Permit Programs: The National Pollutant Discharge Elimination System." TN2769.

40 CFR Part 190. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations." TN739.

40 CFR Part 280. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 280, "Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)." TN6619.

40 CFR Part 355. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 302, "Emergency Planning and Notification." TN5493.

40 CFR Part 370. *Code of Federal Regulations*, Title 40, *Protection of Environmen*t, Part 370, "Hazardous Chemical Reporting: Community Right-To-Know." TN6612.

40 CFR Part 372. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 372, "Toxic Chemical Release Reporting: Community Right-To-Know." TN6613.

40 CFR Part 761. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions." TN6610.

40 CFR Parts 1500–1508. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Subchapter A, "National Environmental Policy Act Implementing Regulations." TN6611.

40 CFR Parts 239–283. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Parts 239–283, EPA Regulations Implementing RCRA. TN6618.

40 CFR Parts 50-99. *Code of Federal Regulations*, Title 40, *Protection of the Environment*, Subchapter C, Parts 50-99, "Air Programs." TN5264.

44 CFR Part 1. *Code of Federal Regulations*, Title 44, *Emergency Management and Assistance*, Part 1, "Rulemaking, Policy, and Procedures." TN6615.

49 CFR Part 172. *Code of Federal Regulations*, Title 49, *Transportation*, Part 172, "Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, Training Requirements, and Security Plans." TN6616.

49 CFR Part 173. *Code of Federal Regulations*, Title 49, *Transportation*, Part 173, "Shippers—General Requirements for Shipments and Packagings." TN298.

49 CFR Part 174. *Code of Federal Regulation*s, Title 49, *Transportation*, Part 174, "Carriage by Rail." TN6622.

49 CFR Part 177. *Code of Federal Regulation*s, Title 49, *Transportation*, Part 177, "Carriage by Public Highway." TN6620.

49 CFR Part 397. *Code of Federal Regulation*s, Title 49, *Transportation*, Part 397, "Transportation of Hazardous Materials; Driving and Parking Rules." TN6621.

49 CFR Parts 171-177. *Code of Federal Regulations*, Title 49, *Transportation*, Subchapter C, "Hazardous Materials Regulations (49 CFR Parts 171-177)." TN5466.

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Fixing America's Surface Transportation Act. 42 U.S.C. § 4370m *et seq*. TN6392.

Hazardous Materials Transportation Act. 49 U.S.C. § 5101 *et seq*. TN6605.

Justice Assistance Act of 1984. 42 U.S.C. § 3701–3799. TN6639.

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Marine Mammal Protection Act of 1972, as amended. 16 U.S.C. § 1361 *et seq*. TN4478.

Marine Protection, Research, and Sanctuaries Act. 33 U.S.C. § 1401 *et seq.* TN6637.

Migratory Bird Treaty Act of 1918. 16 U.S.C. § 703 *et seq.* TN3331.

National Environmental Policy Act of 1969 (NEPA), as amended. 42 U.S.C. § 4321 *et seq.* TN661.

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Safe Drinking Water Act of 1974, as amended. 42 U.S.C. § 300f *et seq*. TN1337.

Toxic Substances Control Act, as amended. 15 U.S.C. § 2601 *et seq.* TN4454.

APPENDIX G

PLANT PARAMETER ENVELOPE AND SITE PARAMETER ENVELOPE

APPENDIX G

PLANT PARAMETER ENVELOPE AND SITE PARAMETER ENVELOPE

The interdisciplinary team of subject matter experts assigned to prepare the advanced nuclear reactor (ANR) generic environmental impact statement (GEIS) used the following methodology to develop the plant parameter envelope (PPE) and site parameter envelope (SPE) values and assumptions in this appendix:

- regulatory limits and permitting requirements relevant to the resource as established by Federal, State, or local agencies
- relevant information obtained from other NRC GEISs, including the License Renewal GEIS (NRC 2013-TN2654) and the Continued Storage GEIS (NRC 2014-TN4117)
- empirical knowledge gained from conducting evaluations and analyses for past new reactor EISs
- values and assumptions derived from other documents applying a PPE/SPE approach (such as the National Reactor Innovation Center PPE Report [NRIC 2021-TN6940])
- subject matter expertise and/or development of calculations and formulas based upon education and experience with the resource.

For details about the PPE and SPE values and assumptions, see the applicable resource section in Chapter 3.0. The PPE and SPE values and assumptions are used only to support the findings for Category 1 issues. Category 2 issues do not have PPE and SPE values and assumptions.

Table G-1 Plant Parameter Envelope and Site Parameter Envelope for Advanced Nuclear Reactors

Parameter	Values and Assumptions	Basis/Methodology
Reactor Site Criteria	Applicable NRC siting such as those at 10 CFR Part 100 (TN282) Subpart B, "Evaluation Factors for Stationary Power Reactor Site Applications on or After January 10, 1997" Reactor siting factors to be considered by the applicant include: 1. 10 CFR 100.20 "Factors to be considered when evaluating sites" 2. 10 CFR 100.21 "Non-seismic siting criteria" 3. 10 CFR 100.23 "Geologic and seismic siting criteria"	Adherence to siting criteria regulations has been determined to minimize impacts associated with environmental review evaluations.
Site Size and Location	1. 100 ac (40.5 ha) 2. Complies with applicable zoning 3. Consistent with the objectives of any relevant land use plans 4. Complies with the Coastal Zone Management Act of 1972 (16 U.S.C. § 1451 *et seq*; TN1243) and the Farmland Protection Policy Act of 1981 (7 U.S.C. §§ 4201 *et seq.*; TN708), if applicable 5. Completed structures would not be sited within 1 mi (1.6 km) of and would not be visible from Federal or State parks or wilderness areas, areas designated as Class I under Section 162 of the Clean Air Act (42 U.S.C. § 7472-TN6954), or a Wild and Scenic River or a National Heritage River, or a river of similar State designation 6. No existing residential areas within 0.5 mi (0.8 km) of site	The NRC staff recognizes that, without a detailed consideration of specific land use conditions, as much as 100 ac (40.5 ha) of land can be dedicated to a project within a feasible setting without noticeably influencing the availability of land for other purposes. The NRC staff assumes any proposed project would meet NRC siting regulations in 10 CFR Part 100 (TN282), or the applicable NRC siting regulations in place at the time the application is docketed. Establishing industrial facilities close to residences can affect the use and enjoyment of residents who desire home environments that are less influenced by the sights, noise, odors, and other parameters acceptable to industrial and commercial workplace settings. A minimum distance of 0.5 mi (0.8 km) bounds a generic determination that potential conflicts with residences would be SMALL, although a consideration of specific site conditions could indicate that closer distances could still be SMALL. An even greater distance (1 mi [1.6 km]) is needed to bound a generic determination that a project would have only a SMALL potential for adversely affecting features such as Federal or State parks and conservation areas, whose qualities are even more sensitive to industrial influences.
Permanent Footprint of Disturbance	1. 30 ac (12 ha) of vegetated lands 2. Counts only land that supports vegetation as of project baseline 3. No prime or unique farmland, or other farmland of statewide or local importance (see Section 3.1.1 for definitions); or site does not abut actively managed agricultural land and is not situated in a predominantly agricultural landscape 4. No floodplains, surface water features, riparian habitat, late-successional vegetation, or dedicated conservation land 5. No more than 0.5 ac (0.2 ha) of wetlands in permanent or temporary disturbance on the site or ROWs 6. The site and any existing ROWs do not have legacy contamination requiring cleanup to protect human health or the environment 7. No Individual Permits required under Section 404 of the Clean Water Act (33 U.S.C. § 1344-TN1019) 8. Use of best management practices (BMPs) for soil erosion, sediment control, and stormwater management 9. Implementation of mitigation specified in Clean Water Act permits 10. Habitat is not known to be potentially suitable for one or more Federal or State threatened or endangered species	The total footprint of disturbance within areas of existing vegetation (30 ac [12 ha] permanent plus an additional 20 ac [8.1 ha] of temporary for a total of 50 ac [20 ha]) constitutes an estimate by NRC staff of how much natural habitat excluding unusually sensitive habitats can be disturbed, regardless of geometric shape, in almost any landscape without noticeably altering wildlife numbers or behavior. The value of 0.5 ac (0.2 ha) of wetlands corresponds to the upper ceiling for project-wide impacts on wetlands under many Nationwide Permits (33 CFR Part 330; TN4318) determined by the U.S. Army Corps of Engineers (USACE) to constitute minimal impact.
Temporary Footprint of Disturbance	1. Additional 20 ac (8.1 ha) of vegetated land 2. Counts only land that supports vegetation as of project baseline 3. Meets assumptions for permanent footprint 4. Restored to original grade and seeded or planted with indigenous vegetation once construction is complete	This additional temporary disturbance is factored together with the assumption of no more than 30 ac (12 ha) permanent disturbance into the overall disturbance area of 50 ac (20 ha) (see above). Temporary disturbance of most natural habitats followed by restoration constitutes less impact per acre than permanent or long-term disturbance. The limit of 0.5 ac (0.2 ha) of wetland impacts in most Nationwide Permits (33 CFR Part 330; TN4318) is a project-wide limit, inclusive of all associated permanent and temporary impacts.
Offsite rights-of-way (ROW)	1. No longer than 1 mi (1.6 km) and no wider than 100 ft (30.5 m), but allows for unlimited additional mileage for linear features built within existing ROWs or directly adjacent to existing ROWs or public highways 2. Does not cause the total project-wide wetland fill to exceed 0.5 ac (0.2 ha) 3. Would not involve ground disturbance to streams greater than 10 ft (3 m) in width	Dimensions of up to 1 mi (1.6 km) long and 100 ft (30.5 m) wide constitutes an upper estimate by the NRC staff as to how much new ROW can be established anywhere in most rural landscapes without noticeably affecting fragmented land uses or natural habitats, without

