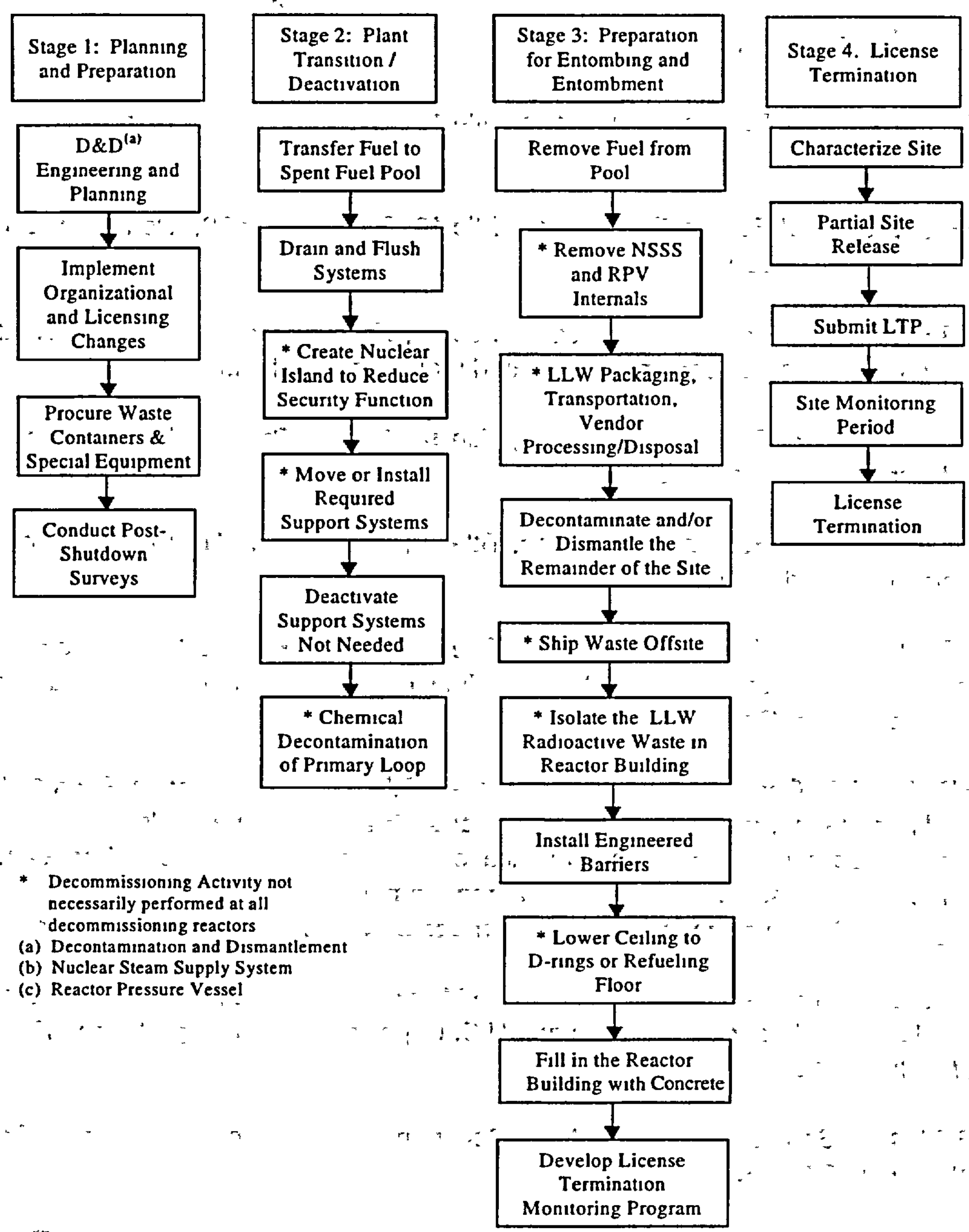

Figure 3-4. Reactor Decommissioning Process - ENTOMB

3.4 References

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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 of 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 sections define the significance and applicability terms used in the Chapter 4 analyses.

4.1.1 Terms of Significance of Impacts

For decommissioning, the staff is using a standard of significance derived from the Council on Environmental Quality (CEQ) terminology for "significantly"[(a)] (40 CFR 1508.27, which considers "context" and "intensity"). The NRC has defined 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 staff assumed that ongoing mitigation measures would continue (including those mitigation measures implemented during plant construction and/or operation) during decommissioning, as appropriate. Additionally, the staff has assumed that a licensee will obtain all relevant permits and appropriate consultations, will continue to comply with the conditions of those permits or consultations, and will use appropriate best management practices (BMPs) to minimize impacts of decommissioning activities. Benefits of additional mitigation measures during or after decommissioning are not considered in determining significance levels.

The cumulative impacts of all activities were assessed. Cumulative impacts are incremental impacts of the decommissioning activity when added to other past, present, and reasonably foreseeable future actions at the licensed site.

4.1.2 Terms of Applicability of Impacts

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

- Generic – For the issue, the analysis reported in this Supplement presents 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 the 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.

For many issues, similar activities may be performed either on the plant site or offsite. In several cases, the conclusions as to generic or site-specific are different for these locations. In this Supplement, the term "operational areas" are the areas within the protected area fences, the intake and discharge structures, the cooling system, and other site structures, and the associated paved, graveled, and maintained landscaped areas. The operational area is defined as the portion of the plant site where most or all of the site activities occur, such as reactor operation, materials and equipment storage, parking, substation operation, facility service and maintenance, etc.

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 identifies activities that occur during decommissioning and shows whether 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. To analyze each issue, the staff used the data obtained from previous studies and environmental reviews, information obtained during site visits and provided by the plants undergoing decommissioning, and information from currently operating nuclear power facilities. The staff's assessment includes an assessment of cumulative impacts. For discussions of cumulative impacts, the NRC used the terminology defined in 40 CFR 1508.7. "Cumulative impact is the impact on the environment, which results from the incremental impact of the action (in the case of this Supplement, that is decommissioning activities) when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." The staff examined the cumulative impacts of decommissioning activities and other past, present, and reasonably foreseeable future activities at the licensed sites.

