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EARLY SITE PERMIT
DEMONSTRATION PROGRAM
Station Design Alternatives Report

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STATION DESIGN ALTERNATIVES REPORT

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STATION DESIGN ALTERNATIVES REPORT

Principal Preparers:

Susan Cooper, NUS Corporation
Jon Cudworth, NUS Corporation
Dale Huls, NUS Corporation
Tish Morgan, NUS Corporation
Joseph Ziegler, NUS Corporation

EXECUTIVE SUMMARY

For the last two decades the utility industry, its support groups, and the regulatory agencies have sought to increase the stability and certainty of nuclear plant siting and licensing processes. In 1989, the Nuclear Regulatory Commission (NRC) revised its regulations by adding provisions for early site permits (ESPs) and combined operating licenses [Title 10 of the Code of Federal Regulations, Part 52, *Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Reactors*]. Regulations already allowed for nuclear plant vendors to seek certification of standard reference plant designs. A streamlined licensing process is based on placing a pre-certified reference plant on a pre-permitted site. The ESP would provide evidence of the acceptability of the site for future nuclear plant siting and the design certification would provide evidence that the station could operate with no unacceptable consequences. There are currently four (4) advanced light water reactor designs for which Standard Safety Analysis Reports (SSARs) have been prepared and which are under review by the NRC. These certified plant safety analysis reports contain site envelopes for parameters of importance to the plant design. If the permitted site falls within the plant design envelope, then no further siting-related analyses would be required at the combined operating license (COL) stage.

The ESP regulation (10 CFR Part 52) does not establish substantive new standards but rather provides a new licensing process to achieve early resolution of site-related issues associated with nuclear power utilization. This process enables issue resolution before an organization makes a major financial investment in committing to build a new plant.

In the early 1970's, a court ruling involving the Calvert Cliffs nuclear plant held that the granting of a permit to build or operate a nuclear plant constituted a "major federal action" on the part of the NRC (then the Atomic Energy Commission). This finding led to the requirement of implementing the National Environmental Policy Act (NEPA) for these decisions to grant permits and licenses. To implement its obligations under NEPA, the NRC is required to assess the potential environmental effects of a facility to ensure that issuance of the permit will be consistent with NEPA goals. In order to obtain information essential to this assessment, the NRC requires each construction permit applicant to submit a report on the potential environmental impacts of the proposed station and associated facilities. This Environmental Report (ER) is used by the NRC in preparing draft and final Environmental Impact Statements (EISs). The public and other Federal agencies are involved in the process of reviewing these documents and participating in public hearings. At the conclusion of the process, a decision is made to grant or deny the permit, and the various environmental documents serve as a significant portion of the Record of Decision.

The new regulations for obtaining an ESP require that application for such permits include an ER. Since no modifications to earlier guidance on the format and content of ERs accompanied the changes in regulations, it can be assumed NRC Regulatory Guide 4.2 (RG-4.2) is still usable as guidance. Power generation alternatives (e.g., fossil, nuclear, and conservation) have been exempted from the ESP process, site alternatives, and system alternatives (e.g., natural draft towers or mechanical draft towers) should be addressed. Chapter 10 of RG-4.2 is devoted to the comparison of Station Design Alternatives (SDAs). These are systems or subsystems which interface directly with environment, and some are not typically part of the "nuclear" or vendor supplied portion of the certified plant designs. As currently outlined in RG-4.2, an applicant would describe the proposed or "preferred" design for each plant or station feature in ER Chapter 3 and then discuss the alternatives to these in ER Chapter 10, including a cost-benefit analysis for the alternatives.

Although, the regulations (10 CFR Part 52) allowing for an ESP were added in 1989, no applications have been made. To demonstrate the practical implementation of the regulations, the Department of Energy initiated an ESP demonstration project in 1991. The project is to culminate in the granting of an ESP but is also expected to result in the development of criteria for additional applications as well as establishing precedents for how the entire process works. To ensure success, the demonstration project began with a phase aimed at early identification and resolution of technical and regulatory issues. A comprehensive report, *Early Site Permit Demonstration Program-Regulatory Criteria Evaluation Report*, outlines the known applicable regulatory requirements for an ESP and describes issues which should be addressed prior to the site selection process. One issue was whether or not the Station Design Alternatives chapter of the ER could be written without undue cost if plant design was not yet selected. In order to address the issue, a three part task was undertaken to examine the basis for the RG-4.2 list of systems, to determine if other acceptable techniques for comparing alternatives could be identified, and then to generically apply the other methods if found acceptable.

The first effort was to research the background for insights regarding the specific list of SDA systems and the table of environmental factors to be considered in the comparisons. The results are reported in Section 1.1, *Basis Assessment*. Little insight on the intent of including the list of systems or the factors could be gained from the public record. Apparently the systems were simply selected based on expert opinions regarding plant system-environment interfaces which were likely to have some environmental impact.

The second effort was to resolve the issue of comparing system alternatives at the ESP application stage and to develop approaches other than the one given in RG-4.2 which would still provide sufficient information to allow NRC to fulfill its NEPA obligations. These requirements on the NRC include a consideration of alternatives and a determination that the applicant has provided sufficient information to allow a reasoned judgement that the preferred alternative has been evaluated through a cost-benefit process. Section 2 of this paper, *Approaches for Evaluation of Station*

Design Alternatives, outlines two possible approaches at the ESP stage and describes briefly which approach would be applied for each of the ten station design alternative systems listed. It was concluded that at least one of these approaches can be successfully applied for the four advanced light water reactor designs and would support preparation of an ER with sufficient information to allow NRC to prepare an EIS.

The final and most significant portion of the effort was the generic application of these approaches to the ten station design alternatives. Section 3, *Application of Alternate Approaches to Evaluating Station Design Alternatives*, uses the techniques described in Section 2, develops a generic impact comparison table for several of the systems, and outlines potential cutoff limits for the remaining systems. Unlike the historical approach used by utilities in past construction permit applications, this technique does not start with a proposed design and examine alternatives to it but starts with a clean sheet of paper to compare across the entire range of possibilities. This method offers an advantage of not justifying proposed system selections but rather provides defensible technical and environmental bases supporting the process leading to the preferred option. The technique is also valid when the ESP applicant does not wish to select only one preferred option but wants to outline the factors considered and show that any one of several possibilities would be equally acceptable. When more than one station, system, or subsystem alternative have no significantly different impacts, the applicant can make a selection based on cost and other discretionary factors. An ESP applicant will have sufficient site and plant design data to complete the tables provided in the Section 3 comparing alternatives at the beginning of application preparation.

Therefore, the original issue of whether or not an applicant can adequately and economically address alternatives for systems or subsystems which interface with the environment is essentially resolved.

It is concluded a comparison and environmental evaluation of station design alternatives can be conducted prior to plant or vendor selection of systems and without significant capital expenditures. At the time of COL, the applicant would need only to validate the system design is within the bounds and assumptions used in the ER.

The overall conclusion is that the portion of an ER dealing with station design alternatives can be developed to a sufficiently detailed level at the ESP application stage to allow the NRC to fulfill its NEPA requirements.

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1.0 PURPOSE AND OBJECTIVE

This report provides the results of investigating the basis for including Station Design Alternatives (SDAs) in the regulatory guidance given for nuclear plant environmental reports (ERs), explains approaches or processes for evaluating SDAs at the early site permit (ESP) stage, and applies one of the processes to each of the ten systems or subsystems considered as SDAs. As used in the context of this report, SDAs are those systems or subsystems which have an interface with the environment but are not generally included in the reactor island or power supply portion of the station or plant. The purpose of this effort was to resolve concerns raised about the ability of evaluating SDAs at the ESP application stage when the overall Advanced Light Water Reactor (ALWR) plant design may not have been selected. ESP applicants need a viable process for evaluating station design alternatives while avoiding the expense of developing detailed system designs. The ESP regulations acknowledge the applicant's potential inability to justify a need for additional power at the application stage, but fail to acknowledge the potential lack of traditional design information historically available at the construction permit application stage. The key objective of this report is to demonstrate an adequate examination of alternatives can be performed without the extensive development of design data. The report discusses the Composite Suitability Approach and the Established Cutoff Approach in evaluating station design alternatives and selects one of these approaches to evaluate alternatives for each of the plant or station subsystems that were considered. Four types of ALWRs have been considered due to the availability of extensive plant data: System 80+, AP600, Advanced Boiling Water Reactor (ABWR), and Simplified Boiling Water Reactor (SBWR). This report demonstrates the feasibility of evaluating station design alternatives when reactor design detail has not been determined, quantitatively compares the potential environmental impacts of alternatives, and focuses the ultimate selection of a preferred alternative on cost and applicant-specific factors. The range of alternatives for each system is deliberately limited to a reasonable number to demonstrate the approach or to the three most commonly used at operating plants.

1.1 BASIS INVESTIGATION

U.S. Nuclear Regulatory Commission (NRC) guidance contained in NRC Regulatory Guide 4.2 (RG-4.2) states that ERs accompanying nuclear power plant license applications should include discussion of station design alternatives. This section assesses the basis for this guidance. For the purpose of this report, station design alternatives mean the entire range of feasible systems and subsystems, such as secondary cooling or biocide treatment, which interface with the site or local environment. It is not intended that there has been any preselection or preference prior to the comparison which is discussed in detail in Section 3. The objectives in determining the basis were to clarify the intent of the specific list of systems contained in RG-4.2 and to discern any underlying technical basis for the list or the environmental factors to be used for evaluation and comparison.

1.2 CONCLUSION

RG-4.2 states that nuclear power plant license applicants should evaluate station design alternatives but provides no explanation for that determination. Public and utility comments on the initial notice of the proposed revision to the guide were not readily available from the archives. The basis for the guidance appears to be a reasonable NRC decision on what would comply with the principles of the National Environmental Policy Act. However, because the basis is not an explicit statutory or regulatory requirement, the NRC has the discretion to decide whether other approaches would also be acceptable. One other approach that should be considered, and that has precedent, is to establish threshold or Established Cutoff limits within which an applicant would not need to perform detailed evaluations of station design alternatives.

1.3 BACKGROUND

In 1989, NRC issued 10 CFR Part 52 which has provisions for issuing ESPs for nuclear plant sites.¹ The Early Site Permit Demonstration Program (ESPDP) is a joint industry and U.S. Department of Energy effort to demonstrate the practical implementation of obtaining an ESP for a site.