Parameter	Values and Assumptions	Basis/Methodology
	4. Does not cross or pass within 1 mi (1.6 km) of parks, wildlife refuges, or conservation lands 5. Does not cross or pass within 1 mi (1.6 km) of, or is not visible from, Federal or State parks or wilderness areas, areas designated as Class I under Section 162 of the Clean Air Act (42 U.S.C. § 7472-TN6954), or a Wild and Scenic River or a National Heritage River, or a river of similar State designation 6. May span wetlands, waters of the United States, floodplains, shoreline, or riparian lands 7. Any new transmission poles or towers would be constructed outside of wetlands and floodplains 8. Pipelines or buried utilities would be directionally drilled under surface waters to avoid physical disturbance of shorelines or bottom substrates 9. Use of BMPs for soil erosion, sediment control, and stormwater management 10. Implementation of mitigation specified in Clean Water Act permits 11. No physical disturbance to streams greater than 10 ft (3 m) in width below the ordinary high-water mark 12. Access roads crossing non-jurisdictional surface water features meet the substantive requirements of Nationwide Permits 12 or 14 regarding limits on disturbance and requirements for mitigation	consideration of project-specific factors. The staff, based on its experience conducting environmental reviews, concludes that co-location of new facilities within existing ROWs or in new ROWs immediately adjacent to existing ROWs or along existing roadways results in minimal land use or ecological impacts. Such ROWs do not fragment existing land uses or natural habitats or introduce utility structures to settings previously lacking such facilities. Additional assumptions address sensitive facilities, which, if present, would necessitate a project-specific analysis to assess the significance of impacts. The limit of 0.5 ac (0.2 ha) of wetland impacts in most Nationwide Permits (33 CFR Part 330; TN4318) is a project-wide limit, inclusive of impacts from all project elements, including offsite features.
Maximum Building and Structure Height	1. 50 ft (15.2 m), except 200 ft (61 m) for meteorological towers and 100 feet for mechanical draft cooling towers 2. None of the structures would be built within or be visible from Federal or State parks or wilderness areas, other areas designated as Class I under Section 162 of the Clean Air Act (42 U.S.C. § 7472-TN6954), or designated Wild and Scenic Rivers 3. No transmission poles/towers over 100 ft (30.5 m)	Fifty feet constitutes a conservative estimate of building heights that would not likely result in significant visual intrusion or wildlife collision mortality in most settings. This conclusion is based upon NRC reviews in past reactor EISs. The staff recognizes that meteorological towers must be taller to function, and that there would be no need for more than one or two meteorological towers per site. A transmission line with poles or towers taller than 100 ft (30.5 m) would be visible in a forested area and would be highly visible in an open area. Most poles shorter than 100 ft (30.5 m) are not highly distinct visually from the distribution poles for lower voltage electric lines that are common visual features in most settings. Mechanical draft cooling towers are typically 50–100 ft (15.2–30.5 m) in height based on previous new reactor EIS analyses.
Intake and Discharge	1. Adhere to the best available technology requirements of Clean Water Act (CWA) 316(b) (33 U.S.C. § 1326-TN4823) 2. Operated in compliance with CWA Section 316 (b) and 40 CFR 125.83 (TN254), including compliance with monitoring and recordkeeping requirements in 40 CFR 125.87 and 40 CFR 125.88, respectively 3. Best available technologies are employed in the design and operation of intake and discharge structures to minimize alterations due to scouring, sediment transport, increased turbidity, and erosion 4. Adherence to requirements in National Pollutant Discharge Elimination System (NPDES) permits issued by the U.S. Environmental Protection Agency (EPA) or a given State	Requirements established in the subject regulations have been developed to be protective of aquatic biota, including protection of aquatic biota from excessive impingement or entrainment.
In-Water Structures (including intake and discharge structures)	1. Constructed in compliance with provisions of the CWA Section 404 (33 U.S.C. § 1344-TN1019) and Section 10 of the Rivers and Harbors Appropriation Act of 1899 (33 U.S.C. §§ 401 *et seq.*; TN660) 2. Adverse effects of building activities controlled and localized using BMPs such as installation of turbidity curtains or installation of cofferdams 3. Any shorelines or other areas temporarily disturbed to build intake and discharge structures would be restored using regionally indigenous vegetation 4. Construction duration would be less than 7 years	Requirements of existing regulations related to in-water construction are protective of aquatic resources and have been found to keep the adverse impacts of building activities localized and temporary.
Cooling Towers	1. No natural draft cooling towers 2. Would be equipped with drift eliminators 3. Makeup water would be fresh (salinity less than 1 ppt)	Various past new reactor EISs indicate that natural draft cooling towers are tall structures over 200 ft (61 m) in height that may be visible from substantial distances and from which salt drift and fogging may affect substantial areas of offsite land.
Other Cooling Features	1. No once-through cooling 2. No new cooling ponds 3. No new reservoirs 4. No spray irrigation ponds	Once-through cooling systems have a substantial potential for significant impacts on aquatic biota from entrainment and impingement and are essentially not possible due to Section 316(b) of the Clean Water Act (33 U.S.C. § 1326-TN4823). Operation of cooling ponds can have potentially significant effects on aquatic and terrestrial biota. Building reservoirs can affect large areas of aquatic and terrestrial habitats, including sensitive wetland, floodplain, and riparian habitats.
Copper Alloy Tubes	1. No use of copper alloy tubes	According to the License Renewal GEIS, copper alloy tubes can introduce metal contaminants into discharged blowdown water that can be harmful to aquatic biota.