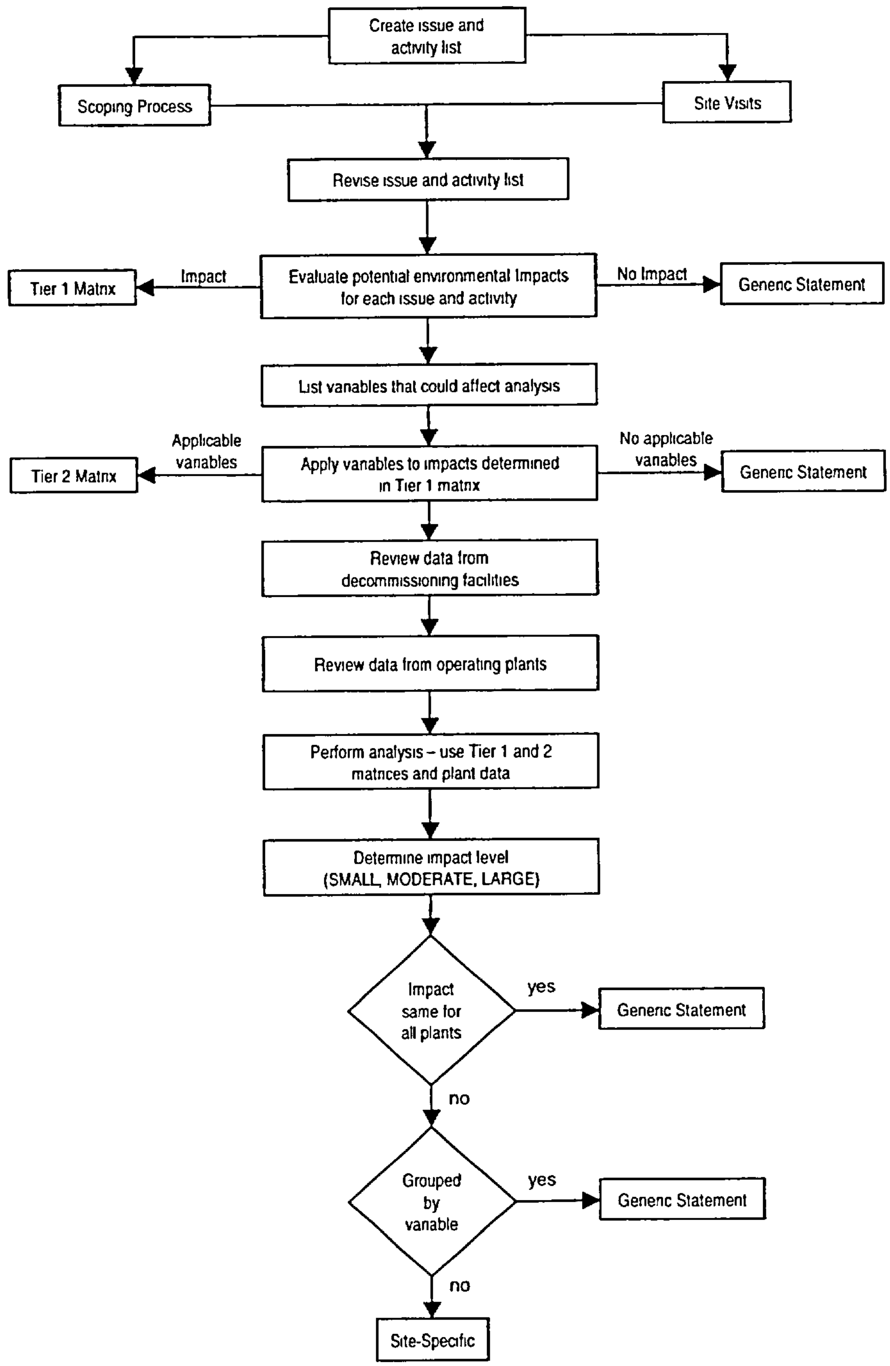

Figure 4-1. Environmental Impact Evaluation Process

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 impacts that are different from those found at other nuclear reactor facilities.

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 – Identifies statutes, regulations, or limits relevant to the issue.

(2) Potential impacts from decommissioning activities - Discusses possible impacts related to the issue and defines, where appropriate, the terms detectable and destabilizing for the issue.

(3) Evaluation – Describes analysis and professional judgement used to estimate whether an activity or group of activities is likely to make a noticeable impact on the environment, considering the available data. If an impact is likely, existing and additional mitigation measures that can be taken to avoid the impact are evaluated. If an impact cannot be avoided, a determination is made as to whether the impact is likely to destabilize the resource.

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

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. Farming and other types of agricultural 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.

4.3.1.1 Regulations

Nuclear power facilities that began initial operation after the promulgation of the National Environmental Policy Act of 1969 (NEPA; 42 USC 4321 to 4347) or the Endangered Species Act of 1973 (ESA; 16 USC 1531 to 1544) were sited and are operated 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 historic and archeological sites, and American Indian grave sites. (Native American Graves Protection and Repatriation Act of 1990; 25 USC 3001 et seq.)

4.3.1.2 Potential Impacts of Decommissioning Activities on Land Use

Temporary changes in onsite land use could occur at a nuclear reactor facility site during decommissioning. Temporary changes may include addition or expansion of staging and laydown areas or construction of temporary buildings and parking areas. These temporary changes in onsite land use do not change the fundamental purpose or use of the reactor site. The major activities that may influence onsite land use are removal of large components, such as the reactor vessel and steam generators, structure dismantlement, and low-level waste (LLW) packaging and storage. Table E-3 in Appendix E describes the activities that occur during decommissioning that influence offsite and onsite land use.

The need for land during decommissioning is affected by the site layout. Most sites have sufficient area existing 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 that are expected to temporarily require land include 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.

Some activities, such as widening and rebuilding access roads or creating or expanding gravel pits for building roads, may occur offsite. The experience of plants that are being decommissioned has not included any needs for additional land offsite.

Changes to land use are considered detectable if changes in the area's general land-use pattern result. The change would be destabilizing if large-scale new development and major changes in the land-use pattern occur. For example, a new local access route through rural land to the plant would represent a detectable, but not destabilizing, change in many localities.

4.3.1.3 Evaluation

Nuclear power facility site areas range from 34 ha (84 ac) for the San Onofre Nuclear Generating Station in California to 9,700 ha (24,000 ac) for the Turkey Point Plant in Florida. According to NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (NRC 1996), of the operating reactors, 29 site areas range from 200 to 400 ha (500 to 1000 ac), with an additional 13 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 being decommissioned are predominantly on the smaller sites, primarily because the older, smaller reactors have already permanently ceased operation. 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).

Almost all of the sites undergoing active decommissioning are utilizing areas used during construction. Land requirements 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 does not appear to be any significant differences in land use between plants using SAFSTOR or DECON options. There is no experience with either ENTOMB option with commercial power reactors in the United States, although there is some entombment 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 batch plant might be set up onsite. There might not be adequate room within the operational area at some of the sites for such a facility, but it is likely that the impact of such a disturbance would be temporary and minor. 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 shows that many activities require the same amount of land for reactors whether the reactor size is small or large. It does not appear that land use will be significantly greater for future decommissioning at remaining sites. Previous or anticipated decommissioning activities at the FBR or 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. Multiple-plant sites that are being decommissioned may be able to economize on space by reusing laydown areas.

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 (NRC 1996). 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 could be returned to its previous uses.

Based on current information collected at sites using the DECON and SAFSTOR options, decommissioning activities that affect offsite land use are not expected 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 detectable or destabilizing. Additional attention to transportation routing and to the organization of activities to minimize the need for transportation re-establishment or upgrade may be able to reduce the impacts to undetectable levels. The ENTOMB options may require additional land offsite for a concrete batch plant, but in most cases the land use for this activity will be temporary, though detectable.

4.3.1.4 Conclusions

The staff has considered available information on the potential impacts of decommissioning on land use, including comments received on the draft of Supplement 1 of NUREG-0586. For facilities having only onsite land-use changes as a result of large component removal, structure dismantlement, and LLW packaging and storage, the impacts on land use are not detectable or destabilizing. Therefore, the staff makes a generic conclusion that the potential impacts to land use onsite are SMALL. The staff has considered mitigation and concludes that no additional measures are likely to be sufficiently beneficial to be warranted.

If changes in land use beyond the site boundary are anticipated, the impacts may or may not be detectable or destabilizing, depending on the site-specific conditions, and cannot be predicted generically. Therefore, the staff has concluded that if new land uses beyond the site boundary are anticipated, the magnitude of the potential impact may be SMALL, MODERATE, or LARGE, depending on the nature, size, and permanence of the disturbance to existing land use and must be determined through a site-specific analysis.

4.3.2 Water Use

Nuclear reactor facilities are usually located near or adjacent to significant water bodies (aquifers, rivers, lakes, etc.) that are important to the region. Operating nuclear reactor facilities use water from multiple sources. For example, water from an adjacent lake might provide cooling water, whereas potable water may come from groundwater wells located onsite. Reactor cooling is the greatest use of water at an operating reactor. Other uses include waste treatment, potable water, process water, and site maintenance.

