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Environmental Impact Assessment of the Swedish High-Level Radioactive Waste Disposal System

- examples of likely considerations

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Sammanfattning / Abstract:

Föreliggande rapport behandlar frågeställningar som kan beaktas då en miljökonsekvensbeskrivning upprättas för en inkapslingsanläggning och/eller ett slutförvar för använt kärnbränsle m.m. Rapporten har ej ambitionen att vara heltäckande på alla områden. Rapporten går i flera avseenden utanför SSI:s myndighetsområde men ambitionen har varit att tyngdpunkten skall vara på direkta och indirekta frågor av intresse för strålskyddet då en inkaplingsstation och/eller ett slutförvar planeras att lokaliseras, upprättas och idrifttagas.

Rapporten har sammanställts på uppdrag av SSI och ingår i Projekt MKB-95.

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Prepared for

the Swedish Radiation Protection Institute
Stockholm, Sweden

By

the Center for Nuclear Waste Regulatory Analyses
San Antonio, Texas

December 1993

This report has been prepared by the Center for Nuclear Waste Regulatory Analyses (CNWRA) for use by the Swedish Radiation Protection Institute (SSI). The purpose of this report is to establish a document which outlines the types of information which would be in an EIA for a three part disposal system like that envisioned by the Swedish Nuclear Fuel and Waste Management Company (SKB) for the disposal of Sweden's HLW.

The views and opinions expressed within this document do not necessarily reflect the Swedish Radiation Protection Institute's policy or judgement regarding the subject material.

Environmental Impact Assessment of the Swedish High-Level Radioactive Waste Disposal System

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1 INTRODUCTION

Sweden is investigating the feasibility of establishing a high-level radioactive waste (HLW) disposal system consisting of three components as follows:

- Encapsulation facility
- System for transporting waste
- Geologic Repository

High-level radioactive waste is today delivered for storage and subsequent aging (designed to lessen the radioactivity and heat generated by the HLW) from Sweden's twelve nuclear power generation facilities to an interim storage facility called CLAB. The HLW will be suitably packaged prior to disposal in a geologic repository located somewhere in Sweden. The packaging of aged HLW at an encapsulation plant is the first component in Sweden's disposal system. The encapsulation plant may be located adjacent to the CLAB facility. In case the encapsulation plant is located separately from the CLAB, HLW will be transported from the CLAB facility to the encapsulation plant. Transportation of waste by sea and/or by land from the encapsulation plant to the repository (and from the CLAB to the encapsulation plant, if applicable) is the second component of the disposal system. The final component is the geologic repository and accompanying handling facility. The geologic repository is expected to function for many years after closure to isolate the HLW from the environment.

Swedish law requires that an Environmental Impact Assessment (EIA) be written for any planned action expected to have a significant impact on the environment. Before embarking on construction and operation of a HLW disposal system, the Swedish government will evaluate the expected environmental impacts to assure that the Swedish people and environmental will not be unduly affected by the disposal system. The EIA process requires that reasonable alternatives to the proposed action, including the 'zero' or 'no action' alternative, be considered so that the final approved plan for disposal will have undergone scrutiny and comparison of alternatives to arrive at a plan which is the best achievable given reasonable physical and monetary constraints.

2 PURPOSE AND SCOPE OF DOCUMENT

This report has been prepared by the Center for Nuclear Waste Regulatory Analyses (CNWRA) for use by the Swedish Radiation Protection Institute (SSI). The purpose of this report is to establish a document which outlines the types of information which would be in an EIA for a three part disposal system like that envisioned by the Swedish Nuclear Fuel and Waste Management Company (SKB) for the disposal of Sweden's HLW. Technical information that would normally be included in an EIA is outlined in this document. The SSI's primary interest is in radiological impacts. However, for the sake of completeness and also to evaluate all environmental impacts in a single document, non-radiological impacts are also included. Swedish authorities other than the SSI may have interest in the non-radiological parts of the document. This document itself is intended to be of a technical nature with no legal implications.

3 APPROACH FOR DEVELOPING THE EIA OUTLINE

The approach to consideration of the EIA of the proposed Swedish HLW disposal system included the following assumptions:

- A total system approach to the organization of the EIA outline is used. The total system is made up of three subsystems which include the waste encapsulation facility, the transportation subsystem, and the geologic repository. These three subsystems are first considered individually and in the end their aggregation is discussed.

  - It is assumed in the document that the CLAB would be the location of the proposed encapsulation facility, thus a transportation subsystem between the CLAB and the encapsulation facility is not required. If another configuration is used, then this outline should be modified to include such transport.

  - Each subsystem discussion is designed to be complete in itself which leads to some repetition of topics. The last section is designed to aggregate the impacts of the subsystems so that system optimization can be discussed.

- The aggregate of experience of the United States of America (US) in the EIA process is used to create the outline. The outline, based on US experience, may contain too much detail in certain areas.

- The no-action option which has been a critical part of US experience has been included in the outline. However, in the US, the HLW has been exempted from consideration of the no-action option. It is the intent that alternative means of encapsulating, transporting, and disposing of HLW will be discussed in the EIA which will include a no-action alternative also.

- The outline examines physical, biological, and cultural aspects of potential impacts from the proposed HLW disposal system.

The concepts suggested to be addressed in the EIA Outline (provided as Appendix A) for the proposed HLW Disposal System include the following:

- Establishment of an environmental baseline.

- Determination of the environmental impact of the planned action over appropriate time spans and each selected alternative on the baseline environment throughout the expected life of each action. Alternatives may include variation in configuration of the three subsystems e.g., location of the encapsulation plant at the CLAB or separate from it; or variation within a subsystem such as waste emplacement in horizontal or vertical drifts or disposal in deep bore holes.

- Determination that either the planned action or selected alternatives will not adversely affect the environment beyond acceptable limits.

- Comparison of the environmental impacts of the planned action to various alternatives to ensure that a balance is achieved between acceptable environmental distress and cost.

- Integration of environmental impacts from different system components (encapsulation plant, transportation, and repository) so that an optimization from the view of the overall system can be achieved.

The environmental baseline should describe the physical (and social, if desired) status of the study area which might be affected by the proposed action(s).

While, the environmental impact of the three subsystems can be determined individually, the aggregate impact should also be provided. A holistic perspective is important because, for example, even though the loss of wildlife habitat at each site might be acceptable, the aggregate of loss might be sufficient to require consideration of alternatives or mitigating measures. Impacts can be classified as inevitable and possible. The possible impacts may not actually occur, while the inevitable impacts such as conversion of land use from one type to another (i.e., forest to industrial) are certain. The concept of possible impacts should be related to probability of occurrence when it is reasonably feasible to do so.

Each of the environmental impacts should be discussed in terms of magnitude and significance. Magnitude refers to the size or extent of an impact such as the acreage of habitat removed, or volume of surface water affected by a contaminant discharge. Significance refers to the evaluation of the effect of an occurrence of a certain magnitude in terms of relative importance, i.e., the loss of w acres of habitat will reduce the population of x which will in turn affect the population of y, and z, all of which changes the area from an acceptable habitat to a marginal habitat. A second example would be when a quantity of contaminant exceeds the allowable limit causing a water source to be changed from potable to non-potable. Examples measuring criteria for significance are environmental laws, quality considerations, or statistical significance. The criteria used for judging the significance of an environmental impact should be clearly stated by the applicant and should be applied in the system wide evaluations.

The time period of interest for environmental impacts may be divided into four segments. The first period is the early operational period which may last from 50 to 100 years. The second time segment covers the period in which short-lived radionuclides will decay may last up to 300 years after repository closure. The third time segment is the long-term effects and may cover up to 10,000 years after closure. Finally the very long-term effects cover the period beyond 10,000 years. Very short- and short-term impacts with small magnitude and little significance can be contrasted with long- and very long-term impacts with large magnitude and great significance and vice-a-versa. In considering the environmental impacts, the concept of short- versus long-term may be the deciding factor as to whether a particular environmental disruption can be tolerated or is unacceptable. Unfortunately, there are no universally acceptable criteria for judging environmental impacts. Each society, in its own way, judges the impact of an action using different criteria and with different tolerances to project-induced adversity. The EIA should strive to qualitatively describe those impacts which are not easily quantifiable and should uniformly attempt to support impact judgments with explicitly stated assumptions and criteria. The EIA should attempt to provide both the adverse and beneficial impacts of various activities.