Parameter	Values and Assumptions	Basis/Methodology
Criteria Pollutant and Hazardous Air Pollutant Emissions	1. Criteria pollutants emitted from vehicles and standby power equipment during construction and operations are less than Clean Air Act de minimis levels set by the EPA if located in a nonattainment or maintenance area 2. Hazardous Air Pollutant emissions will be within regulatory limits 3. Construction and operation activities meet the permitting requirements of applicable State and local agencies 4. Use of BMPs for dust control	Requirements of existing regulations related to air emissions have been found to be protective of human health and the environment.
Greenhouse Gas Emissions	ANR construction and operation, including uranium fuel cycle activities, transportation of fuel and waste, and decommissioning will emit no more than 2,534,000 MT CO_2(e) for the lifespan of the project of 97 years	Appendix H provides estimates of emissions of greenhouse gases associated with building, operation, fuel cycle, transportation of fuel and waste, and decommissioning. 1. Construction equipment would emit 78,000 MT CO_2(e) during a 7-year construction period 2. Construction workforce would emit 86,000 MT CO_2(e) during a 7-year construction period 3. Plant operations would emit 362,000 MT CO_2(e) during a 40- year period 4. Plant workforce would emit 272,000 MT CO_2(e) during a 40- year period 5. The uranium fuel cycle would emit 1,620,000 MT CO_2(e) during a 40-year period. Transportation of Fuel and Waste would emit 42,000 MT CO_2(e) during a 40-year period 6. Decommissioning equipment would emit 38,000 MT CO_2(e) during a 10-year period 7. Decommissioning workforce would emit 16,000 MT CO_2(e) during a 10-year period 8. SAFSTOR workforce would emit 20,000 MT CO_2(e) during a 40-year period Previous new reactor reviews, which have a larger fuel cycle contribution based on Table S–3, have concluded that the impact of the contribution of greenhouse gases is SMALL.
Cooling-System Air Quality	1. Hazardous Air Pollutant emissions will be within regulatory limits 2. Subject to State permitting requirements	The License Renewal GEIS (NRC 2013-TN2654) and supplemental EISs for individual plant relicensing evaluated the impact of continued operation of cooling towers, including natural draft cooling towers, at existing power plants for an additional 20 years and found the impacts to be SMALL.
Ozone and NOx Emissions	Transmission line voltage no higher than 1200 kV	Impacts of existing transmission lines on air quality are addressed in the License Renewal GEIS (NRC 2013-TN2654) and Supplemental EISs for individual plant relicensing, which have found impacts to be SMALL. The License Renewal GEIS evaluated lines up to 1,200 kV.
Total Plant Water Demand	1. Less than or equal to a daily average 6,000 gpm (0.379 m^3/s) 2. The total plant water demand accounts for the maximum amount of water supply required for all plant needs 3. The total plant water demand may include water from multiple sources (e.g., surface water, groundwater, and/or municipal water sources to meet certain water quality criteria)	The NRC staff developed the total plant water demand PPE by considering water requirements for all plant systems from the set of currently known ANR designs considered by NRIC (2021-TN6940). The NRC staff rounded this value up to the nearest 1,000 gpm (0.063 m^3/s) to derive the PPE.
Municipal Water Availability	The amount available from municipal water systems exceeds the amount of municipal water required by the plant (gpm) If municipal water is used for plant water supply: 1. Municipal Water Availability accounts for all existing and planned future uses 2. An agreement or permit for the usage amount can be obtained from the municipality	Municipal water availability at a site is the amount of excess capacity in the municipal systems that is available after accounting for all existing and planned future uses. The NRC staff can generically conclude that the proposed project's municipal water requirements would not noticeably affect water resources at the site, if bounded by municipal water availability and the capacity of the municipal systems.

Parameter	Values and Assumptions	Basis/Methodology
Surface Water Availability – Flowing (Stream or River) (not applicable if plant does not use cooling water)	1. The average rate of plant withdrawal does not exceed 3 percent of the 95 percent exceedance daily flow for the waterbody (cfs) 2. Average plant water withdrawals do not reduce discharge from the flowing waterbody by more than 3 percent of the 95 percent exceedance daily flow and do not prevent the maintenance of applicable instream flow requirements 3. The 95 percent exceedance daily flow accounts for existing and planned future withdrawals 4. Water availability is demonstrated by the ability to obtain a withdrawal permit issued by State, regional or tribal governing authorities 5. Water rights for the withdrawal amount are obtainable, if needed 6. Changes in littoral zone water levels and hydroperiod resulting from surface water withdrawals are within historical annual or seasonal fluctuations 7. If withdrawals are from an estuary or intertidal zone, then changes to salinity gradients are within the normal tidal or seasonal movements that characterize the waterbody	The staff reviewed surface water withdrawals from and related impacts on flowing waterbodies versus low flow metrics at the of currently operating and newly licensed large light-water reactors (LWRs). In the reviews of previous analyses, the staff found that water withdrawal rates at or below 3 percent of the water available during low flow conditions did not result in noticeable impacts. Therefore, the NRC staff generically concluded that plant surface water withdrawals that do not exceed 3 percent of the 95 percent exceedance daily flow in the flowing waterbody used as the source, while accounting for all existing and planned withdrawals, would not noticeably affect surface water resources at the site. Plant water withdrawal may alter salinity gradients in flowing water bodies. The License Renewal GEIS (NRC 1996-TN288 and NRC 2013-TN2654) evaluated the impact of plant withdrawals on altering salinity gradients at operating plants and found the impacts to be SMALL if they are localized and are within the normal tidal or seasonal movements of salinity gradients that characterize the waterbody.
Surface Water Availability – Non-Flowing (not applicable if plant does not use cooling water)	1. Water availability of the Great Lakes, the Gulf of Mexico, oceans, estuaries, and intertidal zones exceeds the amount of water required by the plant 2. Water availability is demonstrated by the ability to obtain a withdrawal permit issued by State, regional, or tribal governing authorities 3. Water rights for the withdrawal amount are obtainable, if needed 4. Changes in littoral zone water levels and hydroperiod resulting from surface water withdrawals are within historical annual or seasonal fluctuations 5. If withdrawals are from an estuary or intertidal zone, then changes to salinity gradients are within the normal tidal or seasonal movements that characterize the waterbody 6. Coastal Zone Management Act of 1972 (16 U.S.C. §§ 1451 *et seq.*; TN1243) consistency determination is obtainable, if applicable	The staff can generally conclude that the total plant water demand of 6,000 gpm (0.379 m^3/s) would not result in water use conflicts in the Great Lakes, the Gulf of Mexico, oceans, estuaries, and intertidal zones, because the plant demand would be negligible as compared to water availability. The staff acknowledges, however, that smaller non-flowing surface waterbodies (e.g., inland lakes, man-made ponds, and reservoirs) have limited water availability. These waterbodies are not included in the staff's generic analysis. Plant water withdrawal may alter salinity gradients in non-flowing waterbodies. The License Renewal GEIS (NRC 1996-TN288 and NRC 2013-TN2654) evaluated the impact of plant withdrawals on altering salinity gradients at operating plants and found the impacts to be SMALL if they are localized and are within the normal tidal or seasonal movements of salinity gradients that characterize the waterbody.
Municipal Systems' Available Capacity to Receive and Treat Plant Effluent	1. The available capacity of the municipal systems to treat effluent exceeds the expected amount of plant effluent (gpm) 2. Municipal Systems' Available Capacity to Receive and Treat Plant Effluent accounts for all existing and planned future discharges 3. Agreement to discharge to a municipal treatment system is obtainable	Municipal systems' available receiving and treatment capacity is determined while accounting for all existing and reasonably foreseeable future discharges. The NRC staff can generically conclude that plant effluent treated by a municipal system would not noticeably affect water resources at the site, if bounded by the municipal systems' available capacity. The constituents present in plant effluent are addressed in the municipal systems' discharge permits.
Groundwater Withdrawal for Plant Uses	1. Less than or equal to 50 gpm (0.003 m^3/s) 2. Withdrawal results in no more than 1 ft (0.3 m) of drawdown at the site boundary 3. Withdrawals are not derived from an EPA-designated Sole Source Aquifer, or from any aquifer designated by a State, tribe, or regional authority to have special protections to limit drawdown 4. Withdrawals meet the permitting requirements of applicable State and local agencies 5. Changes in wetland water levels and hydroperiod resulting from groundwater use are within historical annual or seasonal fluctuations 6. Parameter value of 50 gpm (0.003 m^3/s) is the total withdrawal for all plant uses (excluding dewatering)	This site parameter was based on the staff's determination in the License Renewal GEIS that ≤100 gpm (0.006 m^3/s) groundwater withdrawal creates negligible or small impacts at operating nuclear power plants because this use rate would not generally lower groundwater levels beyond the site boundary. The groundwater withdrawal rate parameter was adjusted lower based on simplified modeling showing that effects on groundwater levels at the site boundary from pumping 50 gpm (0.003 m^3/s) on a 100 ac (40.5 ha) site would approximate the effects from pumping 100 gpm (0.006 m^3/s) on a larger site the size of a typical large LWR. The staff assumed that groundwater withdrawals for plant uses would result in less than a 1 ft (0.3 m) reduction in groundwater levels at the site boundary. The threshold of 1 ft (0.3 m) was selected as a *de minimis* value likely to be less than the natural annual fluctuations in groundwater levels at most sites.