One ESP requirement is submittal of an ER with an ESP application.² NRC general guidance regarding ER contents is found in RG-4.2.³ Although last revised in 1976, and thus did not directly address the ESP process, this is the only NRC guidance on contents of ERs available. Chapter 10 of RG-4.2 states that the ER should include an evaluation of alternatives for the following station systems:

- Circulating water system (exclusive of intake and discharge)
- Intake system for circulating water
- Discharge system for circulating water
- Other cooling systems (including intake and discharge not treated in the preceding three items)
- Biocide systems (all cooling circuits) that are subject to Clean Water Act new source performance standards for steam electric generating plants⁴
- Chemical waste treatment
- Sanitary waste system

- Liquid radwaste systems*
- Gaseous radwaste systems*
- Transmission facilities
- Other systems

An ESPDP study expressed uncertainty as to whether an ESP applicant would have sufficient information with which to provide the type of station design alternatives analyses historically envisioned in RG-4.2.⁵ Two factors led to this uncertainty; first, detailed subsystem requirements might not be available for all advanced reactor designs and, secondly, detailed designs of subsystems could change with advances in technology between the time of the ESP and actual site use. It was believed insight into the original inclusion of this guidance in the regulatory guide or explanations of the selection of parameters and factors to be compared would support determination of possible optional approaches.

1.4 BASIS DOCUMENTATION

1.4.1 Alternatives

As discussed below, several statutory and regulatory provisions require consideration of alternatives to proposed actions such as nuclear power plant license issuance:

National Environmental Policy Act (NEPA) - NEPA requires Federal agencies to address alternatives in two ways:

- For all actions, agencies must study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources.⁷
- For major Federal actions significantly affecting the environment, a detailed statement on alternatives to the proposed action must be prepared.⁸

Executive Order (EO) 11514 - EO 11514 directs Federal agencies to develop procedures for providing the public with relevant information on alternative courses of action⁹ and to comply with CEQ regulations.¹⁰

* Radwaste systems are part of the vendor supplied ALWR designs and are therefore "certified" along with the reactor design. Additional comparison of alternatives to those certified is unnecessary.

CEQ Regulations - Federal agencies are required to follow CEQ regulations ¹¹ if they do not adopt their own regulations to implement NEPA, to expand on the alternatives requirement for major, significant actions, calling it "... the heart of the environmental impact statement..." and to require rigorous exploration and objective evaluation of all reasonable alternatives.¹²

NRC Regulations - NRC's predecessor agency, the Atomic Energy Commission, issued its first requirements implementing NEPA in 1970 as Appendix D to its 10 CFR Part 50 regulations.¹³ Subsequently, Appendix D requirements were modified and moved to 10 CFR 51.¹⁴ This regulation requires that ERs address alternatives but does not delineate what alternatives to address.

Therefore, NEPA, CEQ, and NRC regulations require consideration of alternatives but do not specify what alternatives, or range of alternatives, to consider and do not specify station design alternatives. The issue of what alternatives or what range of alternatives an agency must consider has been subject to extensive litigation.¹⁵ Generally, court decisions have held that an agency must consider and document a reasonably comprehensive range of alternative courses of action so that the public is informed of the agency's decision making process including alternative considerations and the basis for its decision.

1.4.2 Station Design Alternatives

When the Atomic Energy Commission first issued the guidance that was to become RG-4.2, the guidance was no more specific than NEPA and the implementing regulations.¹⁶ The next issuance, however, was proposed in 1972 and included station design alternatives discussion generally as it exists today.¹⁷ However, the Federal Register notices of availability of the proposal¹⁸ and the final guidance¹⁹ do not address why station design alternatives should be discussed or why the specified systems were chosen. Investigation into NRC Public Document Room records did not provide any additional clarification. An additional source of information may be NRC staff members, who may have personal recollection or access to additional informal records. This source, however, was not investigated.

The RG-4.2, *Introduction*, indicates that the basis for RG-4.2 lies in NRC's need to comply with NEPA.²⁰ The RG-4.2, Chapter 10, introductory section points out that significant environmental interfaces of a nuclear power station will be associated with the operation of certain identifiable systems. The implication is that the basis for choosing the systems identified for analysis (e.g., intake system for circulating water) was the potential significance of their environmental interfaces. Such a basis appears appropriate given the potential interaction of these systems with the environment. As with the need to examine alternative courses of action (i.e., conserve energy instead of building new facilities) and to examine alternative means of meeting the selected course of action (i.e., fossil, solar, nuclear, and hydro power plants), it is logical to take the examination further into an examination of

various systems or methods of treatment which could have varying environmental impacts.

1.5 ANALYSIS

The basis for the RG-4.2 station design alternatives guidance appears to be an NRC interpretation of what is needed to comply with NEPA. Because station design alternatives evaluation is not a statutory or regulatory requirement, NRC has discretion on how rigorous the evaluation must be and the form that is acceptable. The discretion is reflected in the fact that RG-4.2, Chapter 10, uses two approaches to evaluating station design alternatives.

The first approach in Chapter 10 provides the guidance for a detailed comparison of the impact of different designs on specified environmental factors (e.g., impingement or entrapment by cooling water intake structure). The second approach in Chapter 10 is currently noted as an option only for liquid and gaseous radwaste systems and requires no detailed analysis so long as the applicant can show conformance to limits specified in Appendix I of 10 CFR Part 50.

Because two different approaches are already provided in Chapter 10, it appears reasonable to suggest that NRC has the discretion to apply the second approach to systems other than liquid and gaseous radwaste systems (e.g., the discharge system for circulating water) and to accept different approaches. Such a suggestion was made as early as the first version of RG-4.2,²¹ but no NRC reaction to the idea is documented. Section 2 expands on the possibility of conformance to established limits or cutoffs and introduces an additional approach for comparing the impacts of various alternatives for each station design system or subsystem.

2.0 - APPROACHES FOR COMPARING AND SELECTING STATION DESIGN ALTERNATIVES

2.1 INTRODUCTION

Potential equivalent approaches for addressing nuclear plant/station design alternatives as described in Regulatory Guide 4.2 (RG-4.2) have been identified. Each technique is described individually, the ten sections (systems) of Chapter 10 of RG-4.2 are discussed in terms of the applicability of one or more of the alternate techniques, and an approach is selected for application to each system. Initially, the techniques of extrapolating from operating plants and use of bounding values were considered as separate options. After further examination, it was determined a combination of the two techniques provided a more defensible approach. This "Composite Suitability Approach" is based on the range of alternatives currently in use at operating nuclear plants and considers the environmental impacts to be bounded through use of plant design data or the Plant Parameter Envelope (PPE) data. Each station design or subsystem alternative is discussed and the basis for selecting the approach to examine alternatives is presented.

2.2 CONCLUSION

An additional approach for fulfilling the intent of Chapter 10 of RG-4.2 has been identified and the established cutoff technique used for radwaste systems is expanded to propose established cutoff limits for other systems. Use of one of these approaches allows an ESP applicant to assemble sufficient information to develop an ER discussing system and subsystem alternatives for each of the four ALWR designs.

2.3 DISCUSSION

Three techniques or methods for examining and comparing environmentally acceptable alternatives for plant systems which interact directly with the environment are discussed below. Two approaches were developed and are summarized based on the techniques outlined. Background information is provided in Section 1 as justification or explanation for the feasibility of exceptions or modifications to the guidance provided in RG-4.2.

2.3.1 Established Cutoff Approach

This approach was suggested in 1974 by the Atomic Industrial Forum as a means of streamlining the environmental evaluations of numerous station/subsystem alternatives. The approach is based on a concept of defining acceptable numerical cutoff limits for effluent releases and/or impacts to the extent possible. Once an applicant commits to or proposes an alternative which can be shown to comply with the established limits, no further consideration of alternatives is required. This approach was developed in the early 1970's for radwaste treatment systems, and

RG-4.2 recognizes compliance with Appendix I to 10 CFR 50 limits as acceptable with no further consideration of alternative designs. Sections 10.7 and 10.8, states that discussions and descriptions of radwaste systems need not be detailed if compliance with Appendix I can be shown. Since 40 CFR 423 and other regulatory statutes provide numerical limits for certain effluents (i.e., chemical, thermal, and suspended solids), station design alternatives such as chemical treatment would be a candidate for this approach. As with radiological releases, if the applicant committed to a known technology or detailed system which could be evaluated as complying with limits for total suspended solids, priority pollutants, pH, and the other specified contaminant limits in the New Source Performance Standards, further evaluation of alternatives would not be necessary.

2.3.2 Composite Suitability Approach

It was recognized that for most station design alternatives an integration of the two techniques described as bounding and extrapolating provided the most defensible approach. Combining the concepts of bounding data with extrapolation from current plants results in the Composite Suitability Approach. In the sections that follow, the basis for selecting the evaluation approach for each of the ten SDAs is provided. By using the approach selected, the station design/subsystem alternatives portion of an environmental report and impact statement can be developed sufficiently to meet the intent of NEPA requirements.

Only one system could not be readily judged as completely evaluated by use of this approach -- Transmission Facilities. The evaluation of alternate transmission line systems/corridors is site-specific. However, it is possible the applicant could determine the bounding requirements for supply of power to each of the ALWR designs and project the maximum station capacity or output at the ESP stage. A Composite Suitability approach matrix is developed for three example corridors to demonstrate the viability of evaluating alternatives.

2.3.2.1 Enveloping Technique

This technique involves use of the PPE to bound or envelop parameters of interest in evaluating alternatives for a particular system or subsystem (e.g., circulating water or intake system). Since design descriptions from the ALWR Standard Safety Analysis Reports (SSARs) and operating parameters specified in the URD formed the basis for the PPE, it provides sufficient information to allow a comparison of alternative designs on a relative basis in terms of cost and relative impact. Chapter 9 of RG-4.2 discusses examination of alternative sites when absolute data is not available and allows for an evaluation to determine if a site other than the one proposed would result in a "significantly different" environmental impact.

... [when] quantification is not possible due to lack of data ... qualitative and general comparative statements supported by documentation may highlight significant environmental differences among alternative[s)].

Using this technique for system alternatives, the ESP application would contain an evaluation of impacts as being less than or equal to the bounding or enveloping numbers (may be qualitative for the site or the impacted environment [e.g., % of intake flow]) for the "generic" subsystem design. For example, the impact of travelling screens with no barrier at a specified depth for intake would be conservatively estimated with supporting analysis to demonstrate no significant adverse impact. The applicant would use an actual/detailed design which had no greater impact than the bounding or enveloping design. The relative cost of additions to the base subsystem could be evaluated against the relative benefit (e.g., for 100% more dollars the entrainment during spawning or of a particular species of interest could be reduced by 10%, which may or may not be significant).