4.3.2.1 Regulations

Water use at nuclear reactor facilities is regulated by State- and locally-issued permits. Most States require permits for surface water or groundwater withdrawals.

4.3.2.2 Potential Impacts of Decommissioning Activities on Water Use

Cessation of plant operations will result in a significant decrease in water consumption because reactor cooling is no longer required. Although water will still be required for spent fuel cooling, this demand will decrease as the fuel ages. Dewatering systems may remain active during decommissioning of a nuclear facility to control the water pathway for the release of radioactive material. Table E-3 in Appendix E lists decommissioning activities that may influence water use. These activities include fuel removal, staffing changes, large component removal, decontamination and dismantlement (using high-pressure water sprays), structure dismantlement, and entombment.

Impacts to water resources of decommissioning activities would be considered detectable if such activities result in a significant change in water supply reliability. The reliability of water supplies is impacted by a variety of factors, such as natural climatic variability and the reliability of the regional and local water-supply infrastructures. For example, an additional incremental drawdown attributable to a groundwater well at a decommissioning site may be measurable at an offsite well. However, this does not necessarily constitute a detectable change in the reliability of the water supply. It would be detectable if the offsite well is unable to withdraw its permitted volumes as a result of this increased drawdown. The impacts of decommissioning activities are considered destabilizing if they result in a permanent and/or significant loss of water supply reliability. For instance, heavy pumping of an aquifer that results in subsidence may cause a permanent loss of aquifer capacity. Another example of a destabilizing impact is a change in site drainage or stream-channel changes that would result in a detectable and significant change in the probability of flooding.

4.3.2.3 Evaluation

In general, the impact of nuclear reactor facilities on water resources dramatically decreases after plants cease operation. 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 plant. This operational demand for cooling and makeup water is largely eliminated after the facility permanently ceases operation. As the plant staff decreases, the demand for potable water also generally decreases. However, in a few cases staffing levels have temporarily increased above 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 or construction of any 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. There are some activities affecting water resources and decommissioning nuclear facilities that are different from other industrial non-nuclear activities. The demand for water for spent fuel maintenance (approximately 200 to 2000 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 large, 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 of the systems or piping may continue to be used during decontamination and dismantlement to provide shielding from radiation for workers who are dismantling structures, systems, and components (SSCs) in the vicinity. For example, 912,000 L (240,000 gal.) of water was used at one site to fill the reactor cavity in preparation for the segmentation of the reactor vessel.

Common engineering practices, such as water reuse, are used to limit water use impacts at most construction or industrial sites. However, use of some of these practices may be limited by radiological exposure considerations at decommissioning sites.

Water use at decommissioning nuclear reactor facilities is significantly smaller than water use during operation. The water use will be greater in facilities that are undergoing decontamination and dismantlement than those that are in the storage phase. During ENTOMB, water will be required as the concrete for entombment is mixed. Greater amounts of water will be needed for the ENTOMB2 option than for 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 impact that is different from those found at other nuclear reactor facilities.

4.3.2.4 Conclusions

The staff considered available information on the potential impacts of decommissioning on water use, including information received on the draft of Supplement 1 of NUREG-0586. This information indicates that the impacts of decommissioning on water use are neither detectable nor destabilizing. Therefore, the staff makes a generic conclusion that the potential impacts to water use are SMALL. The staff has considered mitigation and concludes that no additional measures are likely to be sufficiently beneficial to be warranted.

4.3.3 Water Quality

There are quality standards for drinking water, protection of aquatic and terrestrial habitats, and release of potential pollutants to surface and groundwater environs. Nuclear reactor facilities are usually located above aquifers or adjacent to important sources of water. Intended and accidental releases of potential pollutants may impact the quality of these waters. This section considers water quality impacts of nonradioactive material for both surface water and groundwater during the decommissioning process. Impacts from releases of radioactive material in liquid effluents are discussed in Section 4.3.8, "Radiological."

4.3.3.1 Regulations

Intentional releases of nonradioactive discharges to surface waters are regulated through the National Pollutant Discharge Elimination System (NPDES; Section 402 of the Federal Water Pollution Control Act, commonly referred to as the Clean Water Act [CWA] [33 USC 1251 to 1387]) to protect water quality. Congress has delegated the responsibility for NPDES implementation to the U.S. Environmental Protection Agency (EPA). When the EPA determines that State programs are equivalent to the Federal NPDES program, the NPDES permitting process is delegated to the State. Generally, discharge limits specified by the NPDES permit are revisited every 5 years. Ongoing monitoring programs may be required as part of an NPDES permit.

The Resource Conservation and Recovery Act of 1976 (RCRA; 42 USC 6901 et seq.) addresses the need to investigate and clean up contamination in the event of the release of nonradioactive hazardous material not covered within the limits of the NPDES permit. As with the NPDES permitting process, Congress has delegated the responsibility for RCRA implementation to the EPA. Because NPDES permits regulate only intentional discharges to surface water, any accidental releases of nonradioactive hazardous materials that may impair water quality (surface water or groundwater) are regulated through the RCRA process. RCRA requires responsible parties to clean up environmental contaminants regardless of the time of their release. The degree of investigation and subsequent corrective action necessary to protect human health and the environment vary significantly among facilities. When the EPA determines that State programs are equivalent to the Federal RCRA program, the corrective action program is delegated to the State.

Based on an October 1978 decision by the Atomic Safety and Licensing Board, (TVA 1978a, TVA 1978b), NRC authority does not extend to matters within the jurisdiction of the 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. This decision would also apply to decommissioning nuclear reactor facilities.

4.3.3.2 Potential Impacts of Decommissioning Activities on Water Quality

Table E-3 in Appendix E shows the activities during decommissioning that may affect water quality. These major activities include fuel removal, stabilization, decontamination and dismantlement, and structure dismantlement. Separate assessments of potential impacts were performed for surface water and groundwater. Surface waters are most likely to be impacted either by stormwater runoff or by releases of substances during decommissioning activities.

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 pumping 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 pattern of recharge and surface-water runoff. The convergence of surface water over unvegetated soils may result in accelerated erosion and the delivery of sediment to important downstream habitat.

Impacts to water quality of decommissioning activities would be considered detectable if such activities result in a significant change in water-supply reliability. For example, stormwater erosion at a facility undergoing decommissioning may result in a measurable increase in suspended sediment in an adjacent stream or disposal of concrete onsite could alter local water chemistry of the groundwater. However, this does not constitute a detectable change in the reliability of the water supply unless the incremental change in sediment concentration precludes permitted or environmental uses. The impacts of decommissioning activities would be considered to be destabilizing on water quality if they result in a permanent or significant loss of water-supply reliability. For instance, significant increases in erosion might result in a permanent loss of benthic habitat for certain fish species.

4.3.3.3 Evaluation

Both the decommissioning activities themselves and the order in which the activities are performed control the impacts to water quality. 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 during SAFSTOR may exacerbate water-quality issues. For example, the aging of structures may create new pathways for groundwater to enter contaminated subgrade structures. This would be less of an issue for entombment of a facility, where the plant's contaminated SSCs are encased in concrete and maintained as a solid structure isolated from the environment.

Stormwater runoff and erosion control are issues faced at many industrial sites, and it is expected that after application of common BMPs, any changes in surface-water quality will be nondetectable and nondestabilizing.