Parameter	Values and Assumptions	Basis/Methodology
Groundwater Withdrawal for Excavation or Foundation Dewatering	1. Dewatering rate less than or equal to 50 gpm (0.003 m^3/s) 2. Dewatering results in negligible drawdown at the site boundary 3. Dewatering discharge has minimal effects on the quality of the receiving waterbody (e.g., as demonstrated by conformance with NPDES permit requirements) 4. Changes in wetland water levels and hydroperiod resulting from dewatering are within historical annual or seasonal fluctuations 5. Parameter value of 50 gpm (0.003 m^3/s) represents the long-term dewatering rate (the initial rate may be larger)	The groundwater dewatering parameter was based on the staff's determination that impacts would be small if dewatering would not lower groundwater levels beyond the site boundary, which is consistent with the License Renewal GEIS. Based on simplified modeling, the staff determined that, relative to the plant site area, the effects on groundwater levels caused by dewatering withdrawals of 50 gpm (0.003 m^3/s) at a 100 ac (40.5 ha) ANR site would be similar to the effects caused by dewatering withdrawals of 100 gpm (0.006 m^3/s) on a larger site the size of a typical large LWR. Consistent with the smaller site area for the ANR, the staff assumed in this simplified modeling that the area to be dewatered and the depth of groundwater drawdown at the excavation/foundation would be smaller for an ANR than for a typical large LWR.
Groundwater Quality	1. The plant is outside the recharge area for any EPA-designated Sole Source Aquifer, or any aquifer designated to have special protections by a State, tribal, or regional authority 2. The plant is outside the wellhead protection area or designated contributing area for any public water supply well 3. No planned plant discharges to the subsurface (by infiltration or injection), including stormwater discharge 4. Applicable requirements and guidance on spill prevention and control are followed, including relevant BMPs and Integrated Pollution Prevention Plan 5. A groundwater protection program conforming to NEI 07-07 (NEI 2019-TN6775) is established and followed	Because groundwater quality degradation would have the greatest effects on other users of the resource when groundwater at the plant site contributes to the source water for other users, the potential impacts on groundwater quality from plant construction and operation will be minimized when the plant is located outside the recharge areas for critical groundwater supplies and when there are no planned discharges to the subsurface. In addition, spill prevention/control requirements and a groundwater protection program help prevent releases of contaminants to groundwater and to minimize the impacts of any releases that inadvertently occur.
Impacts on Aquatic Biota	1. Adherence to regulatory limits in 40 CFR 125.84 (TN254) 2. Adherence to requirements in NPDES permits issued by the EPA or a given State	Requirements of existing regulations related to aquatic biota impacts are protective of aquatic resources and have been found to keep adverse impacts localized and temporary.
Radiological Environmental Hazards	For protection against radiation, the applicant must meet the regulatory requirements of: • 10 CFR 20.1101 "Radiation Protection Programs" (10 CFR Part 20-TN283) if issued a license • 10 CFR 20.1201 "Occupational dose limits for adults" • 10 CFR 20.1301 "Dose limits for individual members of the public" • Appendix B of 10 CFR Part 20 "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage" • Applicable NRC radiation protection regulations, such as 10 CFR 50.34a (10 CFR Part 50-TN249) "Design objectives for equipment to control releases of radioactive material in effluents—nuclear power reactors" • Applicable NRC radiation protection regulations, such as 10 CFR 50.36a "Technical specifications on effluents from nuclear power reactors" Applicants would demonstrate in their application that any radiological nonhuman biota doses would be below IAEA (1992-TN712) and NCRP (1991-TN729) guidelines Application contains sufficient technical information for the staff to complete the detailed technical safety review Application will be found to be in compliance by the staff with the above regulations through a radiation protection program and an effluent release monitoring program	Requirements of existing regulations related to radiological health have been found to be protective of workers and members of the public and are minimized through a radiation protection program that implements ALARA.
Nonradiological Environmental Hazards	1. The applicant must adhere to all applicable Federal, State, local, or tribal regulatory limits and permit conditions for chemical hazards, biological hazards, and physical hazards from a proposed advanced nuclear reactor 2. The applicant will follow nonradiological public and occupational health BMPs and mitigation measures, as appropriate, to govern building and operations-related activities	Requirements of existing regulations related to nonradiological environmental hazards are protective of human health and have been found to keep the adverse impacts of building and operations-related activities localized and temporary.

