

Abstract

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3
4 This document is a supplement to the U.S. Nuclear Regulatory Commission (NRC) document
5 *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*
6 issued in 1988 (NUREG-0586, referred to here as the 1988 Generic Environmental Impact
7 Statement [GEIS]). This Supplement was prepared because of the technological advances in
8 decommissioning operations, experience gained by licensees, and changes made to NRC
9 regulations since the 1988 GEIS.

10
11 This Supplement updates the information provided in the 1988 GEIS. It is intended to be used
12 to evaluate environmental impacts during the decommissioning of nuclear power reactors as
13 residual radioactivity at the site is reduced to levels that allow for termination of the NRC
14 license. This Supplement addresses only the decommissioning of nuclear power reactors
15 licensed by the NRC. It updates the sections of the 1988 GEIS relating to pressurized water
16 reactors, boiling water reactors, and multiple reactor stations. It goes beyond the 1988 GEIS to
17 consider high-temperature gas-cooled reactors and the fast breeder reactors. This document
18 can be considered a stand-alone document such that readers should not need to refer back to
19 the 1988 GEIS. The environmental impacts described in this Supplement supersede those
20 described in the 1988 GEIS.

21
22 The scope of this Supplement is based on the decommissioning activities performed to remove
23 radioactive materials from structures, systems, and components from the time that the licensee
24 certifies that they have permanently ceased power operations until the license is terminated.
25 The scope of the document was determined through public scoping meetings and meetings
26 with other Federal agencies and the nuclear industry. An evaluation process was then
27 developed to determine environmental impacts from nuclear power reactor facilities that are
28 being decommissioned. The evaluation process involved determining the specific activities that
29 occur during reactor decommissioning and obtaining data from site visits and from licensees at
30 reactor facilities currently being decommissioned. The data obtained from the sites were
31 analyzed and then evaluated against a list of variables that defined the parameters for facilities
32 that are currently operating but which will one day be decommissioned. This evaluation
33 resulted in a range of impacts for each environmental issue that may be used for comparison
34 by licensees that are or will be decommissioning their facilities.
35

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Executive Summary

This document is a supplement to the U.S. Nuclear Regulatory Commission (NRC) document *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*, issued in 1988 (NUREG-0586, referred to here as the 1988 Generic Environmental Impact Statement [GEIS]).^(a) As a supplement, this document considers the technological advances in decommissioning, the experience gained by licensees, and the changes in NRC regulations since the 1988 GEIS. The information from the 1988 GEIS that is still current and applicable to permanently shutdown and currently operating commercial nuclear power reactors is included here. This Supplement is intended to be used to evaluate 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.

The NRC elected to supplement the GEIS:

- (1) to further the purposes of the National Environmental Policy Act (NEPA)
- (2) to update the information in the GEIS
- (3) to provide additional information to the public on decommissioning activities
- (2) to establish an envelope of environmental impacts that could be associated with decommissioning activities.

Unlike the 1988 GEIS, which took a broad look at decommissioning of a variety of sites and activities, this Supplement addresses only nuclear power reactors licensed by the NRC. It updates the sections of the 1988 GEIS relating to pressurized water reactors, boiling water reactors, and multiple reactor stations. It goes beyond the 1988 GEIS and considers the existing permanently shut down high-temperature gas-cooled reactor and the fast breeder reactor. It does not include research and test reactors or the decommissioning of reactors that have been involved in accidents. It also does not include other types of fuel-cycle facilities, such as fuel-reprocessing plants or small mixed oxide fuel-fabrication plants.

The intent of this Supplement is to consider in a comprehensive manner all aspects related to the radiological decommissioning of nuclear reactor facilities by incorporating updated information, regulations, and analyses. Since the 1988 GEIS was written, the NRC and the industry have gained substantially more nuclear power facility decommissioning experience. Based on the number of reactors shut down and the date that they permanently ceased operations, over 200 facility-years' worth of decommissioning experience have accumulated since the NRC published the 1988 GEIS. Currently, there are 19 commercial power reactors undergoing some phase of the decommissioning process. This includes nine that permanently ceased operations after the NRC published the 1988 GEIS. Since the 1988 GEIS, there are

(a) The GEIS is considered "generic" in that it evaluates environmental impacts from decommissioning activities common to a number of nuclear power facilities.