Impacts can be classified as primary or secondary. Primary impacts result directly from the action(s) undertaken. For example, if a facility is built on a 200 acre site, then 200 acres of one land use type are generally converted to a different land use type; such change in land use is a primary impact. In another example, the construction of a facility may require additional workmen at the site (direct impact), who will require temporary housing which will impact the local public housing market (secondary impact). Secondary impacts are many times overlooked. The adverse environmental effects, stress and strain on local or regional services, facilities, aesthetics, etc. by secondary effects may be the aggregate of effects which cause the environmental baseline change to be unacceptable. Even though the secondary effects are usually more easily lessened or mitigated and controlled than the primary effects, secondary effects must not be overlooked in the impact evaluation process.

Some impacts may be reversible and should be so described in the impact statement. As an illustration, if the construction of a facility on a 1000 acre site requires the removal of 400 acres of forest which can be replanted after original construction is complete, then the environmental degradation can be reversed. Some reversal of environmental impact will take place naturally without human intervention; any healing of the adverse impact resulting from the passage of time should be identified. Reversible impacts, when properly discussed, may not degrade the overall acceptability of a given project.

5 SUMMARY

The draft annotated outline of the EIA for the HLW disposal system in Sweden, included in its entirety in Appendix A, contains the following major sections:

- **1 EXECUTIVE SUMMARY**
- **2 INTRODUCTION TO THE FEATURES OF THE MAJOR COMPONENTS OF THE HIGH LEVEL RADIOACTIVE WASTE (HLW) DISPOSAL SYSTEM**
- **3 EIA OF ENCAPSULATION PLANT COMPONENT OF DISPOSAL SYSTEM**
- **4 EIA OF TRANSPORTATION COMPONENT OF HLW DISPOSAL SYSTEM**
- **5 EIA OF HLW GEOLOGIC REPOSITORY COMPONENT OF DISPOSAL SYSTEM**
- **6 EIA OF OVERALL HLW DISPOSAL SYSTEM**

APPENDIX A

EXAMPLES OF LIKELY CONSIDERATIONS IN AN ENVIRONMENTAL IMPACT ASSESSMENT OF THE SWEDISH HIGH-LEVEL RADIOACTIVE WASTE DISPOSAL SYSTEM

1 EXECUTIVE SUMMARY

The executive summary shall include a description of the entire high-level waste disposal system in Sweden i.e. the encapsulation facility, transportation component, and geologic repository. The environmental baseline for each of the disposal system components should be described and significant impacts on the environment for each component and the aggregate of the entire system should be discussed. Impacts in various time segments should be described, e.g., during operational period (~50 years), in the short period in which most fission products decay (~500 years), the long period of 10,000 years, and the very long period beyond 10,000 years. Of particular interest are the anticipated effects of radiation on the workers and the general public as well as the effects of such radiation on the plant and animal life. The long-term anticipated performance of the geologic repository should be described. Any mitigating of remedial measures planned to alleviate or compensate for any significant environmental effects should be discussed along with the anticipated lessening of radiation release/dose risk attributed to the planned ameliorating actions. The executive summary should succinctly present the reasons and assumptions underlying the findings reported in the EIA. Appropriate summary charts, tables, maps, and graphs should be included to convey information to the reader accurately and efficiently.

2 INTRODUCTION TO THE FEATURES OF THE MAJOR COMPONENTS OF THE HIGH LEVEL RADIOACTIVE WASTE (HLW) DISPOSAL SYSTEM

A brief discussion of the purpose of the integrated high-level radioactive waste disposal system should be presented. A summation of the physical characteristics of each of the subsystem components of Sweden's high-level radioactive waste disposal system should be presented to acquaint the reader with the concept of the subsystem components.

3 EIA OF ENCAPSULATION PLANT COMPONENT OF DISPOSAL SYSTEM

3.1 REGULATIONS AND REGULATORY AGENCIES

All applicable agencies responsible for the encapsulation facility activities, potential environmental effects, and the evaluation of hazard from radiation and nuclear safety should be identified and their relevant regulations described. Important regulatory activities which could change or impact the existing regulations should be discussed.

3.2 DESCRIPTION OF ENCAPSULATION FACILITIES AND OPERATIONS

A description of the physical facility and the activities which are conducted there should be presented. Each major facet of the encapsulation plant from the receipt of HLW to the egress from the facility of canisters of encapsulated waste bound for the geologic repository should be discussed. The elements of the outline contained in this section are based on a reasonable assumption of the kinds of activities expected to be accomplished at the encapsulation facility. Each of the sub-headings in this outline should be described in sufficient detail to evaluate the likely environmental impact of facility construction, operation, closure and post-closure monitoring.

3.2.1 Encapsulation Facility[1]

Each activity at the encapsulation facility including the reception, treatment, handling, encapsulation, and preparation for transshipment of the HLW should be discussed in sufficient detail to allow for the estimation of radiation dose to employees, general public, and the plant and animal environment and any general release of radioactive materials.

All radioactive materials packaging of transportation/disposal canisters/casks should be described in detail. Load capacities and radiological shielding capabilities of each package should be included. Any certification or licenses required by existing regulations should also be discussed. The results of tests representing a variety of potential accident conditions including head on impact, fire, immersion in water, and projectile impact should be described for all transportation packages. Operational safety features of the packages should also be considered.

3.2.1.1 Receiving At Encapsulation Facility

A complete description of the handling and transport of radioactive wastes received from the CLAB should be presented. The description should be complete and provide enough information to allow the calculation of occupation radiation doses.

3.2.1.2 Storage At Encapsulation Facility

If some storage of received material prior to encapsulation or if storage of encapsulated fuel is required, the means of storage should be discussed. The description of the storage related activities should be sufficiently complete to allow the estimation of radiation dose to workers, public and the environment.

3.2.1.3 Handling At Encapsulation Facility

Any handling of the radioactive materials should be discussed. Design and operation of the hot cell(s), unpacking, repacking of the fuel bundles, and

[1] In general, it is assumed in this document that the encapsulation facility is constructed adjacent to the CLAB interim storage facility.

introduction of bundles into the canister should be described such that radiation doses to the workers and the environment can be estimated.

3.2.1.4 Secondary Waste Handling/Disposal At Encapsulation Facility

Any secondary handling of the radioactive waste materials including subsequent disposal of the handling/operational wastes should be discussed. Design and operation of the secondary waste produced in the normal operations should be described such that radiation doses to the workers and the environment can be calculated and verified.

3.2.1.5 Loading for Transportation At Encapsulation Facility

The loading of encapsulated waste should be thoroughly described. The description should be sufficient to allow the calculation of radiation doses to the environment, public, and the workers.

3.2.1.6 Sources of Potential Releases of Radioactive Material At Encapsulation Facility

Any sources of potential release of radioactivity from the encapsulation facility should be identified. Means to lessen such furtive emissions should be discussed.

3.2.1.7 Radiation Protection Considerations At Encapsulation Facility

Plans to provide radiation protection at the encapsulation facility should be provided. Detail should be sufficient to allow determination of doses and that an optimization of radiation protection has been attained.

3.2.1.8 Plans for Decommissioning Of Encapsulation Facility

All clean-up plans associated with the decommissioning of the facility should be provided. Plans to protect the worker, public, and the environment from the undesirable effects of radiation should be included. Optimization of the protection afforded after decommissioning should be discussed. If the encapsulation facility is co-located with the CLAB then the CLAB should be included in a discussion of the decommissioning of the encapsulation facility.

3.2.1.9 Quality Assurance (QA) Program For Encapsulation Facility

A discussion of the QA program with appropriate references to governing documentation should be provided to ensure that each activity has been properly scrutinized during the life of the facility.

3.2.2 Emergency Planning At Encapsulation Facility

Emergency response notification and evacuation plans designed to protect the workers and the public and the environment in the event of accidents should be described. This should include a description of contingency plans for different classifications of disruptive events and identification of responsible authorities.

3.2.3 Safeguards At Encapsulation Facility

A plan for safeguarding the fissile and other controlled materials should be developed and presented in accordance with the applicable regulations.

3.3 DESCRIPTION OF BASELINE ENVIRONMENTAL CONDITIONS AT THE ENCAPSULATION FACILITY SITE

The environmental impacts of the encapsulation facility and the system to transport waste from this facility to the repository will be of relatively shorter period (on the order of 10s of years). The present generation and especially the workers employed at the encapsulation facility and those engaged in transportation will be the primary recipients of the impact. Once the repository is closed, the encapsulation facility and the transportation system will no longer be needed and with appropriate remediation measures, there will be no future environmental impact from them.