At the ESP stage, considerable information in the PPE will be available to make this comparison. Using the example of the intake system, the following parameters will be available for the various ALWR plants:

- The flow rate average, minimums, and maximums.
- The minimum and maximum inlet temperature requirements plotted versus plant output.
- The number and capacity of intake pumps (e.g., specified as two 100% or three 50% capacity).
- The condenser/heat exchanger duty (thermal load) and time across condenser.

Using this information, the base case could be established by determining the number, size, and type of travelling screens; adding various types of barriers; changing the depth of the withdrawal point; or altering the design of the intake piping. This examination would allow NRC to comply with the intent of NEPA by having essential information needed to examine alternatives and their potential impacts. Continual examination of new technologies would not be necessary since the intent of NEPA is to consider alternatives, not necessarily to select the option which has least impact. If several combinations of design alternatives have no significantly different impacts, the applicant would be able to select a preferred alternative at a later time, at COL licensing, without altering the conclusions reached about the acceptability of the system discussed in the ESP application. This results in a system design preference based on site-specific factors and monetary cost.

2.3.2.2 Extrapolation to Operating Plants Technique

This technique is a straightforward comparison of the various station design (subsystem) alternatives already in use at currently operating nuclear and other large power or industrial sites for which environmental impacts have been assessed. The premise is ERs and Environmental Impact Statements (EISs) for these existing plants have examined the available technology and alternatives for the various

systems listed in Chapter 10 of RG-4.2. Additionally, the draft generic EIS for license renewal assesses numerous issues related to the actual and estimated environmental impact of the operating stations. The information contained in the Safety Analysis Reports, ERs, and EISs of these existing plants and analysis of their respective environmental monitoring program data would enable an evaluation to be made of alternatives for the ALWRs at the ESP stage. Subsystems, such as the Discharge System, would be a candidate for this approach. Basically, there are only so many acceptable ways to discharge water, so an assessment of the effective means currently employed versus the permitted and monitored releases of those stations would lead to preferred alternatives which could be judged as to whether they have any significant adverse impact. If approved prior to the first ESP application, the license renewal EIS would address many of the issues related to the basis for examining station design alternatives (e.g., thermal shock is assessed as not being as significant an issue as once believed, so further evaluation of discharge system designs to reduce the consequences of thermal shock is unwarranted if the ESP application contains evaluation of a system which can be acceptably extrapolated from the operating plants). As with the bounding technique, this evaluation would allow NRC to fulfill its NEPA obligations by reviewing the applicant's evaluations of feasible alternatives. Since each of the operating plants must seek periodic renewal of their National Pollutant Elimination Discharge System (NPDES) permit, the environmental impacts of discharges are continually reviewed and, through renewal of each permit, found acceptable.

2.3.2.3 Composite Suitability Approach Methodology

Consideration of station design alternatives can be accomplished using the Composite Suitability Approach. This section contains a description of suggested elements of adapting the Composite Suitability Approach to consideration of various station design alternatives. This section serves as the basis for a comprehensive checklist of plant/site parameters and criteria and provides an example to quantify the relative suitability of the various station design alternatives. This overall approach is very similar to the alternative site consideration method described in the *EARLY SITE PERMIT DEMONSTRATION PROJECT Siting Guide* prepared by Dames and Moore for the Early Site Permit Demonstration Program. The suggested elements of the approach are as follows:

1. **Bounding Criteria** - Develop criteria which represent plant parameters, site parameters, and environmental factors which should be taken into account to bound the various subsystems. This element is similar to the bounding technique discussed earlier in that the maximum values or parameters for any of the four ALWRs would be used in the comparison.
2. **Criterion Scoring** - Development of a site-specific quantity used to designate the relative suitability or impact of a specific subsystem design to a single bounding criteria. The score given would be a unitless numerical value based on

analyses and expert judgement regarding the score of one alternative versus another for that same environmental factor.

3. **Weighting/Composite Suitability** - Develop weight factors which reflect the relative importance of individual bounding criterion factors and develop composite suitability value which reflects subsystem tradeoffs among criteria.
4. **Consideration of Station Design Alternatives** - Compare station design alternatives using the previous suggested elements by adding to the composite suitability, the monetary cost, and applicant discretionary factors.

2.3.2.4 Bounding Criteria

Plant parameters. Plant parameters that affect station design alternatives are selected from the PPE. These parameters characterize the interface between an ALWR design and a potential site and quantify the interface through values selected from the URD, vendor design information, or engineering assessments. Using the parameters provided in the PPE, it is possible to quantitatively describe the ALWR plant resource requirements from a potential site and the potential impacts of an ALWR design on a site.

Site parameters. Site parameters are those parameters specifying conditions that have a direct, significant impact on plant structures, systems, or components (SSCs) but are of such site-specific variability that customized analyses or design features are necessary to ensure the ALWR plants are compatible with the site. Site parameters that affect station design alternatives are considered when comparing the various systems. These parameters assume that the site selection process has been accomplished, and the site selected has been accomplished, and the site selected has been determined to be capable of supporting the ALWR(s) envisioned for the site.

Environmental factors. The environmental factors that should be considered in comparing station design alternatives are shown in Appendix A. The environmental factors shown in Appendix A were taken directly from table 5 of RG-4.2. These environmental factors should not be considered all-inclusive but should serve as the minimum environmental factors to be considered.

These factors provide the framework for an issue-by-issue analysis using composite suitability values and allow the ESP applicant to consider actual tradeoffs in environmental impacts and site-specific costs quantitatively. This information should be presented in a tabular format using table 5 of RG-4.2 as a model. Table 5 also provides for three key elements to evaluate the environmental "costs" or impact. The three key elements are a description of each effect to be measured, the suggested measurement units, and a suggested methodology of computation.

2.3.2.5 Criterion Scoring

To evaluate the suitability of each station design alternative, each criterion (i.e., parameter or factor) is first evaluated independently. This evaluation is accomplished by a scoring technique that translates quantifiable subsystem characteristics into a common suitability scale expressing preferences for one alternative over another. In this report, the suitability scale ranges from 1 to 5, where 1 is the lowest level of suitability (least preferable or most impact) and 5 is the highest (most preferable). An example of applying this scoring technique might be acreage for different circulating water system alternatives where the small acreage (6 acres) for mechanical draft towers would be assigned a 5, the moderate acreage (65 acres) for natural draft cooling towers would be assigned a suitability of 4, and the very large acreage (3000 acres) required for a cooling pond without spray would be assigned a suitability of 1. Using this scoring for this single parameter or factor, mechanical draft cooling towers are preferable to cooling ponds without sprays since they impact significantly less acreage. If the parameter of fogging potential in terms of days per year were compared for the same alternatives, the natural draft towers would score low for many sites and the cooling ponds would likely be scored as 5 in terms of fogging. As is demonstrated by this example, any significant factors should be scored and the particular weight assigned to the factor will put it in the proper reference to other factors. In this example, the site could be in a location or environment where fogging is a significant problem, which might balance or overcome the land use factor. Scoring the significant factors leads to a composite score which is determined by the weighting process described next.

2.3.2.6 Weighting/Composite Suitability

In view of the tradeoffs between suitability criteria, it is necessary to assign a relative importance to each criterion in considering station design alternatives; the relative importance should be reflected as a numerical weight value. Assignments of weights is a sensitive issue in comparison studies of alternative systems because the expert opinions and value-judgements as to the relative importance of individual criteria vary with the perspectives of the individual or group.

It is recommended that the ratio weighting technique be utilized when assigning importance weights to criteria. In this process, criteria or factors are placed in order of importance and a value of 1 is assigned to the least important criterion. Then a numerical weighting is assigned such that each of the remainder of the criteria receives a weight value depicting how much more important it is relative to the other criteria or factors. These relative rates are then normalized to 1.0 (i.e., all are divided by the highest value). The suitability scores (1-5) are then multiplied by these normalized weights and summed to get an overall weighted score (composite suitability value) for each alternative design. These composite suitability values can then be used to rank or compare alternatives in terms of overall favorability. Continuing with example above, the weight for land use in terms of acreage lost for other purposes would be multiplied by the relative score assigned by the applicant.

This number would be summed with the weighted scores for the other circulating water cooling alternatives. The composite suitability score might reflect cooling ponds as the preference rather than the natural draft towers which emerged through a comparison of only one factor. Because a proper balance of importance and impact can be achieved by judicious development of the composite score, this process is a defensible and visible method for evaluating alternatives.

2.3.3 Consideration of Station Design Alternatives

Consideration of station design alternatives is the end result of the previous three elements. Once the composite suitability values have been assembled for all the applicable criteria and subsystem alternatives, an objective consideration of the various station design alternatives can be accomplished with regard to potential impacts of the various subsystems. The composite suitability values may then be combined with the cost and any discretionary factors for the various station design alternatives as the basis for a preferred station design selection during the design process. Discretionary factors may include such examples as utility experience with a system alternative or a proven vendor supplier. Previously, a subsystem design was tentatively selected and other alternatives were compared to it. This process could imply a prejudicial bias for the base case subsystem design. However, since at the ESP stage a preferential subsystem design has not been selected, all subsystem alternatives may be considered equally. As a result, all subsystem alternatives may be objectively considered and the results of that consideration may be used to influence the actual design selection process. Detailed monetary cost comparisons are not necessary since the comparisons are made on a relative basis. Since the comparison made at the application stage could be based on bounding data if the reactor vendor and type has not been chosen, the preference which emerges remains valid so long as one of the four ALWRs discussed in the PPE is selected. In conclusion, it is determined that use of this process of consideration of station design alternatives at the ESP stage should be unchallenged at the combined operating license stage.

2.3.3.1 Circulating Water System

The PPE data for the four ALWRs contains sufficient information to allow a comparison of a reasonable range of alternatives for cooling. Vendor or PPE generated data is available for (1) mechanical draft towers, (2) natural draft towers, (3) once-through cooling, and (4) cooling ponds. While other alternatives exist (e.g., dry towers), these four options are in common use and represent a variety of impacts. Impacts can be extrapolated from operating plant data.

At the ESP stage, the applicant could generate a matrix of circulating water system alternatives based on the bounding values for the four ALWR choices and use of the factors noted in RG-4.2. This would meet the intent of comparing alternatives. Feasibility, economics, and environmental impact of the four alternatives are well-known and documented for existing power plants.