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1 three facilities that have completed decommissioning and terminated their licenses. There are
2 also new technologies and approaches applicable to decommissioning that the 1988 GEIS does
3 not address. The regulations for decommissioning reactors have also undergone significant
4 changes since the 1988 GEIS.

5 6 **Scope of the Supplement**

7
8 The content of this Supplement was initially defined by the scope of the 1988 GEIS and was
9 modified based on current decommissioning regulations, input received during four public
10 scoping meetings, letters and comments received during the scoping period, and meetings
11 between the NRC and the U.S. Environmental Protection Agency (EPA) and the Council on
12 Environmental Quality (CEQ).

13
14 The scope of this Supplement is based on the decommissioning activities performed to remove
15 radioactive materials from structures, systems, and components (SSCs) from the time that the
16 licensee certifies that they have permanently ceased power operations until the license is
17 terminated. As a result, the activities performed before permanent cessation of operations
18 (except for decommissioning planning) or impacts that are related to the decision to
19 permanently cease operations (for example, the impact from the loss of generation capacity)
20 are outside the scope of this document.

21
22 The Commission defines decommissioning as “to remove a facility or site safely from service
23 and reduce residual radioactivity to a level that permits (1) Release of the property for
24 unrestricted use and termination of the license; or (2) Release of the property under restricted
25 conditions and termination of the license.” The staff has included activities that are directly
26 related to the removal of radioactive material from the facility or that must be performed in order
27 to facilitate the removal of contaminated SSCs, as well as the activities and impacts related to
28 the removal of uncontaminated SSCs (such as the intake structure or cooling towers) that were
29 required for the operation of the reactor.

30
31 The decommissioning process continues until the licensee requests termination of the license
32 and demonstrates that radioactive material has been removed to the levels that permit
33 termination of the NRC license. At that point, the NRC no longer has jurisdiction over the site
34 and the owner of the site is no longer subject to NRC regulations. As a result, activities
35 performed after license termination and the resulting impacts are outside the scope of this
36 Supplement. These activities may include any non-NRC required monitoring, site restoration
37 (grading, planting of vegetation, etc.), continued dismantlement (removal of uncontaminated
38 structures or those that have been radiologically decontaminated), or continued use of the site
39 for activities such as power production using natural gas, oil, or coal.

40
41 Any potential radiological impacts following license termination that are related to activities
42 performed during the decommissioning period are not considered in this Supplement. Those
43 impacts are covered by the *Generic Environmental Impact Statement in Support of Rulemaking*

1 *on Radiological Criteria for License Termination of NRC-Licensed Nuclear Facilities* (NUREG-
2 1496). Nonradiological impacts following license termination that are related to activities
3 performed during the decommissioning period are considered in this Supplement.
4

5 **Levels of Significance and Applicability of Environmental Impacts**

6

7 This Supplement provides a measure of (a) the significance and severity of potential
8 environmental impacts and (b) the applicability of these impacts to a variety of plants both
9 permanently shut down and operating. The significance of the environmental impacts is
10 described as either SMALL, MODERATE or LARGE. The applicability of these impacts to a
11 variety of plants is categorized as either generic or site-specific.
12

13 Levels of Significance: The NRC's standard of significance was established using the CEQ
14 terminology for "significantly" (40 CFR 1508.27, which considers "context" and "intensity").
15 Using the CEQ terminology, the NRC established three significance levels: SMALL,
16 MODERATE, or LARGE.
17

18 SMALL - Environmental impacts are not detectable or are so minor that they will neither
19 destabilize nor noticeably alter any important attribute of the resource. For the purposes of
20 assessing radiological impacts in this Supplement, the NRC has concluded that those
21 impacts that do not exceed permissible levels in the Commission's regulations are
22 considered small.
23