A description of the environment at the encapsulation facility site should be developed in this section so that all relevant environmental impacts attributable to the encapsulation facility can be explored and evaluated.

In preparing the description of the environment the following should be presented in the EIA:

- Description of the baseline environment before the existence of the encapsulation facility and as it would be in the future in the absence of the facility.
- Descriptions should be broad enough to provide a meaningful basis for evaluating both direct and secondary impacts.
- A basic understanding of the interrelationships between social, economic, and environmental elements.
- Effects of cumulative impacts. The proposed project should be evaluated not only against its own anticipated set of impacts but also against the aggregate of impacts which may arise because of interaction with other environmental stresses.
- Provide sufficient detail to allow public reviewers to make independent impact assessments while minimizing delays in the EIA review process.

3.3.1 Physical Conditions At the Encapsulation Facility Site

The location of the proposed encapsulation facility should be indicated on a map. Environmental conditions in the vicinity of the proposed site should be described. This could include mapping of animal life, surface and groundwater resources, climate conditions and geological conditions, etc.

3.3.2 Land Use

The EIA should discuss local land use laws, ordinances, regulations, plans or other administrative entities and instruments that may affect the project. The EIA should

carefully describe how the facility conforms (or does not conform) to existing land use plans. Maps showing planned land uses should be provided. Even where no land use plans exist, the EIA should reflect the anticipated land uses during the project life. A discussion concerned with developing industrial or other land use trends should be a part of the EIA. It is possible that trends which are not a part of an existing plan may dominate future growth in the study area.

3.3.3 Biology

Major terrestrial and aquatic biological systems as related to climatic, soil, topographic and other features should be discussed. The location of unique natural communities should be mapped. Any migratory wildlife and their habitat should be discussed. Rare or endangered species should be identified and their habitat mapped. Biota maps of both terrestrial and aquatic systems should be prepared for the study area including natural vegetation, animal population and range, and migratory routes. Animals or birds which habitually migrate through the area should be identified in addition to year-round inhabitants.

3.3.4 Meteorology and Climatology

A description of meteorologic/climatic attributes such as: 1) average annual and monthly average temperatures including extremes, 2) average annual and monthly precipitation (rain/snow) and extremes, 3) peak storm precipitation, seasonality, variability, and frequency of occurrence, 4) occurrence of unusual storms including their frequency and magnitude, and 5) analysis of wind directions and speeds should be provided.

3.3.5 Air Quality

Ambient air quality should be described. Any pollutant, radioactive and non-radioactive, expected to be emitted from the proposed encapsulation facility should be treated specifically when describing baseline air quality.

3.3.6 Noise

Ambient noise levels should be established at reasonable distances from the proposed facility both during expected work hours and outside. Any local zoning regulations which set allowable noise levels should be reported.

3.3.7 Aesthetic Resources

The intangible resources of the study area should be documented and evaluated. Historic communities or edifices, natural wildlife areas, scenic vistas, and desirable attributes of the regional setting should be identified such that any adverse effects of the siting of the encapsulation facility on these intangible resources can be identified and documented. The value of land adjacent to the proposed facility should be determined as a baseline for projections of growth/decline in land value because of aesthetic considerations.

3.3.8 Cultural Resources

Any cultural, historical, and/or religious monument present in the region that may be impacted by the facility should be described.

3.3.9 Radiation Background

The background radiation level at the site and nearby should be documented and discussed. Some original sampling of air, land, and biota to establish a radiation baeline will probably be required. If a monitoring plan is already in place it should be discussed. The report on background radiation should be sufficient to allow the calculation of addition of such radiation to the environment as a result of the construction, operation, and decommissioning of the encapsulation facility. Likely current dose of background radiation to the environment, public, and radiation workers should be documented.

3.3.10 Environmentally Sensitive Areas

Any zones within the study area that have been identified as environmentally sensitive (e.g. biota that is easily disrupted by change in the local environment) should be identified, mapped, and discussed in detail. The relationship of the environmentally sensitive zones to the encapsulation facility site should be shown clearly. Environmentally sensitive areas might include protected surface waters, marshlands, wetlands, estuaries, floodplains, groundwater recharge areas, steeply sloping lands, forests, prime agricultural lands, habitats of rare and endangered species, public outdoor recreation areas, sensitive geologic areas, and archaeological and historical sites.

3.4 DESCRIPTION OF BASELINE SOCIOECONOMIC CONDITIONS AT THE ENCAPSULATION FACILITY SITE

The economic and social conditions of the study area should be adequately described such that the impact of construction, operation, closure and any subsequent monitoring of the encapsulation facility on the area can be evaluated. Commerce, industry, population, governmental, and social factors are to be included in the discussion of the study area.

3.4.1 Economic Conditions

The economics of the study area should be described. Prominent industry, agricultural products, mining, and the overall workforce should be described. The location of industrial, commercial, agricultural, and governmental centers should be mapped. Income and earnings for individuals and businesses should be documented.

3.4.2 Population Density/Demographics

Current and projected population levels for the life of the facility should be determined. The population trends at the proposed site should be discussed along with growth rates for the region. Appropriate governmental and industrial

projections should be evaluated. Any unusual programs or developments in the region should be highlighted if they may have an impact on the area population. If a major interaction between the encapsulation facility-induced socioeconomic considerations and that of other actions in the area is anticipated, the interactions should be discussed.

3.4.3 Community Services

The various services which are provided to the public should be identified and discussed. Any public facilities should be identified as well as any recognized constraints on expansion or change in such facilities. Community services should be described in areas such as housing, education, water supply, waste water treatment, solid waste treatment, energy utilities, public safety services, medical/social services, library facilities, and parks/recreation/tourism.

3.4.4 Social Conditions

Regional social structure should be described. The lifestyle of the inhabitants should be documented along with any unique community attributes. The relationship of the surrounding community (rural/urban) to the current encapsulation facility site should be evaluated and reported. Social conditions such as social organization/structure, culture/lifestyle, unique community attributes, and local attitude towards the facility should be reported.

3.5 ENVIRONMENTAL IMPACTS OF CONSTRUCTION, OPERATION, AND DECOMMISSIONING OF THE ENCAPSULATION FACILITY

The significant impacts of each component requirement and operation on the environment should be identified, evaluated, and described by analyzing each component requirement and operation. The impacts can be aggregated using the same environmental elements employed in describing the baseline environment. The evaluation and description of the impacts (both individual and aggregated) should include a specification of their magnitude[2] and significance[3] among other characteristics. The extent to which the proposed project will affect the no-project baseline environmental forecast should be discussed.

Risk assessments to the workers and the general public should be conducted using realistic scenarios based upon consideration of anticipated normal operation and accident conditions. Potential exposures from relevant pathways should be used in these risk analyses. Risk results should be compared with existing relevant risks experienced by the host population(s) to establish a context for understanding and communicating these risks to the public and other concerned parties.

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[2] Magnitude refers to a quantitative description of an effect.

[3] Significance is described qualitatively in terms of the relative benefit or detriment of a particular action.

3.5.1 Evaluation of Change In Physical Conditions At Encapsulation Facility Site

Changes in site topography due to construction or operation and decommissioning of the encapsulation facility and CLAB (if appropriate) should be identified and described. The changes in ground water and surface water conditions that are caused by the project should also be identified and described.

Environmental consequences due to these changes should be investigated and reported in the EIA. If necessary, mitigating actions for the adverse effects should be identified.

3.5.2 Land Use

Any changes to local land use plans should be discussed. The impact of loss of agricultural or forest land due to site construction, operation, and decommissioning should be included.

3.5.3 Biology

The effects of construction, operation, and decommissioning of the encapsulation facility on the local and regional terrestrial and aquatic biota should be estimated. The loss of habitat should be documented and mitigative actions to protect biota should be identified as required.

3.5.4 Meteorology and Climatology

Effects of construction, operation, and decommissioning of an encapsulation facility on local microclimate and micrometeorology should be identified. Changes in factors such as snowcover, runoff, formation of a heat island, and vegetative cover should be evaluated to determine the likely changes from baseline ambient conditions.

3.5.5 Air Quality

Any anticipated changes in air quality from the ambient should be identified and reviewed. Such changes may be due to emission from construction equipment and other facility related machinery as well as from pollutants emitted from the encapsulation facility. Any pollutant, radioactive and non-radioactive, expected to be emitted from the encapsulation facility should be treated specifically when describing ambient air quality.

