4.0 Environmental Impacts of Decommissioning Permanently Shutdown Nuclear Power Reactors

This section discusses the environmental impacts of decommissioning permanently shutdown nuclear power reactor facilities. Section 4.1 defines the terms used to describe environmental impacts of decommissioning activities. Section 4.2 briefly describes the process that was used to identify the environmental impacts based on the decommissioning activities. The environmental impacts, including the staff's conclusions, are discussed in Section 4.3.

4.1 Definition of Environmental Impact Standards

This Supplement provides a measure of (1) the significance and severity of potential environmental impacts and (2) the applicability of these decommissioning impacts to a variety of facilities, both permanently shutdown and operating. The significance of each environmental impact is described as SMALL, MODERATE, or LARGE. The applicability of these impacts to a class of plants or site characteristics is categorized as either generic or site-specific. The following defines the significance and applicability terms used in the Chapter 4 analyses.

4.1.1 Terms of Significance of Impacts

The U.S. Nuclear Regulatory Commission's (NRC's) standard of significance was established using the Council on Environmental Quality (CEQ) terminology for "significantly"[(a)] (40 CFR 1508.27, which considers "context" and "intensity"). Using the CEQ terminology, the NRC established three significance levels: SMALL, MODERATE, and LARGE.

> SMALL – Environmental impacts 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 in this Supplement, the NRC has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small.

(a) The National Environmental Policy Act of 1969 (NEPA) requires consideration of both *context* and *intensity* when determining the significance of an environmental impact. **Context** means that the significance of an action must be analyzed in several contexts, such as society as a whole (human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of the proposed action. **Intensity** refers to the severity of the impact and depends on many different factors, such as the unique characteristics of the site and the degree to which the proposed action affects public health or safety or may establish a precedent.

MODERATE – Environmental impacts are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.

LARGE – Environmental impacts are clearly noticeable and are sufficient to destabilize important attributes of the resource.

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

4.1.2 Terms of Applicability of Impacts

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

- Generic – For each issue, the analysis reported in this Supplement shows the following:

  (a) Environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues to plants of a specific size, a specific location, or having a specific type of cooling system or site characteristics, and

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

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

- Site-specific – For each issue, the analysis reported in this Supplement has shown that one or more of the generic criteria was not met. Therefore, additional plant-specific review is required. An example of a site-specific issue is threatened and endangered species.

4.2 Evaluation Process

This section briefly describes the process that the staff used to determine the environmental impacts from decommissioning nuclear power facilities. For a detailed description of this process see Appendix E, "Evaluation Process for Identifying the Environmental Impacts of Decommissioning Activities." Figure 4-1 is a flowchart showing the evaluation process. Figure 4-1 begins with identifying the specific activities that occur during decommissioning and then determining if the activities affect any of the identified environmental issues. The environmental issues analyzed by the staff are the following: onsite/offsite land use, water use, water quality, air quality, aquatic ecology, terrestrial ecology, threatened and endangered species, radiological, radiological accidents, occupational issues, cost, socioeconomics, environmental justice, cultural impacts, aesthetic issues, noise, transportation, and irretrievable resources. The staff used the data obtained from previous studies and environmental reviews, site visits, information provided from the decommissioning plants, and information from currently operating nuclear power facilities to analyze each issue. After analyzing each issue, the staff determined the nature of the impact (site-specific or generic) and the significance level of the environmental impact (SMALL, MODERATE, or LARGE). This evaluation resulted in a range of impacts for each issue that may be used for comparison by licensees that are or will be decommissioning their facilities.

4.3 Environmental Impacts from Nuclear Power Facility Decommissioning

The following sections are organized by issue and discuss environmental impacts. Each section has four parts:

(1) Regulations – Identify statutes, regulations, or limits relevant to this issue.

(2) Potential impacts from decommissioning activities - Discuss possible impacts related to the issue expected, based on data and experience at decommissioning plants.

(3) Results of evaluation – Taking variability among operating plants into account, determine which decommissioning activities relate to the issue.

(4) Conclusion – Provide the staff's conclusion on significance (SMALL, MODERATE, LARGE) and applicability (generic or site-specific) of impacts to the issue.

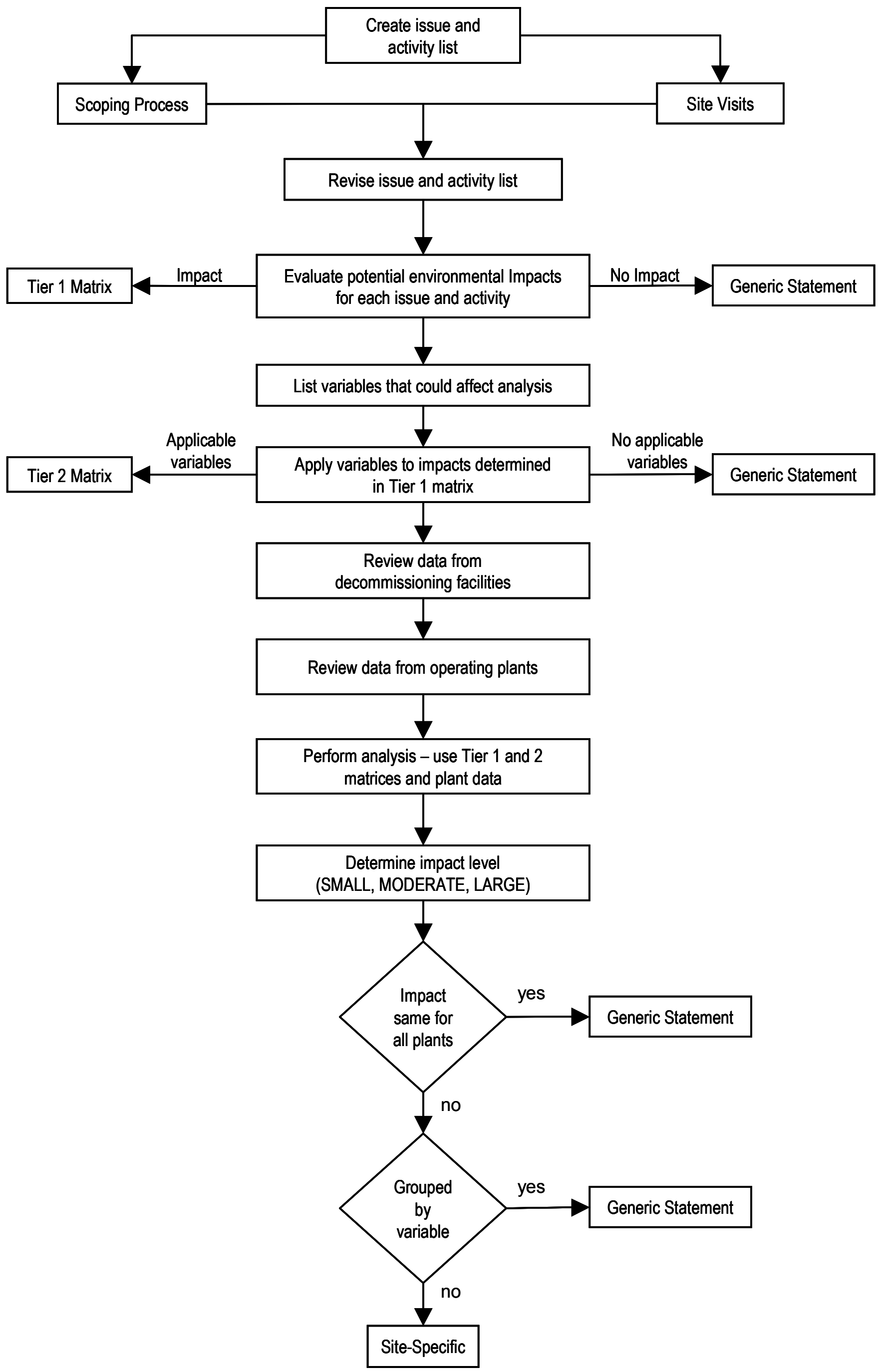

Figure 4-1. Environmental Impact Evaluation Process

The conclusions from this chapter are summarized in two tables in Appendix H. Table H-1 provides a list of decommissioning activities that have been determined to have no environmental impacts. These activities can be performed by licensees without further analysis. Table H-2 provides a comprehensive summary of the decommissioning activities and associated environmental issues that have been determined by the staff to have potential environmental impacts. Providing they fall within the range of the impacts identified, these activities can be performed with no further analysis by the licensee.

4.3.1 Onsite/Offsite Land Use

Nuclear power facilities are large physical entities, of which 20 to 40 ha (50 to 100 ac) may actually be disturbed during plant construction. Other land commitments can amount to many thousands of hectares for transmission line rights-of-way (ROWs) and cooling lakes.

4.3.1.1 Regulations

Nuclear power facilities that began initial operation after the promulgation of the National Environmental Policy Act of 1969 (NEPA) or the Endangered Species Act of 1973 (ESA) are sited and operate in compliance with these statutes. Any modifications to the facilities after the effective dates of these acts and others (see Appendix L-2) must be in compliance with the requirements of these statutes. The ESA applies to both terrestrial and aquatic biota. The individual States may also have requirements regarding threatened and endangered species; the State-listed species may vary from those on the Federal lists. In addition, activities such as decommissioning must take into account and avoid disturbance of historical and archeological sites and American Indian grave sites.

4.3.1.2 Potential Impacts of Decommissioning Activities on Land Use

Currently operating nuclear power facilities' site areas range from 34 ha (84 ac) for the San Onofre Nuclear Generating Station in California to 12,000 ha (30,000 ac) for the McGuire Nuclear Station in North Carolina. According to NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (NRC 1996), 28 site areas range from 200 to 400 ha (500 to 1000 ac), with an additional 12 sites ranging from 400 to 800 ha (1000 to 2000 ac). Thus, almost 60 percent of the plant sites encompass 200 to 800 ha (500 to 2000 ac). Larger land-use areas are associated with plant cooling systems that include reservoirs, artificial lakes, and buffer areas.

The nuclear reactor facilities currently being decommissioned are predominantly on the smaller sites, primarily because the older, smaller reactors have already permanently ceased operations. Only 6 out of 21 sites (29 percent) were between 400 and 800 ha (100 to 2000 ac);

6 (29 percent) were larger than 800 ha (2000 ac), and the rest (43 percent) were smaller than 400 ha (1000 ac) (see also Appendix F).

Farming and other types of land use occur on some nuclear reactor facility sites. Some utilities have designated portions of their sites for land uses such as recreation, management of natural areas, and wildlife conservation.

Changes in onsite land use at a nuclear reactor facility site could result from decommissioning because land in excess of what is used during construction and operation may be needed to conduct decommissioning. This can include staging and laydown areas not previously disturbed during the construction and operations periods. Some licensees have found it necessary to build temporary buildings and parking areas for the decommissioning work force.

The need for land for some activities is affected by the site layout. Most sites have areas where sufficient area exists within the previously disturbed area (whether during construction or operation of the site) and, therefore, no additional land needs to be disturbed. The major activities projected to occur for decommissioning are expected to require temporary land use for activities such as staging of equipment and removal of large components. In addition, the large number of temporary workers needed to accomplish the major decommissioning activities may require that temporary facilities be installed for onsite parking, training, site security access, office space, change areas, fabrication shops, mockups, and related needs. Land away from the plant site may be disturbed to upgrade or install new transportation systems. For example, a new rail line may be needed to support removal and transport of large components.

The magnitude of change to offsite land use would be considered SMALL if very little new development and minimal changes to an area’s land use pattern result. MODERATE change would result if considerable new development and some changes to the land use pattern occur. The magnitude of change would be LARGE if large-scale new development of previously undisturbed land along with a major change in the land use pattern occurred.

4.3.1.3 Results of Evaluation

Large component removal is similar in its land requirements to major component replacement activities such as steam generator replacement and refurbishment activities. Based on previous experience with steam generator replacement at a pressurized water reactor (PWR), it was estimated in NUREG-1437 that ~1 to 4 ha (~2.5 to 10 ac) of land may be needed to accommodate laydown, staging, handling, temporary storage, personnel processing, mockup and training, and related needs. The impacts of steam generator or other major component removal during decommissioning should be similar or less. Generally, this land has been previously disturbed during the construction of the facility. Once the major decommissioning activities are completed, this land might be returned to its prior uses.

Almost all of the sites currently undergoing active decommissioning are using areas previously disturbed during construction for decommissioning. There do not appear to be any significant differences in land use between plants using SAFSTOR or DECON options. Land requirement for decommissioning activities appear to be well within the range of land requirements for activities during major outages that occur in the course of normal operations. There is no experience with either ENTOMB option with commercial power reactors although there is some experience with former U.S. Department of Energy (DOE) scientific and nuclear materials production reactors. Because of the potential need for large amounts of concrete and aggregate for ENTOMB2, it is possible that a concrete batching plant might be set up onsite. There might not be adequate room within the previously disturbed areas at some of the sites for such a facility, but it is likely that the impact of such a disturbance would be temporary and SMALL. Smaller amounts of concrete and aggregate would likely be required for the ENTOMB1 option. Many of the facilities currently being decommissioned are relatively small reactors and located on small areas of land. However, a comparison of the land use needs with the larger reactors currently being decommissioned shows that many of the activities require the same amount of land for reactors, whether small or large. It does not appear that land use will be significantly greater for future decommissionings. Previous or anticipated decommissioning activities at the fast breeder reactor (FBR) or high temperature gas cooled reactor (HTGR) have not and are not expected to result in onsite or offsite land use impacts that are different from those found at other nuclear reactor facilities. There has been limited experience with multi-unit sites. Decommissioning of multiple-plant sites may be able to economize on space by reusing laydown areas.

4.3.1.4 Conclusions

There will be little or no increase in land disturbance for future decommissioning of commercial reactors using the DECON and SAFSTOR options. The ENTOMB options may require additional land for a concrete batching plant, but in most cases the increased land use for this activity will be SMALL.

It is rare for decommissioning activities to affect offsite land use, and most of these will be SMALL unless major upgrades to transportation links are required. It may be necessary to establish or re-establish road, rail, or water transportation links into the site for the purpose of bringing in equipment (especially large equipment), removing large components, and shipping offsite certain chemicals, waste concrete and metal, or other materials created, contaminated, or used in the decontamination and dismantlement processes. In such cases, offsite land use impacts may be MODERATE or LARGE and site-specific.

The staff concludes that the issue of onsite and offsite land use for all decommissioning activities is generic and that the environmental impacts for these activities will be SMALL unless major transportation upgrades are necessary in which case a site specific analysis would be required.

4.3.2 Water Use

Throughout the United States, increasing demand for reliable, clean water has made water resources a growing public concern. Nuclear reactor facilities are often located adjacent to significant water bodies (a river, lake, or ocean) that are very important to the region. Often, nuclear reactor facilities use water from multiple sources. For example, water from an adjacent lake might provide cooling water, whereas makeup water may come from a groundwater well located onsite. Conflicts over each type of water source must be considered independently.

4.3.2.1 Regulations

Water usage at nuclear reactor facilities must comply with State and local regulations. Most States require permits for surface water usage. Groundwater usage regulations vary considerably from State to State, and permits are typically required.

4.3.2.2 Potential Impacts of Decommissioning Activities on Water Use

In general, the impact of a nuclear reactor facility on water resources decreases considerably after the plant has ceased to operate. The flow through the condenser of an operating plant can range from 3 to 78 m^3/s (49,000 to 1,200,000 gpm) (NRC 1996), depending upon the size of the plant and source of cooling water. This operational demand for water (cooling water and makeup water) is largely eliminated after the facility permanently ceases operation. As the plant staff is decreased, the demand for potable water also generally decreases. However, in a few cases staffing levels have temporarily increased above the levels that were common for routine operations. For these short periods of time, commonly during the early stages of decontamination and dismantlement activities, there may be a slight increase in demand for potable water.

Most of the impacts to water resources likely to occur during decommissioning of a nuclear facility are also typical of the impacts that would occur during decommissioning of a large industrial facility. For example, providing water for dust abatement is a concern for any large construction project, as is potable water usage. However, the quantities of water required are trivial compared to the quantity used during operations.

However, there are also some activities affecting water resources at decommissioning nuclear facilities that are different from other industrial non-nuclear facilities. The demand for water for spent fuel maintenance (approximately 200 to 2020 L [50 to 500 gal.] of water per day depending on the size and location of the pool) and wet decontamination methods (such as a full flush of the primary system or hydrolasing embedded piping in place), although not a large demand, are unique to nuclear facilities. One facility reported using approximately 9500 to 11,000 L (2500 to 3000 gal.) of water per day for spent fuel pool spray cooling during the summer months. Additionally, water in some systems or piping may continue to be used during decontamination and dismantlement to provide shielding from radiation to workers who are dismantling structures, systems, and components (SSCs) in the vicinity. For example, one site indicated that they used 912,000 L (240,000 gal.) of water to fill the reactor cavity in preparation for the segmentation of the reactor vessel.

Dewatering systems may have to remain active during decommissioning a nuclear facility to control the water pathway for the release of radioactive material. Several common engineering practices to limit water use impacts in other construction activities (e.g., water reuse) may be used to reduce dose exposure.

For a nuclear facility undergoing decommissioning, a SMALL impact level would be appropriate in cases where environmental effects of water usage are not detectable or would not noticeably alter any important attribute of the resource (the groundwater or surface water reservoir). MODERATE impacts would occur if the withdrawal of water noticeably altered but did not destabilize the surface water or groundwater source. LARGE impacts would occur if the water withdrawals were clearly noticeable and also destabilized the surface water or groundwater source.

4.3.2.3 Results of Evaluation

Water use at decommissioning nuclear reactor facilities is significantly smaller than that used during operation. The water use will be greater in facilities that are undergoing decontamination and dismantlement than those that are in storage phase of the option. During ENTOMB, water will be required as the concrete for entombment is mixed and poured. Greater amounts of water would be needed for the ENTOMB2 option than ENTOMB1. However, in both cases, this process would be of short duration and would not consume quantities of water in excess of those used in the construction of large buildings.

Previous or anticipated decommissioning activities at the FBR or HTGR have not and are not expected to result in water use impacts that are different from those found at other nuclear reactor facilities.

4.3.2.4 Conclusions

The overall water use of a nuclear facility will dramatically decrease once the reactor has stopped operating and the demand for cooling and makeup water ceases. However, demand from some individual sources of water may increase or remain the same. For example, potable water demand from a nearby municipal water supply might temporarily increase or remain nearly the same during certain phases or times of major decontamination or dismantlement activities. Only a few activities in the decommissioning process with impacts to water supply are unique to nuclear facilities (e.g., full flush decontamination). For example, standard water reuse options may be limited by dose concerns. Most activities with water use impacts are standard in the construction or demolition of any large industrial facility (e.g., dust control and potable water). Standard engineering practices provide a variety of options to limit and mitigate water use impacts.

The staff concludes that the issue of water use for all decommissioning activities is generic and that the environmental impacts for these activities will be SMALL.

4.3.3 Water Quality

Because nuclear reactor facilities are often located adjacent to water bodies or overlay aquifers that are important sources of water, intended and unintended liquid releases may impact the quality of sources of water. Each of these water bodies may provide a pathway to other water bodies. This section considers water quality impacts of nonradioactive liquid effluents discharged from nuclear power facilities. Impacts from the discharge of radioactive material in liquid effluents is discussed in Section 4.3.8, “Radiological.”

4.3.3.1 Regulations

Intentional discharges that result in changes in water quality are regulated to protect the quality of the water resource. Compliance with environmental quality standards and requirements of the Clean Water Act (CWA) is not a substitute for and does not negate the requirement for the NRC to consider the environmental impacts of a proposed action on the quality of water and to consider alternatives to a proposed action or methods of mitigating the action that reduce the adverse impacts. This position is based on an October 1978 decision by the Atomic Safety and Licensing Board. The Licensing Board sanctioned a Limited Work Authorization (see 10 CFR 50.10(e)) for the Tennessee Valley Authority’s Yellow Creek facility (7 NRC 215 [1978]). In that partial initial decision, subsequently upheld by the Atomic Safety and Licensing Appeal Board (8 NRC 702 [1978]), the Licensing Board held that the NRC authority does not extend to matters within the jurisdiction of the U.S. Environmental Protection Agency (EPA). More specifically, the NRC authority is limited for those matters expressly assigned to the EPA by the Federal Water Pollution Control Act Amendments of 1972. According to the Appeal Board, “The role of the NRC is one of factoring anticipated water pollution into its NEPA benefit-cost balance analyses on proposed nuclear plants.”