24 MODERATE - Environmental impacts are sufficient to alter noticeably but not to destabilize
25 important attributes of the resource.
26

27 LARGE - Environmental impacts are clearly noticeable and are sufficient to destabilize
28 important attributes of the resource.
29

30 The discussion of each environmental issue in this Supplement includes an explanation of how
31 the significance level was determined. In determining a significance level, the NRC staff
32 assumed that ongoing mitigation measures would continue (including those mitigation
33 measures implemented during plant construction and/or operation) during decommissioning, as
34 appropriate. Benefits of additional mitigation measures during or after decommissioning are not
35 considered in determining significance levels.
36

37 Applicability: In addition to determining the significance of environmental impacts, this
38 Supplement includes a determination of whether the analysis of the environmental issues could
39 be applied to all plants, and whether additional mitigation measures would be warranted. An
40 environmental issue may be assigned to one of two categories:
41

- 42 • Generic - For each environmental issue, the analysis reported in this Supplement shows
43 the following:
44
 - 45 (1) Environmental impacts associated with the issue have been determined to apply
46 either to all plants, or for some issues to plants of a specific size, specific location or
47 having a specific type of cooling system or site characteristics, and

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1
2 (2) A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned
3 to the impacts, and
4

5 (3) Mitigation of adverse impacts associated with the issue has been considered in the
6 analysis, and it has been determined that additional plant-specific mitigation
7 measures are likely not to be sufficiently beneficial to warrant implementation.
8

- 9 • Site-specific - For each environmental issue, the analysis reported in this Supplement has
10 shown that one or more of the generic criteria was not met. Therefore, additional plant-
11 specific review is required. Examples of site-specific issues are threatened and
12 endangered species, and environmental justice.
13

14 **Use and Development of this Supplement**

15
16 This Supplement can be used by the public to understand the decommissioning process, the
17 activities performed during decommissioning, and the potential environmental impacts of these
18 activities. It identifies activities that can be bounded by a generic evaluation. Licensees can
19 rely on the information in this Supplement as a basis for meeting the requirements in 10 CFR
20 50.82(a)(6)(ii). This requirement states that the licensee must not perform any
21 decommissioning activity that causes any significant environmental impact not previously
22 reviewed. The NRC staff will also rely on this Supplement as a basis for determining if
23 anticipated decommissioning impacts require an additional review.
24

25 The staff first created an initial list of environmental issues and activities that this Supplement
26 should address. The initial list of environmental issues was developed from issues (such as air
27 quality, aquatic ecology, and radiological impacts) identified in the 1988 GEIS and in the list
28 specified in 10 CFR Part 51, Subpart A, Appendix B, for license renewal. This list was used
29 because it represents the potential impacts associated with nuclear power facilities. The initial
30 list of decommissioning activities was modified based on experience, the scoping process, site
31 visits to six facilities currently being decommissioned, and meetings with EPA and CEQ.
32

33 After compiling the issue and activity lists, the staff assessed which activities might have
34 environmental impacts for each of the issues. The next step was to identify the variables that
35 might affect the decommissioning impact for a specific issue and activity. For example, the
36 proximity of the plant to a barge slip or railroad might affect the licensee's decision to remove
37 the steam generator or other large components intact and ship them to a waste site. If the
38 barge slip needs additional dredging, or an additional railroad line needs to be installed, then
39 the environmental impacts may change.
40

41 The analyses in this Supplement include data from both operating and decommissioning
42 facilities in order to appropriately span the range of impacts that could be expected. Data from

1 decommissioning facilities was used to determine whether the potential impacts from
2 decommissioning activities for the various issues are generic or site-specific. Data from
3 operating facilities were used to ensure that this Supplement will be valid for all commercial
4 nuclear power reactors.

5 6 **Alternatives**

7
8 The alternative to the action of decommissioning is not to decommission the facility. The option
9 to restart the reactor is not considered to be an alternative to decommissioning because the
10 decision to permanently cease operation prevents the licensee from operating the reactor
11 without a significant safety and environmental review by the NRC staff.