All commercial nuclear power facilities have NPDES permits that regulate intentional releases of hazardous materials. Historically, 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. Some of the groundwater parameters measured in the license termination plan (LTP) 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.

Certain decommissioning activities or options may result in changes in local water chemistry. For example, if licensees dismantle structures by demolition and disposal of the concrete rubble on the site, then there is a potential that the hydration of concrete could cause an increase in alkalinity of groundwater. 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 demolition debris, it is reasonable to expect the leachate pH to be rapidly reduced (within meters) 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 (notably metals) in the subsurface although this transport would not be detectable offsite. Surface spreading of the demolition debris over large areas may provide adequate opportunity for soils to buffer the pH to background. Because the nonradiological impacts would be nondetectable, they are considered to be generic for all sites. However, concentrated disposal of demolition debris, either within or outside of existing below-grade structures, would require below-grade compliance with RCRA guidelines. The radiological aspects of onsite disposal of slightly contaminated material would require a site-specific analysis and would be addressed at the time the LTP is submitted.

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 staff considered available information on the potential impacts of decommissioning on nonradioactive aspects of water quality for both surface water and groundwater, including comments received on the draft of Supplement 1 of NUREG-0586. This information indicates that for all facilities the impacts of decommissioning on water quality will be neither detectable nor destabilizing. Therefore, the staff makes a generic conclusion that for all facilities, the impacts on nonradioactive aspects of water quality are SMALL. The staff has considered mitigation and concludes that no additional measures are likely to be sufficiently beneficial to be warranted.

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 transportation of decommissioning workers to and from the site. This section discusses the nonradiological impacts of decommissioning on air quality. Radiological impacts on air quality are addressed in Section 4.3.8, "Radiological."

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).

EPA's regulations are found in Title 40 of the Code of Federal Regulations. The National Primary and Secondary Ambient Air Quality Standards are found in 40 CFR Part 50. The standards related to particulate matter (40 CFR 51.06 and 40 CFR 51.07) are particularly relevant to decommissioning activities. Other regulations that may cover decommissioning activities are found in 40 CFR Part 61, which deals with hazardous air pollutants such as asbestos, chlorofluorocarbons, and radionuclides; 40 CFR Part 81, which deals with designation of areas for air-quality planning purposes; and 40 CFR Part 82, which deals with protection of stratospheric ozone.

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.

4.3.4.2 Potential Impacts of Decommissioning Activities on Air Quality

Table E-3 in Appendix E shows activities that may have an effect on air quality. These include organizational changes, stabilization, storage preparation for SAFSTOR, decontamination and dismantlement, structural dismantlement, entombment, and transportation. The potentially adverse impacts identified include (1) degradation of air quality caused by emissions (e.g., NO_x, CO, and hydrocarbons) from internal combustion engines, (2) increased particle loading of the atmosphere caused by the movement of vehicles and equipment, demolition of structures, dismantlement of systems, and operation of concrete batch plants, and (3) alteration of other characteristics of the atmosphere (e.g., the ozone layer) by releases of gases used in plant systems (e.g., in fire suppression or refrigeration).

Air-quality impacts of emissions from internal combustion engines and changes in atmospheric particle loading can be assessed by comparison with standards set in air-quality regulations. These potential impacts are considered detectable if a decommissioning activity is likely to cause a measurable increase in the concentration of one or more regulated air pollutants that can be directly attributed to the activity. The impact is considered to be destabilizing if the impact is detectable and causes a change in the attainment status of the region. Air-quality impacts of the releases of other gases can be assessed by comparison with the magnitude of potential releases during decommissioning with the magnitude of releases of the same or similar gases from other sources.

4.3.4.3 Evaluation

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

- worker transportation to and from the site
- dismantling of systems and removing of equipment
- movement and open storage of material onsite
- demolition of buildings and structures
- shipment of material and debris to offsite locations, and
- operation of concrete batch plants.

These activities 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.

Worker transportation: Air-quality impacts of transportation of workers to and from the site are caused by emissions from the vehicles and by fugitive dust from traffic on paved and unpaved roads. Consequently, the impacts can be estimated directly from the size of the work force. 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 during decommissioning is smaller than the construction work force and the work force during refueling outages, and almost always smaller than the work force during facility operation.

Assuming that neither the mix of vehicles used for worker transportation nor the vehicle occupancy is different during decommissioning than during plant construction or operation, emissions from vehicles and fugitive dust associated with traffic is expected to decrease during the decommissioning period. These decreases are expected to improve air quality rather than degrade it. Consequently, the change in air quality associated with changes in worker transportation during decommissioning should not be detectable or destabilizing at any site.

Dismantling systems and removing equipment: Air-quality impacts of dismantling systems and removing equipment may be caused by the generation and release of particulate matter associated with the physical activities of dismantling and by the release of gases from the systems (for example, refrigeration systems and fire-protection systems).

The predominant potential effluent from system dismantling and removal of equipment will be particulate matter and fugitive dust. This material will generally be released in and remain within buildings and other structures because most decommissioning activities associated with dismantling systems and removing equipment will be conducted inside the containment, auxiliary, and fuel-handling buildings. These buildings have systems to minimize airborne contamination, such as whole-building air filtration. Filtration systems control the release of particulate matter to the environment. These systems, which are typically maintained and periodically operated during decommissioning, reduce the impact of airborne particulate material. Where filtration systems are not in place to control particulate releases, temporary systems can be established, as needed. Special air-ventilation pathways may be established before the start of a SAFSTOR period to ensure that air ventilates from the building through high efficiency particulate air (HEPA) filters. It is unlikely that particulate matter released to the environment as a result of system dismantlement and equipment removal will be sufficient to be detectable offsite. 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."

Various systems associated with reactors contain gases that are of environmental concern. For example, some gases used in refrigeration systems and fire-suppression systems have been identified as ozone-depleting compounds. Venting of these gases to the atmosphere is prohibited by law. Standard methods exist to purge systems with these gases and limit releases to the environment to insignificant quantities. Other fire suppression and refrigeration systems may contain greenhouse gases. The quantities of these gases at a nuclear plant are generally small in comparison with the quantities of greenhouse gases released hourly by a fossil-fuel combustion plant used for heating or power generation. The impacts of ozone-depleting and greenhouse gases are global rather than local. Therefore, it is unlikely that releases of ozone-depleting or greenhouse gases during decommissioning of any nuclear power plant will be detectable or destabilize the environment.

<u>Movement and open storage of material onsite</u>: Movement of equipment and open storage of materials onsite during decommissioning are similar to activities during construction or demolition of an industrial facility. The air-quality impacts of the movement of equipment and open storage of materials onsite are primarily associated with fugitive dust. Movement of equipment outside of the buildings may generate fugitive dust. Movement of equipment may also alter the size distribution of particles on the ground, making the particles more susceptible to suspension by the wind. Mitigation measures will be taken to minimize dust to comply with local air-quality regulations. Common mitigation measures include watering and other soil stabilization measures, such as spraying sealants on the area and seeding. Therefore, it is unlikely that the movement of equipment and open storage of materials will be detectable or destabilize regional air quality.

<u>Demolition of buildings and structures</u>: Once decontamination has been completed, the demolition of buildings and other structures at a nuclear power plant is similar to demolition of buildings and structures at industrial facilities. Demolition of buildings and major structures may cause a temporary increase in fugitive dust from the site. Fugitive dust from demolition of buildings and structures will involve large particles that will settle to the ground quickly. Demolition will generally be limited to a small number of short-duration events. Mitigation measures will be used to minimize dust. Therefore, it is unlikely that the fugitive dust from demolition of buildings and structures will be detectable or destabilize air quality.