This system is assessed using the Composite Suitability Approach .

2.3.3.2 Intake System

The plant parameters envelope (PPE) data contains the rate of water influx and temperature requirements for each of the subject ALWRs. Specific intake structure designs and point of withdrawal are not specified or derived. The URD stipulates traveling screens and trash racks are used with ALWR intake structures. Qualitative data will be developed generically to compare alternative designs such as (1) shoreline, off-shore, or deep water intakes; (2) design and functions of traveling screens and fixed screens; (3) barrier design and uses; and (4) designs of intake pipes and beds. Feasibility, economics, and environmental impact are well documented for existing power plants and can be extrapolated to the alternatives at the ESP stage. By applying 316(b) of Federal Water Pollution Control Act (FWPCA) and using bounding data from the PPE, the Composite Suitability Approach is most suited to this evaluation.

2.3.3.3 Discharge System

The discussion in 2.3.3.2, *Intake System*, is relevant to the Discharge System. There are a finite number of designs for discharging water into a water body. A variety of designs and water bodies are in use with current power stations and other large industrial sites. The PPE provides data for expected and maximum flow rates and temperatures for effluents. The URD provides expected plant capacity factors.

This system is amenable to a comparison using the Composite Suitability Approach.

2.3.3.4 Chemical Waste Treatment

The limits for chemical effluents are established by 40 CFR Part 423. The primary sources for chemical effluents are known for the four ALWRs. Secondary sources could be enveloped by an assessment of utility practices for the various functions resulting in chemical discharges.

This system(s) is amenable to an Established Cutoff Approach similar to Appendix I for radiological releases [i.e., by selecting economic and feasible method(s) of generating/introducing chemicals and treating them, the NRC would exercise its discretion by not requiring the applicant to compare additional alternatives if the proposed system(s) ensures compliance]. The effects of chemical wastes are readily controlled through NPDES permitting and periodic modifications, as needed to gain permit renewal. An evaluation of the environmental monitoring programs of existing plants could be performed to demonstrate the margin of compliance with 40 CFR 423 limits for chemical effluents.

An assessment of current practices and the resulting discharges would reveal optimum choices for achieving compliance. The ESP applicant could base the

preferred system on the e.g., 10% best operating plants data or other measure of what could be achieved.

2.3.3.5 Biocide Treatment

Limits for chlorine are established by 40 CFR Part 423 and limits on 126 priority pollutants are to be "below detection." With over 100 operating nuclear plants and a host of other industrial sites, the use of biocides is extremely well documented. The effects of biocides are readily controlled through NPDES permit and periodic modifications as necessary. An assessment of current practices and evaluation of the generic EIS could be performed to demonstrate compliance with limits for biocides such as chlorine whose limits are set forth in 40 CFR 423.

This system/method is amenable to an Established Cutoff Approach. Demonstrating compliance "is sufficient" without additional detailed investigation of alternatives. As with chemical treatment, the limits have not been the subject of rulemaking, so an applicant may want to compare to the e.g., best 10% of operating plants or other acceptable industrial averages.

2.3.3.6 Sanitary Waste System

Using data from the PPE for consumption rates and scaling plant staff size based on current plant documentation, sufficient information should be available to determine volume, rate, and makeup of sanitary waste. A generic sanitary waste system for the two different ALWR sizes could be developed for comparison with several alternatives whose feasibility, economics, and environmental impact are known.

The system is amenable to a Composite Suitability Approach using the plant staff estimates for each size station, extrapolating to the operating plants for both methodologies used and current staff sizes.

2.3.3.7/2.3.3.8 Liquid/Gaseous Radwaste

For ALWRs, the quantities of radioactive material in the effluents will be limited to those set forth in Appendix I of 10 CFR Part 50; no further consideration need be given to the reduction of radiological impacts in developing alternative designs. Thus, discussions and descriptions of radioactive waste systems need not be detailed if compliance to Appendix I can be shown. Compliance to Appendix I will be demonstrated at design certification.

Since RG-4.2 provides for these systems to be evaluated using the established cutoff approach, little additional detail is provided. For the four ALWRs, the radwaste systems are part of the standard plant designs, and it would not be appropriate to conduct an evaluation of alternatives.

2.3.3.9 Transmission Facilities

The cost and environmental effects of alternative routes for required new transmission facilities should be discussed by the ESP applicant. Using data from the PPE for the subject ALWRs, generic transmission facility requirements for the two different sizes of ALWRs could be developed. After the generic power transmission needs are identified, proposed alternate transmission corridors could be compared. The applicant could bound the impacts by setting corridor width and tower design at the maximum anticipated. As refinements are made, the route selection matrix scores could be changed. In any event, if the impact from the maximized transmission corridor was not significantly adverse, these impacts would bound impacts from refinements made to the maximized routing.

The Composite Suitability Approach is the appropriate process to use in examination of alternate transmission line corridors.

2.3.3.10 Other Systems

An example of "other systems" could be emergency diesels or access highways and rail spurs. Diesel impact could be extrapolated from operating plants through a Composite Suitability Approach. Alternative access highways and rails could be treated in the same manner as transmission line corridor alternatives. Applicant-specific "other" systems could be evaluated using one of the two approaches discussed.

3.0 APPLICATION OF APPROACHES FOR COMPARING AND SELECTING STATION DESIGN ALTERNATIVES

Using the Composite Suitability Approach and the Established Cutoff Approach, ESP applicants can perform an evaluation of station design alternatives even when design details have not been specified. The application of these approaches results in a comparison matrix for the Composite Suitability Approach and proposed threshold limits for the Established Cutoff Approach.

3.1 SUMMARY OF SYSTEM SELECTION BASIS

Chapter 10 of RG-4.2 identifies the subsystems to be considered for station design alternatives. These subsystems directly interface with the environment, and alternatives must be evaluated before an ESP can be issued. The subsystems were selected for one of the two approaches that best accomplished the intent of RG-4.2. The bases for the following selections are described in Section 2.3.3.

The subsystems that were selected for the Composite Suitability Approach for evaluating station design alternatives are as follows:

- Circulating Water Systems
- Intake Systems
- Discharge Systems
- Transmission Facilities
- Sanitary Waste Systems
- Other Systems (e.g., access highways or solid waste handling).

The subsystems selected for the Established Cutoff Approach for evaluating station design alternatives are as follows:

- Radioactive Waste Systems (Liquid and Gaseous)
- Biocide Treatment Systems
- Chemical Waste Treatment Systems.

The generic analyses comparing subsystem alternatives have been outlined for all but transmission line corridors and sanitary waste systems. In lieu of generic analyses for transmission line corridors and access highways, the process and tools available for conducting the consideration of alternatives are described. Bounding impacts are summarized in terms of corridor width and range of impact, but actual

comparison for an unknown site cannot be generically done. Sanitary waste system alternative comparisons are based on known existing technology and performance standards in lieu of specific numerical cutoffs.

The overall conclusion from this investigation is that most station design alternatives can be generically evaluated and compared prior to final site selection and certainly prior to reactor/plant selection. The remaining subsystems can be evaluated and compared once site-specific data is known. In all cases, the RG-4.2-suggested evaluation regarding the consideration of station design alternatives enabling a reasoned decision regarding preferred alternatives, is met.

3.2 DISCUSSION OF SYSTEMS

3.2.1 Circulating Water Systems

The PPE provides plant parameters for four different types of circulating water systems. These systems are mechanical draft cooling towers, natural draft cooling towers, once-through cooling systems, and cooling ponds. Two sets of parameters are established for these cooling systems. The first set of parameters are those which constitute the parameters for a normal plant heat sink as shown in table 1, and the second set are those that constitute the parameters for an ultimate heat sink (not shown). Table 1 represents parameters for the "generic" ALWR; however, if a more specific ALWR plant has been chosen prior to this stage (i.e., evolutionary or passive), the more specific parameter values can be selected.

Site parameters that have a direct, significant impact on circulating water systems are identified. A comparison of the site-specific characteristics or parameters with the appropriate plant parameters can provide a first-cut determination of subsystem suitability for a site. For example, if an early estimate of plant water requirements appeared to exceed a significant percentage of normal streamflow, once-through cooling might be dismissed as a viable alternative. However, the water use values for the ALWR plants are typically much lower than the water available for currently operating plants. Several examples of site characteristics relating to circulating water systems are as follows:

- Cooling Water Source
- Onsite River Flow, Average
- Source Water Temperature, Maximum
- 10 Year - 7 Day, Low River Flow
- Net Consumptive Water Use, Evaporative Loss, Average
- Cooling Water Flow Rate, (Once-through)

If plant parameters for any of the circulating water system alternatives do not fall within the potential site envelope, that subsystem(s) should be screened from further consideration.

Environmental factors to be used in the consideration of circulating water systems are listed in Appendix A, which are extracted from RG-4.2. An example of the use of environmental factors in the consideration of circulating water system alternative would be the primary impact of passage through or retention in cooling systems (Appendix A, section 1.2). Fish are one of the resource populations affected by passage through a cooling system with an assumed 100% mortality rate. To prepare this portion of the ESP ER, reconnaissance level data would be used if available or a field study would be performed to identify all important species and estimate the annual weight and number of each species that will be destroyed. The results of that analysis would then be used to develop a numerical score based on the estimated weight, number, and percentage of each species impacted by each specific circulating water system alternative. Thus, those alternatives with low volume flows resulting in lower kill weights and numbers would be scored low (1 or 2), while those with high volume flows resulting in higher kill weights and numbers could be scored high (4 or 5) if the intake volume represents a significant percentage of the total available flow or a 3 if the intake volume was a small percentage of available flow. Through an appropriate weighting system, a comparison matrix or worksheet may be developed to compare the impact of several factors for the various alternatives.

An example of the composite suitability values worksheet is demonstrated in table 2. The four circulating water system alternatives are matrixed to several environmental factors chosen to demonstrate the process. The scoring column represents a quantification of the potential impact that each of the various subsystem alternatives would have for the corresponding environmental factor. Each of the environmental factors is assigned a weighting factor that is used to multiply the criterion scoring to obtain the composite suitability factor for each circulating water system alternative. It should be noted that the weighting could be region- or utility-specific, but a generic engineering judgement weighting was assigned for this worksheet. Table 2 deals only with environmental factors, however, site-specific parameters, applicant discretionary factors, and monetary costs are to be included in generating an actual composite suitability matrix to support selection or preference of alternatives. The overall selection worksheet is shown in table 3.

Table 1: PPE Parameters

PPE (Rev. 0) normal plant heat sink parameters for circulating water system alternatives.