Parameter	Values and Assumptions	Basis/Methodology
Wildlife-Related Noise Generation	85 dBA 50 ft (15.2 m) from the source	NRC staff has historically relied upon the Federal Highway Administration Construction Noise Handbook (WSDOT 2017-TN5313) to determine that a noise level of 85 dBA 50 ft (15.2 m) from the source is typical.
Human-Related Noise Generation	1. 65 dBA at site boundary, unless a relevant State or local noise abatement law or ordinance sets a different threshold, which would then be the presumptive threshold for PPE purposes 2. If an applicant cannot meet the 65 dBA threshold through mitigation, then the applicant must obtain a various or exception with the relevant State or local regulator 3. Project will implement BMPs, including such as modeling, foliage planting, construction of noise buffers, and the timing of construction and/or operation activities	The License Renewal GEIS (NUREG-1437; NRC 2013-TN2654) determined that noise levels are considered acceptable if the day-night average sound level outside a residence is less than 65 dBA. This limit is also included in the NRC Environmental Standard Review Plans (NUREG-1555; NRC 2000-TN614).
Radiological Waste Management	Applicants must meet the regulatory requirements of 10 CFR Part 20 (TN283) (e.g., 20.1406 and Subpart K), 10 CFR Part 61 (TN252), 10 CFR Part 71 (TN301), and 10 CFR Part 72 (TN4884) Quantities of LLRW generated at an ANR would be less than the quantities of LLRW generated at existing nuclear power plants, which generate an average of 21,200 ft^3 (600 m^3) and 2,000 Ci (7.4×10^{13} Bq) per year for boiling water reactors and half that amount for pressurized water reactors (NRC 2013-TN2654) Resource Conservation and Recovery Act (RCRA) Small-Quantity Generator (EPA 2020-TN6590) for Mixed Waste	Requirements of existing regulations related to radiological waste management have been found to be protective of human health and the environment.
Nonradiological Waste Management	1. Applicants must meet all applicable permit conditions, regulations, and BMPs related to solid, liquid, and gaseous waste management 2. For hazardous waste generation, applicants must meet the conformity with the appropriate hazard waste quantity generation level in accordance with RCRA (EPA 2020-TN6590) 3. For sanitary waste, applicants must treat sanitary waste in a permitted process 4. Perform mitigation measures, to the extent practicable, such as recycling, process improvements, or using a less hazardous substance	Requirements of existing regulations and applicable permits related to nonradiological waste management have been found to be protective of human health and the environment and have been found to keep the adverse impacts of building and operation activities localized and temporary.
Postulated Accidents	For design basis accidents,[41] the exclusion area boundary maximum total effective dose equivalent (TEDE) for any 2-hour period and the low-population zone maximum TEDE for the duration of the accident release For accidents involving releases of hazardous chemicals: • ANR inventory of a regulated substance is less than its Threshold Quantity (TQ). TQs are found in 40 CFR 68.130, Tables 1, 2, 3, and 4 (TN5494); and • ANR inventory of an EHS is less than its Threshold Planning Quantity (TPQ). TPQs are found in 40 CFR Part 355, Appendices A and B (TN5493) • A cost-screening analysis determines that the maximum benefit for avoiding an accident is so small that a SAMDA analysis is not justified based on a minimum cost to design an appropriate SAMDA • The proposed site is not within the jurisdiction of the United States Court of Appeals for the Ninth Circuit	Requirements of existing regulations related to postulated accidents are protective of human health. The applicant would have to demonstrate meeting the dose requirements by comparing the design basis accident doses with the dose criteria given in regulations related to the application (e.g., 10 CFR 50.34(a)(1) [TN249], 10 CFR 52.17(a)(1) and 10 CFR 52.79(a)(1) [10 CFR Part 52-TN251]), standard review plans (SRPs) (e.g., SRP criteria, Table 1 in SRP Section 15.0.3 of NUREG-0800 [NRC 2007/2019-TN6221]), and RGs, (e.g., RG 1.183 [NRC 2000-TN517]), as applicable. For hazardous chemical accidents, the applicant would make a comparison of hazardous chemical inventories to the TQs found in 40 CFR 68.130, Tables 1, 2, 3, and 4 (TN5494); and the TPQs in 40 CFR Part 355, Appendices A and B (TN5493). For SAMDAs, the staff expects that the safety analysis would have core damage frequencies (CDFs) that would likely be substantially less than CDFs associated with the current reactor fleet. For non-LWR SAMA screening and assessments, event or release category frequency could be used in place of CDFs. In such cases a cost screening analysis could determine that the maximum benefit for avoiding an accident is so small that a SAMDA is not justified based on a minimum cost to design an appropriate SAMDA. This cost-screening process would be based on the

41 For the purposes of this GEIS, "Design Basis Accidents" are related to a spectrum of accidents that will be evaluated for satisfying siting requirements (e.g., 10 CFR Part 100-TN282) and the safety analysis requirements (e.g., 10 CFR Part 50-TN249, 10 CFR Part 52-TN251) or the applicable NRC safety and siting regulations in place at the time the application is docketed).

Parameter	Values and Assumptions	Basis/Methodology
		available risk information from the safety analysis report and apply the cost formulas from NUREG/BR-0058 (NRC 2020-TN6806). Acts of terrorism: If within the jurisdiction of the United States Court of Appeals for the Ninth Circuit, appropriate staff analysis would be performed based in part on the physical protection requirements under 10 CFR Part 73 (TN423).
Site Employment	Peak project-related in-migrating workforce including families does not exceed established local planning and growth projections for infrastructure and service demands	Some construction and operations workers and their families are assumed to relocate to the economic region of the proposed project. Staff assumes growth planning for the affected infrastructure and services would factor these changes into baseline service demand projections. This assumption is based on staff experience since 2005 for more than 20 license application reviews. Peak project-related workforce increases are assumed to cause minimal effects on most services and infrastructure as long as increases are within local government planning projections.
Community Services and Infrastructure (e.g., housing availability; school capacities)	1. the housing vacancy rate in the affected economic region remains at least 5 percent of the housing stock after removing sufficient rental units to accommodate the in-migrating construction workers 2. student:teacher ratios in the affected economic region do not decline below the locally mandated levels after including the school age children of the in-migrating construction worker families housing and education resources would be the only resource areas where noticeable impacts might occur	This assumption is based on staff experience since 2005 with more than 20 license application reviews. Staff experience indicates a healthy housing market maintains a vacancy rate of five percent of the total housing stock, and any local, regional, or state mandated threshold (e.g., a student:teacher ratio) establishes the point of inflection from a SMALL impact to a MODERATE impact.
Transportation Systems and Traffic	Level of service (LOS) determination for affected roadways does not change	Movement between LOS classes (A, B, C, D, E, F) would be noticeable to drivers. Increased traffic that does not trigger a movement between these classes would be a minor impact. This assumption is based on the industry-standard LOS approach that has been used in previous NRC NEPA assessments since 2005.
Fuel Cycle	Table S–3 bounds the impacts for ANRs fuels, because of uranium fuel cycle changes since WASH-1248 (AEC 1974-TN23), including: • Increasing use of in situ leach uranium mining • Transitioning of U.S. uranium enrichment technology from gaseous diffusion to gas centrifugation. • Current LWRs are using nuclear fuel more efficiently due to higher levels of fuel burnup • Less reliance on coal-fired electrical generation plants Reprocessing capacity up to 900 MTU/yr Uranium fuel cycle impacts will bound the thorium fuel cycle impacts Waste and spent fuel inventories, as well as their associated certified spent fuel shipping and storage containers, are not significantly different from what has been considered for LWR evaluations in NUREG-2157 (NRC 2014-TN4117) Must satisfy the regulatory requirements of 10 CFR Part 40 (TN4882) “Domestic Licensing of Source Material,” 10 CFR Part 50 (TN249) “Domestic Licensing of Production and Utilization Facilities,” 10 CFR Part 70 (TN4883), “Domestic Licensing of Special Nuclear Material,” 10 CFR Part 71 (TN301), “Packaging and Transportation of Radioactive Material,” 10 CFR Part 72 (TN4884), “Licensing Requirements for the Independent Storage of Spent Fuel, High-Level Radioactive Waste, and Reactor-related Greater Than Class C Waste,” and 10 CFR Part 73 (TN423), “Physical Protection of Plants and Materials”	Advances in the uranium fuel cycle (as noted in the values and assumptions columns) have reduced the various impacts of the fuel cycle from what is presented in Table S–3. For example, higher burnup levels allow for longer periods of time between refueling thus reducing the annual number of fuel assemblies discharged from a reactor. As such, Table S–3 bounds the impacts associated with ANR fuel cycles. Requirements of existing regulations related to the safe processing, storage, transportation, and security of nuclear material have been found to be protective of workers and members of the public. Fuel fabrication impacts for metal fuel and liquid-fueled molten salt are not included in the staff’s generic analysis.
Transportation of Unirradiated ANR Fuel	Consistency with thresholds for the maximum shipment distances in Table 3-11 and Table 3-12, 36,760 mi (59,160 km) and 73,520 mi (118,320 km) respectively The shipments are normalized to a net electrical output of 880 MW(e), i.e., 1,100 MW(e) with an 80 percent capacity factor from WASH-1238 (AEC 1972-TN22)	Accident frequencies for transportation of unirradiated fuel are expected to be lower than those used in the analysis in WASH-1238 (AEC 1972-TN22). This is based on the NRC staff review of the trends in improvements in highway safety and security, and an overall reduction in traffic accident, injury, and fatality rates since WASH-1238 was published. Although packages for all types of unirradiated fuel have not been designed or certified by the NRC, these packages must comply with the