This decision would also apply to decommissioning nuclear reactor facilities. If an environmental assessment of aquatic impacts is available from the permitting authority, the NRC will consider the assessment in its determination of the magnitude of the environmental impacts. When no such assessment of aquatic impacts is available from the permitting authority, the

NRC (possibly in conjunction with the permitting authority and other agencies having relevant expertise) should establish its own impact determination, which is described here.

Intentional releases of nonradiological discharges are regulated through the National Pollutant Discharge Elimination System (NPDES) permitting process to protect water quality. Any nuclear reactor facility decommissioning will be required to comply within the limits of the NPDES permit. The discharge limits during decommissioning are generally the same limits that are enforced for an operating plant. The NPDES permitting agency may require a monitoring program.

4.3.3.2 Potential Impacts of Decommissioning Activities on Water Quality

Liquid releases to surface waters are tested by licensees before the release to ensure that they are below the regulated NPDES permit levels. The water quality monitoring programs are also required to detect unintended discharges during operations and these monitoring programs are usually continued through the decommissioning period. While discharges to the surface water can be detected quickly due to the rapid transport in surface water, the slow transport rates in groundwater mean that discharges to the subsurface may take many years to detect.

Because water quality and water supply are interdependent, changes in water quality must be considered simultaneously with changes in water supply. For example, reduced groundwater pumpage may result in a rise in the water table, providing a new pathway for contaminants currently in the subsurface. Changes in the landscape (terrain and vegetation) during decommissioning can alter the hydrologic patterns of recharge and surface water runoff. The convergence of surface water runoff over unvegetated soils may result in accelerated erosion and the delivery of sediment to important downstream habitat. Changes to the landscape during decommissioning, combined with the natural climatic variability could potentially impact the hydrology unless standard “good practices” are used to control stormwater discharges.

This would be less of an issue for entombment of the facility, where the plant’s contaminated SSCs are encased in concrete and maintained as a solid structure isolated from the environment.

Nonradiological impacts to surface water quality can be considered to be SMALL as long as they are within the guidelines specified by the facility’s NPDES permit for releases.

4.3.3.3 Results of Evaluation

Both the activities themselves and the order in which the activities are performed must be considered in assessing the impacts of decommissioning on water resources. The same activities performed in a different order can have a significantly different impact on water quality. The time between activities may also be important in assessing impacts. Delaying activities occuring in the SAFSTOR option may exacerbate water quality issues. For example, the ongoing aging of structures may create new pathways for groundwater to enter contaminated subgrade structures.

Certain decommissioning activities or options may result in changes in local water chemistry. For example, if licensees dismantle structures by rubbilizing and disposing of the concrete rubble on the site, then there is a potential that the hydration of concrete could cause an increase in alkalinity of water. The pH of interstitial (pore) water very close to the concrete rubble would remain above 10.5 for several hundred thousand years (Krupa and Serne 1988). However, as the leachate migrates away from the rubble, it is reasonable to expect the leachate pH to be rapidly reduced to natural conditions due to the large buffering capacity of soils. While the leachate's pH may not be a water quality concern, such leachate may affect the transport properties of radioactive and nonradioactive chemicals in the subsurface.

Historically, such unintentional releases of hazardous substances have been an infrequent occurrence at decommissioning facilities. Because the focus of decommissioning is the ultimate cleanup of the facility, considerable attention is placed on minimizing spills. Except for a few substances, such as hydrocarbons (diesel fuel), such hazardous spills are localized, quickly detected, and relatively easy to remediate. Relevant regulations are listed in Appendix L. The license termination plan (LTP) submitted by the licensee to the NRC will specify a final site survey for radionuclides. Some of the groundwater parameters measured in the LTP (such as pH) might also be indicators of a heretofore undetected nonradiological subsurface plume. If such indications were observed, further characterization and corrective actions would be dictated by the relevant regulations discussed in Appendix L, and permits, if appropriate.

Current or anticipated decommissioning activities at the FBR or HTGR have not and are not expected to result in water quality impacts that are different from those found at other nuclear reactor facilities.

4.3.3.4 Conclusions

The releases to surface and groundwater are expected to be within the guidelines specified by the facility's NPDES permit. The staff concludes that the issue of surface or groundwater quality for all decommissioning activities is generic and that the environmental impacts for these activities will be SMALL.

4.3.4 Air Quality

Decommissioning activities have the potential to adversely impact air quality. The activities may be direct, such as demolition of buildings, or indirect, such as from emissions from decommissioning workers' vehicles. This section discusses the non-radiological impacts of decommissioning on air quality. Radiological impacts on air quality are addressed in Section 4.3.8.

4.3.4.1 Regulations

The purpose of the Clean Air Act (CAA), as amended (42 USC 7401 et seq.) is 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.” Section 118 of the CAA, as amended, requires that each Federal agency, such as NRC, with jurisdiction over any property or facility that might result in the discharge of air pollutants, comply with “all Federal, state, interstate, and local requirements” with regard to the control and abatement of air pollution. Pursuant to the Act, the EPA established National Ambient Air Quality Standards to protect public health, with an adequate margin of safety, from known or anticipated adverse effects of regulated pollutants (42 USC 7409). Hazardous air pollutants and radionuclides are regulated separately (42 USC 7412). In addition, State and local agencies have developed and enforce a variety of air quality regulations. These regulations require permits for emission sources, limit emission rates, and set maximum atmospheric concentrations for pollutants. Finally, different regulations apply to indoor air quality and worker safety. Licensees must be aware of these regulations and abide by them.

4.3.4.2 Potential Impacts of Decommissioning Activities on Air Quality

Decommissioning activities that have the potential to have nonradiological impact on air quality include

- emissions from workers’ vehicles
- dismantling systems and removing equipment
- movement and open storage of material onsite
- demolition of structures and buildings and
- emissions from shipment of material and debris to offsite locations.

These activities will typically take place over a period of years from the time the facility ceases operation until the decommissioning is complete and the license is terminated. The magnitude and the timing of the potential impacts of each activity will vary from plant to plant, depending on the decommissioning options selected by the licensee and the status of facilities and structures at the time of license termination.

Environmental Impacts

Experience with decommissioning indicates that for most sites the onsite work force tends to decrease from the time that plants cease operation until decommissioning is complete. There are occasional increases during specific decontamination and dismantlement activities. However, the work force numbers during decommissioning are well below numbers of the construction work force and the work force during refueling outages, and almost always less than the work force during facility operation. As a result, emissions from workers' vehicles should be lower during the decommissioning period than during plant construction or outages and usually lower than during plant operations.

Most decommissioning activities will be conducted inside the containment, auxiliary, and fuel handling buildings. These buildings have systems to minimize airborne contamination, such as whole building filtration and monitored release points. These systems are typically maintained and periodically operated during decommissioning and will reduce the impact of nonradiological airborne contaminants. The predominant potential effluent from system dismantling and removal of equipment will be particulate matter and fugitive dust. This material will generally be released within and remain within buildings and other structures. Special precautions are required for worker protection where hazardous materials such as asbestos may become airborne, as discussed in Section 4.3.10, "Occupational Issues." In addition, building air is filtered as needed prior to being exhausted to the environment. Therefore, materials released when systems are dismantled and equipment is removed are not likely to be released to the environment in significant quantities. Often, special air ventilation pathways are established before the start of a SAFSTOR period to ensure that air ventilates from the building through high efficiency particulate air (HEPA) filters. Monitoring of air quality occurs during periods of both decontamination and dismantlement and storage.

Movement of equipment outside of the buildings has the potential to generate fugitive dust. If fugitive dust is a problem, it is likely that the problem will be confined to the immediate vicinity of the equipment and mitigation measures will be taken to minimize dust. Demolition of buildings and major structures, including rubblization, may result in a temporary increase in fugitive dust emissions from the site. However, in general, the dust emissions will be limited to a small number of events and will be of relatively short duration. Mitigation measures will also be used to minimize dust. Impacts associated with fugitive dust will be significantly less than experienced during plant construction.

Dismantled equipment, material, and debris from the decommissioning process are typically removed from the site as decommissioning progresses. The number of shipments required during the decommissioning period depends on the method of transportation and the decomm-issioning option used. Although the number of shipments required may be relatively large, the decommissioning period extends over several years. As a result, the number of shipments per day is small. Current experience indicates that there is an average of less than one shipment per day of low-level waste (LLW) from the plant (see Section 4.3.17, "Transportation"). Although other material is shipped to and from the facility, in most cases the number of ship-ments will be small compared to those for LLW. Consequently, emissions associated with the transportation of material from the plant (carbon monoxide, oxides of nitrogen, volatile organic compounds, and particulate matter) are not expected to have a significant impact on air quality.

Air quality impacts are considered SMALL if they are not noticeable offsite and if best-management practices can be easily employed to mitigate the impacts. Impacts would be MODERATE if the air quality impacts are noticeable but still able to be mitigated. Air quality impacts would be LARGE if they are noticeable and cannot easily be mitigated.

4.3.4.3 Results of Evaluation

A number of activities associated with decommissioning may adversely impact air quality. However, the adverse impacts are expected to be minor and of short duration.

Fugitive dust is likely to be the most evident adverse impact. Fugitive dust during decommissioning should be less than during plant construction because the size of the disturbed areas is smaller, the period of activity is shorter, and paved roadways may exist. Use of best-management practices, such as seeding and wetting, can be used to minimize fugitive dust. During demolition activities, including rubblization, some particulate matter in the form of fugitive dust may be released into the atmosphere, but much of this fugitive dust consists of large particles that settle quickly. To date, licensees decommissioning nuclear reactor facilities have taken appropriate and reasonable control measures to minimize fugitive dust. No anticipated new methods of conducting decommissioning and no peculiarities of operating plant sites are anticipated to affect this pattern.

Exhaust emissions from workers' vehicles, transportation of material and debris from the site, and onsite heavy equipment could also adversely affect air quality. Workers involved directly in decommissioning activities do not represent an additional onsite work force. They replace workers involved in plant operations. As a result, the total number of workers onsite during the decommissioning period is not expected to increase except temporarily during specific activities. Instead, the total will decrease with time as decommissioning activities are completed. This decrease should have a positive impact on air quality.

The selection of the decommissioning option (DECON, SAFSTOR, ENTOMB1, or ENTOMB2) would more likely affect the timing of the air quality impacts more than it would the magnitude of the impacts. Immediate decontamination and dismantlement of the facility (DECON) would result in impacts earlier than the SAFSTOR option, in which most decommissioning activities are postponed to permit residual activity in the plant to decay. ENTOMB1 and ENTOMB2 might include the dismantlement of structures outside of containment and thus would result in air quality impacts related to fugitive dust that would be the same as or greater than during DECON.

Previous or anticipated decommissioning activities at the FBR or HTGR have not and are not expected to result in air quality impacts that are different from those found at other nuclear facilities.

4.3.4.4 Conclusions

Most decommissioning activities will be conducted inside the containment, the auxiliary building, and the fuel-handling buildings. Fugitive dust from those activities performed outside of the buildings is temporary, can be controlled by mitigative measures, and will generally not be noticeable offsite. Air quality impacts from workers' vehicles and for movement of materials to and from the site are expected to be negligible.

The staff concludes that the issue of air quality for all decommissioning is generic and that the environmental impacts for these activities will be SMALL.

4.3.5 Aquatic Ecology

Aquatic ecology issues incorporate all of the plants, animals, and species assemblages in the rivers, streams, oceans, estuaries or any other aquatic environment near the nuclear power facility. Aquatic ecology also includes the interaction of those organisms with each other and the environment.

For most aquatic ecology impact related to nuclear power facilities, the environmental impact statement (EIS) focuses on issues like entrainment and impingement of fish and shellfish, heat and cold shock, and other changes in water quality related to facility operations. Following permanent shutdown, less water is pumped from the environment, less effluent is released to the environment, and there are fewer potential uses of aquatic resources. Therefore, the potential operational impacts to the aquatic environs from decommissioning a nuclear power facility are less than those expected during plant operation.

Aquatic ecology evaluations are usually directed at habitat and important species. Important species include plants and animals that are important to industry, recreation activities, the area ecosystems, and those protected by endangered species regulations or legislation. The most critical species, Federally listed threatened and endangered species, are addressed in a separate section of this Supplement (Section 4.3.7, "Threatened and Endangered Species"). There are also many species identified by State agencies as endangered or threatened. Potential impacts to State-protected species should also be evaluated and mitigated as appropriate, as discussed in Section 4.3.7. Important habitat resources include areas designated as critical habitats for endangered or threatened species, wetlands, riparian areas, shorelines, streambeds, littoral and lentic communities, and benthic and planktonic communities. Some States have programs to formally designate priority or rare habitat types. American Indian tribes could also have conflicts with the impacts from decommissioning activities related to water use plans, policies, and controls. These types of conflicts will also be addressed as part of the aquatic ecology analysis.

4.3.5.1 Regulations

Federal statutes that are included within a NEPA evaluation of aquatic ecology issues include the CWA (33 USC 1251 to 1387); the ESA of 1973 (16 USC 1531 to 1544); the Fish and Wildlife Coordination Act (16 USC 661 to 667c); and NEPA (42 USC 4321 to 4347). Although some biota may be affected by a number of decommissioning activities, full consideration is usually reserved for the more important aquatic resources, which may be either individual species or habitat-level resources.

4.3.5.2 Potential Impacts of Decommissioning Activities on Aquatic Ecological Resources

Aquatic ecological resources may be impacted during the decommissioning process via either the direct or the indirect disturbance of native plant or animal communities near the plant site. Direct impacts can result from activities such as the removal of near-shore or in-water struct-ures (i.e., the intake or discharge facilities), dredging a stream, river or ocean bottom, or filling a stream or bay. Indirect impacts may result from effects such as runoff. During decommiss-ioning, the aquatic environment at the site may be disturbed for the construction of support facilities to dock barges or to bridge a stream or aquatic area. Aquatic environment s away from the site may also be disturbed to upgrade or install new transportation systems. For example, a new rail spur or an upgrade to an existing barge loading or offloading facility may be necessary for large component removal. Installing or altering existing transmission lines could also have an effect on the aquatic environment. In most cases, aquatic disturbances will result in relatively short-term impacts, and the water body will either recover naturally or the impacts can be mitigated. Minor impacts to aquatic resources could result from sediment runoff due to ground disturbance, surface erosion, and runoff. More significant impacts may occur if shore-line or underwater structures, such as the intake or discharge facilities and pipes, are removed. Most of these impacts are minor and temporary and will not be significant issues after the completion of decommissioning. The impacts can also be minimized using standard best-management practices. The important exception may occur if near-shore or in-water structure removal results in the establishment of nonindigenous or noxious plants and animals to the exclusion of native species.

If decommissioning does not include significant in-water activities, very little aquatic habitat is expected to be disturbed. If all activities are confined to the previously disturbed aquatic and terrestrial areas, impacts are expected to be minor. The minor impacts would probably be a result of increased sediment runoff from physical alterations of the site. If no disturbances occur beyond the regular industrial areas of the site, it is expected that the impact to aquatic resources will be SMALL, temporary, and easily mitigated.

In some instances, there are impacts to the aquatic environment in the previously disturbed areas. Usually, aquatic habitats disturbed during the construction of the site will continue to be of low habitat quality during plant operation and decommissioning. However, sometimes during plant construction, important aquatic resources could either develop on the site or an important species could colonize the area disturbed by the construction. For example, reworking the ground surface during construction could have altered the surface drainage patterns such that wetlands develop on the original construction site. These wetlands may be inhabited by sensitive species at the time of decommissioning. This type of species habitation is also considered in assessing the impacts to the aquatic ecology during plant decommissioning.

The primary factors considered in evaluating the adverse impacts in areas previously disturbed by construction include the quantity of habitat to be disturbed, the length of time since initial disturbance, and the successional patterns of the aquatic communities (especially nuisance species). For disturbances beyond the original construction site areas, the potential impact is SMALL if the aquatic environment has been characterized, sensitive resources are managed to protect them from plant-related operations, and the protection objectives are not changed by decommissioning activities. If decommissioning activities occur in aquatic environments that have not been characterized, or the decommissioning activities will adversely impact protected environments, or compliance with established protection objectives is not possible, then the potential impact cannot be characterized generically and a site-specific assessment is needed.

4.3.5.3 Results of Evaluation

The aquatic environment required to support the decommissioning process is relatively small and is normally a very small portion of the overall facility site. Usually, the areas disturbed or utilized to support decommissioning are within the previously disturbed areas of the site and typically are immediately adjacent to the reactor, auxiliary, and control buildings. Discharge permits to the aquatic environment for operation are almost always greater than the discharges planned during decommissioning. In most cases examined, the licensees expect to restrict activities to previously disturbed areas and operate within the limits of operational permits.

The potential for adverse impacts appears low regardless of the decommissioning option selected. The activity most likely to result in impacts to aquatic environments is specific to removal of near-shore or in-water structures. The decision to remove these structures may be made for a variety of reasons. Returning the facilities to “greenfield” is the most likely reason to remove the structures.

Previous or anticipated decommissioning activities at the FBR or HTGR have not and are not expected to result in impacts on aquatic ecology that are different from those found at other nuclear facilities.

4.3.5.4 Conclusions

The staff has concluded that for sites where no disturbance is expected to occur beyond the previously disturbed areas (i.e., within the security fences or surrounding paved, graveled, or otherwise developed areas without removal of near-shore or in-water structures), the impact to the aquatic ecology for all decommissioning activities is generic and that the environmental impacts for these activities will be SMALL. If the use of areas beyond the previously disturbed areas is anticipated, and there have been previous ecological surveys that indicate a low probability of adversely affecting ecological resources, then the impact to the aquatic ecology is generic and the environmental impacts for these activities will be SMALL. However, the magnitude (i.e., SMALL, MODERATE, LARGE) of potential impacts will be determined through a site-specific analysis if the use of areas beyond the previously disturbed areas is anticipated and (1) there is a potential to impact the aquatic environment, (2) there are no protection plans in place to protect the aquatic environment, or (3) the established protection objectives must be changed to allow adverse impacts.

4.3.6 Terrestrial Ecology

Terrestrial ecology incorporates all of the plants, animals, and species assemblages in the vicinity of the nuclear power facility. Terrestrial ecology also includes the interaction of those organisms with each other and the environment.

For most terrestrial ecology impacts related to nuclear power facilities, the EIS focuses on issues such as drift from cooling towers, bird flight pathways around cooling towers or transmission lines, or maintenance of transmission line ROW. Following permanent cessation of operations, the structures impacting the terrestrial environment may be removed. Therefore, the potential operational impacts to the terrestrial environs from decommissioning a nuclear power facility are less than those expected during plant operation.

Terrestrial ecology evaluations are usually directed at habitat and important species, including plants and animals that are important to industry, recreational activities, the area ecosystems, and those protected by endangered species regulations and legislation. The most critical species, Federally listed threatened and endangered species, are addressed in a separate section of this Supplement (Section 4.3.7). There are also many species identified by State agencies as endangered or threatened. Potential impacts to State-protected species should also be considered and mitigated as appropriate. Important habitat resources include designated critical habitat for Federally recognized endangered or threatened species, wetlands, riparian areas, resting or nesting areas for large numbers of waterfowl, rookeries, communal roost sites, strutting or breeding grounds for gallinaceous birds, and areas containing rare plant communities. Some States have programs to formally designate priority or rare habitat types.

4.3.6.1 Regulations

Federal statutes that are directly applicable in a NEPA evaluation of terrestrial ecology issues include the ESA of 1973 (16 USC 1531-1544), the Migratory Bird Treaty Act of 1918 (MBTA) (16 USC 703-712), and portions of other statutes, such as the wetlands provisions of the CWA (See Section 4.3.5.1, “Regulations”).

The MBTA was initially enacted in 1918 to implement the 1916 Convention between the U.S. and Great Britain (for Canada) for the protection of migratory birds. Specifically, the Act established a Federal prohibition, unless otherwise regulated, to pursue, hunt, take, capture, or kill any bird included in the terms of the convention, or any part, nest, or egg of any such bird. The MBTA was amended in 1936 to include species included in a similar convention between the U.S. and Mexico, in 1974 to include species included in a convention between the U.S. and Japan, and in 1978 in a treaty between the U.S. and the Soviet Union. Executive Order 13186 (2001) further defined the responsibilities of Federal agencies, such as the NRC, to ensure the protection of migratory birds and to consider potential impacts to migratory birds during the preparation of NEPA documents.