3.5.6 Noise

Expected noise levels during construction, operation, and decommissioning of the facility should be compared to ambient baseline noise levels. Noise levels exceeding desired limits should be reported and mitigating actions to reduce noise should be discussed.

3.5.7 Aesthetic Resources

Like noise, the reduction in perception of the quality of the site and surroundings during construction, operation, and decommissioning of the encapsulation facility and CLAB, if appropriate, should be compared to the ambient baseline perceptions of the populace. Adverse effects on aesthetic appreciation of the site should be discussed and means to reduce adverse effects by activities should be discussed.

3.5.8 Cultural Resources

Possible impact of the planned facility on any cultural, historical, and/or religious monuments or archaeological resources present in the region should be described.

3.5.9 Radiation Background

Any projected increase in radiation in the environs of the site should be identified and means to limit such increases to "within acceptable limits" should be discussed. This information should be confined to normal operating conditions in this section. Likely increase (or decrease) in dose to workers, public, and environment should be discussed.

3.5.10 Environmentally Sensitive Areas

Of particular importance are local areas which have been identified as environmentally sensitive. The EIA should discuss the likely effects on such areas from project activities and should identify any mitigative actions which can lessen expected adverse effects.

3.5.11 Economic Conditions

A description should be given of beneficial or adverse changes in economic conditions which will result from the proposed encapsulation facility. Special attention should be given to define who or what will be benefitted and by how much. Assumptions or judgments inherent in such assessments should be discussed.

3.5.12 Population Density

Changes in study area population should be projected for the life of the encapsulation facility. Short-term impacts accruing from the construction of the facility should be discussed as well as long-term effects on area population.

3.5.13 Community Services

The impacts of the construction work force and the operations work force on local community infrastructure and services such as water supply, sewerage, public health, housing, education and other considerations should be determined. Mitigating actions such as provision of affected services to the local citizens by the constructing entity should be suggested and the ameliorating effects of special plans should be discussed. The discussion should include topics such as housing,

education, water supply, waste water treatment, solid waste treatment. energy utilities, public safety services, medical/social services, library facilities, and parks/recreation/tourism facilities.

3.5.14 Social Conditions

Any likely effects of construction, operation, and decommissioning of the encapsulation facility (and CLAB, if appropriate) on the local social conditions should be identified. Lifestyle changes (i.e. from rural to urban environment) should be noted. Public acceptance/refusal of the facility should be documented and any mitigating factors should be discussed. Discussion should include topics such as social organization/structure, culture/lifestyle, community attributes, and community attitudes toward the facility.

3.5.15 Radiation Impacts of Normal Operation

A radiological risk assessment for detrimental effects shall be conducted based on anticipated normal operating (i.e., incident free) conditions during the period of operation. Methods used in the risk assessments shall be discussed in detail including a description of all evaluations, assumptions and simplifications used. Risks to workers, the general public, and environment in general shall be investigated. These assessments shall estimate radiation doses and evaluate cancer and genetic risks from all activities involving exposure including unloading, and reloading waste for shipment, and processing of secondary radioactive wastes. Public risks shall consider any exposures from radiation emissions which migrate offsite (if applicable). If any long-term effects are anticipated they should also be discussed.

3.5.15.1 Risk Assessment Methods

The methods used to document and assess risk should be presented and discussed. Basic assumptions should be clearly stated and conclusions well-documented.

3.5.15.2 Occupational Risk Assessment Results

The results of assessment of risk to workers should be presented. The discussion should include topics such as inhalation pathway, direct radiation exposure, dermal contact, and ingestion pathway.

3.5.15.3 Public Risk Assessment Results

The results of assessment of risk to the public should be presented. The discussion should include topics such as inhalation pathway, direct radiation exposure, dermal contact, and ingestion pathway.

3.5.15.4 Environmental Risk Assessment Results

The results of assessment of risk to animal and plant life should be presented. If possible, the discussion should include topics such as inhalation pathway, direct radiation exposure, dermal contact, and ingestion pathway.

3.5.15.5 Mitigation Measures

Any measures which are designed to alleviate or remove the risk of adverse effects of radiation on the worker, the public, or plant or animal life should be identified and discussed.

3.5.16 Radiation Risks from Accidents

An radiation risk assessment for detrimental effects shall be conducted based on postulated accident conditions at the encapsulation facility during the period of operation. Methods used in the risk assessments shall be discussed in detail including a description of all calculations, assumptions and simplifications used. Risks to both workers and the general public shall be investigated. Worker risk accident scenarios will be based upon information provided in the encapsulation facilities and operations description as well as data obtained from previous HLW handling operations. Public risks shall consider exposures from direct radiation, dermal exposure, and inhalation resulting from loss of containment and subsequent dispersion of radionuclides (if applicable). The ingestion pathway considers both short term and longer term risks from ingestion of contaminated water, local crops, domestic and game animals, etc.

3.5.16.1 Risk Assessment Methods

The methods used to document and assess accident risk should be presented and discussed. Basic assumptions should be clearly stated and conclusions well-documented. The rationale behind the establishment of accident scenarios should be presented.

3.5.16.2 Occupational Risk Assessment Results

The results of assessment of accident risk to workers should be presented. The discussion should include topics such as inhalation pathway, direct radiation exposure, dermal contact, and ingestion pathway.

3.5.16.3 Public Risk Assessment Results

The results of assessment of accident risk to the public should be presented. The discussion should include topics such as inhalation pathway, direct radiation exposure, dermal contact, and ingestion pathway.

3.5.16.4 Environmental Accident Risk Assessment Results

The results of assessment of accident risk to the plant and animal species should be presented. The discussion should include topics such as inhalation pathway, direct radiation exposure, dermal contact, and ingestion pathway.

3.5.16.5 Mitigation Measures for Accident Consequences

Any measures which are designed to alleviate or remove the risk of adverse effects of radiation from accidents on the worker, the public, or nonhuman species should be identified and discussed. Such measures may include engineering design, site features, and emergency preparedness. The

reduction in accident risk obtained by implementing such measures should be specifically identified.

3.5.17 Environmental Impacts from Decommissioning and Post Closure Considerations

The EIA should include a discussion of the impacts of both radioactive and non-radioactive wastes expected to accrue from the decommissioning and post-closure activities at the encapsulation facility site (and CLAB, if appropriate). If the site must be disrupted to remove contamination after dismantling of the facility the effect of such disruption on the facets of the environment previously identified should be provided. Any unique effects due to post-closure considerations should be identified.

3.5.17.1 Risk Assessment Methods

The methods used to evaluate decommissioning and post-closure risk should be presented and discussed. Basic assumptions should be clearly stated and conclusions well-documented. The rationale behind the establishment of risk scenarios should be presented.

3.5.17.2 Occupational Risk Assessment Results

The results of assessment of decommissioning and post-closure risk to workers should be presented. The discussion should include topics such as inhalation pathway, direct radiation exposure, dermal contact, and ingestion pathway.

3.5.17.3 Public Risk Assessment Results

The results of assessment of decommissioning and post-closure risk to the public should be presented. The discussion should include topics such as inhalation pathway, direct radiation exposure, dermal contact, and ingestion pathway.

3.5.17.4 Environmental Decommissioning and Post-closure Related Risk Assessment Results

The results of assessment of accident risk to the plant and animal species should be presented. If possible, the discussion should include topics such as inhalation pathway, direct radiation exposure, dermal contact, and ingestion pathway.

3.5.17.5 Mitigation Measures for Decommissioning and Post-closure Risk Consequences

Any measures which are designed to alleviate or remove the risk of adverse effects of radiation from decommissioning and post-closure activities on the worker, the public, or nonhuman species should be identified and discussed. Such measures may include engineering design, site features, and emergency preparedness. The reduction in such risk obtained by implementing such measures should be specifically identified.

3.5.17.6 Long Term Effects During Decommissioning and Post-closure

Long-term impacts which persist for many years should be identified. Certain radioactive materials and heavy metals, for example, have a significantly longer half-life or persistence of toxicity than others and such materials should be described in terms of their long-term adverse impacts on the environment.

3.5.18 Unavoidable Adverse Impacts

Those adverse impacts from construction, operation, closure, decommissioning, and post-closure activities for which no reasonable mitigation is possible should be identified. Some impacts such as reducing forest land at a proposed site could be mitigated by converting land elsewhere to the "lost" land use.