If residual contamination is present at the time of demolition, then the demolition of buildings and structures must be conducted using techniques that keep releases of contaminated material within regulatory limits. For purposes of assessing radiological impacts, impacts are of small significance if doses and releases do not exceed limits established by the Commission's regulations.

<u>Shipment of material and debris to offsite locations</u>: Dismantled equipment, material, and debris from decommissioning 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 decommissioning option chosen. Although the number of shipments may be relatively large, the decommissioning period extends over several years. As a result, the number of shipments per day is small. Current experience is that there is an average of less than one shipment per day of LLW from the plant (see Section 4.3.17, "Transportation"). Therefore, it is unlikely that the emissions from a shipment or a small number of shipments per day would be detectable or destabilize local or regional air quality at any nuclear power plant undergoing decommissioning.

<u>Operation of a concrete batch plant</u>: The ENTOMB options will require a large amount of concrete and aggregate. Unloading, movement, and dispensing of the materials that make concrete result in fugitive dust in the vicinity of concrete batch plants. Most of the dust is associated with unloading dry cement at the concrete batch plant and loading mixers or trucks. This dust tends to consist of large particles that settle out of the air quickly. As a result, dust associated with concrete batch plant operations is likely to be localized near the concrete batch plant. There will also be emissions from heavy equipment at concrete batch plants and vehicles used to transport concrete from the concrete batch plant to the entombment site. The likely impacts of these emissions will be smaller than those from dust.

There are a number of mitigation measures that can be used to control dust. Dust control measures commonly used at concrete batch plants include enclosure of dumping and unloading areas and conveyors, use of filters, and use of water sprays. There would be no significant difference between a concrete batch plant used in the ENTOMB option and a batch plant used for any other major construction activity. Therefore, the staff considers it unlikely that the environmental impacts of operation of a concrete batch plant for a plant undergoing entombment would be detectable or destabilize air quality.

In summary, the most likely impact of decommissioning on air quality is degradation of air quality by fugitive dust. 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 BMP, such as seeding and wetting, can be used to minimize fugitive dust. During demolition activities, 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.

The selection of the decommissioning option (DECON, SAFSTOR, ENTOMB1, or ENTOMB2) is more likely to affect the timing of air-quality impacts than the magnitude of the impacts. Immediate decontamination and dismantlement of the facility (DECON) results 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 may include the dismantlement of structures outside of containment and, thus, could 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

The staff has considered available information on the potential impacts of decommissioning on air quality, including comments received on the draft of Supplement 1 of NUREG-0586. This information indicates that the impacts of decommissioning on air quality are neither detectable nor destabilizing. Therefore, the staff makes the generic conclusion that the impacts on air quality are SMALL. The staff has considered mitigation and concludes that current and commonly used measures are sufficient and no additional measures are likely to be sufficiently beneficial to be warranted.

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 environments near a nuclear power facility. Aquatic ecology also includes the interaction of those organisms with each other and the environment.

4.3.5.1 Regulations

Federal laws that are included within a NEPA evaluation of aquatic ecology issues include the CWA, the ESA of 1973, the Fish and Wildlife Coordination Act (16 USC 661 to 667c), and NEPA. 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. Some activities, such as removal of in-stream or shoreline structures, may require permits from other agencies.

4.3.5.2 Potential Impacts of Decommissioning Activities on Aquatic Ecological Resources

Table E-3 in Appendix E identifies decontamination and dismantlement and structural dismantlement as activities that may affect aquatic ecology. Aquatic ecological resources may be impacted during the decommissioning process via either the direct or the indirect disturbance of plant or animal communities near the plant site. Direct impacts can result from activities such as the removal of shoreline or in-water structures (i.e., the intake or discharge facilities), the active dredging of a stream, river, or ocean bottom, or the filling of a stream or bay while indirect impacts may result from effects such as runoff. During decommissioning, aquatic environs at the plant site may be disturbed for the construction of support facilities, such as to build a dock for barges or to bridge a stream or aquatic area. Additionally, aquatic environs away from the plant site may be disturbed to upgrade or install new transportation systems (e.g., a new rail line to support large component removal) or to install or modify transmission lines. In most cases, aquatic disturbances will result in relatively short-term impacts and the aquatic environs will either recover naturally or impacts can be mitigated. Minor impacts to aquatic resources could result from sediment runoff generation due to ground disturbance and surface erosion and runoff. Impacts may occur if shoreline or in-water structures, such as the intake or discharge facilities and pipes, are removed. These impacts will typically be temporary and will not be detectable nor will they destabilize important attributes of the resource. It is important that shoreline or in-water structure removal is managed in a manner that does not result in the establishment of nonindigenous or noxious plants and animals to the exclusion of native species.

If decommissioning does not include removal of shoreline or in-water structures, very little aquatic habitat is expected to be disturbed during decommissioning. Thus, practically all aquatic habitat that was used during regular plant operations or, at a minimum, was not previously disturbed during construction of the site will not be impacted. If all activities are confined to the plant operational areas, impacts are expected to be minor and would primarily result from increased sediment from physical alterations of the site. If no disturbances occur beyond the regular operational areas of the site, it is expected that the impact to aquatic resources will be nondetectable, nondestabilizing, and easily mitigated.

In some cases, the aquatic habitats that were originally disturbed during the construction of the site will continue to be of low habitat quality at the time of site decommissioning, even beyond the normal operations boundaries. However, important resources could either develop on the site or colonize the area disturbed by the construction. If a decommissioning activity results in the "removal" of species from an area (e.g., if a commercial or recreational fishery is no longer possible), this may be detectable. Reworking the ground surface during construction could alter the surface-drainage patterns such that wetlands on the original construction site may no longer support an aquatic community. If this is an important local or regional resource, it may be considered destabilizing.

4.3.5.3 Evaluation

The primary factors that must be considered in evaluating the potential for 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). Most of the important aquatic ecological resources are not likely to occur on most plant sites. If they do occur, the decommissioning activities can probably be planned to avoid or minimize detectable and destabilizing effects.

Two decommissioning activities may result in impacts to the aquatic environment: removal of structures from the shoreline or in-water environment and removal of contaminated soil from the site (the latter applies only if the soil is in or near an aquatic environment).

Additionally, dredging and modification of barge loading facilities may result in impacts to aquatic ecological resources. Periodic permitted, maintenance dredging of the barge unloading facility is not expected to result in long term detectable or destabilizing impacts to the aquatic environment. Impacts to the aquatic resources would be within the bounds of the generic assessment. However, a significant expansion of the barge unloading facility necessary to accommodate, for example, a large shipping package such as a reactor vessel would require a site specific assessment. The environmental assessment may be performed by the U.S. Corps of Engineers as part of the review to permit the enlargement of the barge unloading facility.

In most cases, the aquatic environment 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 boundaries of the site operational areas 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 planned or realized during decommissioning. In almost all cases examined, licensees expect to restrict activities to previously disturbed areas and operate within the limits of operational permits.

The potential for adverse impacts are likely to be nondetectable or nondestabilizing regardless of the decommissioning option selected. The activity most likely to result in impacts to aquatic environments is specific to removal of shoreline or in-water structures. The decision to conduct these activities would not be dependent on the decommissioning option. The only option where shoreline or in-water structure removal appears to be guaranteed is for those plants where return to a "Greenfield" is desired or required.

When there is a decommissioning activity outside the operational area, the significance of the potential impacts are more difficult to define 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 overall importance of the plant or animal species or communities to be disturbed. If important resources may be affected by the decommissioning activities, the impacts may be detectable and destabilizing.