4.3.6.2 Potential Impacts of Decommissioning Activities on Terrestrial Ecological Resources

Terrestrial ecological resources may be impacted during the decommissioning process via either the direct or the indirect disturbance of native plant or animal communities in the vicinity of the plant site. Direct impacts can result from activities such as the active clearing of native vegetation or filling of a wetland. Indirect impacts may result from effects such as erosional runoff or noise disturbance of communal roost sites. During decommissioning, land at the site may be disturbed for the construction of laydown yards, stockpiles, and support facilities. Additionally, land away from the plant site may be disturbed to upgrade or install new transportation systems. For example, building a new rail line may be necessary to support large component removal. Installing or altering existing transmission lines could also have an effect on the terrestrial environment. In most cases, land disturbances will result in relatively short-term impacts and the land will either recover naturally or will be landscaped appropriately for an alternative use after completion of decommissioning. Minor impacts to terrestrial resources could result from increased dust generation due to ground disturbance and traffic, noise from dismantlement of facilities and heavy equipment traffic, surface erosion and runoff, and migratory bird collisions with crane booms or other construction equipment. Most of these impacts are minor and temporary and will not be significant issues after the completion of decommissioning. The impacts can also be minimized using standard best-management practices.

In some instances, there are impacts to the terrestrial environment in the previously disturbed site areas. Usually, terrestrial habitats disturbed during the construction of the site will continue to be of low habitat quality during plant operation and decommissioning. However, sensitive habitats could develop on the site or rare species could colonize the area disturbed by the construction. For example, reworking the ground surface during construction could have altered the surface drainage patterns such that wetlands develop on the original construction site. Trees could also be grown to the point where they become usable as roosting or nesting sites for eagles, osprey, or wading birds. These habitats may be inhabited by sensitive species at the time of decommissioning. A notable example of rare species colonization at a nuclear plant site occurs at a facility with a cooling canal system. The canal system has been colonized by the endangered American crocodile and is foraged by the endangered wood stork. This type of species habitation is also considered in assessing the impacts to the terrestrial environment during plant decommissioning.

The primary factors considered in evaluating the adverse impacts in areas previously disturbed by construction include the acreage to be disturbed, the length of time since initial disturbance, and the successional patterns of the native communities. Sites in areas with very slow successional patterns, such as many semi-arid sites, may be in a highly disturbed state even 60 yrs after construction is completed. In other areas such as the humid southeast, the sites may develop significant second-growth forests by the time of final decommissioning. This is especially the case if the site has been in SAFSTOR for several decades.

The magnitude of impacts to terrestrial ecological resources would be considered SMALL if all decommissioning activities are confined to the previously disturbed areas or if there are no significant terrestrial resources potentially affected by the decommissioning activities. For disturbances beyond the original construction site areas, the potential impact is SMALL if the terrestrial environment has been characterized, sensitive resources are managed to protect them from plant-related operations, and the protection objectives are not changed by decommissioning activities. If significant decommissioning activities occur in terrestrial environments that have not been characterized, or the activities will adversely impact protected environments, or compliance with established protection objectives is not possible, then the potential impact cannot be characterized and a site-specific assessment is needed.

4.3.6.3 Results of Evaluation

In most cases, the amount of land required to support the decommissioning process is relatively small and is normally a very small portion of the overall plant site. Usually, the areas disturbed or utilized to support decommissioning are within the previously disturbed areas of the site and typically are immediately adjacent to the reactor, auxiliary, and control buildings. Usually there is sufficient room adjacent to the major activity areas to function as temporary storage, laydown, and staging areas. In many cases, management, engineering, and administrative staff would be assigned space in existing support or administration buildings. However, in some instances it may be advantageous to dismantle the support or administration buildings earlier. For example, if asbestos abatement is required in those buildings, land might be disturbed to install trailers or other temporary structures. In almost all cases examined, the licensees expect to restrict activities to previously disturbed areas and within the area disturbed during original site construction. The licensees typically anticipate utilizing an area of between 0.4 ha (1 ac) to approximately 10.5 ha (26 ac) to support the decommissioning process. Big Rock Point required a new transmission line ROW to provide electrical power to the plant site during decommissioning (this line will also provide power to the onsite independent spent fuel storage installation [ISFSI] after decommissioning is completed). However, construction of a new transmission line ROW is probably an unusual situation. It is expected that some sites will require the reconstruction or installation of new transportation links, such as railroad spurs, road upgrades, or barge slips.

The potential for adverse impacts appears low regardless of the decommissioning option selected. The different options are likely to alter the timing of the impact to ecological resources more than the magnitude of the impacts. DECON may require slightly more land area to support a larger number of simultaneous activities. The ENTOMB2 option would probably have the least likelihood of adverse impacts because some large components may be left in place, reducing the land requirements needed for large construction equipment, waste storage, and barge or rail loading areas. However, impacts of ENTOMB2 could be larger if additional land disturbance is required to install a concrete batch plant and associated material stockpiles. The potential impacts of SAFSTOR may be smaller than DECON, depending on the time over which activities are performed. If decontamination and dismantlement occur slowly over many years (incremental DECON), the same storage and staging areas can be reused for sequential activities. If many activities are performed over a short time period at the end of the SAFSTOR period, the impacts may be as large as those for DECON. The activity of rubblization of construction material should not have significant nonradiological impacts beyond other decommissioning activities except for potential short-term noise and dust effects.

Previous or anticipated decommissioning activities at the FBR or HTGR have not and are not expected to result in impacts on terrestrial ecology that are different from those found at other nuclear facilities.

4.3.6.4 Conclusions

The staff has concluded that for sites where no disturbance is expected to occur beyond the previously disturbed areas (i.e., within the security fences or surrounding paved, graveled, or otherwise developed areas) the impact to the terrestrial ecology would be SMALL and generic for all facilities. If the use of areas beyond the previously disturbed areas is anticipated, and there have been previous ecological surveys that indicate a low probability of adversely affecting ecological resources, then the magnitude of the potential impact would also be SMALL and is generic for all sites. However, if the use of areas beyond the previously disturbed areas is anticipated and there are no existing protection plans in place to protect the terrestrial environment, or if the protection objective must be changed to allow adverse impacts, or if a previous ecological survey indicates the potential of adverse impact to important terrestrial resources, then the magnitude (i.e., SMALL, MODERATE, LARGE) of potential impacts will be determined through a site-specific analysis.

4.3.7 Threatened and Endangered Species

Plants and animals protected under the ESA of 1973 (16 USC 1531-1544) may be present at all commercial nuclear power facility sites (Sackschewsky 1997). It is anticipated that the potential impacts of nuclear power facility decommissioning on threatened or endangered species will normally be no greater and likely less than the effects of plant operations. However, in some cases the potential impacts during decommissioning may be greater than during plant operation if additional habitats are disturbed during decommissioning (e.g., removal of near-shore or in-water structures, dredging to accommodate new barge traffic), if there are significant upgrades to the offsite transportation network, or it there is increased erosion.

4.3.7.1 Federal Regulations

The ESA is the Federal statute that is directly applicable in a NEPA evaluation of threatened and endangered species issues. The ESA is intended to protect plant and animal species that are threatened with extinction and to provide a means to conserve the ecosystems on which they rely. Under the ESA, the USFWS is responsible for all terrestrial and freshwater organisms. Marine and anadromous fish species are the responsibility of NMFS. The ESA prohibits the taking of listed species and the destruction of designated critical habitat for listed species. “The term take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in such conduct” (16 USC 1532). The ESA applies to Federal agencies as well as individuals. However, in general, the prohibitions against take in respect to listed plant species are only applicable to Federal agencies or to individuals on Federal lands.

Section 7 of the ESA provides a means for Federal agencies to consult with USFWS and NMFS concerning impacts to endangered species resulting from Federal actions. Although USFWS and NMFS are the administering agencies, it is the responsibility of the performing agency to determine the potential impacts of a proposed action (including licensing actions) on endangered or threatened species via the preparation of a biological assessment. If the consultation process results in a determination that there may be adverse impacts to listed species, Section 10 of the ESA provides a means for permitted takes that are incidental to otherwise legal activities.

4.3.7.2 Potential Impacts of Decommissioning Activities on Threatened and Endangered Species

Threatened and endangered resources may be impacted during the decommissioning process through either direct or indirect disturbances of native plant or animal communities near the plant site. Permanent cessation of operation and the early stages of decommissioning could result in habitat changes that are initially favorable for the establishment of threatened or endangered species. Likewise, an extended period of SAFTOR may allow for the establishment of onsite populations of protected species that may be adversely affected by facility decontamination and dismantlement at the end of the storage period. By far the greatest potential for impact to protected species is associated with the actual decontamination and dismantlement of the facility during active decommissioning. The physical dismantlement of the facility, changes in nearby land use, and alterations to the aquatic environment also directly affect protected species. Impacts can result from activities such as the removal of near-shore or in-water structures (e.g., the intake or discharge facilities), the active dredging of stream, river, or ocean bottom or filling of a stream or bay, active clearing of native vegetation, or filling of a wetland. Indirect impacts may result from effects such as runoff or noise disturbance of communal roost sites. During decommissioning, aquatic environment at the plant site may be disturbed for the construction support facilities to dock barges or to bridge a stream or aquatic area. Additionally, terrestrial and aquatic environments away from the plant site may be disturbed to upgrade or install new transportation systems. For example, a new rail line may be necessary to support large component removal. Installing or altering transmission lines could also affect the terrestrial and aquatic environment. In most cases, disturbances will result in relatively short-term impacts. The environment will either recover naturally or impacts can be mitigated. Minor impacts to threatened and endangered species could result from sediment runoff generation due to ground disturbance, surface erosion, and runoff; increased dust generation due to ground disturbance and traffic; noise from dismantlement of facilities and heavy equipment traffic; and migratory bird collisions with crane booms or other construction equipment. Impacts may occur if shoreline or underwater structures, such as the intake or discharge facilities and pipes, are removed. Most of these impacts are minor and temporary and will not be significant issues after the completion of decommissioning. The impacts can also be minimized using standard best-management practices. An important exception may occur if near-shore or in-water structure removal results in the establishment of nonindigenous or noxious plants and animals to the exclusion of threatened or endangered species.

Usually, very little land will be disturbed during decommissioning that was not used during regular plant operations or previously disturbed during construction of the facility. If all activities are confined to the site areas previously disturbed, impacts are expected to be minor. The impacts would primarily result from increased noise and dust generation from physical alterations of the plant site and from increased truck traffic to and from the site. If no disturbances occur beyond the previously disturbed areas of the site, it is expected that the impact to threatened or endangered species will be relatively small, temporary, and mitigable.

When areas beyond the previously disturbed areas are affected, the significance of the potential impacts may be SMALL, MODERATE, or LARGE, and will depend on site-specific considerations. The primary factors that need to be considered include the total acreage of habitat to be disturbed, and the particular threatened or endangered species that may be disturbed. Therefore, because the ecological impacts beyond the operational or construction areas cannot be determined without considering site-specific details, the magnitude of impacts are not generic to all sites and the potential impacts must be evaluated on a site-specific basis.

4.3.7.3 Results of Evaluation

The potential impacts to threatened and endangered species are almost totally related to their presence or absence. This issue requires consultation with appropriate agencies to determine whether threatened or endangered species are present and whether they would be adversely affected. Consultation under Section 7 of the ESA must be initiated to determine if protected species are near the plant. If species are identified, an assessment of the potential impacts of decommissioning must be determined.

Previous or anticipated decommissioning activities at the FBR or HTGR have not and are not expected to result in impacts on threatened and endangered species that are different from those found at other nuclear facilities.

4.3.7.4 Conclusions

The ESA imposes two basic requirements on the NRC. First, the ESA requires the NRC to ensure that any action authorized, funded, or carried out by NRC is not likely to jeopardize the continued existence of any endangered species or threatened species, or to result in the destruction or impairment of any critical habitat for such species. Second, the NRC is required to consult with the Secretary of the Interior (for freshwater and terrestrial species through the USFWS) or the Secretary of Commerce (for oceanic and coastal matters through the NMFS) to determine if any listed species may be affected by an action. This consultation may be formal or informal, depending on the nature of the action, the species potentially affected, and the level of impacts to those species.

Acknowledging the site- and species-specific nature of threatened and endangered species and the special obligations imposed on the NRC by the ESA, the staff has concluded that threatened and endangered species is not a generic issue. The NRC will meet its responsibilities under the ESA by addressing this issue on a site-specific basis during any decommissioning process.

4.3.8 Radiological

The NRC considers radiological doses to workers and members of the public when evaluating the potential consequences of decommissioning activities. Radioactive materials are present in the reactor and support facilities after operations cease and the fuel has been removed from the reactor core. Exposure to these radioactive materials during decommissioning may have consequences for workers. Members of the public may also be exposed to radioactive materials that are released to the environment during the decommissioning process. All decommissioning activities were assessed to determine their potential for radiation exposures that may result in health effects to workers and the public. This section considers the impacts to workers and the public during decommissioning activities performed up to the time of the termination of the license. Any potential radiological impacts following license termination are not considered in this Supplement. Such impacts are covered by the *Generic Environmental Impact Statement in Support of Rulemaking on Radiological Criteria for License Termination of NRC-Licensed Nuclear Facilities*, NUREG-1496 (NRC 1997).

4.3.8.1 Regulations

Decommissioning reactors in the United States continue to be licensed by the NRC and must comply with NRC regulations and conditions specified in the license. The regulatory standards for radiation exposure to workers and members of the public are found in 10 CFR Part 20 (see detailed discussion in Appendix G). Title 10 CFR Part 20 requires that the sum of the external and internal doses (total effective dose equivalent, or TEDE) for a member of the public may not exceed 1 mSv/yr (0.1 rem/yr). Compliance is demonstrated (1) by measurement or calculation, to show that the highest dose to an individual member of the public from sources under the licensee's control do not exceed the limit or (2) that the annual average concentrations of radioactive material released in gaseous and liquid effluents do not exceed the levels specified in 10 CFR Part 20, Appendix B, Table 2, at the unrestricted area boundary. In addition, the dose from external sources in an unrestricted area should not exceed 0.02 mSv (0.002 rem) in any given hour or 0.5 mSv (0.05 rem) in 1 yr. Occupational doses are limited to a maximum of 0.05 Sv (5 rem) TEDE per year, with separate limits for dose to various tissues and organs.

Potential radiological impacts following license termination are not covered in this Supplement. Specific radiological criteria for license termination were added as Subpart E of 10 CFR Part 20 in 1997, and the basis for public health and safety considerations is discussed in NUREG-1496 (NRC 1997). These criteria limit the dose to members of the public to 0.25 mSv/yr (25 mrem/yr) from all pathways following unrestricted release of a property. In cases where unrestricted release is not feasible, the licensee must provide for institutional controls that would limit the dose to members of the public to 0.25 mSv/yr (25 mrem/yr) during the control period and to 1 mSv/yr (100 mrem/yr) after the end of institutional controls. These criteria will largely determine the types and extent of activities undertaken during the decommissioning process to reduce the radionuclide inventory remaining onsite.

Power reactor licensees are required to meet the specifications in 10 CFR 50.36a for effluent releases after permanent cessation of operations. Licensees are also required to keep releases of radioactive materials to unrestricted areas at levels as low as reasonably achievable (ALARA).

In addition to NRC limits on effluent releases, nuclear power facility releases to the environment must comply with EPA standards in 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations." These standards specify limits on the annual dose equivalent from normal operations of uranium fuel-cycle facilities (except mining, waste disposal operations, transportation, and reuse of recovered special nuclear and by-product materials). Radon and its decay products are excluded from these standards.

The NRC has not established standards for radiological exposures to biota other than humans on the basis that limits established for the maximally exposed members of the public would provide adequate protection for other species. In contrast to the regulatory approach applied to human exposures, the fate of individual nonhuman organisms is of less concern than the maintenance of the endemic population (NCRP 1991). Because of the relatively lower sensitivity of nonhuman species to radiation, and the lack of evidence that nonhuman populations or ecosystems would experience detrimental effects at radiation levels found in the environment around nuclear power facilities, these effects are not evaluated in detail for the purposes of this Supplement.

4.3.8.2 Potential Radiological Impacts from Decommissioning Activities

Radiological impacts during decommissioning include offsite dose to members of the public and occupational dose to the work force at the facility. For this Supplement, public and occupational radiation exposures from decommissioning activities have been evaluated on the basis of information derived from recent decommissioning experience. Effluent releases anticipated during decommissioning were estimated from experiences in recent decommissioning activities from both PWRs and boiling water reactors (BWRs).

Many activities that take place during decommissioning are generally similar to those that occur during normal operations and maintenance activities. Those activities include decontamination of piping and surfaces in order to reduce the dose to nearby workers. Removal of piping or other components, such as pumps and valves, and even large components such as heat exchangers, is performed in operating facilities during maintenance outages. However, some of the activities, such as removal of the reactor vessel or demolition of facilities, would be unique to the decommissioning process. Those activities would have the potential to result in exposures to workers in close to contaminated structures or components, and to provide pathways for release of radioactive materials to the environment that are not present during normal operation.

In estimating the health effects resulting from both offsite and occupational radiation exposures as a result of decommissioning of nuclear power facilities, the staff used risk coefficients per unit dose recommended by the International Commission on Radiological Protection (ICRP) (1991) for stochastic health effects such as development of cancer or genetic effects. The coefficients consider the most recent radiobiological and epidemiological information available and are consistent with the United Nations Scientific Committee on the Effects of Atomic Radiation. The coefficients used in this Supplement are the same as those published by ICRP (1991) in connection with a revision of its recommendations for public and occupational dose limits. Excess hereditary effects are listed separately because radiation-induced effects of this type have not been observed in any human population, as opposed to excess malignancies that have been identified among populations receiving instantaneous and near-uniform exposures in excess of 0.1 Sv (10 rem). Regulatory limits for radiation exposure to specific organs and tissues are set at levels that would prevent development of nonstochastic effects. Therefore, nonstochastic effects, such as development of radiation-induced cataracts, would not be expected in any individual whose exposure remains within the regulatory limits.

The standard defining a small radiological impact has been designated as sustained compliance with the dose and release limits applicable to the activities being reviewed. The Atomic Energy Act of 1954, as amended (42 USC 2011 et seq.), requires NRC to promulgate, inspect, and enforce standards that provide an adequate level of protection of the public health and safety and the environment. These responsibilities, singly and in the aggregate, provide a margin of safety. The definitions of the significance level of an environmental impact (SMALL, MODERATE, or LARGE) applied to most other issues addressed in this Supplement are based on an ecological model that is concerned with species preservation, ecological health, and the condition of the attributes of a resource valued by society. However, health impacts on individual humans are the focus of NRC regulations limiting radiological doses. A review of the regulatory requirements and the performance of facilities provides the basis to project continuation of performance within regulatory standards. For the purposes of assessing radiological impacts, the Commission has concluded that impacts are of SMALL significance if doses and releases do not exceed limits established by the Commission’s regulations. This definition of “SMALL” applies to occupational doses as well as to doses to individual members of the public.

4.3.8.3 Results of Evaluation

For this Supplement, information gained from experience in decommissioning facilities has been used to evaluate radiological dose to workers and members of the public. Occupational doses, radionuclide emissions, and doses to members of the public during decommissioning were compared to those experienced during periods of routine operation at the same facilities or at similar facilities. They were also compared to estimates presented in the 1988 GEIS. This comparison was intended to demonstrate that the radiological consequences actually experienced at facilities undergoing decommissioning were bounded either by the site’s EIS for normal operations or by the 1988 GEIS. The data were also used to determine whether it was appropriate to update the estimates for these impacts as presented in the 1988 GEIS.

<u>Occupational Dose</u>: As part of the occupational dose analysis, data were collected for annual occupational doses, doses by activity, and total dose from decommissioning, when that information was available. Because many of the facilities that provided information have not completed the decommissioning process, the data included in this analysis is from both actual operating data and from projections for specific activities. Routine occupational doses as reported to the NRC were used to compare collective worker doses during normal operations to those experienced during decommissioning. Projections for specific activities were also used to determine which were the greatest contributors to the cumulative occupational doses over the entire decommissioning period.