3.5.19 Irreversible Commitment of Resources

The EIA should report on those aspects of the environment which are irreversibly altered and should determine the relative severity of such permanent alteration.

3.6 CONSEQUENCES OF PROPOSED ALTERNATIVE(S)

Alternatives to the proposed encapsulation facility should be considered as a means of lessening environmental impacts. In the case of an encapsulation facility, different methods for handling the HLW might be investigated. Techniques investigated will differ with, for example, one presenting the least risk of upset, another, the least cost, or still another the least upset to the baseline environment. The likely consequences of proposed alternatives should be compared and a given alternative selected. This tradeoff study should be performed in the context of the overall system which includes the system to transport the encapsulated fuel to the repository and the repository itself. The rationale supporting the selection of a particular technique(s) should be presented. Impact identification requires a thorough understanding of the environmental baseline, the goals of the proposed project, various impact control technologies, and the relationships between the engineering designs and the natural environment. The estimated cost of each alternative should be presented.

3.6.1 CONSEQUENCES OF NO ACTION

The consequences in the study area of the no-action alternative should be presented.

4 EIA OF TRANSPORTATION COMPONENT OF HLW DISPOSAL SYSTEM

The EIA for the transportation component of the HLW disposal system should contain a description of existing and proposed transportation activities and assessment of radiological and non-radiological impacts of the proposed action regarding potential human and environmental health impacts. The transportation system is expected to include shipments of spent fuel as well as wastes resulting from the decommissioning of facilities. Transportation of radioactive waste should adhere to international regulations applicable to such hazardous

materials. Alternatives to the proposed transportation activities should also be described and assessed for impacts and compared with the proposed action. All modes of transportation and routing should be identified and incorporated into representative scenarios used for radiological risk assessments. Background environmental conditions along the proposed transportation route should be described. Potential exposures from relevant pathways under both incident free and accident transportation conditions should be used in these risk analyses. Risk results should be compared with other relevant risks experienced by the host population(s) to establish a context for understanding and communicating these risks to the public and other concerned parties.

4.1 REGULATIONS AND REGULATORY AGENCIES

All applicable agencies responsible for the regulation of transportation activities and the possession and movement of radioactive materials should be identified and their regulations described. Important regulatory activities which could change or impact the existing regulations should be discussed.

4.2 TRANSPORTATION COMPONENT DESCRIPTION

This section includes a description of the proposed system for transportation of waste along with the facilities and equipment which will be involved. The discussion of facilities should describe how facilities and equipment are integrated to function together safely and are fully compatible with the systems in which they will be operating.

4.2.1 Modes/Alternatives

Proposed and alternative transportation modes should be described. This description emphasizes the advantages and disadvantages of each mode under consideration. Consideration of transportation safety, radiological safety, interfaces with other modes, and cost should be included.

4.3 RADIOACTIVE MATERIAL PACKAGING

All radioactive material packaging for transportation/disposal should be described in detail. Load capacities and radiological shielding capabilities of each package should be included. Any certification or licenses required by existing regulations should also be discussed. The results of tests representing a variety of potential accident conditions including head on impact, fire, immersion in water, and projectile impact should be described for all transportation packages. Operational safety features of the packages should also be considered.

4.4 LAND TRANSPORTATION

4.4.1 Routing Considerations

Alternative potential routes for land transportation should be described. Criteria used for the selection of the routes for the proposal should be discussed. These criteria could include, for example, consideration of population density along

proposed routes, capacity and traffic conditions, infrastructure conditions, special transportation safety considerations, and proximity to important food producing areas, water resources, and sensitive ecological systems.

4.4.2 Radiological Impacts Under Incident-Free Transportation Conditions

A radiological risk assessment should be conducted based on anticipated normal operating (i.e., incident free) conditions. Methods used in the risk assessments should be discussed in detail including a description of all calculations, assumptions and simplifications used. The rationale behind the establishment of risk scenarios should be presented. Risks to both workers, the general public, and plants and animals should be investigated. Worker risk scenarios should be based on the transportation system description and should include radiation doses from all transportation related activities including packaging, loading, transportation, and unloading. Public risks should consider any exposures from direct radiation along the transportation route including scheduled stops.

4.4.2.1 Mitigation Measures for Incident-free Transportation Consequences

Any measures which are designed to alleviate or remove the risk of adverse effects of radiation from normal, incident-free transportation activities on the worker, the public, or nonhuman species should be identified and discussed. Such measures may include engineering design, site features, and emergency preparedness. The reduction in such risk obtained by implementing such measures should be specifically identified.

4.4.2.2 Long Term Effects

Potential health effects from incident-free exposure to external radiation should be assessed over a period of time sufficient to detect potential latent effects. Chronic exposures should be considered, where applicable.

4.4.2.3 Economic Impacts from Incident-Free Transportation

Economic impacts to communities along the transportation route should be assessed. Local and regional attitudes regarding transportation of HLW will have to be considered to determine if negative perceptions exist which could affect tourism, immigration, or business opportunities. Impacts from the creation or enhancement of service economies along routes should also be considered.

4.4.3 Radiological Impacts from Transportation Incidents

A radiological risk assessment for detrimental effects due to transportation incident effects should be conducted based on postulated accident conditions. Methods used in the risk assessments should be discussed in detail including a description of all calculations, assumptions and simplifications used. The rationale behind the establishment of risk scenarios should be presented. Risks to both workers, the general public, and plants and animals should be investigated. Worker risk scenarios will be based on the transportation system description and should

include doses from accidents during loading, transportation, and unloading. Public risks should consider exposures from direct radiation at the scene of an accident as well as potential dermal exposure, and inhalation resulting from loss of containment. The ingestion pathway considers long term risks from ingestion of contaminated water, local crops, domestic and game animals.

4.4.3.1 Mitigation Measures for Transportation Incident Consequences

Any measures which are designed to alleviate or remove the risk of adverse effects of radiation from transportation incident on the worker, the public, or plant and animal species should be identified and discussed. Such measures may include engineering design, site features, and emergency preparedness. The reduction in such risk obtained by implementing such measures should be specifically identified.

4.4.3.2 Long Term Effects

Long-term impacts which persist for many years should be identified and consequences due to the impacts should be assessed.

4.4.3.3 Economic Impacts from Transportation Incidents

Potential economic impacts from transportation incidents on communities along the transportation route should be assessed. Estimated environmental contamination from postulated accidents used for calculation of ingestion doses should be used to estimate the cost of cleanup of contaminated soil and water to levels of radioactivity which are considered safe by current regulations. Economic impacts to local farms, industries, and other economic entities from potential contamination should be addressed.

4.4.4 Non-Radiological Impacts of Transportation Incidents

A discussion of non-radiological impacts from accidents should consider the frequency of shipments in conjunction with the current accident rates for specific routes to determine the potential for accidents and the likely non-radiological consequences.

4.4.5 Financial Responsibility for Accidents

The party responsible to bear monetary costs of land transportation accidents should be identified.

4.5 SEA TRANSPORTATION

4.5.1 Routing Considerations

Routes for sea transportation should be described. If applicable, criteria used for the selection of the routes for the proposal should be discussed. These criteria should include consideration of population density along proposed routes, capacity and traffic conditions, special transportation safety considerations, and proximity

to important food producing areas, water resources, and sensitive ecological systems.

4.5.2 Radiological Impacts Under Incident-Free Sea Transportation Conditions

A radiological risk assessment should be conducted based on anticipated normal operating (i.e., incident free) conditions. Methods used in the risk assessments should be discussed in detail including a description of all calculations, assumptions and simplifications used. The rationale behind the establishment of risk scenarios should be presented. Risks to workers, the general public, and plants and animals should be investigated. Worker risk scenarios will be based on the transportation system description and should include radiation doses from all transportation related activities including packaging, loading, secondary (i.e., truck) and primary (i.e., sea vessel) transportation, and unloading. Public risks should consider any exposures from direct radiation along the transportation route, if applicable, including scheduled stops.

4.5.2.1 Mitigation Measures for Incident-Free Sea Transportation Consequences

Any measures which are designed to alleviate or remove the risk of adverse effects of radiation from normal, incident-free sea transportation activities on the worker, the public, or nonhuman species should be identified and discussed. Such measures may include engineering design, site features, and emergency preparedness. The reduction in such risk obtained by implementing such measures should be specifically identified.