12
13 The alternative to decommissioning at the end of the licensing period is a "no action"
14 alternative, implying that a licensee would simply abandon or leave a facility after ceasing
15 operations. NRC regulations do not allow the option of not decommissioning. Under NRC
16 regulations, the original operating license for a nuclear power plant is issued for up to 40 years.
17 The license may be renewed for an additional 20 years if NRC requirements are met. However,
18 at the end of the licensing period (whether it has been extended or not), the regulations require
19 that the facility be decommissioned. Once the facility permanently ceases operation, if the
20 licensee does not conduct decommissioning activities to an extent that meets the license
21 termination criteria in 10 CFR Part 20, Subpart E, then the license will not be terminated
22 (although the licensee will not be authorized to operate the reactor). The licensee will be
23 required to comply with the necessary requirements for the operating license. As a result, the
24 environmental impacts for maintaining the nuclear reactor facility will be considered to be in the
25 bounds of the appropriate, previously issued Environmental Impact Statements.

26 27 **Conclusions**

28
29 Table ES-1 presents each evaluated environmental issue and identifies whether the issue is
30 considered generic or site-specific. If the issue is considered generic, then it is assigned a
31 significance level of either SMALL, MODERATE or LARGE. Of the environmental issues
32 assessed, most of the impacts are generic and SMALL for all plants regardless of the activities
33 and identified variables (see Appendix E for a list of the variables). The two issues determined
34 to be site-specific are threatened and endangered species and environmental justice. Four
35 additional issues are conditionally site-specific. Land use activities requiring major
36 transportation upgrades, aquatic and terrestrial ecology, and cultural and historic resources are
37 site-specific for activities occurring outside the disturbed areas in which there is no recent
38 environmental assessment.

39
40 Licensees undergoing or planning decommissioning of a commercial nuclear power reactor can
41 use this Supplement in support of their evaluation of the environmental consequences from
42 decommissioning. The impacts identified in this Supplement are designed to span the range of
43 impacts from all plants that are currently permanently shutdown as well as the plants that are
44 currently operating, including the plants that have or may renew their licenses beyond the
45 original 40-year license; a renewed license can be issued for a period not to exceed 20 years

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1 beyond the expiration of the operating license. When planning a specific decommissioning
2 activity, licensees that fall within the bounds of the impacts, as described in Chapter 4, may
3 proceed with the activity with no further analysis. However, if a site falls outside the bounds of
4 the identified environmental impacts, then the activity cannot be performed until the licensee
5 performs a site-specific analysis of the activity. Depending on the results of the site-specific
6 evaluation, the staff may determine that it is appropriate to consult with another agency (such
7 as the U.S. Fish and Wildlife Service or a State Historic Preservation Office). If the activity
8 would result in an impact that is outside the bounds of the GEIS or other environmental
9 assessments, the licensee would be required to submit a license-amendment request.

Table ES-1. Summary of the Environmental Impacts from Decommissioning Nuclear Power Facilities

	Issue	Generic	Impact
5	Onsite/Offsite Land Use		
6	- onsite land use activities	Yes	SMALL
7	- offsite land use activities	Yes	SMALL
8	- offsite activities that require major transportation upgrades	No	Site-specific
9	Water Use	Yes	SMALL
10	Water Quality		
11	- Surface water	Yes	SMALL
12	- Groundwater	Yes	SMALL
13	Air Quality	Yes	SMALL
14	Aquatic Ecology		
15	- Activities within the boundaries of previously disturbed areas or outside the disturbed areas with a current ecological assessment	Yes	SMALL
17	- Activities outside the boundaries of previously disturbed areas and no recent ecological assessment	No	Site-specific
19	Terrestrial Ecology		
20	- Activities within the boundaries of previously disturbed areas or outside the disturbed areas with a current ecological assessment	Yes	SMALL
22	- Activities outside the boundaries of previously disturbed areas and no recent ecological assessment	No	Site-specific
24	Threatened and Endangered Species	No	Site-specific
25	Radiological		
26	- Activities resulting in occupational dose to workers	Yes	SMALL
27	- Activities resulting in dose to the public	Yes	SMALL
28	Radiological Accidents	Yes	SMALL, or MODERATE, or LARGE
29	Occupational Issues		
30	- Noise, temperature, ergonomic, and biological hazards	Yes	SMALL
31	- Physical hazards from construction activities, electrical shock, and accidental falls	Yes	MODERATE
32	Cost	NA ^(a)	NA
33	Socioeconomic		
34	- Population change <3%	Yes	SMALL
35	- Population change between 3% and 5%	Yes	MODERATE
36	- Population change >5%	Yes	LARGE
37	- Annual tax revenue loss <10%	Yes	SMALL
38	- Annual tax revenue loss between 10% and 20%	Yes	MODERATE
39	- Annual tax revenue loss >20%	Yes	LARGE
40	Environmental Justice	No	Site-specific