Circulating Water System Alternatives (Normal Plant Heat Sink)				
Parameters:	Mechanical Draft Cooling Towers	Natural Draft Cooling Towers	Once-Through Cooling	Cooling Ponds (w/o spray)
Acreage	50 Acres	6 Acres	*****	3000 Acres
Approach Temperature	10 F above ambient	10 F above ambient	*****	*****
Blowdown Flowrate	5200 (17,700) GPM	5200 (17,700) GPM	*****	5200 (17,700) GPM
Blowdown Temperature	100 F	100 F	*****	100 F
Cooling Tower Temperature Range	Condenser Temp Rise 29 F	Condenser Temp Rise 29 F	*****	*****
Cooling Water Flow Rate	696,000 GPM	696,000 GPM	1,100,000 GPM	696,000 GPM
Cycles of Concentration	4 (2 Minimum)	4 (2 Minimum)	*****	4 (2 Minimum)
Evaporation Rate	15,400 (17,700) GPM	15,400 (17,700) GPM	9300 (10,700) GPM	15,400 (17,700) GPM
Heat Rejection Rate	26 E6 BTU/HR	26 E6 BTU/HR	9.7 E9 BTU/HR	26 E6 BTU/HR
Height	60 FT	550 FT	*****	*****
Makeup Flow Rate	20,600 (35,400) GPM	20,600 (35,400) GPM	*****	20,600 (35,400) GPM
Maximum Consumption of Raw Water	17,700 GPM	17,700 GPM	*****	12,400 GPM
Monthly Average Consumption of Raw Water	15,400 GPM	15,400 GPM	*****	10,800 GPM
Noise	55 DBA @ 1000 FT	55 DBA @ 1000 FT	*****	*****
Stored Water Volume	10.5 E6 GAL	10.5 E6 GAL	*****	14.7 E9 GAL
Cooling Water Temperature Rise	*****	*****	18 F	*****
Cooling Water Discharge Temperature	*****	*****	118 F	*****

Table 2: Circulating Water System Comparison Worksheet

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STATION DESIGN ALTERNATIVES →		NATURAL DRAFT TOWERS		MECHANICAL DRAFT TOWERS		ONCE-THROUGH COOLING		COOLING PONDS	
↓ ENVIRONMENTAL FACTORS ¹	WEIGHT ²	SCORE ³	WEIGHTED SCORE ⁴	SCORE	WEIGHTED SCORE	SCORE	WEIGHTED SCORE	SCORE	WEIGHTED SCORE
Fogging and icing- vegetation	.1	1	0.1	3	0.3	5	0.5	4	0.4
Fogging and icing-air	.2	1	0.2	3	0.6	4	0.8	5	1.0
Fogging and icing- water	.3	4	1.2	4	1.2	1	0.3	5	1.5
Plankton passage through CW system	.4	5	2.0	5	2.0	1	0.4	5	2.0
Land use, aesthetics	.4	1	0.4	3	1.2	4	1.6	5	2.0
Salt discharged	.6	1	0.6	2	1.2	5	3.0	4	2.4
Fogging and icing- ground/roads	.7	3	2.1	1	0.7	5	3.5	3	2.1
Land use, acreage	.8	4	3.6	2	1.8	5	4.5	1	0.9
Fish passage through CW system	1.0	4	4.0	4	4.0	1	1.0	5	5.0
		COMPOSITE SUITABILITY SCORE ⁵		COMPOSITE SUITABILITY SCORE		COMPOSITE SUITABILITY SCORE		COMPOSITE SUITABILITY SCORE	
		14.2		13.0		15.6		17.3	

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¹Taken from Table 5 of RG 4.2 for factors applicable to circulating water system alternatives

²The weighting assigned for this investigation is a judgement call or qualified opinion of the overall importance of the

³individual factor for use in making relative comparisons

⁴The score is developed as described in the text as a relative assessment of the alternatives place on an impact scale of 1 to 5
(with 5 meaning lower impact)

⁵This is the weight times the score

⁶This is sum of the weighted scores. Higher composite suitability scores indicate preferences or relative ranking

Table 3: Circulating Water System Selection Worksheet

	NATURAL DRAFT TOWERS	MECHANICAL DRAFT TOWERS	ONCE- THROUGH COOLING	COOLING PONDS
Environmental Composite Suitability Score	14.2	13.0	15.6	17.3
Costs Capital O & M	\$60 M	\$48 M	\$44 M	\$110 M
	\$2 M/yr	\$5 M/yr	\$3 M/yr	\$1 M/yr
Discretionary Factors	Significant piping costs for this alternative add 50% to the base capital			

For the purposes of this worksheet, composite suitability scores within less than 15% of each other are treated as not having "significantly different" environmental impacts. [Sensitivity studies of human perception to changes in their surroundings (i.e., lighting, noise, color intensity, etc.) show that the "least noticeable difference" which is readily detected is approximately 15 percent.] Using the selection worksheet above, a likely scenario is the mechanical draft cooling tower option is eliminated from consideration due to environmental impact and discretionary factors and the cooling pond alternative is eliminated due to cost considerations. The applicant could then choose between the remaining options with a defensible basis for the selected choice. As site specific and applicant specific information is developed, the scores and other factors would better refine the selection preference.

3.2.2 Intake Systems

The variety of intake systems is extensive due to their dependence on site-specific characteristics and varying circulating water system requirements. Generally, cooling water intake systems consist of an intake structure used to direct water (e.g., a channel or piping) into the components of the cooling systems wherein the cooling function takes place, usually the main condenser. However, there are many variations for these intake system components. For instance, the nuclear plant at Palo Verde has no intake system, but pipes water directly from a city water reclamation plant, while the Perry nuclear power plant uses a submerged offshore siphon and intake conduit system. For the purposes of this report, intake system component design alternatives will be limited to the following:

- Channel structures
- Shoreline structures
- Offshore structures
- Traveling screens
- Barriers
- Perforated-pipe intakes
- Infiltration-bed intakes

The PPE does not directly provide any parameters for ALWR intake systems. However, since intake systems must accommodate plant water flow requirements, several PPE parameters will influence the design of an intake system based on the once-through or make-up water (closed-cycle) flow for the circulating water system chosen. Raw water consumption for sewage and potable drinking water also can be factored into the intake design requirements. Based on the once-through or closed-cycle circulating water scenarios, assumptions for design factors such as intake velocity and circulating pump specifications can be compared for cost and environmental impact. Other design alternatives such as deterrent devices and pipeline configurations can also be considered. For instance, the URD contains a requirement for trash racks and travelling screens to be used on ALWR plant cooling water systems. Several design and operational requirements for these intake system components are also included in the URD. Finally, the URD provides for consideration of dual flow screens over traveling screens, if appropriate.

The Federal Water Pollution Control Act Amendments of 1972 (FWPCA), as referenced in Chapter 10 of RG-4.2, requires cooling water intake structures to reflect the best available technology available for minimizing adverse environmental impact. Thus, if a traveling screen has been identified as a feature which significantly minimizes environmental impact, the alternative of not having a screen is not likely to be valid under Section 316(b) of FWPCA. Screen alternatives (e.g., vertical, horizontal, angle-mounted, and single entry-double exit) may be considered for cost-benefit under the guidelines provided in Chapter 10.

Site parameters that have a direct, significant impact on intake structures are identified. Often, proper intake siting is the only way to minimize adverse environmental impacts. A site parameter of primary importance in the consideration of intake system design alternatives would be the water source for the circulating water system. For example, an open channel may be considered for conveying water to a pumphouse for a large open reservoir as the most economical and least environmental impact as opposed to a submerged siphon type intake. However, if the reservoir has a strong current causing the depositing of substantial amounts of sand and shore material in the channel requiring constant maintenance by either pumping or dredging, a submerged siphon intake may become a more economical solution. Other site parameters that can affect the consideration of intake system alternatives are seismic, flooding, ship collision, and ice build-up. If any of the parameters identified preclude a specific intake system design, that subsystem component alternative should be removed from further consideration.

Appendix A describes the basic environmental factors to be used in the consideration of intake system alternatives. A primary environmental factor listed in the table examines the impact of impingement or entrapment by cooling water intake systems (Appendix A, section 1.1). Fish are the resource population affected by impingement or entrapment on intake screens. To prepare this portion of the ESP ER, an analysis or field study would be performed to identify all important species of fish and estimate the annual weight, number, and percent of population of each species that will be impacted. The results of this analysis would then be incorporated into a numerical score that would compare the estimated weight and number of each species affected by each intake structure alternative. Through an appropriate weighting system, comparison matrices and worksheets may be developed to compare the impact of various factors for the various alternatives.

An example of how the composite suitability values would work is demonstrated in tables 4 - 6. It should be noted that the score and weighting values used in these tables are generic values provided to demonstrate the process. Table 4 shows three different types of intake structures whose designs are dominantly based on their locations (i.e., inland, shoreline, and offshore). The score column represents a quantity assigned to the potential impact that each of the various subsystem alternatives would have on the corresponding environmental factor. Each of the environmental factors would then be assigned a weighting factor that is used to multiply the criterion scoring to obtain the composite suitability factor for these particular intake structure alternatives. The weighting could be region- or utility-specific, but a sample generic engineering judgement weighting was assigned for this example. Table 5 provides examples of intake structure component alternatives and sample suitability scores. As previously mentioned, the traveling screen alternative shown in table 5 can be broken down into different configuration alternatives with associated suitability scores. Finally, while table 5 deals only with environmental factors, site parameters (i.e., water sources and meteorology) and monetary costs are to be included in generating an actual composite suitability value as shown in table 6.