The data used for this evaluation are presented in Appendix G. Average occupational doses during the 5 yrs of normal operations preceding shutdown ranged from about 1.5 to 5 person-Sv (150 to 500 person-rem) per year for each reactor. The average annual collective doses during the years following shutdown were generally lower, ranging from less than 0.1 to 1.8 person-Sv (10 to 180 person-rem), although specific years during the most active decommissioning period may have produced collective worker doses comparable to, or greater than, those typically experienced during normal operation. Average annual doses to individual workers are also generally lower during decommissioning than during normal operation.

Table 4-1 compares cumulative occupational dose estimates from the 1988 GEIS to estimates for plants that are currently in the decommissioning process. In general, estimates for currently decommissioning plants fell within the range of estimates in the 1988 GEIS, and in some cases were substantially lower than the GEIS estimates for the corresponding type of reactor and decommissioning option.

The estimated cumulative doses for the entire decommissioning process ranged from about 3.5 to 16 person-Sv (350 to 1600 person-rem) for the facilities that provided data. Estimated doses for the reference facilities discussed in the 1988 GEIS ranged from 3 to 19 person-Sv (300 to 1900 person-rem). Because the range of cumulative occupational doses reported by reactors undergoing decommissioning was similar to the range of estimates for reference plants presented in the 1988 GEIS, it was not considered necessary to update the estimates in the previous document at this time.

Activities that resulted in the largest doses during decommissioning included removal of large components, such as the reactor vessel and steam generators. Dismantling the internal structures within the containment building was the activity producing the largest overall doses. Transportation and management of spent fuel each accounted for less than 10 percent of the total. Appendix G provides a more in-depth review of the exposures recorded and anticipated or various activities.

Table 4-1. Comparison of Occupational Dose Estimates from the 1988 GEIS to Those for Decommissioning Reactors

Reactor Type/ Decommissioning Option	1988 GEIS Estimates - Cumulative Occupational Dose, person-Sv (person-rem)	Range of Estimates for Decommissioning Plants - Cumulative Occupational Dose, person-Sv (person-rem)[(a)]
Boiling Water Reactors		
DECON	18.74 (1874)	7 - 16 (700 - 1600)
SAFSTOR	3.26 - 8.34 (326 - 834)	3.5 (350)
ENTOMB	15.43 - 16.72 (1543 - 1672)	–
Pressurized Water Reactors		
DECON	12.15 (1215)	5.6 - 10 (560 - 1000)
SAFSTOR	3.08 - 6.694 (308 - 664)	4.8 - 11 (480 - 1100)[(b)]
ENTOMB	9.16 - 10.21 (916 - 1021)	–
Other Reactors		
(HTGR; FBR)	–[(c)]	4.3 (430)

(a) These data are based on information provided by plants that are undergoing or have completed the decommissioning process. For facilities that have been completely decommissioned, they represent actual doses accumulated during the decommissioning period. For facilities that are still undergoing decommissioning, they represent a combination of actual doses accumulated during activities that have been completed and projected doses for future activities.
(b) The plant reporting a dose estimate of 1100 person-rem is designated as having elected the SAFSTOR option; however, the period between shutdown and active decommissioning was shorter than the minimum 10-yr SAFSTOR period that was evaluated in the 1988 GEIS. Therefore, it may be more appropriate to compare the estimated dose for that facility to the 1988 GEIS estimates for the DECON option.
(c) The 1988 GEIS did not provide dose estimates for reactors other than reference light-water reactors. Therefore, there are no previous estimates with which to compare the doses for decommissioning the high temperature gas cooled reactors (HTGRs) and fast breeder reactor (FBR), which are somewhat unique in the commercial nuclear power industry. The dose estimates are expected to be consistent with PWRs and BWRs.

One of the major decommissioning activities that is not performed during routine operation or refurbishment is removal of the reactor vessel. Industry experiences from this activity were reviewed to estimate worker exposure and the amount of radioactive material removed (see Appendix H). As each utility performed this major activity, experiences were shared within the industry and the lessons learned have been used to reduce collective dose to workers and improve the process. Collective worker dose at these sites ranged from 0.14 to 1.8 person-Sv (14 to 180 person-rem). The dismantlement of radioactive structures for the ENTOMB2 option would involve placement of contaminated SSCs in the reactor or containment building.

Facilities could use a rubblization process for dismantlement of radioactive or slightly radioactive structures; there is a potential for this activity to occur during the dismantlement phases of SAFSTOR, DECON, or ENTOMB1 options. The rubblized material could be sent to a LLW site (except for the ENTOMB1 option where it would be disposed of in the reactor or containment building structure). However, in cases where the remaining activity was low enough such that the licensee could meet the criteria in 10 CFR Part 20, Subpart E and other regulations, the rubblized material could potentially be disposed onsite for either the DECON or SAFSTOR options. Occupational doses during the activity of rubblizing the material would be similar to those for dismantlement of the facility in preparation for demolition and offsite disposal. The occupational doses would need to meet the regulatory standards in 10 CFR Part 20. Disposal of rubblized material on site would also have to meet the radiological criteria for license termination given in 10 CFR Part 20,Subpart E.

Public Dose: This section addresses the impacts on members of the public of radiation doses caused by decommissioning activities, including doses from effluents as well as from direct radiation. To determine the relative significance of the estimated public dose for decommissioning, the staff compared dose projections for decommissioning with the historical (baseline) doses experienced at PWRs and BWRs during normal operations. The dose estimates were based on reports evaluating effluent releases during decommissioning efforts and are shown in Appendix G. Levels of radionuclide emissions from facilities undergoing decommissioning decreased, because the major sources generating emissions in gaseous and liquid effluents are absent in facilities that have been shut down. However, decommissioning facilities continued to report low levels of radionuclide emissions that resulted from the residual radioactive materials remaining in the facilities. The doses to members of the public from these emissions were also very low. Collective doses to members of the public within 80 km (50 mi) were lower than 0.01 person-Sv (1 person-rem) per year at all decommissioning facilities for which data were available, and in most cases they were comparable to, or lower than, the doses from operating facilities. Doses to a maximally exposed individual were less than 0.01 mSv/yr (1 mrem/yr) at both operating and decommissioning facilities, which is well within the regulatory standards in 10 CFR Part 20 and Part 50.

Previous or anticipated decommissioning activities at the FBR or HTGR have not and are not expected to result in occupational dose or public dose that are different from those found at other nuclear facilities.

4.3.8.4 Conclusions

Occupational Dose: Occupational doses to individual workers during decommissioning activities are estimated to average approximately 5 percent of the regulatory dose limits in 10 CFR Part 20, and to be similar to, or lower than, the doses experienced by workers in operating facilities. The average increase in fatal individual cancer risk to a worker during decommissioning, about 8×10^{-5} per year of employment, is less than 2 percent of the lifetime accumulation of occupational risk of premature death of 4.8×10^{-3}. Because the ALARA program continues to reduce occupational doses, no additional mitigation program is warranted. For all decommissioning options, the impact on worker health from radiological exposure meets the criteria for SMALL significance. The staff therefore concludes that occupational dose impacts for all decommissioning activities are generic and that the impacts will be SMALL.

Public Dose: Offsite doses to the public attributable to decommissioning have been examined for both the maximally exposed individual and the collective doses to the population within 80 km (50 mi) of the plants. To date, effluents and doses during periods of major decommissioning have not differed substantially from those experienced during normal operation. Consequently, direct exposure and effluents in gaseous and liquid discharges are not expected to result in maximum individual doses exceeding the design objectives of Appendix I to 10 CFR Part 50, the dose and effluent concentration limits in 10 CFR Part 20, or the limits established by EPA in 40 CFR Part 190. Both the average individual dose and the 80-km (50-mi) radius collective doses are expected to remain at least 1000 times lower than the dose from natural background radiation. It should also be noted that the estimated increased risk of fatal cancer to an average member of the public is much less than 1×10^{-6}. The evaluation of offsite radiation doses attributable to decommissioning determined that their significance is SMALL for all plant types and decommissioning options, based on the criteria that public exposures have been, and are expected to continue to be, well within regulatory limits.

Therefore, the staff concludes that the public health impact from radiological dose for all decommissioning activities is generic and the impact will be SMALL.

4.3.9 Radiological Accidents

As indicated in the Introduction to this Supplement, the staff relies on the Waste Confidence Rule for determining the acceptability of environmental impacts from the storage and maintenance of fuel in the spent fuel pool. The Rule states, in part, that there is, "reasonable assurance that, if necessary, spent fuel generated in any reactor can be stored safely and without significant impact for at least 30 yrs beyond the licensed life for operation...of that reactor at its spent fuel storage basin" (54 FR 39767).[a] However, for the purpose of public information, the staff has elected to include a discussion of potential accidents related to the spent fuel pool in this Supplement.

The likelihood of a large offsite radiological release that could impact public health and safety from a facility that has permanently ceased operation is considerably lower than the likelihood of such a release from an operating reactor when including initiating events associated with normal and abnormal operations, design-basis accidents (DBAs), and beyond DBAs (severe accidents).

Two classes of accidents are evaluated for operating nuclear power facilities: DBAs and severe accidents. DBAs are those accidents that both the licensee and the NRC staff evaluate to ensure that the plant can withstand normal and abnormal transients and a broad spectrum of postulated accidents without undue hazard to the health and safety of the public. For the most part the evaluated accidents focus on reactor operation and are not applicable to

(a) The Commission reaffirmed this finding of insignificant environmental impacts in 1999 (64 FR 68005). This finding is codified in the Commission's regulations in 10 CFR 51.23(a).

decommissioning. In the case of a decommissioning plant, the only SSCs subject to DBA evaluation are those associated with the spent fuel pool. A number of these postulated accidents are not expected to occur during the life of the plant, but have been evaluated to establish the design basis for the preventive and mitigative safety systems of the facility.

Severe accidents for a decommissioning reactor are those that are more severe than DBAs because they could result in substantial damage to the spent fuel, whether or not there are serious offsite consequences.

4.3.9.1 Regulations

Regulations governing accidents which must be addressed by nuclear power facilities, both operating and shutdown are found in 10 CFR Part 50 and 10 CFR Part 100.

The environmental impacts of DBAs are evaluated during the initial license process, and the ability of the plant to withstand these accidents is demonstrated to be acceptable before issuance of the operating license. The results of these evaluations are found in license documentation, such as the staff's safety evaluation report, the final environmental statement (FES), as well as in the licensee's final safety analysis report (FSAR). The consequences for these events are evaluated for the hypothetical maximally exposed individual. The licensee is required to maintain the acceptable design and performance criteria throughout the life of the plant.

4.3.9.2 Potential for Radiological Accidents as a Result of Decommissioning Activities

The types of accidents and malfunctions of equipment evaluated or considered by licensees of nuclear power facilities that are permanently shutdown are significantly different from those considered during operations. The activities that occur during decommissioning are similar to activities such as decontamination and equipment removal that commonly occur during maintenance outages at operating plants. However, during decommissioning such activities may occur more often than similar activities for an operating reactor. Therefore, the accidents that may result from these activities could have a greater frequency of occurrence during decommissioning than when the plant is operating, with the exception of those accidents related to the spent fuel pool, such as a cask or heavy load drop into the spent fuel pool, the DBAs contained in a facility's FSAR are no longer applicable to a defueled decommissioning facility.

After permanent shutdown of the reactor, the only severe accident of concern is one where the fuel in the spent fuel pool becomes uncovered and results in a zircaloy fire. In this regard, the staff recently conducted a study of spent fuel pool accident risk at decommissioning nuclear power facilities to support development of a risk-informed technical basis for reviewing exemption requests and a regulatory framework for integrated rulemaking (NRC 2001). As part of its effort to develop generic, risk-informed requirements for decommissioning, the staff performed of the frequency of beyond-design-basis spent fuel pool accidents. The event initiators included:

- seismic events (earthquakes)
- aircraft crashes
- tornadoes and high winds
- impact of a dropped heavy load (such as a fuel cask) resulting in pool drainage or compression or buckling of stored assemblies.

Those spent fuel pool accident sequences that resulted in the spent fuel being uncovered were assumed to culminate in a zirconium fire. The consequences of a zirconium fire event are likely to be severe. The staff's study performed some bounding consequences analysis.

Accidents with SMALL impacts would be those where the consequences of the accident do not cause significant physical injuries either onsite or offsite, or result in doses above those allowable for the workers or the public. These accidents would include temporary loss of services, certain decontamination-related accidents such as liquid spills or leaks during in situ decontamination, and, in some cases, the temporary loss of offsite power or compressed air.

Accidents with MODERATE impacts would be those where the consequences have the potential to cause physical injuries of a serious, non-life-threatening nature, or result in doses above those allowable for workers or the public but that do not result in long-term damage. Such accidents would include fires in LLW storage facilities or the loss of HEPA filtration or containment during dismantlement procedures.

Severe accidents are those that could result in LARGE consequences such as offsite dose consequences in excess of the EPA's protective action guidelines (PAGs) (EPA 1991).

4.3.9.3 Results of Evaluation

The information in this section is based on reviews of existing information from licensees' documents analyzing accidents from decommissioning activities and from a technical review of spent fuel pool accident risk at decommissioning nuclear power facilities performed to support development of a risk-informed technical basis for reviewing exemption requests and a regulatory framework for integrated rulemaking (NRC 2001). Further detail on the sources of information that were used to develop the analysis is given in Appendix I. The sources of information included the FBR and the HTGR and therefore the results given in this section are applicable for these facilities.

The accidents and malfunctions considered in licensing documents that were reviewed were divided into subgroupings within five main categories:

- <u>Fuel-related accidents</u>: These include maintenance and storage of fuel in the spent fuel pool and the movement of fuel into the pool which could result in fuel rod drops, heavy load drops, and loss of water.

- <u>Other radiological (nonfuel) related accidents</u>: These include onsite accidents related to decontamination or dismantlement activities (such as material handling accidents or accidental cutting of contaminated piping) or storage activities (such as fires or ruptures of liquid waste tanks).

- <u>External events</u>: These include aircraft crashes, floods, tornadoes and extreme winds, earthquakes, volcanic activity, forest fires, lightening storms, freezing, and sabotage.

- <u>Offsite events</u>: These consist solely of transportation accidents that occur offsite (transportation accidents are discussed in Section 4.3.17).

- <u>Hazardous (nonradiological) chemical-related accidents</u>: These have the potential for injury to the offsite public, either directly from the accident or as a result of further actions initiated by the accident.

A detailed list of the types of accidents that could occur in each of these five categories is given in Appendix I.

Appendix I also contains a table showing the estimated dose consequences of accidents during the decommissioning period that were reported in various licensing-basis documents. The highest doses result from postulated fuel-related accidents and radioactive-material-related accidents. Information obtained from licensing-basis documents for the fuel-related accidents showed that the highest doses were from the cask or heavy load handling accidents, the accidents that assumed a 100 percent fuel failure, and the spent fuel handling accidents. The postulated DBA with the greatest estimated offsite dose was a spent resin handling accident that had a calculated offsite dose consequence accident of 0.0096 Sv (0.96-rem) TEDE.

The likelihood of an accident as well as its consequence are activity dependent. Accidents related to dropping fuel elements only occur when the fuel is being moved. Accidents related to dismantlement activities would only occur during the decontamination and dismantlement process and not during a storage period or after a facility has been entombed. External events, however, could occur during any activity or decommissioning option. Appendix I contains a table that compares the types of accidents with the different activities that are performed during SAFSTOR, ENTOMB, and DECON.

In addition to the licensing-basis documents reviewed, the staff's *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants* report (NRC 2001), discussed previously, provides an analysis of the consequences of the spent fuel pool accident risk and included a limited analysis of the offsite consequences of a severe spent fuel pool accident. These analyses showed that the consequences of a spent fuel accident could be comparable to those for a severe reactor accident. As part of its effort to develop generic, risk-informed requirements for decommissioning, the staff performed analysis of the offsite radiological consequences of beyond-design-basis spent fuel pool accidents using fission product inventories at 30 and 90 days and 2, 5, and 10 yrs. The results of the study indicate that the risk at spent fuel pools is low and well within the Commission's Quantitative Health Objectives. The risk is low because of the very low likelihood of a zirconium fire even though the consequences from a zirconium fire could be serious.

4.3.9.4 Conclusions

The staff concludes that the issue of accidents during decommissioning is generic and the environmental impacts from the accident will be SMALL, MODERATE, or LARGE. The impact level depends in part on the type of the accident, the timing of the accident (in relationship to when the reactor last operated), and the activity that causes the accident.

4.3.10 Occupational Issues

Occupational hazards are one example of direct effects, as defined by Section 1508 of the CEQ Regulations for Implementing NEPA, i.e., as effects that are caused by an action and that occur at the same time and place as that action. For NRC licensees, the implementing regulations for NEPA are given in 10 CFR Part 51.

In general, human health risks for most decommissioning options are expected to be dominated by occupational injuries to workers engaged in activities such as construction, maintenance, and excavation. Historically, actual injury and fatality rates at nuclear reactor facilities have been lower than the average U.S. industrial rates. Occupational injury and fatality risks are reduced by strict adherence to NRC and Occupational Safety and Health Administration (OSHA) safety standards, practices, and procedures. Appropriate State and local statutes must also be considered when assessing the occupational hazards and health risks for any decommissioning activity.

Typically, any significant operation, such as decommissioning, will have an Environment, Safety and Health (ES&H) Plan that serves as the guidebook for anticipating and preventing any injury or harm occurring to the worker while working on that particular job. This plan addresses all the major occupational hazards and is used to ensure that OSHA standards are met. The Federal government passed the Occupational Safety and Health Act in 1970 (29 USC 651 et seq.) to safeguard the health of the worker. Other State and local regulations may apply to worker-protection issues, but, generally, OSHA standards are the regulations most applicable to the site. The occupational hazards described in this Supplement should not be used for ensuring the protection of worker health and safety. The site-specific ES&H plan for a decommissioning plan should be referred to for detailed information regarding worker health and safety information.

4.3.10.1 Potential Impacts of Decommissioning Activities on Occupational Issues

Typical hazards of concern can be grouped into the following categories: physical, chemical, ergonomic, biological, and radiological (Plog 1988). Radiological hazards are discussed in Section 4.3.8, and other hazards are discussed in this section in the context of decommissioning activities.

Physical hazards: During the decommissioning process, the major sources of physical occupational hazards involve the operation and use of construction and transportation equipment. Vehicles, grinders, saws, pneumatic drills, compressors, and torches are some of the more common equipment that can cause injury if improperly used. Heavy loads, which are often moved about by cranes and loaders, must be controlled to avoid injury. The majority of these hazards will be part of dismantlement. Workplace designs and controls should be the first line of defense when preventing workplace injuries. Hard hats and other personal protective equipment (PPE) are also important interventions and can serve as a secondary protective measure should workplace controls fail.

Noise is also a physical hazard that will be significant during decommissioning. The majority of noise will come from equipment such as rivet busters, grinders, and fans. Table 4-2 lists the typical A-weighted sound levels (decibel [dBA] levels) of standard construction equipment without the use of noise control devices or other noise reducing design features. Although workplace controls and designs are the best methods for reducing noise, PPE (e.g., earplugs) can also be used to protect against hearing loss. If workers need to use PPE, their ability to communicate effectively is reduced and safety may be compromised.

Temperature is a physical hazard that will vary, depending on the decommissioning location and the amount of indoor versus outdoor activity. Heat and cold stress should be considered in any decommissioning plans. Fluctuations in core temperatures 37.6°C ([99.6°F] is normal, as measured by mouth at 37°C [98.6°F]) of 1.1°C (2°F) below or 1.7°C (3°F) above the normal impair performance markedly. If this range is exceeded, health hazards, e.g., hypothermia or heatstroke, exist (Plog 1988).

Table 4-2. Predicted Noise Ranges from Significant Construction Equipment (EPA 1971)

Equipment	Levels in dBA at 15 m (50 ft)
Trucks	82-95
Front loader	73-86
Cranes (derrick)	86-89
Pneumatic impact equipment	83-88
Jackhammers	81-98
Pumps	68-72
Generators	71-83
Compressors	75-87
Back hoe	73-95
Tractor	77-98
Scraper/grader	80-93

Electrical hazards are a significant concern during decommissioning. During stabilization, licensees often rewire the site to eliminate unneeded electrical circuits or repower certain operations from outside. For SAFSTOR, monitoring equipment may need to be installed and some systems will need to be de-energized. All of these activities, plus various other activities (operating cranes near power lines, digging near buried cables, etc.), pose an electrical threat to workers. Proper precautions should be taken to avoid injury.