4.5.2.2 Long Term Effects

Potential health effects from incident-free exposure to external radiation should be assessed over a period of time sufficient to detect potential latent effects. Chronic exposures should be considered, where applicable.

4.5.2.3 Economic Impacts from Incident-Free Sea Transportation

Economic impacts to communities along the transportation route should be assessed. Local and regional attitudes regarding transportation of HLW will have to be considered to determine if negative perceptions exist which could affect tourism, immigration, or business opportunities. Impacts from the creation or enhancement of service economies along routes should also be considered.

4.5.3 Radiological Impacts from Sea Transportation Incidents

A radiological risk assessment for detrimental effects due to sea transportation incident effects should be conducted based on postulated accident conditions. Methods used in the risk assessments should be discussed in detail including a description of all calculations, assumptions and simplifications used. The rationale behind the establishment of risk scenarios should be presented. Risks to workers, the general public, and plants and animals should be investigated. Worker risk

scenarios will be based on the transportation system description and should include doses from accidents during loading, transportation, and unloading. Public risks should consider exposures from direct radiation at the scene of an accident as well as potential dermal exposure, and inhalation resulting from loss of containment. The ingestion pathway considers long term risks from ingestion of contaminated water, local crops, domestic and game animals.

4.5.3.1 Mitigation Measures for Sea Transportation Incident Risk Consequences

Any measures which are designed to alleviate or remove the risk of adverse effects of radiation from normal, sea transportation incident induced activities on the worker, the public, or nonhuman species should be identified and discussed. Such measures may include engineering design, site features, and emergency preparedness. The reduction in such risk obtained by implementing such measures should be specifically identified.

4.5.3.2 Long Term Effects

Long-term impacts which persist for many years should be identified and consequences due to the impacts should be assessed.

4.5.3.3 Economic Impacts From An Incident During Sea Transportation

Economic impacts to communities along the sea transportation route should be assessed. Local and regional attitudes regarding transportation of HLW will have to be considered to determine if negative perceptions exist which could affect tourism, immigration, or business opportunities. Impacts from the creation or enhancement of service economies along routes should also be considered.

4.5.4 Non-Radiological Impacts of Sea Transportation Incidents

A discussion of non-radiological impacts from sea transportation incidents should consider the frequency of shipments in conjunction with the current accident rates for specific routes to determine the potential for accidents and the likely non-radiological consequences.

4.5.5 Financial Responsibility for Seafaring Accidents

The party responsible to bear monetary costs of sea transportation accidents should be identified.

4.6 CONSEQUENCES OF PROPOSED ALTERNATIVES

Conduct analyses similar to those conducted in sections 4.4. and 4.5 for selected transportation alternatives and compare impacts identified with the impacts determined for the proposed transportation activities.

4.7 CONSEQUENCES OF NO ACTION

Describe the consequences of not transporting the HLW. Areas including public health, impacts to the human and natural environment, social and economic conditions should be emphasized. If, for example, the geologic repository is co-located with the CLAB and the encapsulation facility then there would be no risk associated with transportation and Section 4 would not be required.

5 EIA OF HLW GEOLOGIC REPOSITORY COMPONENT OF DISPOSAL SYSTEM

5.1 REGULATIONS AND REGULATORY AGENCIES

All applicable agencies responsible for the geologic repository facility related activities, potential environmental effects, and the evaluation of hazard from radiation should be identified and their relevant regulations described.

5.2 DESCRIPTION OF GEOLOGIC REPOSITORY FACILITIES AND OPERATIONS

A description of the physical facility and the activities which are done there should be presented. Each major facet of the geologic repository operations area and underground facilities, from the receipt of HLW canisters to the emplacement of canisters of encapsulated waste within the geologic repository, should be discussed. Each of the sub-headings in this outline should be described in reasonable detail such that the likely environmental impact of facility construction, operation, closure, post-closure monitoring, and long-term waste isolation can be evaluated later.

5.2.1 Disposal Facility

It is assumed that the HLW coming from the encapsulation facility will be received at a surface facility where handling of the waste canisters (i.e. removal from the temporary shipping pallets, casks, or whatever construction the HLW is transferred in), and preparation of the waste canisters for disposal will take place. Each step of the receipt, treatment, handling, disposal, sealing, closure, surface facility decommissioning, and post-closure monitoring should be discussed in sufficient detail to allow for the estimation of radiation dose to employees, general public, and the plant and animal environment including any general release of radioactive materials.

5.2.1.1 Receiving

A complete description of the handling of the waste at surface facility shall be provided. If any temporate storage of canisters are planned, this storage should also be described. The description should be complete and provide enough information to allow calculation of radiation doses to workers.

5.2.1.2 Disposal

A complete description of the handling of the waste at the underground facility shall be provided. The description should be complete and provide enough information to allow calculation of radiation doses to workers.

5.2.1.3 Wastes Generated and Systems for Control and Handling

Both radioactive and non-radioactive waste generated by the interim storage and ultimate underground disposal activities should be reported. Means of routinely disposing of such waste should be discussed so that environmental impact of such geologic disposal can be determined.

5.2.1.4 Sources of Potential Releases of Radioactive Material

All sources of possible release of radioactive materials should be identified. Potential pathways to the environment should be discussed. The means to limit the release of radioactive materials should be discussed so that possible environmental impact of release can be accurately determined.

5.2.1.5 Radiation Protection Considerations

Routine measures taken to curtail the release and/or impact of radiation on the environment should be discussed. Of particular interest is the protection afforded the workers and the general public.

5.2.1.6 Plans for Decommissioning the Surface and Subsurface Portions of the Geologic Repository

Plans for decommissioning the facility should be presented in sufficient detail to afford the determination of likely environmental effects of the decommissioning activities. Of particular interest is the proposed means of sealing shafts and boreholes to insure long-term protection from the release of radiation due to leakage from the geologic repository.

5.2.1.7 Post-Closure Monitoring At the Geologic Repository

The plans for post-closure monitoring of the site should be presented. Expected levels of radiation or other contaminants should be identified along with the selected means to measure or calculate concentrations.

5.2.1.8 Post-Closure Protection of the Public

The plan for short- and long-term protection of the public should be presented. The use of archives and site marking to preclude inadvertent intrusion into the geologic repository should be discussed.

5.2.1.9 Summary of Quality Assurance (QA) Program For the Geologic Repository

A summary of the QA program with appropriate references to governing documentation should be provided to ensure that each activity at the geologic repository has been properly scrutinized during the life of the facility.

5.2.2 Emergency Planning At Geologic Repository

Emergency response notification and evacuation plans designed to protect workers, the public, and the environment in the event of accidents should be described. This should include a description of contingency plans for different classifications of disruptive events and identification of relevant authorities.

5.2.3 Safeguards At Geologic Repository

A plan for safeguarding the fissile and other controlled materials should be developed and presented in accordance with the applicable regulations.

5.3 DESCRIPTION OF BASELINE ENVIRONMENTAL CONDITIONS AT PROPOSED GEOLOGIC REPOSITORY FACILITY SITE

A description of the environment at the geologic repository site must be developed in this section with sufficient detail and breadth so that all relevant environmental impacts attributable to the geologic repository can be explored and evaluated. Impacts for both short (during construction and operation) and longer (during post-closure) durations are to be assessed.

In preparing the description of the environment the following should be addressed in the EIA:

- Description of the baseline environment before the existence of the geologic repository and as it would be in the future in the absence of the facility.
- Descriptions should be broad enough to provide a meaningful basis for evaluating both direct and secondary impacts.
- A basic understanding of the interrelationships between social, economic, and environmental elements.
- Effects of cumulative impacts. The proposed project should be evaluated not only against its own anticipated set of impacts but also against the aggregate of impacts which may arise because of interaction with other environmental stresses.
- Provide sufficient detail to allow reviewers to make independent impact assessments while minimizing delays in the EIA review process.

5.3.1 Physical Conditions At the Geologic Repository Site

The location of the proposed geologic repository site should be indicated on a map. Environmental conditions in the vicinity of the proposed site should be described. This could include mapping of animal life, surface and groundwater resources, climate conditions and geological conditions, etc.

5.3.2 Land Use

The EIA should discuss local land use laws, ordinances, regulations, plans or other administrative entities and instruments that may affect the project. The EIA should carefully describe how the facility conforms (or does not conform) to existing land use plans. Maps showing planned land uses should be provided. Even where no land use plans exist, the EIA should reflect the anticipated land uses during the project life. A discussion concerned with developing industrial or other land use trends should be a part of the EIA. It is possible that trends which are not a part of an existing plan may dominate future growth in the study area.