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

4.3.5.4 Conclusion

The staff has considered available information on the potential impacts of removing facility structures or contaminated soil from or near the aquatic environment on the aquatic ecological resources, including comments received on the draft of Supplement 1 of NUREG-0586. For facilities where disturbance of lands beyond the operational areas is not anticipated, the impacts on aquatic ecology are not detectable or destabilizing. The staff believes that activities within operational areas including the removal of shoreline or in-water structures, will have minimal impact on aquatic resources provided all applicable BMPs are employed and required permits are obtained. Therefore, the staff makes a generic conclusion that for such activities, the potential impacts to aquatic ecology are SMALL. The staff has considered mitigation measures and concludes that no additional mitigation measures are likely to be sufficiently beneficial to be warranted.

If disturbance beyond the operational areas is anticipated, the impacts may or may not be detectable or destabilizing, depending on site-specific conditions and cannot be predicted generically. Therefore, the staff concludes that if disturbance beyond the operational areas is anticipated, the potential impacts may be SMALL, MODERATE, or LARGE, and must be determined through site-specific analysis.

4.3.6 Terrestrial Ecology

Terrestrial ecology considers all of the plants, animals, and species assemblages in the vicinity of the nuclear power facility as well as the interaction of those organisms with each other and the environment. Evaluations of impacts to terrestrial ecology are usually directed at important habitats and species, including plants and animals that are important to industry, recreational activities, the area ecosystems, and those protected by endangered species regulations and legislation. Federally listed threatened and endangered species, and designated critical habitat for such 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, and potential impacts to such species should be evaluated and mitigated, as appropriate. Important habitat resources include (but are not limited to) wetlands, riparian areas, resting or nesting areas for large numbers of waterfowl, rookeries, communal roost sites, strutting or breeding grounds for gallinaceous birds, calving grounds, and areas containing rare plant communities. Some States have programs to formally designate priority or rare habitat community 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, 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 United States 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 United States and Mexico, in 1974 to include species included in a convention between the United States and Japan, and in 1978 in a treaty between the United States 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

Table E-3 in Appendix E identifies stabilization, large-component removal, structure dismantlement, and decontamination and dismantlement as activities that may affect terrestrial ecology. Terrestrial ecological resources may be impacted during the decommissioning process via direct or indirect disturbance of native plant or animal communities in the vicinity of the plant site. Direct impacts can result from activities such as the clearing of native vegetation or filling of a wetland. Indirect impacts may result from effects such as erosional runoff, dust, or noise. 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 or utility 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 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 minor, indirect impacts are temporary and will not be significant issues after the completion of decommissioning. The effects of such impacts can also be minimized using standard BMPs.

Impacts to terrestrial resources are considered to be detectable if they result in changes to local species populations or plant or animal communities beyond the typical levels of natural variability (i.e., normal year-to-year variations). The impacts are considered to be destabilizing if they result in the extirpation of important species or result in long-term changes in ecological functions (such as flow of energy), species richness, diversity, or proportion of invasive species.

4.3.6.3 Evaluation

At most commercial nuclear facilities, there is a relatively distinct operational area where most or all site activities occur (e.g., materials and equipment storage, parking, substation operation, facility service and maintenance, etc.). This operational area usually includes all areas within the protected area fence, the intake, discharge, cooling, and other associated structures, as well as adjacent paved, graveled, and maintained landscaped areas. The operational area may include the entire area disturbed during facility construction, but is often considerably smaller.

Terrestrial habitats disturbed during the construction of the site will often continue to be of low habitat quality during plant operation and decommissioning. However, sensitive habitats can develop on the site or rare species can colonize the area disturbed during construction. This is especially true if the site has been in SAFSTOR for several decades. For example, reworking the ground surface during construction may have altered the surface-drainage patterns such that wetlands develop on the original construction site. Trees could grow 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. Rare species have colonized portions of the site at several operating commercial nuclear power plants.

In most cases, the amount of land required to support the decommissioning process is relatively small and is a small portion of the overall plant site. Usually, the areas disturbed or utilized to support decommissioning are within the operational areas of the site and typically are within the protected area. Usually, there is sufficient room within the operational areas to function as temporary storage, laydown, and staging sites. In most cases, management, engineering, and administrative staff would have been assigned space in existing support or administration buildings. In some cases, the licensees have installed trailers or temporary buildings to house engineering and administrative staff or to otherwise support decommissioning. Most licensees expect to restrict decommissioning activities to highly disturbed operational areas but a few expect to use lands beyond the operational areas, as defined above. 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. One facility (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. Activities conducted within the operational areas are not expected to have a detectable impact on important terrestrial resources. Activities conducted outside the operational areas may have detectable impacts, depending on the magnitude and type of activity and the resources potentially affected.

None of the decommissioning options have a greater likelihood of resulting in detectable or destabilizing impacts to terrestrial resources. The selection of the decommissioning option is more likely to affect the timing of the impact on ecological resources than it is 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 onsite 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 demolition 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 considered available information on the potential impacts of decommissioning activities on terrestrial resources, including comments received on the draft of Supplement 1 of NUREG-0586. For facilities where habitat disturbance is limited to operational areas, the impacts on terrestrial ecology are not detectable or destabilizing. Therefore, the staff makes a generic conclusion that for such facilities the potential impacts to terrestrial ecology are SMALL. The staff has considered mitigation measures and concludes that no additional mitigation measures are likely to be sufficiently beneficial to be warranted.

If habitat disturbance beyond the operational areas is anticipated, the impacts may or may not be detectable or destabilizing, depending on site-specific conditions and cannot be predicted generically. Therefore, the staff concludes that if disturbance beyond the operational areas is anticipated, the potential impacts may be SMALL, MODERATE, or LARGE and must be determined through site-specific analysis.

4.3.7 Threatened and Endangered Species

Plants and animals protected under the ESA of 1973 may be present at or near all commercial nuclear power facilities (Sackschewsky 1997). At operating plants, the most common potential impacts to endangered aquatic species are effects related to the operation of the cooling water system via impingement, entrainment, or occasional temperature or chemical effects. Because the cooling system is not used at a plant undergoing decommissioning, it is anticipated that the potential impacts of decommissioning on threatened or endangered aquatic species will normally be no greater than and likely far less than the potential impacts of plant operations.

For terrestrial species that are threatened or endangered, the most common potential impacts for operating plants are from transmission ROW maintenance activities. Most transmission lines beyond the switchyard are expected to remain energized, even after a commercial nuclear power facility closes operation, and the ROW maintenance activities are expected to continue. Therefore, the potential impacts of decommissioning on terrestrial species will normally be no greater than the potential impacts of plant operations.

4.3.7.1 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 U.S. Fish and Wildlife Service (USFWS) is responsible for all terrestrial and freshwater organisms. Marine and anadromous fish species are the responsibility of the National Marine Fisheries Service (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 action 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

Table E-3 in Appendix E indicates that stabilization, large-component removal, structural dismantlement, and decontamination and dismantlement are activities that may affect threatened or endangered species. Such species may be impacted during the decommissioning process either through direct take (kill, maim, or unable to reproduce) or via disturbances of native plant or animal communities near the plant site that the species relies on for food or shelter. Additionally, an extended period of SAFSTOR may allow 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.