<u>Chemical hazards</u>: Inhalation and dermal contact with chemicals are serious worker health hazards. Ingestion is typically not a voluntary route of exposure but accidental ingestions (pipetting with mouth, siphoning gasoline, etc.) have been known to occur at the job site. Solvents and particulates are the two contaminants of greatest concern. Some of the key chemicals of concern found in building materials, paints, light bulbs, light fixtures, switches, electrical components, and high-voltage cables include asbestos, lead, polychlorobiphenyls (PCBs), and mercury. Other chemicals that have been found during decommissioning activities include low levels of potassium, sodium chromate, and nickel found in the suppression chamber. Also, quartz and cristobalite silica were detected during concrete demolition. Fumes, often including lead and arsenic, and smoke from flame cutting and welding are significant sources of chemical exposure during decommissioning.

Decommissioning involves many activities that expose workers to chemical hazards:

- chemical decontamination of the primary loop

- removal of reactor components
- decontamination of the piping walls
- removal of contaminated soil
- removal of radioactive structures
- removal of hydrocarbon fuel from storage
- removal of hazardous coatings
- removal of asbestos.

Proper planning, workplace design, and engineering controls should be supplemented with PPE and appropriate administrative solutions to ensure adequate worker protection from not only chemical hazards but all hazards.

Ergonomic hazards: The physiological and psychological demands of decommissioning work create ergonomic hazards in the workplace. Discomfort and fatigue are two indicators of ergonomic stress that can lead to decreased performance, decreased safety, and increased chance of injury (Plog 1988). The typical sources of ergonomic stress during decommissioning activities include mechanical vibrations, lifting, and static work. Workplace designs, work shifts, and breaks should be planned accordingly to avoid ergonomic stress.

Biological hazards: Biological hazards include any virus, bacteria, fungus, parasite, or living organism that can cause a disease in human beings (Plog 1988). Typical sanitation practices can help avoid the obvious vectors for disease. Having clean, potable drinking water, marking nonpotable water, and providing cleansing areas are the most important elements of a sanitation system.

Given that many nuclear reactor facilities undergoing decommissioning are old, there is an increased chance that workers will be exposed to molds and other biological organisms that grow in and on the buildings. Molds and fungus, when inhaled, can cause minor to serious pulmonary problems. Dermal contact could cause rash and/or irritation. A thorough inspection of the facility should be conducted and proper cleansing and PPE should be used when biological agents are identified.

4.3.10.2 Results of Evaluation

Physical hazards are prevalent at all the decommissioning sites. The loudest dBA noise hazard at one plant was the fan noise of 107 dBA (see Section 4.3.16, “Noise”). One facility undergoing decommissioning provided information on the number of safety occurrences (minor and injuries), accident prevention notices, PPE violations, near misses, and OSHA reportables. Many PPE violations appear to be repeat offenders. Most of the injuries and incidents noted occur in the construction area. The maximum yearly number of incidents and injuries (37) appeared in 1998 with a high number of PPE violations (53) also occurring during this reporting year. Typically, no lost work time is attributed to injuries or incidents.

Chemical hazards at another facility undergoing decommissioning included lead and arsenic vapors, created from torch cutting and using the plasma arc, and quartz and cristobalite particulates, created from chipping and hammering. At the facility, air sample summary logs indicate a few exposures that exceeded OSHA's permissible exposure limit (PEL). Arsenic (PEL = 0.01 mg/m^3) levels exceeded the PEL four times during the sampling period. The highest arsenic reading was 0.03 mg/m^3 when using the torch and grinder to cut a hole during one activity. The same activity reported the only lead (PEL = 0.05 mg/m^3) reading above PEL at 1.5 mg/m^3. Quartz (PEL = 0.1 mg/m^3) and cristobalite (PEL = 0.05 mg/m^3) particulates greatly exceeded the PELs when using the chipping hammer (817.84 and 1.5 mg/m^3, respectively). The drill and chipping hammer also created too much quartz dust (9.2 mg/m^3).

Previous or anticipated decommissioning activities at the FBR or HTGR have not and are not expected to result in occupational hazard issues that are different from those found at other nuclear reactor facilities.

4.3.10.3 Conclusions

Physical and chemical hazards will continue to dominate occupational concerns during decommissioning activities. Physical hazards such as injury during construction activities, electrical shock, and accidental falls pose a MODERATE concern; they impact decommissioning but typically do not destabilize the project or impede progress. Chemical hazards associated with torch operations, chipping, grinding, and other conditions where vapors or breathable particles are generated pose a MODERATE concern. Occupational noise, temperature, ergonomic, and biological hazards should not be overlooked, but they pose a SMALL concern if proper ES&H procedures are followed.

The staff has concluded that the issue of occupational accidents is generic and the impacts for these activities are SMALL for noise, temperature, ergonomics, and biological hazards. The impacts are MODERATE for physical and chemical hazards where vapors and breathable particles are generated. Proper use of PPE and the development and implementation of a site specific ES&H plan are sufficient to protect the workforce and therefore no additional mitigation activities are needed.

4.3.11 Cost

While NEPA does not specifically require an assessment of the cost of the alternatives being considered in this Supplement, it is an important consideration in the decommissioning of nuclear reactor facilities. The mission of the NRC includes ensuring that decommissioning of all nuclear reactor facilities will be accomplished in a safe and timely manner and that adequate licensee funds will be available for this purpose. Inadequate funds could result in delays and/or in improper, unsafe decommissioning. For licensees to have adequate funds to decommission their plants in a safe and timely manner, an estimate of the cost of decommissioning is necessary, as is an assurance from the licensee that the funds will be available when needed.

4.3.11.1 Regulations

The procedure for decommissioning a nuclear power facility is set out principally in NRC regulations in 10 CFR 50.75, 50.82, 51.53, and 51.95. The regulations to ensure the safe and timely decommissioning of nuclear power facilities and the availability of decommissioning funds were originally established by the NRC in 1988. These regulations, principally 10 CFR 50.75, specify the minimum amount of funds that a licensee must have to demonstrate reasonable assurance of sufficient funds for decommissioning. The minimum decommissioning funds required by the NRC reflect only the efforts necessary to achieve termination of the 10 CFR Part 50 license. Costs associated with other activities related to facility deactivation and site closure, including operation of the spent fuel storage pool, construction, operation, and decommissioning of an ISFSI, demolition of uncontaminated or decontaminated structures that meet release criteria, and site restoration activities after sufficient residual radioactivity has been removed to meet NRC license termination requirements are not included in the minimum decommissioning fund requirement.

The regulations in 10 CFR 50.75 also require that licensees submit, at least once every 2 yrs, a report on the status of its decommissioning fund, including specifying the amount of funds accumulated, and a schedule for accumulating the remainder to be collected. This report is to be submitted annually for plants that are within 5 yrs of the end of licensed operations. 10 CFR 50.75 (f)(i) also requires that each power reactor licensee shall report the status of its decommissioning trust fund annually if the facility has already closed (before the end of its licensed life).

In addition to the financial assurance requirements for decommissioning in 10 CFR 50.75, other requirements in 10 CFR 50.75 and 50.82 specify requirements for submitting cost estimates for decommissioning to the NRC:

- 10 CFR 50.75(f)(2) requires that a licensee shall, at or about 5 yrs prior to the projected end of operations, submit a preliminary decommissioning cost estimate

- 10 CFR 50.82(a)(4)(i) requires a licensee to provide an estimate of expected costs for the activities being proposed in the post-shutdown decommissioning activities report (PSDAR)

- 10 CFR 50.82(a)(8)(iii) requires a licensee to provide a site-specific decommissioning cost estimate within 2 yrs following permanent cessation of operations and

- 10 CFR 50.82(a)(9)(ii)(F) requires a licensee to provide an updated site-specific estimate of remaining decommissioning costs as part of its LTP.

The regulations in 10 CFR 50.82 also specify the criteria that a licensee must meet before they can withdraw funds from the decommissioning fund for decommissioning activities.

4.3.11.2 Potential Impacts of Decommissioning Activities on Cost

The sections below discuss how the cost of decommissioning is impacted by the various decommissioning activities considered in this Supplement. As discussed previously, the NRC defines decommissioning as the removal of a facility or site safely from service and the reduction of residual radioactivity to a level that permits either (1) release of the property for unrestricted use and termination of the license, or (2) release of the property under restricted conditions and termination of the license (10 CFR 50.2). Decommissioning activities do not include the maintenance, storage, and disposal of spent nuclear fuel, or the removal and disposal of nonradioactive structures and materials beyond that necessary to terminate the NRC license (i.e., returning the site to a “greenfield” status or cleaning up the site to meet criteria more stringent than those specified by NRC regulations [10 CFR Part 20, Subpart E]). Although some of these additional activities are considered in this Supplement from an environmental impact perspective, they are not considered as a cost impact because the licensees are not required to accumulate funds for these activities.

The cost of decommissioning nuclear power facilities is directly related to the cost of the individual decommissioning activities. However, while the process for decommissioning nuclear power facilities is now well established, the cost of decommissioning varies from one nuclear facility to the next. The variability is due to the following major factors:

- <u>Type of reactor</u>: A BWR will generally cost more to decommission than a PWR because of the larger number of contaminated SSCs associated with a BWR that must be decontaminated, dismantled, and disposed of as LLW.

- <u>Size of reactor</u>: Larger power reactors will generally cost more to decommission than the smaller power reactors.

- <u>Extent of environmental contamination</u>: The degree to which soil and groundwater on the plant site have been contaminated from site operations, including approved onsite disposals under 10 CFR 20.2002 (and in the past 10 CFR 20.302 and 20.304), can have a significant impact on the cost of decommissioning the plant and terminating the license.

- <u>Approach to project management and oversight</u>: The cost of decommissioning is strongly influenced by the level of project management and contractor oversight determined to be necessary to carry out the decommissioning safely and effectively.

- <u>Amount of property taxes</u>: The amount of annual property taxes that a nuclear power reactor licensee must continue to pay after a plant has been permanently shut down can vary significantly from one locality to another.

- <u>Low-level waste, volume, and disposal cost</u>: The volume of LLW generated from decommissioning activities can vary significantly between plants, based on the type of reactor and housekeeping standards maintained during plant operations. The unit cost of disposal of the LLW is dependent on the level of treatment prior to disposal, the waste classification (e.g., class A, B, or C), and the disposal facility being used (see NUREG-1307, Rev. 9, *Report on Waste Burial Charges* [NRC 2000]).

While these factors result in a large variability in decommissioning cost estimates for different nuclear power facilities, they are often quantifiable based on site-specific factors.

To date, only three commercial nuclear power facilities (Fort St. Vrain, Shoreham, and Pathfinder) have actually completed the decommissioning process and had their nuclear licenses terminated. Variability in cost is largely due to the cost of waste management and disposal of the LLW generated during decommissioning and the uncertainty associated with regulatory requirements.

The former uncertainty arises because the Barnwell Low-Level Radioactive Waste Management Disposal Facility, the last remaining facility that is available to dispose of all classifications of LLW generated by all but two nuclear power facilities located throughout the United States, is scheduled to stop accepting waste from all NRC licensees except those located in the Atlantic Compact by 2009 (see NUREG-1307, Rev. 9, *Report on Waste Burial Charges* [NRC 2000]). However, decommissioning of most of the nuclear power facilities in the United States is not expected to occur until sometime after 2009. This cost uncertainty is generally applicable to most of the nuclear power facilities that are currently being decommissioned and those that will be decommissioned in the future. This cost uncertainty, however, is somewhat mitigated by the availability of the Envirocare disposal facility in Utah. Envirocare can accept most Class A LLW for disposal from any generator in the United States. (More than 95 percent of LLW generated during nuclear power facility decommissioning is Class A.) Other LLW storage and disposal sites are also currently being proposed.

The regulatory uncertainty is a reflection of the different requirements and standards for cleanup applied by different States and localities. While NRC cleanup requirements for terminating a license are well defined, these other external requirements may significantly influence the cost of decommissioning. For example, a local jurisdiction can impose stricter cleanup requirements than those imposed by the NRC. The cost of the extra cleanup is not reflected in the decommissioning fund required by the NRC.

4.3.11.3 Results of Evaluation

The estimated cost of decommissioning all of the nuclear power facilities that have been built and operated in the United States is provided in Table 4-3 (in January 2001 dollars). The costs provided in the table are those estimated by the owners of the individual plants and reported to the NRC.

Table 4-3. Cost Impacts of Decommissioning (in January 2001 Dollars)

Nuclear Plant	Electric Power Generation Rating	Reactor Type	Decommissioning Option	Estimated Decommissioning Cost, $ million
Decommissioning Completed				
Fort St. Vrain	330 MWe	HTGR	DECON	230 (189 [1996])[(a)]
Pathfinder	59 MWe	BWR	SAFSTOR	20 (13 [1992])[(a)]
Shoreham	809 MWe	BWR	DECON	258 (182 [1994])[(a)]
Currently Being Decommissioned				
Big Rock Point	67 MWe	BWR	DECON	364
Dresden, Unit 1	200 MWe	BWR	SAFSTOR	340
Fermi, Unit 1	61MWe	FBR	SAFSTOR	36
GE-VBWR	13 MWe	BWR	SAFSTOR	10
Haddam Neck	619 MWe	PWR	DECON	404
Humboldt Bay, Unit 3	65 MWe	BWR	SAFSTOR	284
Indian Point, Unit 1	257 MWe	PWR	SAFSTOR	259
La Crosse	50 MWe	BWR	SAFSTOR	111
Maine Yankee	860 MWe	PWR	DECON	400
Millstone, Unit 1	660 MWe	BWR	SAFSTOR	563
Peach Bottom, Unit 1	40 MWe	HTGR	SAFSTOR	54
Rancho Seco	913 MWe	PWR	SAFSTOR	597
San Onofre, Unit 1	410 MWe	PWR	SAFSTOR	427
Saxton	NA	PWR	SAFSTOR	44
Three Mile Island, Unit 2	792 MWe	PWR	SAFSTOR	502
Trojan	1130 MWe	PWR	DECON	250
Yankee Rowe	167 MWe	PWR	DECON	244
Zion, Unit 1	1085 MWe	PWR	SAFSTOR	386
Zion, Unit 2	1085 MWe	PWR	SAFSTOR	495
Currently Operating				
69 PWR Reactors	486 - 1270 MWe	PWR	DECON/ SAFSTOR	264 - 695
35 BWR Reactors	514 - 1265 MWe	BWR	DECON/ SAFSTOR	152 - 663
"Reference PWR"	1130 MWe	PWR	ENTOMB1/ ENTOMB2	290-400
"Reference BWR"	1100 MWe	BWR	ENTOMB1/ ENTOMB2	410-750

(a) Actual cost to complete the decommissioning and the year the license was terminated.

Shown in the table are the actual costs to complete the decommissioning and terminate the 10 CFR Part 50 licenses for each of those facilities that have reached this milestone of their life-cycle. Facility-specific estimates are also provided for each plant that has been permanently shut down and is either undergoing decommissioning or is in safe storage awaiting decommissioning. The costs shown are estimates developed by the licensee and reported in their PSDARs, site-specific cost estimate reports, LTPs, etc. These estimates are adjusted to January 2001 dollars.

Table 4-3 also provides the range of costs estimated by utilities to decommission all of the nuclear power facilities that are currently operating or have not indicated an intent to permanently shut down. Cost ranges, rather than facility-specific cost estimates, are provided for these plants, reflecting the fact that these estimates are not as well developed as for those plants that have already permanently shut down. These cost ranges were developed from licensee provided estimates in the March 1999 bi-annual decommissioning reports adjusted to January 2001 dollars.

Finally, Table 4-3 also provides a range of decommissioning cost estimates for the ENTOMB options. These options have not been used or considered by any U.S. nuclear power facility licensee to date. Cost estimation methods for the ENTOMB options are, thus, not as well developed as for the DECON and SAFSTOR methods. The values quoted in the table were developed from an analysis of the two entombment scenarios described in Chapter 3 for a “reference” (i.e., typical) PWR and BWR. The “reference” PWR was assumed to be the Trojan Plant in Oregon; the “reference” BWR was assumed to be the Columbia Generating Station in Washington.

4.3.11.4 Conclusions

The cost of decommissioning results in impacts on the price of electricity paid by ratepayers. These impacts generally occur over the life of the facility as the decommissioning fund is being collected. However, for those nuclear reactor facilities that shut down prematurely (as is the case for the majority of the facilities identified in Table 4-3), the impact may also occur for a number of years after permanent shutdown while the under-collected portion of the fund continues to be collected.

This analysis assesses the impact of cost by evaluating the total cost to decommission a nuclear power facility and terminate its Part 50 license. This impact is summarized in Table 4-4. As can be seen, the cost to decommission a large (>200 MWe) nuclear power facility is estimated to range from $150 million to $700 million and is highly dependent on the factors discussed previously.

Table 4-4. Summary of Cost Impacts by Decommissioning Option and Reactor Type and Size (January 2001 Dollars)

	Decommissioning Cost Range, $million					
Decommissioning Option	**PWR < 200 MWe**	**PWR ≥ 200 MWe**	**BWR < 200 MWe**	**BWR ≥ 200 MWe**	**HTGR**	**FBR**
DECON	244	250-404	364	>182[a]	189	--
SAFSTOR	44	259-597	13-284	340-563	54	36
DECON/SAFSTOR (Currently Operating Reactors)	--	264-695	--	152-663	--	--
ENTOMB1/ENTOMB2	--	290-400	--	410-750	--	--

(a) Cost data from the Shoreham plant, which only generated one effective full power day. There was little or no contamination to many plant systems. Not representative of other large BWRs.

4.3.12 Socioeconomics

Decommissioning work forces vary over time, by type and size of facility and by the types of activities undertaken in the decommissioning process. Generally, however, the decommissioning work force is significantly smaller and more temporary in nature than the operating work force. Loss of the operations work force can have significant socioeconomic effects on the economy of the facility's host community.

There are two primary pathways through which decommissioning activities have socioeconomic impacts on the area surrounding the plant. The first is through direct expenditures in the local community for labor in the decommissioning work force, plus any purchases of goods and services required for decommissioning activities. On average, the decommissioning work force is smaller than the work force during operations, so this will represent a smaller demand than the operating work force for services of the local business community and will reduce demand for some public services such as education. The surrounding area may lose much of the facility-related population at the end of operations, and this may only be partially offset by the influx of decommissioning workers.

The second pathway for socioeconomic impact is through the effects on local government tax revenues and services. At some point during the closure and decommissioning process, the shutdown facility goes off the local property tax rolls, resulting in a large drop in property tax revenue for local taxing jurisdictions. When the facility-related population associated with the operating facility leaves and is only partially replaced by the population related to decommissioning, there is a potential decline in the demand for and price of housing, also reducing property taxes. There is a resulting decline in the ability to pay for certain public services, such as schools, utilities, and transportation infrastructure, which, despite less demand, may become more expensive to maintain on a per capita basis.

4.3.12.1 Regulations

Although there are no Federal or State regulations pertaining to any particular level of socioeconomic impacts, as there are for some environmental effects, socioeconomic impacts are an element of NEPA documentation that must be addressed and mitigated, if warranted.

4.3.12.2 Potential Impacts of Decommissioning Activities on Socioeconomics

The size of the work force varies considerably among operating U.S. nuclear power facilities, with the onsite staff generally consisting of 600 to 800 personnel per reactor unit. The average permanent staff size at a nuclear power facility site ranges from 800 to 2400 people, depending on the number of operating reactors at the site. In rural or low population communities, this number of permanent jobs can provide employment for a substantial portion of the local work force. In addition to the work force needed for normal operations, many nonpermanent personnel are required for various tasks that occur during outages. Between 200 and 900 additional workers may be employed during these outages to perform the normal outage maintenance work. These are work force personnel who will be in the local community only a short time, but during these periods of extensive maintenance activities, the additional personnel will have a substantial effect on the locality. If, as expected, the decommissioning process requires a smaller work force than the onsite operating staff (typically 100 to 200 staff) and if the local economy is stable or declining, the result of the reduction in work force could be economic hardships, including declining property values and business activity, and problems for local government as it adjusts to lower levels of tax revenues. However, even this reduced work force will tend to mitigate temporarily the full adverse socioeconomic effects of terminating operations.