Parameter	Values and Assumptions	Basis/Methodology
	The parameter does not apply to situations where an ANR applicant proposes shipping the unirradiated fuel by air, ship, or barge; or where an applicant proposes that an unirradiated fuel transportation package be approved using the provisions of 10 CFR 71.12, 10 CFR 71.41(c), or 10 CFR 71.41(d) (10 CFR Part 71-TN301)	packaging requirements contained in 10 CFR Part 71 (TN301) and for this reason, the impacts of radiological accidents during transport of unirradiated fuel to ANR are expected to be smaller than those listed in Table S–4 in 10 CFR 51.52 (TN250). The PPE applies to situations where the enrichment of the unirradiated ANR fuel is 20 percent or less, based on the unlimited A_2 value in Table A-1 in 10 CFR Part 71 for unirradiated uranium enriched to 20 percent or less (10 CFR Part 71-TN301).
Transportation of Radioactive Waste from ANRs	Consistency with thresholds for the maximum shipment distance in Table 3-16, 182,152 mi (293,145 km) The shipments are normalized to a net electrical output of 880 MWe, i.e., 1,100 MWe with an 80 percent capacity factor and a shipment volume of 2.34 m^3/shipment from WASH-1238 (AEC 1972-TN22) This PPE does not apply to situations where an ANR applicant proposes shipping the radioactive waste by air, ship, or barge; or where an applicant proposes that a radioactive waste transportation package be approved using the provisions of 10 CFR 71.12, 10 CFR 71.41(c), or 10 CFR 71.41(d) (10 CFR Part 71-TN301)	Reviewed impacts from previous LWR early site permit (ESP) and combined license (COL) environmental analyses, which have concluded that the impacts of transportation of radioactive waste were SMALL. ANRs are expected to generate lower volumes of low-level radioactive wastes than LWRs because they have less complex systems, structures, and components.
Transportation of Irradiated Fuel from ANRs	Consistency with the thresholds for the maximum shipment distances, and burnup included in Table 3-17, Table 3-18, and Table 3-19, 314,037 mi (505,393 km) and 628,073 mi (1,010,786 km) The shipments are normalized to a net electrical output of 880 MWe, i.e., 1,100 MWe with an 80 percent capacity factor and a shipment capacity of 0.5 MTU/shipment from WASH-1238 (AEC 1972-TN22) This PPE is based on a maximum peak rod burnup of 62 GWd/MTU for uranium oxide fuel and 133 GWd/MTU for TRISO (TRi-structural ISOtropic) fuel This PPE does not apply to situations where an ANR applicant proposes shipping the irradiated ANR fuel by air, ship or barge; or where an ANR applicant proposes that an irradiated ANR fuel transportation package be approved using the provisions of 10 CFR 71.12, 10 CFR 71.41(c), or 10 CFR 71.41(d) (10 CFR Part 71-TN301) such as might be applied for when shipping a complete irradiated ANR core In addition, the irradiated ANR fuel must be shipped in a transportation package that meets all of the applicable NRC regulations	Reviewed impacts from previous LWR ESP and COL environmental analyses, which have concluded that the impacts of transportation of irradiated fuel were SMALL.
Decommissioning	The ANR would be within the bounds of the Decommissioning GEIS (NRC 2002-TN665) based on the following assumptions: 1. Doses to the public would be well below applicable regulatory standards regardless of which decommissioning method considered in the Decommissioning GEIS is used 2. Occupational doses would be well below applicable regulatory standards during the license term 3. The quantities of Class C or greater than Class C wastes generated would be comparable to or less than the amounts of solid waste generated by reactors licensed before 2002 4. The air quality impacts of decommissioning are expected to be negligible 5. Measures are readily available to avoid potential significant water quality impacts from erosion or spills. The liquid radioactive waste system design includes features to limit release of radioactive material to the environment, such as pipe chases and tank collection basins. These features will minimize the amount of radioactive material in spills and leakage that would have to be addressed at decommissioning 6. The ecological impacts of decommissioning are expected to be negligible 7. The socioeconomic impacts should be neither detectable nor destabilizing	NUREG-0586 Supplement 1 Decommissioning GEIS (NRC 2002-TN665) Requirements of existing regulations related to decommissioning activities have been found to be protective of workers, members of the public, and the environment.
Operational Life of the Plant	40-year operational life, assuming a 40-year license	10 CFR 50.51(a) (TN249) and 52.104 (TN251).
Construction Phase of the Plant	7-year construction life to complete construction activities	Based off previous new reactor EIS reviews.

G.1 References

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation." TN283.

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material." TN4882.

10 CFR Part 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, "Domestic Licensing of Production and Utilization Facilities." TN249.

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." TN250.

10 CFR Part 52. *Code of Federal Regulations*, Title 10, *Energy*, Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." TN251.

10 CFR Part 61. *Code of Federal Regulations*, Title 10, *Energy*, Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste." TN252.

10 CFR Part 70. *Code of Federal Regulations*, Title 10, *Energy*, Part 70, "Domestic Licensing of Special Nuclear Material." TN4883.

10 CFR Part 71. *Code of Federal Regulations*, Title 10, *Energy*, Part 71, "Packaging and Transportation of Radioactive Material." TN301.

10 CFR Part 72. *Code of Federal Regulations*, Title 10, *Energy*, Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste." TN4884.

10 CFR Part 73. *Code of Federal Regulations*, Title 10, *Energy*, Part 73, "Physical Protection of Plants and Materials." TN423.

10 CFR Part 100. *Code of Federal Regulations*, Title 10, *Energy*, Part 100, "Reactor Site Criteria." TN282.

33 CFR Part 330. *Code of Federal Regulations*, Title 33, *Navigation and Navigable Waters*, Part 330, "Nationwide Permit Program." TN4318.

40 CFR Part 68. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 68, “Chemical Accident Prevention Provisions." TN5494.

40 CFR Part 125. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 125, "Criteria and Standards for the National Pollutant Discharge Elimination System." Washington, D.C. TN254.

40 CFR Part 355. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 302, “Emergency Planning and Notification." TN5493.

33 U.S.C. § 1326. U.S. Code Title 33, *Navigation and Navigable Waters*, Section 1326, "Thermal Discharges." TN4823.

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APPENDIX H

GREENHOUSE GAS EMISSIONS ESTIMATES FOR A REFERENCE 1,000 MWE REACTOR

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APPENDIX H

GREENHOUSE GAS EMISSIONS ESTIMATES FOR A REFERENCE 1,000 MWe REACTOR

The U.S. Nuclear Regulatory Commission (NRC) staff estimated the greenhouse gas (GHG) emissions of various activities associated with the building, operating, and decommissioning of nuclear power plants. The GHG emission estimates include direct emissions from the nuclear facility and indirect emissions from workforce and fuel transportation, decommissioning, and the uranium fuel cycle. The estimates are based on a single installation of 1,000 MWe output with an 80 percent capacity factor henceforth referred to as the reference 1,000 MWe reactor. The estimates may be roughly linearly scaled from the reference 1,000 MWe reactor for other reactor outputs[42] This appendix discusses the calculation of GHG emission estimates for the reference 1,000 MWe reactor.