5.3.3 Biology

Major terrestrial and aquatic biological systems as related to climatic, soil, topographic and other features should be discussed. The location of unique natural communities should be mapped. Any migratory wildlife and their habitat should be discussed. Rare or endangered species should be identified and their habitat mapped. Biota maps should be prepared for the study area including natural vegetation, animal population and range, and migratory routes.

5.3.4 Meteorology and Climatology

A description of meteorologic/climatic attributes such as average annual and monthly temperatures including extremes, average annual and monthly precipitation (rain/snow) and extremes, and analysis of wind directions and speeds should be provided.

Of particular interest in the long-term disposal of radioactive waste is the future climate during the repository lifetime of 10000 or more years. A discussion of expected future climate at the repository site could be a part of the baseline description of climate.

5.3.5 Air Quality

Ambient air quality should be described. Any pollutant, radioactive and non-radioactive, expected to be emitted from the proposed geologic repository should be treated specifically when describing baseline air quality.

5.3.6 Noise

Ambient noise levels should be established at reasonable distances from the proposed facility both during expected work hours and outside. Any local zoning regulations which set allowable noise levels should be reported.

5.3.7 Aesthetic Resources

The intangible resources of the study area should be documented and evaluated. Historic communities or edifices, natural wildlife areas, scenic vistas, and desirable attributes of the regional setting should be identified such that any adverse effects of the siting of the geologic repository on these intangible resources can be

identified and documented. The value of land adjacent to the proposed facility should be determined as a baseline for projections of growth/decline in land value because of aesthetic considerations.

5.3.8 Cultural Resources

Any cultural, historical, and/or religious monument present in the region that may be impacted by the facility should be described.

5.3.9 Radiation Background

The background radiation level at the site and nearby should be documented and discussed. Some original sampling of air, land, and biotic levels of radiation will probably be required. If a monitoring plan is already in place it should be discussed. If radiation is already released to the biota, air, and land, the baseline dose assessments to the human, animal, and plant life should be included. The report on background radiation should be sufficient to allow the calculation of addition of such radiation to the environment as a result of the construction, operation, and decommissioning of the geologic repository. Likely current dose of background radiation to the environment, public, and workers should be documented.

5.3.10 Environmentally Sensitive Areas

Any zones within the study area that have been identified as environmentally sensitive (e.g. biota that is easily disrupted by change in the local environment) should be identified, mapped, and discussed in detail. The relationship of the environmentally sensitive zones to the geologic repository site should be shown clearly. Environmentally sensitive areas might include protected surface waters, marshlands, wetlands, estuaries, floodplains, groundwater recharge areas, steeply sloping lands, forests, prime agricultural lands, habitats of rare and endangered species, public outdoor recreation areas, sensitive geologic areas, and archaeological and historical sites.

5.4 DESCRIPTION OF SOCIOECONOMIC CONDITIONS AT GEOLOGIC REPOSITORY SITE

The economic and social conditions of the study area should be adequately described such that the impact of construction, operation, closure and any subsequent monitoring of the geologic repository on the area can be evaluated. Commerce, industry, population, governmental, and social factors are to be included in the discussion of the study area.

5.4.1 Economic Conditions

The economics of the study area should be described. Prominent industry, agricultural products, mining, and the overall workforce should be described. The location of industrial, commercial, agricultural, and governmental centers should be mapped. Income and earnings for individuals and businesses should be documented.

5.4.2 Population Density/Demographics

Current and projected population levels for the life of the facility should be determined. The population trends at the proposed site should be discussed along with growth rates for the region. Appropriate governmental and industrial projections should be evaluated. Any unusual programs or developments in the region should be highlighted if they may have an impact on the area population. If a major interaction between the geologic repository-induced socioeconomic considerations and that of other actions in the area is anticipated, the interactions should be discussed.

5.4.3 Community Services

The various services which are provided to the public should be identified and discussed. Any public facilities should be identified as well as any recognized constraints on expansion or change in such facilities. The discussion should include topics such as housing, education, w ter supply, waste water treatment, solid waste treatment. energy utilities, public safety services, medical/social services, library facilities, and parks/recreation/tourism facilities.

5.4.4 Social Conditions

Regional social structure should be described. The lifestyle of the inhabitants should be documented along with any unique community attributes. The relationship of the surrounding community (rural/urban) to the current geologic repository site should be evaluated and reported. Discussion should include topics such as social organization/structure, culture/lifestyle, community attributes, and community attitudes toward the facility.

5.5 ENVIRONMENTAL IMPACTS OF CONSTRUCTION AND OPERATION OF HLW GEOLOGIC REPOSITORY FACILITY AND ALTERNATIVES

The significant impacts of each component and operation (e.g., engineered barriers, waste handling system) should be identified, evaluated, and described by analyzing each subsystem requirement and operation. The impacts can be aggregated using the same environmental elements employed in describing the baseline environment. The evaluation and description of the impacts (both individual and aggregated) shall include a specification of their magnitude and significance among other characteristics. The extent to which the proposed project will affect the no-project baseline environmental forecast should be explicitly discussed for each subsection.

Risk assessments should be conducted using realistic scenarios based upon consideration of anticipated normal operation and accident conditions. Potential exposures from all relevant pathways should be used in these risk analyses. Risk results should be compared with existing relevant risks experienced by the host population(s) to establish a context for understanding and communicating these risks to the public and other concerned parties.

5.5.1 Changes In Physical Conditions At the Geologic Repository Site

Changes in site topography due to construction or operation and decommissioning of the proposed geologic repository should be identified and described. The changes in ground water and surface water conditions that are caused by the project should also be identified and described.

Environmental consequences due to these changes should be investigated and reported in the EIA. If necessary, mitigating actions for the adverse effects should be identified.

5.5.2 Land Use

Any changes to local land use plans should be discussed. The impact of loss of agricultural or forest land due to site construction, operation, and decommissioning (surface facilities) should be included. The relative adverse or beneficial changes in land use at the site should be identified.

5.5.3 Biology

The effects of construction, operation, and decommissioning of the geologic repository on the local and regional terrestrial and aquatic biota should be estimated. The loss of habitat should be documented and mitigative actions to protect biota should be identified as required.

5.5.4 Meteorology and Climatology

Effects of construction, operation, and decommissioning (surface facilities) of an geologic repository on local microclimate and micrometeorology should be identified. Changes in factors such as snowcover, runoff, formation of a heat island, and vegetative cover should be discussed to demonstrate the likely changes from baseline ambient conditions.

5.5.5 Air Quality

The effect of emission of any non-radioactive pollutants from the geologic repository should be documented here. Changes from the ambient baseline air quality caused by the construction, operation, and decommissioning of the geologic repository should be addressed. Measures taken to lessen adverse effects on air quality should be highlighted.

5.5.6 Noise

Expected noise levels during construction, operation, and decommissioning (surface facilities) of the geologic repository should be compared to ambient baseline noise levels. Noise levels exceeding desired limits should be reported and mitigating actions to reduce noise during construction, operation, and decommissioning (surface facilities) should be discussed.

5.5.7 Aesthetic Resources

Like noise, the reduction in perception of the high aesthetic quality of the site and surroundings during construction, operation, and decommissioning (surface facilities) of the geologic repository should be compared to the ambient baseline perceptions of the populace. Adverse effects on aesthetic appreciation of the site and means to reduce these effects should be discussed.

5.5.8 Cultural Resources

Possible impact of the planned facility on any cultural, historical, and/or religious monument present in the region should be described.

5.5.9 Radiation Background

Any projected increase in radiation in the vicinity of the geologic repository site should be identified and means to limit such increases to within acceptable limits should be discussed. This information should be confined to normal operating conditions in this section. Means of monitoring radiation must be shown to be sufficient and resultant dose calculations should thoroughly be documented.

5.5.10 Environmentally Sensitive Areas

Of particular importance are local areas which have been identified as environmentally sensitive. The EIA should discuss the likely effects on such areas from project activities and should identify any mitigative actions which can lessen expected adverse effects.

5.5.11 Economic Conditions

A description should be given of economic, social, environmental, or other benefits which will result from the proposed geologic repository. Special attention should be given to define who or what will be benefitted and by how much. Assumptions or judgments inherent in such assessments should be discussed.