If there is a net reduction in the community work force but the economy is growing, the adverse impacts of this ongoing growth (e.g., housing shortages and school overcrowding) could be reduced.

If the decommissioning work force were substantially larger than the operational work force, the result could be increased demand for housing and public services but also increased tax revenues and higher real estate values. If the economy is characterized by decline, then decommissioning could temporarily reverse the adverse economic effects.

In a stable economy, a net increase in the community work force could lead to some shortages in housing and public services, as well as to the higher tax revenues and real estate values mentioned previously. In a growing economy, decommissioning could act as an exacerbating factor to the ongoing shortages that already might exist.

The magnitude of the impact is considered SMALL if there is little or no impact on housing values, education, and other public services, and local government finances are not distinguishable from normal background variation due to other causes. The magnitude of the impact is considered MODERATE if the effects on housing values, some elements of public services, and local government finances are affected noticeably, and even substantially, but the effect is not destablizing and recovery is rapid. The effects are considered LARGE if housing values, elements of public services, and local government finances are destablized with little hope for near-term recovery.

SMALL impacts on housing result when no discernable change in housing availability occurs, changes in rental rates and housing values are similar to those occurring statewide, and no housing construction or conversion occurs. Temporary MODERATE impacts result when there is a discernable increase or reduction in housing availability, rental rates and housing values exceed the inflation rate elsewhere in the State, or minor housing conversions and additions or abandonments occur. LARGE impacts occur when project-related demand results in a very large excess of housing or very limited housing availability, where there are considerable increases or decreases in rental rates and housing values, and substantial conversion or abandonment of housing units.

In general, impacts on public services (education, transportation, public safety, social services, public utilities, and tourism and recreation) are SMALL if the existing infrastructure (facilities, programs, and staff) could accommodate any changes in demand related to plant closure and decommissioning without a noticeable effect on the level of service. MODERATE impacts arise when the changes in demand for service or use of the infrastructure is sizeable and would noticeably decrease the level of service or require additional resources to maintain the level of service. LARGE impacts would result when new programs, upgraded or new facilities, or substantial numbers of additional staff are required because of facility-related demand.

4.3.12.3 Results of Evaluation

Changes in work force and population: Changes of over 3 percent to local population in a single year are expected to have MODERATE effects, while changes of over 5 percent are expected to result in LARGE impacts. These negative impacts include reduction of school system enrollments, weakened housing markets, and loss of demand for goods and services provided by local business. The size of the work force required during decommissioning, relative to that during operations, is an important determinant of population growth or decline.

The impact from facility closure depends on the rate and amount of population change. If decommissioning begins shortly after shutdown with a large work force, then the impact of facility closure is mitigated. Facilities where layoffs are sudden and there is a long delay before active decommissioning begins are likelier to experience negative population-related socioeconomic impacts. Thus, large plants located in rural areas that permanently shut down early and choose the SAFSTOR option are the likeliest to have negative impacts. Considering all variables such as plant size and community size as the same, plants that go into immediate DECON have less immediate negative impacts and the impacts from the ENTOMB option, assuming those preparations were made immediately after shutdown, would be less significant than those of SAFSTOR.

Data was gathered on the changes in work force at facilities that are being decommissioned where information on operational and decommissioning work force is available. This information is presented in Appendix J, Table J-1. The table also shows total population in the host county at the time of plant shutdown, to indicate the potential importance of the facility closure.

In order to identify any unusual downward trends in county population around the time of a facility shutdown, data was collected showing the range of percentage changes in population that have occurred at facilities currently being decommissioned. U.S. Census population data for the counties that house the decommissioning facility are used to assess changes in population around the time of shutdown by comparing percentage changes in the county population with State population changes during the same time period. This information is provided in Appendix J, Table J-2.

In only two cases do the corresponding county populations decline around the time of the closure (Indian Point, Unit 1, in Westchester, New York, and Millstone, Unit 1, in New London, Connecticut). However, during the same time period that the host counties experience population declines, the hosting States also experience population declines. This suggests that the decline in the county population is most likely part of an overall State population trend. Observing population trends over a decade may not capture small population declines or reductions in the rate of growth from one year to the next; however, longer trends should indicate whether or not the county had any large destablizing population or housing impacts from the facility closure.

In 18 out of the 20 facility case studies where populations grew, the populations of the counties where the facilities are located increased more rapidly or at the same rate as the State population. The two cases where the populations of the counties grew at a slower rate include relatively rural counties in California (Humboldt and Alameda) during time periods when the State of California experienced very high urban population growth. In general, the experience base on the decommissioning facilities to date does not show any impacts from population change, either because the changes were small relative to the population base or because they were offset by other growth in the area.

<u>Local tax revenues</u>: Similarly, changes in tax revenues of less than about 10 percent are considered SMALL, i.e., they result in little or no change in local property tax rates and the provision of public services. Losses between 10 percent and 20 percent result in MODERATE impacts, with increased property tax levies (where State statutes permit) and decreased services by local municipalities. Changes over 20 percent have LARGE impacts on the governments involved. Tax levies must usually be increased substantially or services cut substantially, and the payment of debt for any substantial infrastructure improvements made in

the past becomes extremely problematic. Borrowing costs for local jurisdictions may also increase because bond rate agencies downgrade their credit rating. However, it is important to remember that these rules of thumb are based on *uncompensated* changes. For example, if a local taxing jurisdiction lost a nuclear facility that amounted to 35 percent of its tax base, but 30 percentage points of this loss were made up by the opening of a new manufacturing facility, the net impact would be 5 percent or SMALL. Small, rural areas are more likely to be affected than more urban areas having a wider variety of economic opportunities and more sources of tax revenue. Impacts depend on the type of plant, size of plant, and whether or not there are multiple units at a site, all of which help determine the net loss in employment at plant closure as well as the loss of tax base.

More information is available for facilities that have recently closed than for facilities closed more than 10 years ago (see Appendix J, Table J-3). The findings from this body of evidence confirm the findings discussed above. The primary taxing authorities for most of the decommissioning plants are the county and city in which the facility is sited. Tax information is typically provided by local taxing authorities (assessor's office) or from town planners familiar with the tax revenues generated by the facility.

The tax revenue impacts on the local communities of facilities currently being decommissioned vary widely from zero impact (tax-exempt plants) to loss of 90 percent of the community tax base. The magnitude of tax-related impacts varies primarily by the size of the taxing jurisdiction and the taxing structure of the State in which the plant is sited, as well as certain plant characteristic. All else being equal, the smaller the taxing community, hence the less economically diverse, the greater the tax revenue impact when the nuclear facility closes down.

In communities where the revenues from the facility made up over 50 percent of the tax revenue base (with the remaining tax revenues made up primarily of private residential real estate), there were significant increases in the tax rates on the remaining real estate as well as cut-backs in services provided by property-tax revenues.

The manner in which a State calculates the value of the plant also affects both the amount and timing of tax losses when a nuclear power facility closes and how much such a closure disrupts the tax revenue stream in a given community:

- At one plant, the assessed value of the plant was calculated as a proportional share of the value of the parent corporation, where the percentage is based on the book value of assets in the State (or sub-State taxing jurisdiction) compared with the book value of the assets of the entire corporation. This approach kept the plant at full assessed value for 7 years after its permanent closure until it was dropped from the books of the parent corporation as an asset. Several other approaches are discussed in Appendix J.

- Tax rules may or may not permit gradual phase-out. In some cases, the taxable asset value of the plants was allowed to phase out over a period of time (3 to 5 years). In other cases, the plants were simply taken off the tax roles in 1 year.

- The State may or may not share the burden with local government. In one State, school districts' lost property-tax collections were offset by equalization methods at the State level, which reduced the impact due to plant closures. In another State, the small neighboring township was the sole recipient of all property-tax revenues generated by the plant. Thus, the community's tax revenues were significantly reduced when the revenue source shut down.

In addition to characteristics specific to the taxing jurisdiction, the size, age, and ownership of the facilities play a role in how much the facilities affect tax revenues. Generally, the larger the facility (MWt), the larger the tax revenue impact. In addition, aging of the facilities depreciates its book value and its assessed value over time. Usually, the falling assessed value of an aging facility will have reduced the tax revenue of the facility before closure, thus lessening the change in tax revenues generated by the facility after closure. A facility that closes suddenly, well before the end of its license expiration, will have a greater impact on the community tax base. Finally, if a facility is owned by a public entity, there is no effect on the tax base from closure because the facility was never taxable.

The choice of the decommissioning option appears to have had no direct bearing on the loss of tax receipts. The impact has to do with the size and suddenness of the loss of tax revenue (size and age of facility). Nor does the length of delay between shutdown and decommissioning appear to affect the size of the impact on tax revenue losses. No commercial nuclear power reactor has used the ENTOMB options, but there is no reason to expect ENTOMB to have any different impact on tax revenue losses than SAFSTOR or DECON.

<u>Public services</u>: The impacts of decommissioning on public services are generally closely related to the tax-related impacts on the community and are affected by the same characteristics of the plant: its size and age, its tax treatment, and the dependence of the local community on plant-related revenues, but not on the choice of decommissioning option or the amount of time between shutdown and active decommissioning. Inquiries were made to local governments in the vicinity of plants undergoing decommissioning about public service impacts during and after shutdown and decommissioning. Their assessments are discussed in Appendix J and data are shown in Table J-4. Analysis was also conducted in the course of preparing NUREG-1437 (NRC 1996). Based on that experience, the following generalizations can be made.

SMALL impacts result on housing when no discernable change in housing availability occurs, changes in rental rates and housing values are similar to those occurring statewide, and no housing construction or conversion occurs. Temporary MODERATE impacts result when there is a discernable increase or reduction in housing availability, rental rates and housing values exceed the inflation rate elsewhere in the State, or minor housing conversions and additions or abandonments occur. LARGE impacts occur when project-related demand results in a very large excess of housing or very limited housing availability, where there are considerable increases or decreases in rental rates and housing values, and substantial conversion or abandonment of housing units. The prevailing belief of realtors and planners in communities surrounding the case study facilities is that closing the facilities has had a range of effects on the marketability or value of homes in the vicinity. Housing choices of local residents are rarely affected by the presence of the facility, but people may move into the area in response to (temporarily) softer housing prices and commute to a nearby urban area.

The impacts to the following public services may occur during decommissioning: education, transportation, public safety, social services, public utilities, and tourism and recreation.

In general, impacts are SMALL if the existing infrastructure (facilities, programs, and staff) could accommodate any facility-related demand without a noticeable effect on the level of service. MODERATE impacts arise when the demand for service or use of the infrastructure is sizeable and would noticeably decrease the level of service or require additional resources to maintain the level of service. LARGE impacts would result when new programs, upgraded or new facilities, or substantial additional staff are required because of facility-related demand. Specific information for each of the areas of public service for plants undergoing decommissioning is provided in Appendix J.

In general, the communities that suffered the most from the tax-related impacts also have the greatest impacts on public services related to the plant closure. To some extent, the communities themselves control the amount of impact by how they allocate property taxes to local budgets before shutdown and how they prioritize these services post-shutdown. For example, one community channeled a great deal of the surplus revenues into building extensive social services for the elderly and for local youth in its community. After the plant ceased operations, the tax revenues decreased, all of the social services were downsized, and many will be eliminated because these are not considered to be priority programs (relative to public safety and education). In a second case, the county provided relatively few social services. Thus, the impact on social services after the shutdown was SMALL although several other categories of public service experienced MODERATE or MODERATE to LARGE impacts. For example, education was largely funded by plant tax revenues and the responsible school district has recently indicated that it may have to file for bankruptcy, so the impact is MODERATE to LARGE.[a]

Previous or anticipated decommissioning activities at the FBR or HTGR have not and are not expected to result in impacts on socioeconomics that are different from those found at other nuclear facilities.

(a) The size of impact can be significantly influenced by the mechanism that the State uses for funding, e.g., if the State makes up the difference between what the local school districts can fund from the local property tax and what the State has decided is the appropriate level of per-student expenditures.

4.3.12.4 Conclusions

The staff concludes that shutdown and decommissioning of nuclear power facilities produces socioeconomic impacts that are generic. The impacts occur either through the direct effects of changing employment levels on the local demands for housing and infrastructure or through the effects of the decline of the local tax base on the ability of local government entities to provide public services. The effects of employment changes on population growth are expected to be SMALL if population changes (reductions or increases) are less than 3 percent per year, MODERATE if the population change is between 3 percent and 5 percent, and LARGE if the population change is greater than 5 percent per year. Experience with decommissioning so far has shown that in most cases, reductions in employment even at fairly large sites do not generally produce population changes greater than 3 percent, regardless of the type of plant and decommissioning option selected. Accordingly, impacts due to employment changes are expected to be SMALL.

The effect on the local tax base and public services depends on the size of the plant-related tax base relative to the overall tax base of local government, as well as on the rate at which the tax base is lost. Changes in annual tax revenues less than about 10 percent are considered SMALL, i.e., they result in little or no change in local property tax rates and the provision of public services. Losses between 10 percent and 20 percent result in MODERATE impacts, with increased property tax levies (where State statutes permit) and decreased services by local municipalities. Changes over 20 percent have LARGE impacts on the governments involved. Experience has shown that publicly owned plants that are tax-exempt will not have an impact through this mechanism, nor will a small, old, fully depreciated plant, nor a plant that is located in an urban or urbanizing area with a large or rapidly growing tax base. In these cases, the impacts will be SMALL. A large, newer, relatively undepreciated plant, located in a small, isolated community, is much more likely to exceed the 20 percent criterion. If the plant tax base is not phased out slowly in these circumstances, the impact is likely to be LARGE. MODERATE impacts are likely between these extremes. Neither the type of reactor nor the method chosen for decommissioning matters.

4.3.13 Environmental Justice

Executive Order 12898, dated February 16, 1994 (59 FR 7629), directs Federal executive agencies to consider environmental justice under NEPA. This Executive Order ensures that minority and low-income groups do not bear a disproportionate share of negative environmental consequences. The Executive Order does not create whole new categories of impacts that need to be considered; nor does it create any right, benefit, or trust responsibility, substantive or procedural, that can be enforced by law or equity. It is designed to improve internal management of agencies to ensure that low-income and minority populations do not experience disproportionately high and adverse human health or environmental effects because of Federal actions.

Environmental justice has not been evaluated previously for decommissioning activities at reactor facilities.

4.3.13.1 Regulations

The Council on Environmental Quality has provided *Guidance for Addressing Environmental Justice Under the National Environmental Policy Act* (CEQ 1997). Although NRC is an independent agency, the Commission has committed to undertake environmental justice reviews and has provided specific information in Office Instruction LIC-203 Nuclear Reactor Regulation (NRR) *Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues* (NRC 2001). The CEQ guidance and NRR instructions provide several key definitions and the framework for analysis.

Low-income population: Low-income populations in an environmental impact area should be identified where census block groups within the environmental impact area have (1) more than 50 percent low-income persons or (2) the percentage of persons in households below the poverty level is significantly greater (typically, at least 20 age points) than in the geographical area chosen for comparative analysis. In identifying low-income populations, agencies may consider as a community either a group of individuals living in geographic proximity to one another or a set of individuals (e.g., migrant workers or American Indians), where either type of group experiences common conditions of environmental exposure or effect.

Minority: Individuals who are members of the following population groups: American Indian[a] and Alaska Native; Asian; Native Hawaiian and other Pacific Islander; Black or African American, not of Hispanic or Latino origin; or some other race and Hispanic or Latino (of any race).[b]

Minority population: According to the CEQ, minority populations should be identified where either (a) the minority population of the affected area exceeds 50 percent or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis. In identifying minority communities, agencies may consider as a community either a group of individuals living in geographic proximity to one another or a geographically dispersed/transient set of individuals (e.g., migrant workers or American Indians), where either type of group experiences common conditions of environmental exposure or effect. The selection of the appropriate unit of geographic analysis may be a governing body's jurisdiction, a neighborhood, census tract, or other similar unit that is to be chosen so as not to artificially dilute or inflate the affected minority population. A minority population also exists if there is more than one minority group present and the minority percentage, as calculated by aggregating all minority persons,

(a) For consistency, the term "American Indian" is used throughout this document to conform to the definition of "minority population."

(b) "Other" may be considered a separate minority category. In addition, the 2000 Census included multi-racial data. Multi-racial individuals should be considered in a separate minority, in addition to the aggregate minority category.

meets one of the above-stated thresholds. NRR adopted a standard of 20 percentage points as "meaningfully greater."

Disproportionately high and adverse human health effects: When determining whether human health effects are disproportionately high and adverse, agencies are to consider the following three factors to the extent practicable: (a) whether the health effects, which may be measured in risks and rates, are significant (as used by NEPA), or above generally accepted norms (adverse health effects may include bodily impairment, infirmity, illness, or death); (b) whether the risk or rate of hazard exposure by a minority or low-income population, to an environmental hazard is significant (as employed by NEPA) and appreciably exceeds or is likely to appreciably exceed the risk or rate to the general population or other appropriate comparison group; and (c) whether health effects occur in a minority or low-income population, affected by cumulative or multiple adverse exposures from environmental hazards.

Disproportionately high and adverse environmental effects: When determining whether environmental effects are disproportionately high and adverse, agencies are to consider the following three factors to the extent practicable: (a) whether there is or will be an impact on the natural or physical environment that significantly (as used by NEPA) and adversely affects a minority or low-income population (such effects may include ecological, cultural, human health, economic, or social impacts on minority communities, low-income communities, or American Indian tribes when those impacts are interrelated to impacts on the natural or physical environment); (b) whether environmental effects are significant (as employed by NEPA) and are or may be having an adverse impact on minority populations, low-income populations, or American Indian tribes that appreciably exceeds or is likely to appreciably exceed those on the general population or other appropriate comparison group; and (c) whether the environmental effects occur or would occur in a minority or low-income population, affected by cumulative or multiple adverse exposures from environmental hazards.

4.3.13.2 Potential Impacts of Decommissioning Activities on Environmental Justice

There are three general types of environmental impacts from decommissioning that could potentially have environmental justice implications. These are impacts from onsite or offsite land use changes, offsite environmental and human health impacts, and socioeconomic impacts. If the onsite land use changes in previously undisturbed parts of the site as a result of extra space being needed for laydown and staging areas, parking lots, temporary buildings, etc., during decommissioning, then the potential always exists that such previously undisturbed land may contain areas of critical cultural or subsistence importance to minority and low-income populations. Examples would be American Indian grave sites and traditional medicinal plant and food-gathering sites. Such impacts may also occur as a result of offsite land use changes.

Offsite physical environmental impacts of any kind may have an environmental justice component because minority and low-income populations may be located where they are likely to be disproportionally impacted (e.g., near the principal heavy truck route into the site); they are engaged in economic, social, or cultural practices (such as subsistence fishing near the facility); they are exceptionally dependent on certain natural resources that make them particularly vulnerable; or they have previously existing health or social conditions (such as long-term dependence on a contaminated aquifer) that leave them exceptionally susceptible to environmental contamination.

Socioeconomic impacts in the community that occur as a result of net loss of facility employment and tax base also could disproportionately affect the low-income members of the community because they are likelier to hold marginal and insecure jobs and because they are more dependent on local government programs that are threatened by the loss of the local tax base than are others in the community.

4.3.13.3 Results of Evaluation

Impacts due to onsite land use changes are likely to be SMALL because the amounts of land disturbance are generally very small and usually occur in areas of the site previously disturbed by construction or operation of the facility. Impacts from changes to offsite land use will generally not occur because offsite land uses generally do not change as a result of decommissioning. If a new road or rail spur is needed to accomplish decommissioning, the impact on environmental justice is site-specific, because it will depend on the location of the new route relative to low-income populations or resources on which they may depend. Siting and construction of these offsite facilities would include an evaluation of cultural and other resources in the disturbed areas. Usually, offsite physical environmental impacts of decommissioning will be SMALL because offsite environmental impacts from decommissioning are generally SMALL.