Executive Summary

Table ES-1. (contd)

Issue	Generic	Impact
Cultural and Historic Resource Impacts		
- Activities within the boundaries of previously disturbed areas or activities outside the boundaries of previously disturbed areas with a current cultural resource survey available	Yes	SMALL
- Activities outside the boundaries of previously disturbed areas with no current cultural resource assessment	No	Site-specific
Aesthetics	Yes	SMALL
Noise	Yes	SMALL
Transportation	Yes	SMALL
Irretrievable Resources	Yes	SMALL
(a) A decommissioning cost assessment is not a specific National Environmental Policy Act (NEPA) requirement. However, an accurate decommissioning cost estimate is necessary for a safe and timely plant decommissioning. Therefore, this Supplement includes a decommissioning cost evaluation, but the cost is not evaluated using the environmental significance levels nor identified as a generic or site-specific issue.		

Abbreviations/Acronyms

1		
2		
3		
4	μGy	microGray(s)
5	μSv	microSieverts
6		
7	ac	acre(s)
8	AEA	Atomic Energy Act of 1954
9	AEC	U.S. Atomic Energy Commission
10	ALI	annual limits on intake
11	ALARA	as low as reasonably achievable
12	ANPR	advanced notice of proposed rulemaking
13		
14	BLM	Bureau of Land Management
15	Bq	Bequerel(s)
16	BWR	boiling water reactor
17		
18	C	Celsius
19	CAA	Clean Air Act
20	CDE	committed dose equivalent
21	CEDE	committed effective dose equivalent
22	CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
23	CEQ	Council on Environmental Quality
24	CFR	Code of Federal Regulations
25	Ci	Curie
26	CWA	Clean Water Act
27		
28	DAC	derived air concentration
29	dBA	decibel
30	DBA	design-basis accident
31	DDREF	dose or dose rate effectiveness factor
32	DE	dose equivalent
33	DNL	day-night average sound level
34	DOE	U.S. Department of Energy
35	DOT	U.S. Department of Transportation
36		
37	EA	environmental assessment
38	EDE	effective dose equivalent
39	EIS	environmental impact statement
40	EJ	environmental justice

Abbreviations/Acronyms

1	EPA	U.S. Environmental Protection Agency
2	ER	environmental report
3	ESA	Endangered Species Act of 1973
4	ES&H	environment, safety and health
5		
6	F	Fahrenheit
7	FBR	fast breeder reactor
8	FES	final environmental statement
9	FHA	Federal Housing Administration
10	FR	Federal Register
11	FSAR	final safety analysis report
12	ft	foot/feet
13	FWPCA	Federal Water Pollution Control Act (also known as the Clean Water Act of
14		1977)
15	FWS	U.S. Fish and Wildlife Service
16		
17	gal.	gallon(s)
18	GEIS	Generic Environmental Impact Statement
19	gpd	gallons per day
20	gpm	gallons per minute
21	GTCC	Greater than Class C (waste)
22	Gy	gray(s)
23		
24	ha	hectare(s)
25	HDA	high decommissioning activity
26	HEPA	high-efficiency particulate air filter
27	HLW	high-level waste
28	h	hour
29	HTGR	high-temperature gas-cooled reactor
30	HUD	U.S. Department of Housing and Urban Development
31	HVAC	heating, ventilation, and air conditioning
32		
33	IAEA	International Atomic Energy Agency
34	in.	inch(es)
35	I&C	instrumentation and control
36	ICRP	International Commission on Radiological Protection
37	ISFSI	independent spent fuel storage installation
38		
39		