The estimated emissions from equipment used to build a nuclear power plant listed in Table H-1 are based on hours of equipment use estimated for a single nuclear power plant at a site requiring a moderate amount of terrain modification (UniStar 2007-TN1564). Construction equipment carbon monoxide (CO) emission estimates were derived from the hours of equipment use, and carbon dioxide (CO_2) emissions were then estimated from the CO emissions using a scaling factor of 172 tons of CO_2 per ton of CO (Chapman et al. 2012-TN2644). The scaling factor is based on the ratio of CO_2 to CO emission factors for diesel fuel industrial engines as reported in Table 3.3-1 of AP-42 *Compilation of Air Pollutant Emission Factors* (EPA 2012-TN2647). A CO_2 to total GHG equivalency factor of 0.991 is used to account for the emissions from other GHGs, such as methane (CH_4) and nitrous oxide (N_2O) (Chapman et al. 2012-TN2644). The equivalency factor is based on non-road/construction equipment in accordance with relevant guidance (NRC 2014-TN3768; Chapman et al. 2012-TN2644). Equipment emissions estimates for decommissioning are assumed to be one-half of those for construction equipment. Data on equipment emissions for decommissioning are not available; the one-half factor is based on the assumption that decommissioning would involve less earthmoving and hauling of material, as well as fewer labor hours, compared to those involved in building activities (Chapman et al. 2012-TN2644).

Table H-1 GHG Emissions from Equipment Used in Building and Decommissioning (MT CO_2(e))

Equipment	Building Total[(a)]	Decommissioning Total[(b)]
Earthwork and dewatering	12,000	6,000
Batch plant operations	3,400	1,700
Concrete	5,400	2,700
Lifting and rigging	5,600	2,800
Shop fabrication	1,000	500

[42] The term “model LWR" has also been used to describe a 1,000 MWe light water reactor for the purpose of evaluating the environmental considerations of the supporting fuel cycle to the annual reactor operations (WASH-1248, AEC 1974-TN23). It is assumed there are no significant differences between the 1,000 MWe reactor evaluated in WASH-1248 and the 1,000 MWe reference reactor evaluated in this appendix.

Equipment	Building Total[(a)]	Decommissioning Total[(b)]
Warehouse operations	1,400	700
Equipment maintenance	10,000	5,000
Total[(c)]	39,000	19,000

(a) Based on hours of equipment usage over a 7-year period.
(b) Based on equipment usage over a 10-year period.
(c) Results are rounded to the nearest 1,000 MT CO_2(e).

Table H-2 lists the NRC staff's estimates of the CO_2 equivalent[43] (CO_2(e)) emissions associated with workforce transportation. Construction workforce estimates for the reference 1,000 MWe reactor are conservatively based on estimates in various combined license (COL) applications (Chapman et al. 2012-TN2644), and the operational and decommissioning workforce estimates are based on Supplement 1 to NUREG–0586 (NRC 2002-TN665). Table H-2 lists the assumptions used to estimate total miles traveled by each workforce and the factors used to convert total miles to metric tons of CO_2(e). The workers are assumed to travel in gasoline-powered passenger vehicles (cars, trucks, vans, and sport utility vehicles) that get an average of 21.6 mi/gal (9.1 km/L) of gasoline (FHWA 2012-TN2645). Conversion from gallons of gasoline burned to CO_2(e) is based on U.S. Environmental Protection Agency (EPA) emission factors (EPA 2012-TN2643).

Table H-2 Workforce GHG Footprint Estimates

	Construction Workforce	Operational Workforce	Decommissioning Workforce	SAFe STORage Workforce
Commuting Trips (round trips per day)	1,000	550	200	40
Commute Distance (miles per round-trip)	40	40	40	40
Commuting Days (days per year)	365	365	250	365
Duration (years)	7	40	10	40
Total Distance Traveled (miles)[(a)]	102,000,000	321,000,000	20,000,000	23,000,000
Average Vehicle Fuel Efficiency[(b)] (miles per gallon)	21.6	21.6	21.6	21.6
Total Fuel Burned[(a)] (gallons)	4,700,000	14,900,000	900,000	1,100,000
CO_2 Emitted Per Gallon[(c)] (MT CO_2)	0.00892	0.00892	0.00892	0.00892
Total CO_2 Emitted[(a)] (MT CO_2)	42,000	133,000	8,000	10,000

[43] A measure to compare the emissions from various GHGs on the basis of their global warming potential (GWP), defined as the ratio of heat trapped by one unit mass of the GHG to that of one unit mass of CO2 over a specific time period.

	Construction Workforce	Operational Workforce	Decommissioning Workforce	SAFe STORage Workforce
CO_2 Equivalency Factor[(c)] ($MT\ CO_2/MT\ CO_2(e)$)	0.977	0.977	0.977	0.977
Total GHG Emitted[(a)] ($MT\ CO_2(e)$)	43,000	136,000	8,000	10,000

(a) Results are rounded.
(b) Source: FHWA 2012-TN2645.
(c) Source: EPA 2012-TN2643.

Title 10 of the *Code of Federal Regulations* 51.51(a) (10 CFR 51.51(a); TN250) states that every Environmental Report (ER)[44] prepared for an early site permit or COL stage of a light-water-cooled nuclear power reactor shall use Table S–3, Table of Uranium Fuel Cycle Environmental Data, as set forth in 10 CFR 51.51(b) (TN250) as the basis for evaluating the contribution of the environmental effects of uranium fuel-cycle activities to the environmental costs of licensing the nuclear power reactor. Section 51.51(a) (TN250) further states that Table S–3 shall be included in the ER and may be supplemented by a discussion of the environmental significance of the data set forth in the table as weighted in the project-specific analysis for the proposed facility.

Table S–3 of 10 CFR 51.51(b) (TN250) does not directly apply to non-light-water reactors (LWRs), nor does it provide an estimate of GHG emissions associated with the uranium fuel cycle; it only addresses pollutants that were of concern when the table was promulgated in the 1970s. However, Table S–3 states that 323,000 MWh is the assumed annual electric energy use for the Table S–3 reference 1,000 MWe nuclear power plant and that this 323,000 MWh of annual electric energy is assumed to be generated by a 45 MWe coal-fired power plant burning 118,000 MT of coal. These assumptions are based upon 1970s uranium enrichment technology, which has changed substantially since then. The older, energy-intensive gaseous-diffusion plants have been replaced with more efficient centrifuge-based systems. The current operating gas centrifuge uranium enrichment facility in the United States is URENCO-USA (Louisiana Energy Services), which is located in Eunice, New Mexico. The URENCO-USA facility does not rely solely upon coal as an energy source (Napier 2020-TN6443). If a 1,000 MWe plant is assumed to operate at 35 percent thermal efficiency and use uranium fuel enriched to 5 percent in uranium-235 (U-235) with an average burnup of 40,000 MWd/MT for 40 years, then it will require about 1,043 tons of enriched uranium for fuel. To produce 1 ton of 5 percent enriched uranium with 0.25 percent U-235 in the depleted uranium stream requires extraction of 10.3 tons of natural uranium and 7,923 separative work units, or SWUs (Napier 2020-TN6443). The 1,043 tons of uranium enriched to 5 percent U-235 required over the 40-year life of the 1,000 MWe plant would then require 8,264,000 SWUs. Because a centrifuge enrichment facility requires about 50 kWh per SWU (WNA 2020-TN6661), a total of 413,200 MWh is needed to produce 40 years' worth of uranium enriched to 5 percent U-235 for fuel for the lifetime operation of the 1,000 MWe plant. For the existing U.S. centrifuge

[44] The NRC requires most applicants, including all reactor applicants, to submit an environmental report as part of the application. 10 CFR 51.45 and 10 CFR 51.50 (10 CFR Part 51-TN250).

enrichment plant, the regional average CO_2 emission factor is 1,248 lb/MWh,[45] and the total CO_2 emission is about 243,000 MT.

Table S–3 also assumes that approximately 135,000,000 standard cubic feet (scf) of natural gas is required per year to generate process heat for certain portions of the uranium fuel cycle. The NRC staff estimates that burning 135,000,000 scf of natural gas per year results in approximately 7,440 MT of CO_2(e) being emitted into the atmosphere per year because of the process heat requirements of the uranium fuel cycle.[46] For a 40-year operational life, this is 298,000 MT of CO_2(e). This amount is in addition to the CO_2(e) emissions from the enrichment process.