Socioeconomic impacts on minority and low-income populations due to plant closure and decommissioning could range from SMALL to LARGE, depending on the distribution of job impacts within the community and the effects of plant closure on local tax revenues and public services. More generic information on overall socioeconomic impacts can be obtained by observing demographic statistics. In the 21 decommissioning case studies observed, it is concluded that facility decommissioning should have a SMALL socioeconomic impact on low-income and minority populations. In other words, there appears to be no indication that minority or low-income populations would suffer disproportionately high and adverse impacts from the closure and decommissioning activities of the facilities. The environmental justice conclusions are based on demographic information, the overall impact of the facility on the community. Discussions were also held with community members at some sites.

If the area where a facility is located has a small minority population (less than 10 percent) and a relatively high income (the median income is higher than the median income for the State), it was concluded that no disproportionate impact would occur. If the location of the facility did not meet the previously stated criteria, the overall impact of the plant was assessed in terms of population, tax revenue, and socioeconomic impacts. If these were all SMALL, it was concluded that no disproportionate impact on low-income and minority populations is produced by the plant closure. In addition, information provided by local government and social service providers helps determine the socioeconomic impacts on low-income and minority populations.

In many of these case studies, the nuclear facilities are located in primarily white communities and tend to be located near bodies of water where upper-income real estate is built. Those that are employed by the facility tend to fall into the upper-income bracket within the communities where the facilities are located. Selected socioeconomic indicators are found in Appendix J, Table J-5, for the facilities currently in decommissioning status.

The determination of whether the minority or low-income populations are disproportionately high and adversely impacted by facility closure and decommissioning activities needs to be made on a site-by-site basis because their presence and their socioeconomic circumstances will be site-specific. Data indicates there is no reason to expect adverse socioeconomic impacts to be correlated with type of plant addressed in this Supplement or decommissioning option (see Table J-5). However, adverse socioeconomic impact is correlated with large facility size, early shutdown, and small, isolated host communities. If minority and low-income populations are present, adverse impacts from facility closure would be somewhat more likely in small, isolated communities than in larger urban areas. It is not clear whether these effects would be disproportionately high and adverse.

Previous or anticipated decommissioning activities at the FBR or HTGR have not and are not expected to result in environmental justice considerations that are different from those found at other nuclear facilities.

4.3.13.4 Conclusions

Environmental justice impacts of closing and decommissioning nuclear power facilities can occur because of disproportionately high and adverse effects of changes in onsite or offsite land use, offsite environmental and human health impacts, or socioeconomic impacts. Determining environmental justice impacts depends on identifying the location and circumstances of minority and low-income populations in the vicinity of the plant; therefore, the issue is site-specific. However, the impacts of changes in onsite land use, offsite land use, and offsite environmental impacts all are generally expected to be SMALL, except where new road or rail links need to be built into the site to accommodate decommissioning activities. Adverse socioeconomic impacts may be disproportionate, but such effects are likelier to be MODERATE or LARGE in small isolated communities where the plant to be closed and decommissioned is a major part of the local tax base.

The staff concludes that the issue of environmental justice requires a site-specific analysis. The staff has determined that the licensee, as part of the environmental portion of the PSDAR submittal, provide appropriate information related to the issue of environmental justice.

4.3.14 Cultural, Historical, and Archeological Resources

Cultural resources include any prehistoric or historic archeological site or historic property, site, or district listed in or eligible for inclusion in the National Register of Historic Places or otherwise having significant local importance. The Federal agency (in this case the NRC) is responsible for the evaluations through consultations with the State Historic Preservation Officer (SHPO), or if appropriate, the Tribal Historic Preservation Officer (THPO), who is responsible for determining which sites or properties are of significant historic or archeological importance. The NRC is also responsible for including other interested parties and affected American Indian tribes. Disagreements between the parties are resolved by the Advisory Council on Historic Preservation.

Evaluation of the potential presence of cultural resources should not rely solely on a query of the SHPO database, but should be based on field surveys and evaluations of the site. Although these evaluations may have been performed as part of the initial environmental evaluation for the sites or as part of another licensing action (e.g., license renewal), the coverage and adequacy of earlier survey efforts needs to be re-evaluated in cases where an impact may occur. Earlier field surveys and methods may not conform to current standards.

4.3.14.1 Regulations

The Federal statute that is most directly applicable to cultural resource issues during the decommissioning process is the National Historic Preservation Act (NHPA) of 1966 as amended (16 USC 470 et seq.). This Act created the National Register of Historic Places (National Register) and requires the heads of all Federal agencies to consider the impacts of the undertakings on any cultural properties that are listed on the National Register or that are eligible for listing. Section 106 of the NHPA requires each Federal agency to identify, evaluate, and determine the effects of an undertaking on any cultural resource site that may be within the area impacted by that undertaking. This section also requires consultation to resolve adverse effects of an undertaking and establishes mechanisms to obtain and incorporate comments from consulting parties. Federal agencies are directed by 36 CFR Part 800 to comply with the stipulations of NHPA as well as pertinent cultural, historical, and archeological protection provisions of NEPA, the Historic Sites Act of 1935, and the Antiquities Act of 1906 and their implementing regulations. The Historic Sites Act of 1935 (16 USC 461-467) declared a national policy of preserving, for the public, historic sites, buildings, and objects of national significance. It also led to the establishment of the Historic Sites Survey, the Historic American Buildings Survey, and the Historic American Engineering Record within the National Park Service.

Most other cultural, historical, and archeological protection regulations are primarily directed at resource protection on Federal lands, but in some cases these statutes may be applicable to the decommissioning of commercial power reactors. Several nuclear power reactors are located on Federal lands. The Antiquities Act of 1906 (16 USC 431-433) prohibits destruction of vertebrate fossils and archeological sites on Federal lands and regulates their removal under a permitting procedure. These regulations were further strengthened by the Archeological

Resources Protection Act of 1979 (16 USC 470aa-47011), which prohibits the willful or knowing destruction and unauthorized collection of archeological sites and objects located on Federal lands. It also establishes a permitting system for archeological investigations and requires consultation with concerned tribes prior to permit issue. The American Indian Graves Protection and Repatriation Act of 1990 (25 USC 3001 et seq.) protects graves on Federal lands and establishes tribal ownership of human remains and/or associated funerary objects taken from Federal lands and requires the inventory and repatriation to the tribes of any remains or funerary objects held by Federal agencies. Certain more recent Executive Orders regarding consultation with American Indian tribes and protection of religious sites and values could also be relevant.

Many of the States also have statutes that protect cultural, historical, and archeological resources on State lands. Some States also have burial and cemetery statutes that apply to private land as well. These State-level statutes are usually administered through the appropriate SHPO.

4.3.14.2 Potential Impacts of Decommissioning Activities on Cultural Resources

In general, the significant impacts to cultural resources during decommissioning will result only if land that had not been previously disturbed is used for decommissioning activities. The potential for adverse impacts to cultural resources may be slightly greater during decommissioning than during facility operations because of the potential need to clear additional land for laydown areas, support structures, or transportation links. Usually, very little land will be disturbed during decommissioning that was not previously disturbed during construction of the site; however, some disturbed areas may function to preserve or maintain the resource. It is possible that the areas on which large facilities have been constructed are altered to the point that even if archeological materials are found on the site, the setting and context may have been permanently lost. This would depend on whether the area had been excavated for a large building or if it had just been bladed and smoothed for a parking lot or other open area. It might also depend on the local topography and geomorphic setting of the cultural resource sites. Any disturbance beyond the area that was utilized for site construction has a potential to adversely affect archeological resources, depending on the depth of disturbance, and, under the NHPA, must be evaluated on a site-specific basis. Land could be cleared or disturbed to create storage and laydown areas, support structures, or new utility or transportation corridors. In addition to the direct effects of land clearing, indirect effects such as erosion and siltation may adversely affect some cultural resources.

In a few situations, the nuclear facility itself could be potentially eligible for inclusion in the National Register of Historic Places, especially if it is older than 50 years and represents a significant, historic, or engineering achievement. In this case, appropriate mitigation would be developed in consultation with the SHPO.

The magnitude of impacts to cultural resources would be considered SMALL if all decommissioning activities are confined to the existing facility's previously disturbed areas or other highly disturbed lands. The magnitude of the impacts would be considered MODERATE if relatively small amounts of undisturbed, adjacent lands would be utilized during the decommissioning process and if there are few known archeological or historical sites in the general vicinity. The magnitude of the impacts would be considered LARGE if a significant amount of undisturbed land would be disturbed along with sites of known historic or archeological significance.

4.3.14.3 Results of Evaluation

In most cases, the amount of land required to support the decommissioning process is relatively small and is a very small proportion of the overall facility site. Usually, the areas disturbed or utilized to support decommissioning are within the boundaries of the site previously disturbed areas and are immediately adjacent to the reactor, auxiliary, and control buildings. In most cases, there is sufficient room adjacent to the major activity areas to function as temporary storage, laydown, and staging areas. In many cases, management, engineering, and administrative staff would be assigned space in existing support or administration buildings. However, in some instances, it may be advantageous to dismantle the support or administration buildings earlier, e.g., if asbestos abatement is required in those buildings, in which case small amounts of land may be disturbed to install trailers or other temporary structures. In almost all cases examined, the licensees plan to restrict activities to previously disturbed areas, well within the existing facility operational boundaries, or at least within the area disturbed during original site construction. The licensees typically anticipate utilizing an area of between 0.4 ha (1 ac) to approximately 10.5 ha (26 ac). One facility required a new transmission line ROW to provide electrical power to the plant site during decommissioning. This line will also provide power to the onsite ISFSI after decommissioning is completed. However, construction of a new transmission line ROW is probably an unusual situation during the decommissioning process. It is expected that some sites will require the reconstruction or installation of new transportation links such as railroad spurs, road upgrades, or barge slips.

The potential for adverse impacts appears small regardless of the type of facility (BWR, PWR, HGTR, or FBR) or the decommissioning option selected. However, the different decommissioning options are likely to alter the timing of the impact to cultural resources more than the magnitude of the impacts. DECON may require slightly more land area to support a larger number of activities occurring at the same time. ENTOMB2 would probably have the least likelihood of adverse impacts because some large components may be left in place, reducing the land requirements needed for large construction equipment, as well as waste storage and barge or rail loading areas. The potential impacts of SAFSTOR may be smaller than DECON or ENTOMB1, depending on the time period over which activities are performed. If dismantling and decontamination occur slowly over many years (incremental decontamination and dismantlement), the same storage and staging areas can be reused for sequential activities; however, if many activities are performed over a short time period at the end of the SAFSTOR period, the impacts may be as large as DECON.

4.3.14.4 Conclusions

The NHPA imposes requirements on the NRC to identify any historic properties potentially affected by an undertaking, and to consider the effects of any undertaking on historic properties. The NRC must consult with appropriate SHPO (or in some cases THPO) to evaluate the potential impacts of the Commission's actions on historical properties.

The staff has concluded that for sites where no disturbance is expected to occur beyond the previously disturbed areas (i.e., within the security fences or surrounding paved, graveled, or otherwise developed areas) the impact to the cultural resources would be SMALL and generic for all facilities. If the use of areas beyond the previously disturbed area is anticipated and there have been previous ecological surveys that indicate a low probability of adversely affecting cultural resources, then the magnitude of the potential impact would also be SMALL and is generic for all sites. However, if the use of areas beyond the previously disturbed areas is anticipated and there are no existing protection plans in place to protect the cultural resources, or if the protection objective must be changed to allow adverse impacts, then the magnitude (i.e., SMALL, MODERATE, LARGE) of potential impacts will be determined through a site-specific analysis. The NRC will meet its responsibilities under the NHPA and related statutes by addressing this issue on a site-by-site basis during any decommissioning process.

4.3.15 Aesthetic Issues

Aesthetics is the study or theory of beauty and the psychological responses to it. Aesthetic resources include natural and manmade landscapes and the way the two are integrated. In this evaluation, aesthetic resources are considered to be primarily visual and to relate to the structures and the visual attributes of the decommissioning site.

4.3.15.1 Regulations

No agencies have made regulations that relate specifically to the degree to which aesthetics may be impacted by a Federal project. The Bureau of Land Management (BLM), however, has developed a Visual Resource Management (VRM) system,[a] which involves inventorying scenic values, establishing management objectives for those values through the resource-management planning process, and evaluating proposed activities to determine whether they conform with the management objectives. This system provides tools for identifying the visual resources of an area and assigning them to inventory classes. It also provides tools for determining whether the potential visual impacts from proposed activities or developments meet the management objectives established for an area or whether design adjustments will be required. This tool was designed to meet the BLM's responsibilities for maintaining scenic

(a) VRM System (http://www.blm.gov/nstc/VRM/vrmsys.html) July 7, 2001.

values of public lands. It does not directly apply to a decommissioning facility, where the landscape has already been altered by the facility's structure.

4.3.15.2 Potential Impacts of Decommissioning Activities on Aesthetic Issues

Levels of impacts for aesthetic resources are defined largely by the impact of the proposed changes as perceived by the public, not merely the magnitude of the changes themselves. The potential for significance arises with the introduction (or continued presence) of an intrusion into an environmental context, resulting in measurable changes to the community (e.g., population declines, property value losses, increased political activism, tourism losses).

Sites are considered to have SMALL impacts on their host communities' aesthetic resources if there are (1) no complaints from the affected public about a changed sense of place or a diminution in the enjoyment of the physical environment and (2) no measurable impact on socioeconomic institutions and processes. Sites are considered to have MODERATE impacts on their host communities' aesthetic resources if there are (1) some complaints from the affected public about a changed sense of place or a diminution in the enjoyment of the physical environment and (2) measurable impacts that do not alter the continued functioning of socioeconomic institutions and processes. A site is considered to have LARGE impacts on its host community's aesthetic resources if there are (1) continuing and widely shared opposition to the plant's continued operation based solely on a perceived degradation of the area's sense of place or a diminution in the enjoyment of the physical environment and (2) measurable social impacts that perturb the continued functioning of community institutions and processes.

Typically, nuclear power facilities are located in flat-to-rolling countryside in wooded or agricultural areas. In some cases, the facility structures are highly visible for many miles. In other cases, there are only a few views of the facility from the land, although it is more obvious from views in the water (lake, ocean, or bay). Aesthetic issues for the facility structures were addressed in many (but not all) of the Final EISs written for construction and/or operation of the plant. In most cases, the visual impacts were said to have been mitigated to some extent by the surrounding topography or vegetation. In other cases, highly visible structures (such as cooling towers) were said to be "highly visible" but that "the staff does not consider such an impact to be unacceptable." However, for decommissioning the issue related to aesthetics is not one of placing another facility or building on the site, but one of removing the buildings.

The issues evaluated in this section concern the impacts of decommissioning activities on aesthetic resources at and around all types of nuclear power facilities (PWRs, BWRs, HTGR, or FBR). During the decommissioning period, the structure of the facility could be slowly altered as the buildings are dismantled. During this phase, the impact on aesthetic resources would be temporary. The impacts would be limited both in terms of land disturbance and the duration of activity and would have characteristics similar to those encountered during industrial construction: dust and mud around the construction site, traffic and noise of trucks, and construction disarray on the site itself. In most cases, these impacts would not easily be visible offsite. Aesthetic impacts could either improve fairly rapidly in the case of an immediate

DECON when the licensee chose to dismantle the facility, remove the structures, and regrade and revegetate the site before license termination. Impacts could also remain the same or similar in the case where the licensee maintains the structures throughout the decommissioning period and leaves them standing even after license termination (either after decontamination of the structures or possibly along with entombment of the reactor building) or throughout a long SAFSTOR period or ENTOMB. In these latter cases, the aesthetic impacts of the plant would be similar to those that occurred during the operational period.

Nuclear power facilities generally contain four main buildings or structures as discussed in Chapter 3: the containment or reactor building, the turbine building, auxiliary building, and cooling towers (if any). Cooling towers and stacks, some of which may be 20 m (60 ft high) or higher, may be clearly visible from a distance. Sites also contain a number of storage tanks, a large switchyard, where the electric voltage is stepped up and fed into the regional power distribution system, and various administrative and security buildings. Any of these structures may be removed as a result of decommissioning. Several licensees of facilities currently being decommissioned plan to leave the switchyard in place after the termination of the license because it is an integral part of the power distribution grid.

4.3.15.3 Results of Evaluation

The removal of structures is generally considered beneficial to the aesthetic impacts of the site. In a few cases, where facilities have been located on the Great Lakes or ocean coast, the facility may have been used by boaters as a landmark. However, it is highly unlikely that this would become an issue that would preclude dismantlement of the facility structures.

The retention of the structures during a SAFSTOR period or the retention of structures onsite at the time the license is terminated is likewise not an increased visual impact, but instead a continuation of the visual impact analyzed in the facility construction or operations FES. The staff has not identified any mechanism that would result in a greater negative aesthetic impact than had previously been considered during the development of the construction FES.

4.3.15.4 Conclusions

Decommissioning activities will be conducted onsite, both inside and outside existing buildings (in the case of dismantlement or shipping activities). Any visual intrusion (such as the dismantlement of buildings or structures) would be temporary and would serve to reduce the aesthetic impact of the site. At a minimum, the aesthetic impact of the site would not be improved but would remain that of an industrial site as evaluated in the facility’s original FES.

The staff concludes that the issue of visual aesthetics for all decommissioning activities is generic and that the impacts for these activities will be SMALL. Because there will be no readily noticeable visual intrusion beyond what is already present for an operating facility, consideration of mitigation is not warranted.

4.3.16 Noise

Noise is one example of a direct effect, as defined by Section 1508 of the CEQ Regulations for Implementing NEPA, i.e., as effects caused by an action that occur at the same time and place as that action. For NRC licensees, the implementing regulations for NEPA are given in 10 CFR Part 51.

The discussions in this section relate to noise and related impacts that would be heard offsite. The impacts from noise to workers is addressed in Section 4.3.10.

4.3.16.1 Regulations

Noise is usually defined as sound that is undesirable because it interferes with speech, communication, or hearing; is intense enough to damage hearing; or is otherwise annoying. Noise levels often change with time. To compare levels over different time periods, several descriptors were developed that take into account this time-varying nature. These descriptors are used to assess and correlate the various effects of noise, including land use compatibility, sleep and speech interference, annoyance, hearing loss, and startle effects:

- A-weighted sound levels (dBA) - typically used to account for the response of the human ear

- C-weighted scale (dBC) - generally used to measure impulsive noise such as air blasts from explosions, sonic booms, and gunfire

- day-night average sound level (DNL) - used to evaluate the total community noise environment. The DNL is the average A-weighted sound level during a 24-hr period with 10 dB added to nighttime levels (between 10 p.m. and 7 a.m.). This adjustment is added to account for the increased human sensitivity to night-time noise events.

The EPA was given the jurisdiction in the Noise Control Act of 1972 (42 USC 4901 et seq.) to promulgate and enforce the regulations that were issued under the Act. Funding for EPA to perform this function was eliminated in early 1981. However, Congress did not repeal the Noise Control Act. The DNL was endorsed by the EPA and is mandated by the U.S. Department of Housing and Urban Development (HUD), the Federal Aviation Administration, and the Department of Defense for land use assessments. The EPA has determined that no significant effects on public health and welfare occur for the most sensitive portion of the population (within an adequate margin of safety) if the prevailing DNL is less that 55 dB (NAS 1977). The Federal Aviation Administration bases its noise guidelines on land use. For residential uses, sound levels up to 65 dB are acceptable. Certain residential areas with sound-blocking features can handle up to 75 dB. For livestock farming and breeding, compatibility is considered to exist up to 75 dBA. These guidelines are advisory in nature and are not mandatory (14 CFR Part 150).

The Federal Housing Administration (FHA), under HUD, established noise assessment guidelines under 24 CFR 51B (1979; amended April 25, 1996). The FHA/HUD site acceptability levels are summarized as follows:

- Acceptable (DNL is 65 dBA or less) - Typical building materials and construction will make any impacts to indoor noise minimal. Outdoor recreation and activities would not be impacted. No approval requirements or abatement measures are needed under this condition.

- Normally unacceptable (DNL is 65 to 75 dBA) - Noise exposure will impact outdoor use of the area and indoor use may be affected. Walls or other barriers may be needed to reduce outdoor noise levels. Indoor noise levels may need to be reduced using special construction methods.

- Unacceptable (DNL above 75 dBA) - The noise conditions in this situation are unacceptable and the site would need to be approved on a case-by-case basis.