Abbreviations/Acronyms

1	kg	kilogram(s)
2	km	kilometer(s)
3	kV	kilovolt(s)
4	kWh	kilowatt hour(s)
5		
6	L	liter(s)
7	LDA	low-decommissioning activity
8	LER	license event report
9	LET	linear energy transfer
10	LLW	low-level waste
11	LOS	level of service
12	LRA	license renewal application
13	LTP	license termination plan
14	LWR	light water reactor
15		
16	m	meter(s)
17	m ³ /d	cubic meters per day
18	m ³ /s	cubic meters per second
19	MARSSIM	Multi-agency Radiation Survey and Site Investigation Manual, NUREG-1575
20	MBTA	Migratory Bird Treaty Act of 1918
21	mi	mile(s)
22	mGy	milliGray(s)
23	MPC	maximum permissible concentrations
24	mrad	millirad(s)
25	mrem	millirem(s)
26	mSv	milliSievert(s)
27	MTBA	Migrating Bird Treaty Act of 1918
28	MTHM	metric tonnes of heavy metal
29	MT	metric ton(s) (or tonne[s])
30	MTU	metric ton(s)-uranium
31	MW	megawatt(s)
32	MWd/MTU	megawatt-days per metric ton of uranium
33	MW(e)	megawatt(s) electric
34	MW(t)	megawatt(s) thermal
35	MWh	megawatt hour(s)
36		
37	NA	not applicable
38	NAS	National Academy of Sciences
39	NBS	National Bureau of Standards
40	NCRP	National Council on Radiation Protection and Measurements

Abbreviations/Acronyms

1	NEI	Nuclear Energy Institute
2	NEPA	National Environmental Policy Act of 1969
3	NHPA	National Historic Preservation Act
4	NIST	National Institute of Standards and Technology
5	NMFS	National Marine Fisheries Service
6	NO _x	nitrogen oxide(s)
7	NPDES	National Pollutant Discharge Elimination System
8	NRC	U.S. Nuclear Regulatory Commission
9	NRR	Nuclear Reactor Regulation
10	NWPA	Nuclear Waste Policy Act of 1982
11		
12	ODCM	Offsite Dose Calculation Manual
13	OSHA	Occupational Safety and Health Administration
14		
15	PAG	protective action guide
16	PCBs	polychlorobiphenyls
17	PEL	permissible exposure limit
18	POL	possession-only license
19	PPE	personal protective equipment
20	PSDAR	post-shutdown decommissioning activities report
21	PV	pressure vessel
22	PWR	pressurized water reactor
23		
24	QA/QC	quality assurance/quality control
25		
26	RCRA	Resource Conservation and Recovery Act
27	RCS	reactor coolant system
28	ROW	rights of way
29	RPV	reactor pressure vessel
30		
31	SARA	Superfund Amendments and Reauthorization Act
32	SHPO	State Historic Preservation Officer
33	SI	Systeme Internationale (international system of units)
34	SO ₂	sulfur dioxide
35	SO _x	sulfur oxide(s)
36	SSCs	structures, systems, and components
37	Sv	sievert(s)
38		
39	TEDE	total effective dose equivalent
40	THPO	Tribal Historic Preservation Officer

Abbreviations/Acronyms

1	UNSCEAR	United Nations Scientific Committee on The Effects of Atomic Radiation
2	USC	United States Code
3	USFWS	U.S. Fish and Wildlife Service
4		
5	VOC	volatile organic compound
6	VRM	Visual Resource Management (system)
7		
8	wk	week(s)
9		
10	YNPS	Yankee Nuclear Power Station
11	yr	year(s) ^o