The NRC staff estimated GHG emissions related to plant operations from the typical usage of various onsite diesel generators (UniStar 2007-TN1564). CO emission estimates were derived assuming an average of 600 hours of emergency diesel generator operation per year (four generators, each operating 150 hr/yr) and 200 hours of station blackout diesel generator operation per year (two generators, each operating 100 hr/yr) (Chapman et al. 2012-TN2644). A scaling factor of 172 was then applied to convert the CO emissions to CO_2 emissions, and a CO_2 to total GHG equivalency factor of 0.991 was used to account for the emissions from other GHGs such CH_4 and N_2O (Chapman et al. 2012-TN2644).

The number of shipments and shipping distances for transport of fresh nuclear fuel to and spent nuclear fuel and radioactive wastes are presented in Table S-5 of Supplement 1 to WASH-1238 [NRC 1975-TN216], for a 1,100 MWe LWR with an 80 percent capacity factor. WASH-1248 (AEC 1974-TN23) assumes that truck casks weigh 50,000 lb (23 MT) and rail casks weigh 100 T (91 MT). For this analysis, emission rates of CO_2 for trucks are taken to be 64.7 g/T-mi (44.2 g/MT-km) and for rail are taken to be 32.2 g/T-mi (22 g/MT-km) (Cefic and ECTA 2011-TN6966). For the calculation, it is also assumed that return trips with empty casks double the total miles traveled by truck or rail. Table H-3 presents estimated annual CO_2(e) emissions from shipments associated with the reference 1,000 MWe reactor.

Table H-3 Annual Number of Shipments for the Reference 1,000 MWe Reactor

Material	Annual Number of Shipments for the Reference 1,000 MWe Reactor	Typical Distance (mi)[(a)]	Annual CO_2(e) Emissions[(b)]
Unirradiated fuel (truck)	6	1,000	19
Spent fuel (truck)	60	1,000	194
Spent fuel (rail)	10	1,000	64
Radioactive waste (truck)	46	500	74

(a) Source: NRC (1975-TN216), Table S-5.
(b) Results are rounded to the nearest 1,000 MT CO_2(e)

[45] The EPA provides estimates of emissions from electricity production for different regions in the United States at https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid for CO_2 in units of pounds per kilowatt-hour (lb/kWh). The value for southeastern New Mexico has been applied here.
[46] The conversion is 0.0551 (metric tons CO_2/thousand scf) (https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references).

The total GHG emissions for fuel and waste transportation are approximately 352 MT per reference reactor-year from Table H-3. Over a 40-year operating life for the reference 1,000 MWe reactor, the total is approximately 14,000 MT of CO_2(e) emitted.

Given the various sources of GHG emissions discussed above, the NRC staff estimated the total lifetime GHG footprint for the reference 1,000 MWe reactor to be about 990,000 MT CO_2(e), with a 7-year building phase, 40 years of operation, and 10 years of active decommissioning.[47] These components of the GHG emissions footprint are summarized in Table H-4. The uranium fuel cycle component of the footprint is the largest portion of the overall estimated GHG emissions and is directly related to the assumed power generated by the plant. The GHG emission estimates for the uranium fuel cycle are based on newer enrichment technology, assuming that the energy required for enrichment is provided by modern regional electric systems.

Table H-4 Nuclear Power Plant Life-cycle GHG Footprint

Source	Activity Duration (yr)[(a)]	Total Emissions (MT CO_2(e))
Construction equipment	7	39,000
Construction workforce	7	43,000
Plant operations	40	181,000
Operations workforce	40	136,000
Uranium fuel cycle	40	540,000
Fuel and waste transportation	40	14,000
Decommissioning equipment	10	19,000
Decommissioning workforce	10	8,000
SAFe STORage workforce	40	10,000
TOTAL[(b)]		990,000

(a) Nuclear power plant life-cycle for estimating GHG is assumed to be 97 years which includes building, operating, and decommissioning.
(b) Results are rounded to the nearest 1,000 MT CO_2(e)

The Intergovernmental Panel on Climate Change (IPCC) released a special report about renewable energy sources and climate change mitigation in 2012 (IPCC 2012-TN2648). Annex II of the IPCC report includes an assessment of previously published works on life-cycle GHG emissions from various electric generation technologies, including nuclear energy. The IPCC report included only reference material that passes certain screening criteria for quality and relevance in its assessment. The IPCC screening yielded 125 estimates of nuclear energy life-cycle GHG emissions from 32 separate references. The IPCC-screened estimates of the life-cycle GHG emissions associated with nuclear energy, as shown in Table A.II.4 of the IPCC report, ranged from 1 to 220 g of CO_2(e)/kWh, with 25th percentile, 50th percentile, and 75th percentile values of 8 g CO_2(e)/kWh, 16 g CO_2(e)/kWh, and 45 g CO_2(e)/kWh, respectively. The

[47] Under the NRC's regulations, a reactor licensee has up to 60 years to complete the decommissioning of a reactor facility commencing with the licensee's certification that it has permanently ceased reactor operations (10 CFR 50.82(a)(3); TN249). The 60-year decommissioning period may be exceeded subject to NRC approval, if necessary, to protect "public health and safety." *Id*. The estimated 10-year decommissioning period is a subset of the 60-year decommissioning period, during which significant demolition and earth-moving activities may occur (e.g., deployment and operation of equipment at the decommissioning site and shipments by truck or rail to remove irradiated soil, rubble, and debris from the site), as discussed in Supplement 1 to NUREG–0586 (NRC 2002-TN665).

range of the IPCC estimates is due, in part, to assumptions regarding the type of enrichment technology employed, how the electricity used for enrichment is generated, the grade of mined uranium ore, the degree of processing and enrichment required, and the assumed operating lifetime of a nuclear power plant. The NRC staff's life-cycle GHG estimate of approximately 990,000 MT CO_2(e) for the reference 1,000 MWe reactor is equal to about 3.5 g CO_2(e)/kWh, which places the NRC staff's estimate at the lower end of the IPCC estimates in Table A.II.4 of the IPCC report. This placement is primarily because the IPCC estimates were for LWRs that used enrichment technologies that were based on the use of coal-fired generation as the electricity source.

The GHG emissions presented in Chapter 3 of this GEIS use the values presented in this appendix but are scaled based on previous new reactor reviews. The GHG emissions for building and operation (including the fuel waste and transportation of fuel and waste) are discussed in Section 3.3, and in Section 3.16 for decommissioning.

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11. ABSTRACT (200 words or less)

The U.S. Nuclear Regulatory Commission (NRC) staff prepared this generic environmental impact statement (GEIS) in accordance with the National Environmental Policy Act of 1969 (NEPA), as amended, to address the NRC licensing of the building and operation of advanced nuclear reactors (ANRs) in the United States. In this GEIS, the NRC staff uses the values and assumptions in a technology-neutral plant parameter envelope (PPE) for an ANR to evaluate the environmental impacts of constructing and operating an ANR. In addition, this GEIS assumes that a new reactor might be built anywhere in the United States that meets the requirements of the NRC's siting regulations. To accommodate this broad range of siting possibilities, the staff developed a site parameter envelope (SPE) that provides limiting values and assumptions related to the site. The purpose and need for this GEIS is to present impact analyses for the environmental issues that are common to many or most ANRs that can be addressed generically, thereby eliminating the need to repeatedly reproduce the same analyses each time a licensing application is submitted and allowing applicants and NRC staff to focus future environmental review efforts on issues that can only be resolved once a site and facility are identified. The results from this GEIS will

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