Table 4: Intake Structure Alternative Comparison Worksheet

STATION DESIGN ALTERNATIVES →		CHANNEL STRUCTURES		SHORELINE STRUCTURES		OFFSHORE STRUCTURES	
↓ ENVIRONMENTAL FACTORS ¹	WEIGHT ²	SCORE ³	WEIGHTED SCORE ⁴	SCORE	WEIGHTED SCORE	SCORE	WEIGHTED SCORE
Ship Collision Risk	0.1	3	0.3	1	0.1	5	0.5
Ice Build-up Risk	0.3	1	0.3	3	0.9	5	1.5
Flooding Risk	0.4	4	1.6	1	0.4	5	2.0
Water Quality, (Physical) Due to Construction	0.7	5	3.5	3	2.1	1	0.7
Plankton Entrainment	0.8	1	0.8	3	2.4	5	4.0
Fish Entrainment	0.8	1	0.8	3	2.4	5	4.0
Fish Impingement	1.0	1	1.0	3	3.0	5	5.0
		COMPOSITE SUITABILITY SCORE ⁵		COMPOSITE SUITABILITY SCORE		COMPOSITE SUITABILITY SCORE	
		8.3		11.0		17.7	

Notes

¹Table 5 of RG 4.2 provides the minimum guidelines for factors applicable to intake system alternatives

²The weighting assigned for this investigation is a judgement call or qualified opinion of the overall importance of the individual factor for use in making relative comparisons

³The score is developed as described in the text as a relative assessment of the alternatives place on an impact scale of 1 to 5 (with 5 meaning lower impact)

⁴This is the weight times the score

⁵This is sum of the weighted scores. Higher composite suitability scores indicate preferences or relative ranking

Table 5: Intake System Component Alternative Comparison Worksheet

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ALTERNATIVES →		Travelling Screens		Barriers		Perforated-Pipe Intakes		Infiltration-Bed Intakes	
↓ ENVIRONMENTAL FACTORS ¹	WEIGHT ²	SCORE ³	WEIGHTED SCORE ⁴	SCORE	WEIGHTED SCORE	SCORE	WEIGHTED SCORE	SCORE	WEIGHTED SCORE
Phytoplankton Entrainment	0.2	2	0.4	1	0.2	3	0.6	5	1.0
Zooplankton Entrainment	0.2	2	0.4	1	0.2	3	0.6	5	1.0
Ichthyoplankton Entrainment	0.6	2	1.2	1	0.6	3	1.8	5	3.0
Fish Entrainment	0.7	4	2.8	3	2.1	1	0.7	5	3.5
Fish Impingement or Entrapment	1.0	3	3.0	4	4.0	1	1.0	5	5.0
		COMPOSITE SUITABILITY SCORE ⁵		COMPOSITE SUITABILITY SCORE		COMPOSITE SUITABILITY SCORE		COMPOSITE SUITABILITY SCORE	
		7.8		7.1		4.7		13.5	

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Table 5 of RG 4.2 provides the minimum guidelines for factors applicable to intake system alternatives

²The weighting assigned for this investigation is a judgement call or qualified opinion of the overall importance of the individual factor for use in making relative comparisons

³The score is developed as described in the text as a relative assessment of the alternatives place on an impact scale of 1 to 5 (with 5 meaning lower impact)

⁴This is the weight times the score

⁵This is sum of the weighted scores. Higher composite suitability scores indicate preferences or relative ranking

Table 6: Intake System Component Selection Worksheet

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	Travelling Screens	Barriers	Perforated-Pipe Intakes	Infiltration-Bed Intakes
Environmental Composite Suitability Score	7.8	7.1	4.7	13.5
Costs				
Capital	\$2X	\$2X	(Least Expensive) \$X	\$10X
O & M	\$4Y	\$4Y	\$Y	\$2Y
Discretionary Factors		Plant already on site uses bubble barriers		

For the purposes of this worksheet, composite suitability scores within less than 15% of each other are treated as not having "significantly different" environmental impacts. [Sensitivity studies of human perception to changes in their surroundings (i.e., lighting, noise, color intensity, etc.) show that the "least noticeable difference" which is readily detected is approximately 15 percent.] Using Table 5 alternatives based on a sample selection of an offshore intake structure from Table 4, the above worksheet may indicate that barriers are the best choice due to cost, environmental impact, and discretionary factors. The applicant could then demonstrate a defensible basis for the selected choice. As site specific and applicant specific information is developed, the scores and other factors would better refine the selection preference.

3.2.3 Discharge Systems

As with intake systems, the variety of discharge systems is extensive due to their dependence on site-specific characteristics and circulating water system requirements. Generally, discharge systems consist of structures which provide for the return of all required cooling and/or blowdown water to a water source. The system must be designed to mix and disperse the discharge water, such that the increased temperature and chemical concentrations in the water body are low enough to satisfy established regulatory standards and to limit environmental effects. It should be noted that discharges to the air, such as water loss through a cooling tower, will be considered under circulating water system alternatives. For the purposes of this report, discharge system component design alternatives will be limited to the following:

- Dredged Channel
- Submerged Offshore Slot Jet
- Submerged Offshore Diffuser
- Submerged Offshore Round Jet

Again, the PPE does not directly provide any parameters for ALWR discharge systems. However, since discharge systems must accommodate plant water flow requirements, several PPE parameters will influence the design of a discharge system based on the once-through or make-up water (closed-cycle) flow for the circulating system chosen. Based on the once-through or closed-cycle circulating water scenarios, assumptions for design factors such as outfall configurations and exit velocities can be compared for cost and environmental impact. The URD provides requirements that can be used in the consideration of discharge systems. For instance, the URD requires that the blowdown flow for a closed-cycle system shall be taken from the circulating water system downstream of the circulating water pumps and upstream of the condenser. This ensures that the blowdown will be cold in accordance with environmental regulations. Another example, the URD requires that a blowdown ditch be provided as an intermediate discharge reservoir for cooling tower blowdown. This serves as a checkpoint for monitoring and neutralizing chemistry of circulating and service water discharges to the environment.

Site parameters that have a direct, significant impact on discharge structures are identified. As with intake systems, proper discharge siting may be the only way to minimize adverse environmental impact. A site parameter of primary importance in the consideration of discharge system design alternatives would be the water body to which the outfall would discharge. For example, a low velocity discharge into a dredged channel may be the simplest and most economical type of discharge structure. However, because of limited dilution water and stratification, regulatory

limits for thermal discharges may be exceeded causing an increased environmental impact. Other site parameters that can affect the consideration of discharge structure alternatives are seismic, littoral drift patterns, and longshore currents which can cause recirculation. If any of the parameters identified preclude a specific discharge system design, that subsystem component alternative should be removed from further consideration.

Appendix A describes the minimum environmental factors to be used in the consideration of discharge system alternatives. A primary environmental factor listed in the table examines the impact of the discharge area and thermal plume. Fish are one of the resource populations affected directly or indirectly by the thermal plume. To prepare this portion of the ESP ER, an analysis or field study would be performed to identify all important species of fish and estimate the impact. The results of this analysis would then be used to assign a numerical score that would compare the estimated weight, number, and percentage of the population of each species impacted by each discharge structure. Through an appropriate weighting system, comparison tables may be developed to compare the impact of various factors for the various alternatives.

An example of how the composite suitability values would work can be demonstrated in table 7. Four discharge system alternatives are matrixed to several environmental factors chosen to demonstrate the process. It should be noted as in previous examples that the score and weighting values used are provided for demonstration purposes only. Table 7 shows four different types of discharge structures. The scores quantify the potential impact that each of the various system alternatives would have for the corresponding environmental factor. Each of the environmental factors would then be assigned a weighting factor that is used to multiply the criterion scoring to obtain the composite suitability value for these various discharge structure alternatives. The weighting could be region or utility specific, but a sample generic "judgement call" weighting was assigned for this example. Table 7 deals only with environmental factors, while table 8 has example site parameters and cost factors which would be included in order to generate an actual composite suitability value.

Table 7: Discharge System Alternative Comparison Worksheet

STATION DESIGN ALTERNATIVES →		Dredged Channel		Submerged Offshore Slot Jet		Submerged Offshore Diffuser		Submerged Offshore Round Jet	
↓ ENVIRONMENTAL FACTORS ¹	WEIGHT ²	SCORE ³	WEIGHTED SCORE ⁴	SCORE	WEIGHTED SCORE	SCORE	WEIGHTED SCORE	SCORE	WEIGHTED SCORE
Water Quality, Excess Heat	1.0	1	1.0	5	5.0	3	3.0	5	5.0
Water Quality, Oxygen Availability	0.9	1	0.9	5	4.5	2	1.8	4	3.6
Fish (non-migratory)	0.7	1	0.7	4	2.8	5	3.5	4	2.8
Fish (migratory)	0.5	5	2.5	3	1.5	1	0.5	3	1.5
Wildlife	0.3	1	0.3	5	1.5	3	0.9	5	1.5
		COMPOSITE SUITABILITY SCORE ⁵		COMPOSITE SUITABILITY SCORE		COMPOSITE SUITABILITY SCORE		COMPOSITE SUITABILITY SCORE	
		5.4		15.3		9.7		14.4	

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Table 5 of RG 4.2 provides the minimum guidelines for factors applicable to intake system alternatives

¹The weighting assigned for this investigation is a judgement call or qualified opinion of the overall importance of the

²Individual factor for use in making relative comparisons

³The score is developed as described in the text as a relative assessment of the alternatives placed on an impact scale of 1 to 5 (with 5 meaning lesser impact)

⁴This is the weight times the score

⁵This is sum of the weighted scores. Higher composite suitability scores indicate preferences or relative ranking

Table 8: Discharge System Selection Worksheet

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		Dredged Channel	Submerged Offshore Slot Jet	Submerged Offshore Diffuser	Submerged Offshore Round Jet
Environmental Composite Suitability Score		5.4	15.3	9.7	14.4
Costs	Capital	\$5X	\$7X	\$3X	(Least Expensive) \$X
	O & M	\$2X	\$X	\$X	\$X
Discretionary Factors		Corps of Engineers backlog in approving 404 permits			

For the purposes of this worksheet, composite suitability scores within less than 15% of each other are treated as not having "significantly different" environmental impacts. [Sensitivity studies of human perception to changes in their surroundings (i.e., lighting, noise, color intensity, etc.) show that the "least noticeable difference" which is readily detected is approximately 15 percent.] Using the selection worksheet above, a likely preferred alternative for discharge cooling would be the submerged offshore round jet. It is important to note that the slot jet option is within range for environmental considerations but cost becomes a primary factor. As site specific and applicant specific information is developed, the scores and other factors would better refine the selection preference.

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3.2.4 Transmission Line Facilities

Examination of alternate transmission line facilities can occur at the ESP stage through use of the PPE data outlining incoming power supplies and use of the number and rating of the anticipated power output. The ALWR design ratings are in two categories; ~ 600Mw and ~ 1200Mw. At the ESP stage, it is suggested a bounding upper value be used for projected power output from the site (i.e., if it anticipated four 600Mw units or two units would be eventually placed on the site, the transmission line capability should be projected to carry 2400Mw).

For any specific site, there will be existing conditions which will influence potential alternative route selections. The key conditions will be existing incoming power lines or the proximity to transmission system tie-in points. The tie-in points may be to existing nearby lines, to the nearest appropriately-sized substation or to an area of the transmission system where new facilities are anticipated.