5.5.12 Population Density

Changes in study area population should be projected for the life of the geologic repository. Short-term impacts accruing from the construction of the plant should be determined as well as longer term effects on area population.

5.5.13 Community Services

The impacts of the construction and operations work force on local community infrastructure and services such as water supply, sewerage, public health, housing, education and other considerations should be determined. Mitigating actions such as provision of affected services to the local citizens by the constructing entity should be suggested and the ameliorating effects of special plans should be discussed. The discussion should include topics such as housing, education, water supply, waste water treatment, solid waste treatment. energy utilities, public safety

services, medical/social services, library facilities, and parks/recreation/tourism facilities.

5.5.14 Social Conditions

Any likely effects of construction, operation, and decommissioning (surface facilities) of the geologic repository on the local social conditions should be identified. Lifestyle changes (i.e. from rural to urban environment) should be noted. Public acceptance/refusal of the facility should be documented and any mitigating factors should be discussed. Discussion should include topics such as social organization/structure, culture/lifestyle, community attributes, and community attitudes toward the facility.

5.5.15 Radiological Impacts of Normal Operation[4]

A radiological risk assessment for detrimental effects shall be conducted based on anticipated normal operating (i.e., incident free) conditions during the period prior to permanent closure of the geologic repository. Methods used in the risk assessments shall be discussed in detail including a description of all calculations, assumptions and simplifications used. Risks to both workers and the general public shall be investigated. Worker risk scenarios will be based upon information provided in the geologic repository facilities and operations description as well as data obtained from previous HLW handling operations. These assessments shall estimate radiation doses and calculate cancer and genetic risks from all activities involving exposure including waste transfer handling, in-facility storage activities, and emplacement. Public risks shall consider any exposures from radiation emissions which migrate offsite (if applicable).

5.5.15.1 Risk Assessment Methods

The methods used to document and assess risk should be presented and discussed. Basic assumptions should be clearly stated and conclusions well-documented.

5.5.15.2 Mitigation Measures

Any measures which are designed to alleviate or remove the risk of adverse effects of radiation on the worker, the public, or nonhuman species should be identified and discussed. Such measures may include engineering design, site features, and emergency preparedness. The reduction in risk obtained by implementing such measures should be specifically identified.

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[4] In the Swedish program the waste will have been encapsulated in disposal casks prior to receipt at the geologic repository. As a result, this discussion precludes leaking transportation/disposal casks, damaged waste packages, repacking/overpacking etc. from the evaluation of radiological risks from normal operation. Because direct exposure to the waste is not a normal condition, inhalation and dermal contact pathways are not considered here.

5.5.16 Radiological Risks from Accidents

A radiological risk assessment for detrimental effects shall be conducted based on postulated accident conditions at the geologic repository during the period of operation. Methods used in the risk assessments shall be discussed in detail including a description of all calculations, assumptions and simplifications used. Risks to workers, public and environment shall be investigated. Worker risk accident scenarios will be based upon information provided in the geologic repository facilities and operations description as well as data obtained from previous HLW handling operations. Public risks shall consider exposures from direct radiation, dermal exposure, and inhalation resulting from loss of containment and subsequent dispersion of radionuclides (if applicable). The ingestion pathway considers both short term and longer term risks from ingestion of contaminated water, local crops, domestic and game animals.

5.5.16.1 Risk Assessment Methods

The methods used to document and assess accident risk should be presented and discussed. Basic assumptions should be clearly stated and conclusions well-documented. The rationale behind the establishment of accident scenarios should be presented.

5.5.16.2 Mitigation Measures for Accident Consequences

Any measures which are designed to alleviate or remove the risk of adverse effects of radiation from accidents on the worker, the public, or nonhuman species should be identified and discussed. Such measures may include engineering design, site features, and emergency preparedness. The reduction in accident risk obtained by implementing such measures should be specifically identified.

5.5.17 Environmental Impacts from Decommissioning and Post Closure Considerations

The EIA should include a discussion of the impacts expected to accrue from the decommissioning and post-closure activities at the geologic repository site. If the site must be disrupted to remove contamination after dismantling of the facility the effect of such disruption on the facets of the environment previously identified should be provided. Any unique effects due to post-closure considerations should be identified.

Any risk from non-radiological sources such as heavy metal dissolution from eroding canisters should be identified and discussed. Impact of such non-radiological sources on the human, animal, and plant life at the geologic repository should be evaluated. Mitigating measure should be identified to reduce environmental risk, as required.

5.5.17.1 Risk Assessment Methods

The methods used to evaluate decommissioning and post-closure risk should be presented and discussed. Basic assumptions should be clearly stated and

conclusions well-documented. The rationale behind the establishment of risk scenarios should be presented.

5.5.17.2 Occupational Risk Assessment Results

The results of assessment of decommissioning and post-closure risk to workers should be presented. The discussion should include topics such as inhalation pathway, direct radiation exposure, dermal contact, and ingestion pathway.

5.5.17.3 Public Risk Assessment Results

The results of assessment of decommissioning and post-closure risk to the public should be presented. The discussion should include topics such as inhalation pathway, direct radiation exposure, dermal contact, and ingestion pathway.

5.5.17.4 Environmental Decommissioning and Post-closure Related Risk Assessment Results

The results of assessment of accident risk to the plant and animal species should be presented. If possible, the discussion should include topics such as inhalation pathway, direct radiation exposure, dermal contact, and ingestion pathway.

5.5.17.5 Mitigation Measures for Decommissioning and Post-closure Risk Consequences

Any measures which are designed to alleviate or remove the risk of adverse effects of radiation from decommissioning and post-closure activities on the worker, the public, or nonhuman species should be identified and discussed. Such measures may include engineering design, site features, and emergency preparedness. The reduction in such risk obtained by implementing such measures should be specifically identified.

5.5.17.6 Long Term Effects During Decommissioning and Post-closure

Long-term impacts which persist for many years should be identified. Certain radioactive materials and heavy metals, for example, have a significantly longer half-life or persistence of toxicity than others and such materials should be described in terms of their long-term adverse impacts on the environment. Various plausible scenarios to identify risk should be developed and evaluated.

5.5.18 Unavoidable Adverse Impacts From Geologic Repository

Those adverse impacts from construction, operation, closure, decommissioning, and post-closure activities at the geologic repository for which no reasonable mitigation is possible should be identified. Some impacts such as reducing forest land at a proposed site could be mitigated by converting land elsewhere to the "lost" land use. However, the site, itself, would always be adversely affected by the particular action.

5.5.19 Irreversible Commitment of Resources

The EIA should report on those aspects of the environment which are irreversibly altered and should determine the relative severity of such permanent alteration.

5.6 CONSEQUENCES OF PROPOSED ALTERNATIVE(S)

Alternatives to the proposed geological repository are to be considered as a means of lessening serious environmental impacts. In the case of an geologic repository various differing methods for handling the HLW might be investigated. Techniques investigated will differ with one alternative, for example, presenting the least risk of upset, another, the least cost, or still another the least upset to the baseline environment under accident conditions. The likely consequences of proposed alternatives should be compared and a given alternative selected. The rationale supporting the selection of a particular technique(s) should be presented. Impact identification requires a thorough understanding of the environmental baseline, the goals of the proposed project, various impact control technologies, and the relationships between the engineering designs and the natural environment. The estimated costs of each alternative should be compared.

5.7 CONSEQUENCES OF NO ACTION

The consequences in the study area of the no-action alternative should be presented.

6 EIA OF OVERALL HLW DISPOSAL SYSTEM

The integrated environmental impact of the encapsulation facility, transportation component, and final geologic repository should be appropriately described. Specifically, a discussion regarding optimization of the whole system should be provided with emphasis placed on short-term as well as long-term impacts on the workers, general public, and environment.

Workers, the general public, and the environment will be impacted during construction and operation of the three subsystems. The public and environment may also be subjected to long-term impacts. That is, ionizing radiation as well as other impacting agents will be present at the encapsulation facility and the geologic repository and during the transportation of waste between the two components. The entire disposal system should be designed in such a way that the effects/consequences of the impacting agents are minimized. A discussion of how this "optimization" among the various alternatives has been accomplished should be included in the EIA. If the alternative giving rise to the minimum impact is not selected, this should be explained in the EIA.

Since there will be several license applications that address various components and phases of the repository concept, the level of detail in the overall EIA should be dependent on the existing knowledge base for the particular situation.

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