The greatest potential for impact to protected species is associated with physical alteration or dismantlement of the facilities, landscape, or aquatic environment. 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 a stream, river, or ocean bottom; the filling of a stream, bay, or wetland; or the clearing of native vegetation. Indirect impacts may result from runoff, sedimentation, dust generation, or noise disturbance. The aquatic environment at a plant site may be disturbed for the construction of support facilities to allow barges to dock or to bridge a stream or other aquatic area. Additionally, terrestrial and aquatic environments away from the plant site may be disturbed to upgrade or install new transportation or utility 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 and the environment and local populations will either recover naturally or impacts can be mitigated using standard BMPs. An important exception may occur if near-shore or in-water structure removal or land surface disturbances result in the establishment of nonindigenous or noxious plants and animals to the exclusion of threatened or endangered species.

Impacts to endangered or threatened species are considered detectable if there are changes (attributable to the facility) in the species behavior or in the local population size that are greater than normal year-to-year variation. Impacts would be considered destabilizing if they result in direct mortality or major behavior changes (such as abandonment of most suitable habitat areas in the plant vicinity) or if they otherwise jeopardize the local population.

4.3.7.3 Evaluation

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 site operational areas (i.e., within protected area fences, intake, discharge, cooling, and other associated structures, and adjacent paved, graveled, and maintained landscaped areas), the impacts to terrestrial threatened or endangered species are expected to be minor and nondetectable. Any impacts that did occur 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 operational areas of the site, it is expected that the impact to threatened or endangered terrestrial species will be relatively small, temporary, and mitigable. The impacts of activities beyond the operational areas would depend on the activity, the species potentially affected, and the mitigation options available.

Unless there are major structural changes in the aquatic environment, the potential for adverse impacts to aquatic threatened or endangered species is expected to be minimal and nondetectable. Impacts to aquatic threatened or endangered species resulting from runoff/ sedimentation or chemical inputs during decommissioning will be significantly less than the potential entrainment and impingement impacts that were present when the plant was operating because of the drastically reduced water use.

The different decommissioning options will probably not differ significantly in potential impacts to threatened or endangered species, except in those cases where the plant is held in SAFSTOR for extended periods. In those cases, there is a greater potential for rare species to colonize areas that may subsequently be disturbed during the decommissioning process.

The likelihood of impacts to threatened and endangered species is 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 staff has considered available information on the potential impacts of decommissioning on threatened and endangered species, including comments received on the draft of Supplement 1 of NUREG-0586. Based on this information, the staff has considered that the adverse impacts and associated significance of the impacts must be determined on a site-specific basis.

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 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 marine and some anadromous fish 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 the potential impacts to threatened and endangered species may be SMALL, MODERATE, or LARGE, and is not a generic issue. Informal consultation will be initiated by the NRC staff with the appropriate service after the licensee announces permanent cessation of operations. It is expected that any formal or informal consultation will be completed prior to the licensee beginning major decommissioning activities, which can occur 90 days after the submission of the post-shutdown decommissioning activities report (PSDAR). At that time, it will be determined whether such species could be affected by decommissioning activities and whether formal consultation will be required to address the impacts. Each State should also be consulted about its own procedure for considering impacts to State-listed species.

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 potentially 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 by measurement or calculation, to show (1) that the highest dose to an individual member of the public from sources under the licensee's control does 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 requirements 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 of Decommissioning Activities

As indicated in Table E-3 in Appendix E, all decommissioning activities have potential radiological concerns. 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 who are 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.

4.3.8.3 Evaluation

At the cessation of plant operations, there are areas of the plant structures where residual radiation exceeds the radiation standards for license termination set forth in 10 CFR Part 20, Subpart E. One of the goals of decommissioning is to reduce this residual radiation to levels that would permit license termination. Most of the decommissioning activities listed in Table E-3 in Appendix E have the potential for radiological impacts. The staff expects that all of the activities that have potential radiological impacts will be conducted following approved procedures to keep doses ALARA and well within regulatory limits. Radiological impacts are considered to be undetectable and nondestabilizing, in the NEPA sense, if doses remain within regulatory limits.

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 (NUREG-0586 [NRC 1988]). 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.

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 the 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 those used by 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.

<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 years 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 (NRC 1988) to estimates for plants that are currently in the decommissioning process. The types of activities included in these estimates may vary between plants. For example, some estimates include doses from transportation or from activities related to spent fuel management, which are not considered part of the decommissioning process, as defined in the scope of this document. 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 Supplement 1 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 for various activities.

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 demolition process for dismantlement of uncontaminated or slightly contaminated structures; there is a potential for this activity to occur during the dismantlement phases of SAFSTOR, DECON, or ENTOMB1 options. The demolition debris could be disposed of onsite if nonradiologically contaminated. If the debris is radiologically contaminated, it 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 that the licensee could meet the criteria in 10 CFR Part 20, Subpart E, and other regulations, the demolition debris could potentially be disposed onsite for either the DECON or SAFSTOR options. This process has been termed "Rubblization" (see Section 1.3). Rubblization would require a site-specific analysis. The site-specific analysis would be conducted at the time the LTP is submitted for the site. Occupational doses during the activity of crushing 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 the radiologically contaminated demolition debris onsite would also have to meet the radiological criteria for license termination given in 10 CFR Part 20, Subpart E.

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.

Public Dose: This section addresses the impacts on members of the public from 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

Table 4-1. Comparison of Occupational Dose Estimates from NUREG-0586 (NRC 1988) 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-year 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 HTGRs and FBR, which are somewhat unique in the commercial nuclear power industry. The dose estimates are expected to be consistent with PWRs and BWRs

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.

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

4.3.8.4 Conclusions

The staff has considered available information, including comments received on the draft of Supplement 1 of NUREG-0586, on the potential radiological impacts of decommissioning. This information indicates that the radiological impacts of decommissioning will remain within regulatory limits. Therefore, the staff makes the generic conclusion that the radiological impacts of decommissioning activities are SMALL. The staff has considered mitigation measures and concludes that no additional mitigation measures are likely to be sufficiently beneficial to be warranted.

The staff also determined that the issue of the long-term radiological aspects of Rubblization or onsite disposal of slightly contaminated material could not be evaluated generically and would require a site-specific analysis. The site-specific analysis would be conducted at the time the LTP for the site is submitted.

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.

(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).

The likelihood of a large offsite radiological release that impacts public health and safety from a facility that has permanently ceased operation is considerably lower than the likelihood of a release from an operating reactor that impacts public health and safety. This is because the potential accidents associated with reactor operation are no longer relevant after the reactor fuel has been removed.

Radiological accidents considered in licensing nuclear power plants are classified as design basis accidents (DBAs) and severe (beyond design basis) 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. Severe accidents are those that are beyond the design basis of the plant. They are more severe than DBAs because they may result in substantial damage to the fuel, whether or not there are serious offsite consequences. For the most part, DBAs focus on reactor operation and are not applicable to plants undergoing decommissioning. The only DBAs or severe accidents (beyond design basis) applicable to a decommissioning plant are those involving the spent fuel pool. These postulated accidents are not expected to occur during the life of the plant, but are evaluated to establish the design basis for the preventive and mitigative safety systems of the spent fuel storage facility.

4.3.9.1 Regulations

Regulations governing accidents that 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, including those associated with the spent fuel pool, are evaluated during the initial licensing process. 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), and in the licensee's Final Safety Analysis Report (FSAR) or equivalent. 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.

In addition, Appendix E to 10 CFR Part 50 requires each licensee to develop emergency plans and implementing procedures to protect health and safety in the event of an accident. These plans and procedures are maintained up to date during the period of operation of the plant and until such time afer the cessation of plant operations that the NRC grants relief from the emergency planning requirements.