Two computer based applications allow rapid identification of alternate corridors; the geographic information systems (GIS, a computer system containing spatial data layers) and CORRIDOR (an EPRI sponsored computer program allowing input of line rating, corridor width, tower type and geometry, above or below ground placement, reliability, etc.). By using bounding criteria of 200 feet for corridor easement and a one mile width for influence and potential impact, various alternative routes for incoming and outgoing lines can be projected. Input values for minimum station requirements are given as two physically separate (minimum 50 feet) sources of incoming power at or above 27Kv per plant. The 27Kv value is the highest value identified for an ALWR. Obviously, this rating would be increased if more than one unit is projected for the site. Utilities across the country use different graded transmission lines (e.g., TVA uses 500Kv, 161Kv, 69Kv, and 13Kv). For the specific site and transmission system to be considered, the incoming requirements would be matched to the specific utility system but greater than the 27Kv (or multiple) requirement. Vendor data for the tie-in to onsite busses is provided in the PPE as 4160v and 480v, which is standard for operating plants. For the outgoing transmission lines, the alternates would include two or more new corridors from the site, parallel construction to the incoming lines, or parallel to the maximum extent possible of existing nearby transmission lines, railroad corridors, gas lines, etc.

The PPE provides estimates of switchyard acreage and there were no stipulations regarding plant or switchyard orientation to each other or on the site, so some flexibility to consider alternative and optimum orientations exists at the ESP stage.

Using these parameters and bounds, GIS or a similar system can be programmed to model numerous constraints (e.g., endangered species or protected land) and opportunities (e.g., abandoned railroad corridors) to overlay alternate routes onto topographical maps. Applying a standard model based on reconnaissance level or pre-entered data would provide a gross comparison of potential impacts.

The remaining step in the Composite Suitability Approach would be to determine or assign weighting to the appropriate factors and to compare the alternatives. By adding the weighting factors to the GIS-generated routes, an evaluation of the routes is possible. The results of this comparison would reveal one or more tentatively preferred routes and their alternatives. This evaluation is a viable method for meeting the requirements of examining and considering alternatives prior to demonstrating the need for power or beginning any process of actually obtaining transmission line right-of-way. An example table demonstrating how the application of this method would be applied is included as table 9. This list of the environmental factors is taken from the RG-4.2; however, a more comprehensive set of factors can be found in the EPRI sponsored report "A Streamlined Procedure for Obtaining Regulatory Approval for New Transmission Lines," EL-1404, December 1982.

As noted earlier, while a generic comparison of alternatives cannot be completed prior to site selection, there is clearly sufficient vendor detail to allow development and comparison of alternative transmission line corridors, transmission line and tower designs, and switchyard arrangements once the site is selected (i.e., at the ESP application and ER stage).

Table 9: Transmission Line Corridor Comparison Worksheet

ALTERNATIVES →		Corridor "A"		Corridor "B"		Corridor "C"	
↓ ENVIRONMENTAL FACTORS ¹	WEIGHT ²	SCORE ³	WEIGHTED SCORE ⁴	SCORE	WEIGHTED SCORE	SCORE	WEIGHTED SCORE
Operation-wildlife changes	0.2	1	0.2	4	0.8	5	1.0
Adjacent land-access	0.4	2	0.8	5	2.0	1	0.4
Adjacent land-vegetation	0.4	5	2.0	5	2.0	1	0.4
Adjacent land-wildlife	0.5	1	0.5	4	2.0	5	2.5
Operation-beneficial land use	0.5	1	0.5	3	1.5	5	2.5
Route selection-esthetics and visibility	0.6	5	3.0	2	1.2	1	0.6
Adjacent land-erosion	0.6	3	1.8	5	2.4	1	0.6
Route selection-land amount	0.8	5	4.0	1	0.8	4	3.2
Route selection-land use and value	1.0	1	1.0	3	3.0	5	5.0
		COMPOSITE SUITABILITY SCORE ⁵		COMPOSITE SUITABILITY SCORE		COMPOSITE SUITABILITY SCORE	
		13.8		15.7		16.2	

¹Taken from Table 5 of RG 4.2 for factors applicable to circulating water system alternatives

²The weighting assigned for this investigation is a judgement call or qualified opinion of the overall importance of the individual factor for use in making relative comparisons

³The score is developed as described in the text as a relative assessment of the alternatives place on an impact scale of 1 to 5 (with 5 meaning lower impact)

⁴This is the weight times the score

⁵This is sum of the weighted scores. Higher composite suitability scores indicate preferences or relative ranking

3.2.5 Sanitary Waste System

When considering station design alternatives for sanitary waste treatment systems, the environmental effects of primary importance are the flowrate of effluents and the type of effluents discharged into the site water body, as well as the economic practicality of the systems considered.

The effluents of concern from sanitary waste systems generally include the following:

Physical

- Total Suspended Solids (TSS)

Chemical

- Biodegradable organics (e.g., proteins, fats, and carbohydrates)
- Nutrients (e.g., nitrogen and phosphorus).
- Refractory organics (e.g., agricultural pesticides)
- Heavy metals
- Dissolved inorganic solids (e.g., calcium)

Biological

- Pathogens (e.g., fecal coliform)

Limits for these effluents are state regulated and are determined on a case-by-case basis. The ESP applicant must commit to meeting established limits in order to obtain an NPDES Permit, and therefore legally release limited amounts of effluents resulting from onsite generation of sanitary waste.

There are several alternative types of sanitary waste treatment systems presently used at operating plants to meet established limits. Alternatives for various primary treatment, secondary treatment, and combinations of primary and secondary treatment may be evaluated. Examples of these methods include:

Primary treatment:

- Septic tank
- Imhoff tank

Secondary Treatment:

- Extended aeration
- Intermittent sand filter
- Recirculating granular medium filter
- Constructed wetlands

There are also a number of "package" plants for treatment of sanitary wastes which are in use at numerous industrial sites across the country. It could easily be demonstrated which systems meet the effluent restraints in their locations since NPDES permits are required.

The PPE provides the average and maximum expected flowrates for discharge of effluent due to sanitary waste treatment at ABWR, SYS 80+, AP600, and SBWR plants. These values are as follows:

	ABWR	SYS 80	AP600	SBWR
Average	13 gal/min	20 gal/min	35 gal/min	11 gal/min
Maximum	19 gal/min	24 gal/min	70 gal/min	17 gal/min

These parameters, along with expected wastewater characteristics and site characteristics, are essential in determining which treatment system would be more appropriate to use at the proposed ESP site. Sanitary waste treatment site characteristics which should be considered in the station design alternatives evaluation are landscaping (e.g., landscape should be a level, well-drained area when considering septic tank location), geographic features (e.g., creeks and marshes), hydrogeological properties (e.g., depth to groundwater), surface slope, flooding potential, soil properties (e.g., soil texture should preferably be sandy or loamy when considering disposal of wastewater), and existing structures.

Other factors to be used in the consideration of sanitary waste treatment system alternatives are described in Appendix A (e.g., the impacts of system operations such as noise).

Through an appropriate weighting system comparison tables may be developed to compare the suitability of alternative system designs.

An example of how the composite suitability values would work can be demonstrated in table 10. The score and weighting values used in these examples are provided for demonstration purposes. For the purposes of this report, three of the alternative designs will be used as examples to demonstrate the applicability of this approach: septic tank (primary treatment), septic tank with intermittent sand

filter (primary and secondary), and extended aeration (secondary). Five of the factors determined by site characteristics, effluent characteristics, and Appendix A are shown in table 10 as a partial list of environmental factors. The scores reflect an assigned quantity for the potential impact that each of the system design alternatives would have for the corresponding environmental factor. Each of the environmental factors would then be assigned a weight which is used to multiply the criterion scoring to obtain the composite environmental suitability factor for the system design alternatives. To select an alternative from the choices which are not significantly different in impact, the additional factors of monetary costs and any applicant specific discretionary factors would be included in an additional worksheet.

Table 10: Sanitary System Alternative Comparison Worksheet

STATION DESIGNS ALTERNATIVES →		SEPTIC TANK		SEPTIC TANK w/ INTERMITTENT SAND FILTER		EXTENDED AERATION	
↓ ENVIRONMENTAL FACTORS ¹	WEIGHT ²	SCORE ³	WEIGHTED SCORE ⁴	SCORE	WEIGHTED SCORE	SCORE	WEIGHTED SCORE
Land Usage	0.1	5	0.5	5	0.5	1	0.1
Effects of System Operation on People	0.3	5	1.5	5	1.5	1	0.3
Effects of Chemical Effluents on Water Quality	0.8	5	4.0	5	4.0	5	4.0
Contamination of groundwater due to excess nutrients	0.9	1	0.9	2	1.8	5	4.5
Effects of Total Suspended Solids Discharged on Oxygen Availability	1.0	4	4.0	5	5.0	1	1.0
		COMPOSITE SUITABILITY SCORE ⁵		COMPOSITE SUITABILITY SCORE		COMPOSITE SUITABILITY SCORE	
		10.9		12.8		9.9	

¹Table 5 of RG 4.2 provides the minimum guidelines for factors applicable to intake system alternatives

²The weighting assigned for this investigation is a judgement call or qualified opinion of the overall importance of the individual factor for use in making relative comparisons

³The score is developed as described in the text as a relative assessment of the alternatives place on an impact scale of 1 to 5 (with 5 meaning lower impact)

⁴This is the weight times the score

⁵This is sum of the weighted scores. Higher composite suitability scores indicate preferences or relative ranking

3.2.6 Other Systems

Chapter 10 of RG-4.2 describes "other systems" as any station system, other than those previously specified, that is associated with a potentially adverse environmental effect. Other systems are represented by, but not limited to, emergency diesels, access roads, wastewater pipeline routes, and potable water systems. The impacts of these systems can be extrapolated from operating plants and compared through the Composite Suitability Approach methodology. However, discussion of other systems may be impractical at the ESP stage, since other systems may be dependent on the station design chosen.

The PPE and URD offer very little information useful in the comparison of other system alternatives. However, some plant parameters are helpful in determining the operating parameters for some of the various other systems. For instance, the size of the plant population (PPE) will be a factor in the consideration of potable water systems and onsite standby AC power supply system requirements (URD) will factor into the consideration of emergency diesel generators and combustion turbines.