Local and State regulations may also exist regarding noise restrictions and abatement decisions. Many States prohibit only nuisance noise and have not established specific numerical environmental noise standards, while others have very specific requirements. For example, the State of Maine has the following construction sound level requirements:

- Demolition activities that occur between 7 p.m. and 7 a.m. must meet nighttime operational noise limits that depend on existing ambient sound levels in the noise-sensitive residential areas adjacent to the site.

- The most stringent level requirements apply to “protected areas,” defined as areas with pre-development nighttime ambient sound levels of 35 dBA. Higher levels are allowed by permit only.

- Allowable nighttime limit on noise in protected areas is 45 dBA. Sound levels for daytime construction activities are dependent on the duration of the noise. A limit of 87dBA is required for a 12-hr daytime period.

4.3.16.2 Potential Impacts from Noise of Decommissioning Activities

When noise levels are below the levels that result in hearing loss, impacts have been judged primarily in terms of adverse public reactions to the noise. Generally, surveys around major sources of noise such as large highways and airports have found that, when the DNL increases beyond 60 to 65 dBA, noise complaints increase significantly (FICN 1992). Noise levels below 60 to 65 dBA are considered to be insignificant. FHA/HUD uses a DNL of 65 dBA as the primary criterion for impact on residential properties and nearby populations. Business and institutional properties may be less sensitive to changes in noise levels, but all populations of concern should be considered when estimating the noise impact of decommissioning activities.

During the decommissioning process, the major sources of noise that would be heard offsite include construction and transportation vehicles, grinders, saws, pneumatic drills, compressors, and noise from the loud speakers. These sources of noise would have to be compared to current noise levels of the operating facility and the background noise present at the site. Table 4-5 lists predicted noise ranges for significant sources of noise during decommissioning.

The principal sources of noise from facility operations are natural-draft and mechanical-draft cooling towers, transformers, and loudspeakers. Other occasional noise sources may include auxiliary equipment such as pumps to supply cooling water from a remote reservoir. Of these sources, only loudspeakers would be anticipated to continue during the decommissioning period. Generally, these noise sources are not heard by a large number of people offsite. Typically, operating reactor facilities do not result in offsite levels more than 10 dBA above background beyond the site boundary.

However, some sites have calculated impacts to critical receptors at this level and above. Loudspeakers would still be a source of noise in decommissioning facilities. Noise level increases larger than 10 dBA beyond the site boundary would be expected to lead to interference with outdoor speech communication, particularly in rural areas or low-population areas where the day-night background noise level is in the range of 45 to 55 dBA.

In most cases, during decommissioning the sources of noise would be sufficiently distant from critical receptors outside the plant boundaries that the noise would be attenuated to nearly ambient levels and would be scarcely noticeable, as in the case for operating plants. However, in some cases, such as the use of equipment to turn concrete into rubble, the noise levels offsite could be sufficiently loud (60 to 65 dBA at the nearest receptor site) that activities may need to be curtailed during early morning and evening hours. It is highly unlikely, based on past decommissioning experience, that the offsite noise level from a plant during decommissioning would be sufficient to cause hearing loss.

It is anticipated that most decommissioning activities will not represent an audible intrusion on the community for any type of nuclear power facility (BWR, PWR, HGTR, or FBR).

4.3.16.3 Results of Evaluation

Noises from facilities that are currently being decommissioned have been reported at levels of up to 107 dB (dropping to 50 dB less than 1.6 km [1 mi] away), in one case as a result of the spent fuel pool cooling system. Nearby residents complained to the plant staff about these noise levels; engineering changes were made in the fans that were causing the noise and the issue was resolved.

In addition to mitigation of noise levels based on engineering design, noise abatement procedures can be considered in decommissioning plans to reduce noise, particularly at night.

Table 4-5. Predicted Noise Ranges from Significant Decontamination and Dismantlement Sources (INEEL EIS 1999)

			Predicted Noise Level Ranges (dBA) at Various Distances from the Reference Distance			
Source	**Source Strength dBA**	**Reference Distance, m**	**150 m (500 ft)**	**300 m (1000 ft)**	**0.8 km (0.5 mi)**	**1.6 km (1 mi)**
Construction equipment	85-90	15[(a)]	65-75	59-69	51-61	45-55
Truck	85-90	15	65-75	59-69	51-61	45-55
Rail engine	86-96	30[(b)]	76-86	71-81	64-74	58-68
Rail car, 64 km/h (40 mph)	80-86	30	68-74	62-68	53-59	48-54

(a) 15 m ≈ 50 ft.
(b) 30 m ≈ 100 ft.

No differences are expected between the anticipated noise levels during future decommissioning activities at currently operating plants and the observed noise levels during decommissioning at currently decommissioning facilities.

The timing of the noise impacts and the duration or intensity will vary depending on the decommissioning option and the procedures that are used. More noise will occur during active dismantlement than during the storage period of SAFSTOR. Some demolition activities such as rubblization of concrete could increase noise levels temporarily.

4.3.16.4 Conclusions

The staff concludes that the issue of noise for all decommissioning activities is generic and that the impacts will be SMALL.

4.3.17 Transportation

In considering activities for decommissioning, transportation can be considered both an activity and an issue. Transportation of equipment, material, and waste is an activity that is performed throughout the entire decommissioning process. However, it is treated as an issue in this Supplement and is given its own section.

This section addresses impacts related to transporting equipment and materials (radiological and nonradiological) onsite and offsite. Materials transported offsite include nonhazardous waste, LLW, hazardous waste, and mixed waste to offsite disposal facilities. The shipment of spent nuclear fuel is not considered to be within the scope of this Supplement as discussed in Chapter 1. Radiological impacts include exposures of transport workers and the general public along transportation routes. Nonradiological impacts include additional traffic volume and the potential for traffic accidents not related to the release of radioactive material.

4.3.17.1 Regulations

The regulations that apply to the transportation of radioactive material to a LLW site are provided by the U.S. Department of Transportation (DOT) and cited in 49 CFR Parts 171-177. NRC regulations are cited in 10 CFR Part 71, "Packaging and Transportation of Radioactive Material."

The regulations contain requirements for transport vehicles, maximum radiation levels for packages and vehicles, special packaging requirements, driver training, vehicle and packaging inspections, marketing and labeling of packages, placarding of vehicles, and training of emergency personnel to respond to mishaps. Highway routing restrictions for certain shipments of LLW are also included in DOT regulations. NRC regulations contain performance requirements for certain types of transportation packages of radioactive material.

4.3.17.2 Potential Decommissioning Impacts from Transportation

This section addresses both the radiological and nonradiological environmental impacts resulting from shipments of LLW and mixed waste to offsite disposal facilities. The nonradiological impacts are traffic density, weight of the loaded truck or railcar, and transportation accidents. The radiological impacts include possible exposures of transport workers and the general public along transportation routes. Radiation exposure to these groups also may occur through accidents along transportation corridors.

Transportation impacts at a decommissioning nuclear power facility are similar to the transportation impacts of an operating plant. However, there are several factors that could affect the transportation impacts at decommissioning plants:

- increased waste production due to decontamination and dismantlement activities that increase the amount of waste shipped offsite

- changes in the transportation method (between rail, truck, and barge)

- increased dose to the public and workers due to increased waste volume shipped offsite and different mix of waste categories shipped offsite as compared to waste shipped during normal operations

- the need to bring in equipment to complete a decommissioning activity - For example, large equipment for removing large components could be brought in by truck or barge that would not typically be needed during normal operations.

- increased potential for accidents due to increased number of shipments (both radiological and nonradiological).

Transportation impacts are considered SMALL when the impacts are not detectable or are so minor that they are not noticeable. For transportation, this is defined as the number of fatalities from accidents being less than two for all reactor types and decommissioning options. Transportation impacts would be MODERATE when impacts are sufficient to be noticeable but not large enough to destabilize the important attributes of the system (in this case, the transportation system). Transportation impacts would be considered LARGE when the transportation roads and infrastructure had to be changed to accommodate the number of shipments.

4.3.17.3 Results of Evaluation

The transportation impacts are dependent on the number of shipments to and from the facility, the type of shipments, the distance that material is shipped, and the nonradiological waste/fixed waste quantities and disposal plans. The distance that the waste travels varies depending on the plant's proximity to a disposal site. One decommissioning facility, located in Oregon, ships LLW (480 km) (300 mi) to the U.S. Ecology burial site on the Hanford Reservation in Richland, Washington. Another decommissioning facility located in California ships LLW (4300 km) (2700 mi) to the Barnwell facility in South Carolina.

The volume of LLW disposed of annually (at licensed disposal facilities) from operating nuclear power facilities varies by type of reactor. According to NUREG-1437, in 1987, the average operating PWR disposed of approximately 250 m^3/yr (8800 ft^3/yr) in 35 annual shipments. The average operating BWR disposed of about 558 m^3/yr (19,700 ft^3/yr) in 59 annual shipments. However, the volume of LLW has declined over the years and will likely continue to decline because of volume reduction and waste minimization efforts.

In contrast, the number of shipments and volume of waste shipped during the decontamination and dismantlement phases of decommissioning are often greater than during operations. Information on shipments from nine plants was received and is shown in Appendix K. For most plants, there are less than 150 LLW truck shipments a year.

Shipments of nonradioactive material that has been cleared from the site for general disposal will likely be shipped to landfills. However, because licensees cannot release material with detectable amounts of radioactive material, a number of sites may ship much of their solid waste to vendors specializing in the management of LLW or to LLW sites such as that at Clive, Utah.

It is anticipated that many of the shipments to the facility undergoing decommissioning, including shipments of equipment and heavy machinery, would come from local sources and thus the distance traveled would be minimal. However, some shipments may come from more local sources.

A generic analysis was conducted to develop estimates of a range of human health impacts associated with transporting decontamination and dismantlement wastes from reactor sites to

LLW burial grounds. The RADTRAN 5 computer code was used to perform the calculations (Neushauser and Kanipe 1996). RADTRAN 5 is a later version of a code, originally developed by Sandia National Laboratories to support the NUREG-0170 environment impact analysis (NRC 1977). It is commonly used for transportation impact calculations in support of environmental documentation.

RADTRAN 5 calculates the radiological and nonradiological impacts associated with transportation of radioactive materials. The results of the radiological impact calculations are shown in Table 4-6 for PWRs and BWRs and for the three decommissioning options (DECON, SAFSTOR, and ENTOMB). In order to encompass the range of impacts, a distance of 4800 km (3000 mi) was selected. The actual range of distances to the waste vendor or disposal site ranges from 8 km (5 mi) to greater than 4541 km (2838 mi). A further discussion of the input values used to model the transportation of decontamination and dismantlement wastes from reactors to LLW disposal facilities is given in Appendix K.

Because data on waste volume shipments were received from only seven plants, estimates of waste volume and shipment numbers in several cases (as footnoted in the table) reflect only a single facility and may be significantly higher or lower than for the average facility in that grouping. The impacts from FBRs and HTGRs would be encompassed by those for the PWRs and BWRs since the distance shipped is less and the plant sizes are generally smaller.

The results of the radiological impact calculations are shown in Table 4-6 for the total period of “active” decommissioning since very few shipments would be made during SAFSTOR or after entombment. It is assumed that the active period of decommissioning would last from 2 to 6 years. Radiological impacts are divided into those that are “routine” or incident-free (i.e., the shipment reaches its destination without incident) and those that occur as a result of an accident with a subsequent radiological release.

Nonradiological accident impacts are shown in Table 4-7. Again, these numbers reflect the entire decommissioning period. Nonradiological impacts for shipments of decontamination and dismantlement wastes are identical to shipping any commodity. They are not related to the radioactive nature of the cargo.

The number of shipments into the decommissioning facility would be much smaller than those at the facility. The concrete used to entomb a plant would be manufactured at a batch plant onsite, or the licensee would use local sources for the materials needed for entombing a facility. Therefore, transporting the materials to the site would not significantly impact the overall traffic volume or compromise the safety of the public. Shipments of materials into the facility during decommissioning or following the preparation for entombment of the facility would be minimal.

Previous or anticipated decommissioning activities at the FBR or HTGR have not and are not expected to result in impacts on transportation that are different from those found at other nuclear facilities.

4.3.17.4 Conclusions

The staff concludes that the issue of transportation of nonradiological and radiological materials to and from a decommissioning nuclear reactor facility would be generic and the environmental impacts would be SMALL.

Table 4-6. Radiological Impacts of Transporting LLW to Offsite Disposal Facilities[(a)]

Reactor Type	Decommissioning Option	Volume, m^3	No. of Shipments in a 2-6 yr period of active decommissioning	One-way distance, km	Radiological Impacts, (Routine) person-Sv Sv (person-rem)	Radiological Impacts (Accident) person-Sv Sv (person-rem)
PWR	DECON	10,000 (353,000 ft^3)	600	4800 (3000 mi)	0.48 (48)	0.014 (1.4)
	SAFSTOR[(b)]	45000 (1.5 million ft^3)	960[(c)]	4800 (3000 mi)	0.78 (78)	0.022 (2.2)
	ENTOMB1[(c)]	5000 (177,000 ft^3)	300	4800 (3000 mi)	0.24 (24)	0.007 (0.7)
	ENTOMB2[(c)]	500 (17,700 ft^3)	30	4800 (3000 mi)	0.024 (2.4)	0.0007 (0.07)
BWR	DECON[(b)]	2000 (71,000 ft^3)	120	4800 (3000 mi)	0.097 (9.7)	0.0028 (0.28)
	SAFSTOR[(b)]	18,000 (649,000 ft^3)	1100	4800 (3000 mi)	0.87 (87)	0.025 (2.5)
	ENTOMB1[(c)]	5000 (177,000 ft^3)	300	4800 (3000 mi)	0.24 (24)	0.007 (0.7)
	ENTOMB2[(c)]	500 (17,700 ft^3)	30	4800 (3000 mi)	0.024 (2.4)	0.0007 (0.07)

(a) Estimates of impacts based on data available from a limited number of facilities and estimated volumes provided by licensees.
(b) Data was available from a single facility. In some cases the final facility status (i.e., complete removal of all structures) caused the number of shipments and waste volume estimates to appear higher than might be expected.
(c) Data was not available. Volume and number of shipments were estimated.
(d) Data included 94 truck shipments and 960 rail. However, because RADTRAN 5 does not consider trains, the shipments were assumed to go by truck, which will be a conservative estimate.

Table 4-7. Nonradiological Impacts of Transporting LLW to Offsite Disposal Facilities[(a)]

Reactor Type	Decommissioning Option	Volume, m^3	Number of Shipments	One-way Distance, km	Nonradiological Impacts, Fatalities		
					Crew	Public	Total
PWR	DECON	10,000	600	4800	0.2	0.6	0.7
	SAFSTOR[(b)]	45,000	960[(c)]	4800	0.04	0.2	0.2
	ENTOMB1[(c)]	5000	300	4800	0.08	0.3	0.4
	ENTOMB2[(c)]	500	30	4800	0.008	0.03	0.04
BWR	DECON[(b)]	2000	120	4800	0.03	0.11	0.2
	SAFSTOR[(b)]	18,000	1100	4800	0.3	1.0	1.0
	ENTOMB1[(c)]	5000	300	4800	0.08	0.3	0.4
	ENTOMB2[(c)]	500	30	4800	0.08	0.03	0.04

(a) Estimates of impacts based on data available from a limited number of facilities and estimated volumes provided by licensees.
(b) Data was available from a single facility. In some cases the final facility status (i.e., complete removal of all structures) caused the number of shipments and waste volume estimates to be artificially high.
(c) Data was not available. Volume and number of shipments were estimated.
(d) Data included 94 truck shipments and 960 rail. However, because RADTRAN 5 does not consider trains, the shipments were assumed to go by truck, which will be a conservative estimate.

4.3.18 Irretrievable Resources

The irreversible and irretrievable commitments of resources that are anticipated during the decommissioning process are similar to those that were considered in the FESs for facility construction permits and operating licenses. The FESs for plant operation cite uranium as the principal natural resource irretrievably consumed in facility operation. However, following permanent cessation of operations, uranium is no longer consumed. As discussed in Chapter 1, disposal of uranium as part of the spent nuclear fuel is not within the scope of this Supplement. Other resources considered in some FESs include land, concrete, water, and human resources.

4.3.18.1 Regulations

There are no regulations that deal specifically with the concept of irretrievable resources. However, there are regulations that deal with the use of land (addressed in Section 4.3.1, “Onsite/Offsite Land Use”), water use and quality (Sections 4.3.2 and 4.3.3), and air quality (Section 4.3.4). Disposal of uranium is not within the scope of this document. Land devoted to LLW disposal sites or in industrial landfills is addressed in the licensing documents for the disposal site.

4.3.18.2 Potential Impacts of Decommissioning Activities on Irretrievable Resources

Although most FESs addressed primarily uranium fuel, other resources were discussed in some of the FESs. This included land used for plant buildings, components such as large under-ground concrete foundations, and certain other equipment considered irretrievable due to practical aspects of reclamation and/or radioactive decontamination. The use of the environ-ment (air, water, and land) by the facilities was not deemed to represent significant irreversible or irretrievable resource commitments but rather a relatively short-term investment.

Whether land is considered to be an irretrievable resource depends largely on the decisions at the time of license termination. If the license is terminated for unrestricted use, then the land will be available for other uses, whether or not the decommissioning process returned the land to a “greenfield” site or to an industrial complex. If ENTOMB1 is selected, license termination could still allow unrestricted access after 30 to 60 years. However, if the ENTOMB2 option is selected, the land under the facility will not be available for alternative uses and would be considered irretrievable.

The only other irretrievable resources that would occur during the decommissioning process would be materials used to decontaminate the facility (i.e., rags and solvents), and fuel used for construction machinery and for transportation of materials to and from the site. However, these resources are minor.

4.3.18.3 Results of Evaluation

Although the use of land, water, air, and fuel oil during decommissioning is minimal or not existent, the disposal of radioactive waste and nonradioactive waste would be considerable for some options, such as DECON to a "greenfield" (nonindustrial) site. Even though the disposal of radioactive waste is outside the scope of this document, the volume of land required for radioactive waste disposal is estimated in Table 4-8 for the SAFSTOR and DECON options, based on data obtained from six plants. The quantities of waste shown in Table 4-8 for the two ENTOMB options was estimated based on the scenarios described in Chapter 3. The greatest estimated volume of radwaste is from a facility that is being decommissioned to "greenfield" (no structures remaining onsite). It is located in a State that does not allow disposal of the industrial waste within an in-state industrial waste site.

4.3.18.4 Conclusions

The staff concludes that the issue of irretrievable resources for all decommissioning activities is generic and that the impacts will be SMALL.

Table 4-8. Volumes of Land Required for LLW Disposal[(a)]

Decommissioning Option	Reactor Type	Volume of Land Required for LLW Disposal, m^3 (ft^3)	Plant Size (Electrical Capacity, MWe)
DECON	PWR	8000 - 10,000 (282,500 - 353,000 ft^3)	1130 to 1825
	BWR	2000 (71,000 ft^3)	240
SAFSTOR	PWR	600 - 45,000 (21,000 -1.5 million ft^3)	23 to 1437
	BWR	18,000 (636,000 ft^3)	660
ENTOMB1	Either	<5000 (<177,000 ft^3)	variable
ENTOMB2	Either	<500 (<17,700 ft^3)	variable

(a) Data were available from a limited number of facilities and based on actual estimates provided by the licensees.

4.4 References

10 CFR 20. Code of Federal Regulations, Title 10, *Energy*, Part 20, "Standards for protection against radiation."

10 CFR 50. Code of Federal Regulations, Title 10, *Energy*, Part 50, "Domestic licensing of production and utilization facilities."

10 CFR 71. Code of Federal Regulations, Title 10, *Energy*, Part 71, "Packaging and transportation of radioactive material."

10 CFR 100. Code of Federal Regulations, Title 10, *Energy*, Part 100, "Reactor site criteria."

14 CFR 150. Code of Federal Regulations, Title 14, *Aeronautic and Space*, Part 150, "Airport Noise Compatibility Planning."

24 CFR 51B. Code of Federal Regulations, Title 24, *Housing and Urban Development*, Part 51B, "Environmental criteria and standards."

36 CFR 800. Code of Federal Regulations, Title 36, *Parks, Forests, and Public Property*, Part 800, "Protection of Historic Properties."

40 CFR 190. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 190, "Environmental radiation protection standards for nuclear power operations."

40 CFR 1508. Code of Federal Regulations, Title 40, *Protection of Environment*, Part 1508, "Terminology and index."

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