4.3.9.2 Potential for Radiological Accidents as a Result of Decommissioning Activities

Table E-3 in Appendix E indicates that fuel removal, organizational changes, stabilization, chemical decontamination, large component removal, decontamination and dismantlement, system dismantlement, entombment, and transportation are activities that may lead to radiological accidents. Many activities that occur during decommissioning are similar to activities, such as decontamination and equipment removal that commonly take place during maintenance outages at operating plants. However, during decommissioning such activities may be more extensive than similar activities during the period of reactor operations. Consequently, potential accidents associated with these activities may have a higher probability during decommissioning than when the plant is operating. Accidents that occur during these activities may result in injury and local contamination; they are not likely to result in contamination offsite. This section addresses worker injuries from radiological accidents. Injuries from other causes are addressed in Section 4.3.10,"Occupational Issues."

Once the reactor fuel has been moved to the spent fuel pool, the only DBAs contained in the plant's FSAR that are applicable are those associated with the spent fuel pool. These accidents are generally related to fuel handling or dropping heavy objects into the spent fuel pool. As long as the integrity of the spent fuel pool and its supporting systems is maintained, the potential impacts of accidents are bounded by the impacts of those for the spent fuel pool DBAs.

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 2001b). As part of its effort to develop generic, risk-informed requirements for decommissioning, the staff determined the frequency of beyond-design-basis spent fuel pool accidents. The event initiators included:

- seismic events (earthquakes)aircraft crashes
- 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 analyses.

The impacts of accidents where onsite and offsite doses remain below those allowable for the workers or the public are considered to be undetectable. Accidents that are likely to be undetectable 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. The impacts of accidents that could result in offsite doses that exceed EPA's protective action guides (PAGs) (EPA 1991) are considered to be destabilizing. The only accidents that are likely to have destabilizing impacts are those that involve pool drainage that leads to a zirconium fire.

4.3.9.3 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. The review of spent fuel pool accidents at decommissioning reactors was performed to support development of a risk-informed technical basis for reviewing emergency plan exemption requests and a regulatory framework for integrated rulemaking (NRC 2001b). Further detail on the sources of information that were used to develop the analysis is given in Appendix I. Because the sources of information included the FBR and the HTGR, the results given in this section are applicable for these facilities.

The accidents and malfunctions covered by licensing documents can be divided into 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 (e.g., material-handling accidents or accidental cutting of contaminated piping) or storage activities (e.g., fires or ruptures of liquid waste tanks).

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

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

- Hazardous (nonradiological) chemical-related accidents: 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 offsite 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 accident 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 occur only when the fuel is being moved. Accidents related to dismantlement activities would occur only 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. Table I-5 in Appendix I compares the types of accidents with the different activities that are performed during SAFSTOR, ENTOMB, and DECON.

The staff has reviewed activities associated with decommissioning and determined that many decommissioning activities not involving spent fuel that are likely to result in radiological accidents are similar to activities conducted during the period of reactor operations. The radiological releases from potential accidents associated with these activities may be detectable. However, work procedures are designed to minimize both the likelihood of an accident and the consequences of an accident, should one occur, and emergency plans and procedures will remain in place to protect health and safety while the possibility of significant radiological accidents exists.

In addition to the licensing-basis documents reviewed, the staff's report, *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants* (NRC 2001b), provides an analysis of the consequences of the spent fuel pool accident risk and includes 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 years. 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.

The Commission has considered the storage of spent fuel and has concluded in the Waste Confidence Rule in 10 CFR 51.23 that "... spent fuel generated in any reactor can be stored safely and without significant environmental impacts for at least 30 years beyond the licensed life for operation....". The staff has reviewed the potential accidents associated with spent fuel storage during decommissioning, the likelihood of the accidents, and the potential consequences of the accidents. Emergency plans and procedures will remain in place to protect health and safety while the possibility of significant radiological accidents associated with spent fuel exists.

4.3.9.4 Conclusions

The staff has considered available information, including comments received on the draft of Supplement 1 of NUREG-0586, concerning the potential impacts of non-spent-fuel-related radiological accidents resulting from decommissioning. This information indicates, that with the mitigation procedures in place, the impacts of radiological accidents are neither detectable nor destabilizing. Therefore, the staff makes the generic conclusion that the impacts of non-spent-fuel-related radiological accidents are SMALL. The staff has considered mitigation and concludes that no additional measures are likely to be sufficiently beneficial to be warranted.

The staff has considered available information, including comments received on the draft of Supplement 1 of NUREG-0586, on the potential impacts of spent-fuel-related radiological accidents resulting from decommissioning. The staff affirms the conclusions in the Waste Confidence Rule and concludes that the impacts of spent fuel storage are SMALL. The staff concludes that additional mitigation measures are not likely to be sufficiently beneficial to be warranted.

4.3.10 Occupational Issues

Occupational issues are related to human heath and safety. The discussion here includes physical, chemical, ergonomic, and biological hazards. This discussion does not include radiological impacts, which are discussed in Section 4.3.8.

4.3.10.1 Regulations

The Occupational Safety and Health Act of 1970 (29 USC 651 et seq.) was enacted to safeguard the health of the worker. Regulations implementing the act are found in Title 29 ("Labor") of the Code of Federal Regulations, Subtitle B, "Regulations Relating to Labor." Subpart A of 29 CFR Part 1910 adopts, by reference, occupational safety and health standards which have been found to be national consensus standards or established Federal standards. Standards adopted in 29 CFR 1910.6 include, among others, standards of the American National Standards Institute, the American Society for Testing and Materials, the American Welding Society, the National Fire Protection Association, the National Institute for Occupational Safety and Health, the Society of Automotive Engineers, and Underwriters Laboratories. Specific safety and health regulations for Construction are included in 29 CFR Part 1926. These regulations are administered by the Occupational Safety and Health Administration (OSHA).

States may also develop and enforce State standards for occupational safety and health. However, State agencies may not assert jurisdiction over any occupational safety or health issue with respect to which a Federal standard has been issued under Section 6 of the Occupational Safety and Health Act unless the State has a plan for the development and enforcement of State standards. State plans for development and enforcement of State standards are covered by 29 CFR Part 1902. Approved State plans for enforcement of State standards are listed in 29 CFR Part 1952. These plans identify the State agency responsible for development and enforcement of the State standards.

4.3.10.2 Potential Impacts of Decommissioning Activities on Occupational Issues

Table E-3 in Appendix E indicates that nearly all decommissioning activities may impact 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.

The impacts of decommissioning activities on occupational issues are considered detectable if the accident or injury rate during decommissioning exceeds average U.S. industrial accident rates. The impacts of decommissioning activities on occupational issues are considered destabilizing if the accident or injury rate during decommissioning becomes sufficiently large that decommissioning activities must be halted to address worker safety and the decommissioning schedule is threatened.

4.3.10.3 Evaluation

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, State, and other local standards are met. The site-specific ES&H plan for a decommissioning activity should be referred to for detailed information regarding specific worker health and safety information; the occupational hazards described in this Supplement should not be used for ensuring the protection of an individual worker health and safety.

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.

Many activities during decommissioning, for example, the use of cutting torches, have the potential to initiate fires. These activities, which are common during construction and demolition, should be identified in advance. It is expected that precautions will be taken to minimize the likelihood of fires and that suitable measures will be available for dealing with fires should they occur.

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

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. Normal core temperatures are 37.6°C (99.6°F) or 37°C (98.6°F) as measured by mouth. Fluctuations in core temperatures 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).

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.

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 electrical threats 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
- removal of chemical-containing systems, such as demineralizers and acid- and caustic-containing tanks
- removal of sodium and NaK residue.

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.

Chemical hazards at one 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).

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.