The example in table 11 presents a generic comparison of access road route alternatives. A comparison similar to the transmission line corridor comparison can be made by applying the environmental guidelines for transmission lines in Appendix A to the access road example. As previously noted, it is assumed that the site selection process has been accomplished, and the site selected has been deemed suitable for an ALWR.

Table 11: Other (Access Routes) Alternative Comparison Worksheet

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ALTERNATIVES →		Route "A"		Route "B"		Route "C"	
↓ ENVIRONMENTAL FACTORS ¹	WEIGHT ²	SCORE ³	WEIGHTED SCORE ⁴	SCORE	WEIGHTED SCORE	SCORE	WEIGHTED SCORE
Operation-wildlife changes	0.2	3	0.6	1	0.2	5	1.0
Adjacent land-access	0.4	1	0.4	5	2.0	1	0.4
Adjacent land-vegetation	0.4	5	2.0	4	1.6	1	0.4
Adjacent land-wildlife	0.5	3	1.5	1	0.5	5	2.5
Operation-beneficial land use	0.5	1	0.5	2	1.0	5	2.5
Route selection-esthetics and visibility	0.6	4	2.4	5	3.0	1	0.6
Adjacent land-erosion	0.6	3	1.8	1	0.6	5	3.0
Route selection-land amount	0.8	5	4.0	1	0.8	4	3.2
Route selection-land use and value	1.0	5	5.0	3	3.0	1	1.0
		COMPOSITE SUITABILITY SCORE ⁵		COMPOSITE SUITABILITY SCORE		COMPOSITE SUITABILITY SCORE	
		18.2		12.7		14.6	

¹Taken from Table 5 of RG 4.2 for factors applicable to circulating water system alternatives

²The weighting assigned for this investigation is a judgement call or qualified opinion of the overall importance of the individual factor for use in making relative comparisons

³The score is developed as described in the text as a relative assessment of the alternatives place on an impact scale of 1 to 5 (with 5 meaning lower impact)

⁴This is the weight times the score

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3.3 ESTABLISHED CUTOFF LIMIT APPROACH METHODOLOGY

Two basic sources that establish cutoff limits for the systems selected for application of this approach are Appendix I of 10 CFR 50 and 40 CFR 423.

Appendix I of 10 CFR 50 provides guidance on appropriate treatment methods for gaseous and liquid radioactive waste generated from light-water-cooled reactors and sets numerical guidelines for design objectives and limiting conditions of operation. Appendix I states that "radioactive material released...to unrestricted areas be kept as low as is achievable. Design objectives and limiting conditions for operation conforming to the guidelines of this appendix shall be deemed as conclusive showing of compliance with the 'as low as is reasonably achievable' [ALARA] requirements [established in] 10 CFR 50.34a and 50.36a." Appendix I also states that, "The applicant shall include in the radwaste system all items of reasonably demonstrated technology [that would benefit the system when added]." The URD for evolutionary and passive ALWRs specifies that the radioactive waste systems will meet Appendix I limits. Specifically, the URD state in Volume II, Chapter 12, Sections 3.2 and 4.2 and Volume III, Chapter 12, Sections 3.2 and 4.2 that, "The Gaseous/Liquid Waste Process Systems shall be designed to limit effluents in accordance with the objectives of 10 CFR 50, Appendix I and 10 CFR 20." In addition, all four ALWR plants will implement the "Good Neighbor Policy" which establishes goals on gaseous and liquid effluents to further enhance safety and limit releases. The basis for the goals established in this policy is that the total radioactivity, excluding tritium, will be equal to or less than the 1984-85 10% best operating plants of the same type Boiling Water Reactors (BWRs) and Pressurized Water Reactors (PWRs) in the U.S. The ALWRs are compared with the 10% best operating plants because of the advanced features such as special low leakage valve designs.

The Established Cutoff Approach reasons that since the certified standard ALWR designs will meet regulatory criteria and incorporate the latest technology into the liquid radioactive waste treatment systems via the "Good Neighbor Policy," no alternatives to the systems proposed as a part of the ALWR designs undergoing certification reviews need to be evaluated. Because these system designs do meet the guidance provided in RG-4.2, this section of the ESP ER can be written at the site selection stage before a specific plant type is chosen.

Regulations in 40 CFR 423, *Steam Electric Power Generating Point Source Category*, establishes limits on discharge of pollutants from a point source. Pollutants are defined to include "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water." (CWA sect. 502(6), 33 U. S. C. sect. 1362 [6]). Since chemical waste and biocide treatment waste are encompassed in the definition of "pollutant," 40 CFR 423 limits these types of discharges. 40 CFR 423 requires that direct discharges of pollutants meet "best

practicable technology currently available" (BPT) limitations. These established limits are based "on the average of the best existing performance at plants of various sizes, ages, and unit process." Once BPT limitations have been achieved, further limitations based on "best available technology economically achievable" (BAT) must also be met. The BAT limits are based on "the age of equipment and facilities involved, the process employed, the engineering aspects of the control technologies, process changes, the cost of achieving such effluent reduction, and non-water quality environmental impact."

In order for an ALWR plant to legally operate (i.e., discharge any substance into water), a NPDES permit must first be obtained. Since 40 CFR 423 is one of the regulations governing these permits, the ALWR plant must operate within the limits shown to be as low as can be reasonably achieved with available technology.

The Established Cutoff Approach reasons that once a subsystem design has been considered, and it is determined to be within the limits established in 40 CFR 423 or other appropriate legislation, no other subsystems need to be considered as a design alternative. This reasoning is based on the assumption that since BPT and BAT limitations are based on the best technology currently available, meeting these non-radiological limitations is similar to meeting "ALARA" criteria which the radioactive waste treatment systems are required to meet. The BAT at the time of site use may have changed since the time of the ESP; however, it is expected that the continual required renewal of NPDES permits for all industrial outfalls will demonstrate both the reasonableness and achievability of these limits. This approach is not to be considered a continual optimization process and recognizes certain impacts are unavoidable. The key idea behind the Established Cutoff Approach is that when all alternatives are within certain ranges, then selection can be based on other criteria, as long as the environmental impacts have been identified and considered in the decision-making process.

3.3.1 Gaseous/Liquid Radioactive Waste Treatment Systems.

The basic method that ALWRs will use for processing gaseous radioactive waste is established in the URD. The URD describes a system which consists of charcoal adsorbers to treat the gaseous waste. Humidity is controlled by cooling with the plant chilled water system. This treatment system is considered to be a simple and reliable passive system.

The URD also describes the basic method for processing liquid radioactive waste. This waste is treated by filtration and ion exchange. This process consists of equipment and components to maintain a simple system (e. g., automated precoat filter operations).

The treatment methods described above are similar for PWR and BWR radioactive waste; however, there are certain differences that exist between them which will affect the system design. These differences, and the design components they affect,

are discussed in the URD (i.e., sections 1.5.7.1 and 1.5.7.2 of volumes II and III, respectively).

The URD commits the gaseous and liquid radioactive waste systems described to maintaining limits established in 10 CFR 50, Appendix I. In addition, the URD commits to implementing a "Good Neighbor Policy" which establishes goals on gaseous and liquid effluents to further limit releases. This policy establishes limits for total annual radioactivity excluding tritium. The limit for gaseous effluents is 2000 Curies (Ci) per year for BWRs and 200 Ci per year for PWRs. The limit for liquid effluents is 0.05 Ci per year for both BWRs and PWRs. These limits are based on the total annual radioactivity of the 1984-1985 10% best operating plants of the same type in the U.S.. The basis for this comparison with the best 10% operating plants is that the radioactive waste systems for the ALWRs will use advances in technology wherever possible (e.g., valves with lower leakage rates).

Gaseous and radioactive waste treatment system designs have been selected for each of the four ALWR types that comply with the regulations of 10 CFR 50, Appendix I, as well as "Good Neighbor Policy" limits. These systems will be a part of the certified standard designs. For this reason, no alternative design consideration of these waste systems is necessary.

3.3.2 Biocide Treatment Systems.

Treatment of raw water with biocides may be necessary to control micro-organisms which cause components of plant water systems to foul or corrode and organisms (e.g., clams) which clog raw water systems by accumulating in the intake lines. The most common biocides used at currently operating plants are injections of chlorine and sodium hypochlorite. The URD specifies no gaseous chlorine should be used for the ALWR system designs; however, liquid chlorine use remains a viable practice. Other generally acceptable and practical biocides include injection of chlorine dioxide, bromine chloride, chlorinated bromide salts, or ozone. It is noted that other methods of biocide treatment may be appropriate which do not use chemicals (e.g., heat treatment and use of strainers). However, chlorine is the predominant biocide used so the focus of the application of the established cutoff approach is limited to chlorine.

40 CFR 423 establishes effluent limitation guidelines and new source standards for biocide systems. For example, effluent limitations based on BPT and BAT are established for the maximum and average discharge of chlorine and 126 other pollutants. Different limits are established and are dependent upon the type of circulating water system used in the ALWRs, as well as the biocide chosen. For example, 40 CFR 423.13 (d)(1) places BAT limits on pollutants discharged in cooling water blowdown. It states that the quantity of free available chlorine shall not exceed the quantity determined by multiplying the flow of cooling tower blowdown times the concentration limits of a maximum 0.5 mg/l and an average 0.02 mg/l.

Since BPT and BAT limitations are based on the best technology available, proposing a station design alternative which meets these limitations is considered equivalent to meeting established cutoff criteria. Therefore, when a biocide treatment system has been identified that remains within the limits established in 40 CFR 423, no additional treatment system alternatives need to be considered. Sufficient data is available from operating plants to allow a comparison of methods for biocide treatment at the ESP state once the circulating water system has been selected and the source water quality parameters are known.

3.3.3 Chemical Waste Systems

There are two basic methods of chemical waste treatment which will be used at ALWRs. Chemical waste will be processed either by filtration or by ion exchange via a floor drain processing system. In order for an ALWR to legally discharge chemical effluents, a NPDES permit must be obtained. Part of the stipulation in obtaining a NPDES permit is that the ALWR comply with 40 CFR 423 regulations; therefore, the chemical effluents must be within BPT and BAT limits provided in 40 CFR 423. For example, effluent limitations based on BPT and BAT are established for the maximum and average discharge of 126 priority pollutants contained in chemicals added for cooling tower maintenance. All limits provided in 40 CFR 423 are dependent upon the flow rate of the chemical waste sources and the concentration of the particular chemicals used.

Since BPT and BAT limitations are based on the best technology available, meeting these limitations is considered similar to meeting 10 CFR 50, Appendix I criteria. Therefore, when a chemical waste treatment system has been identified that remains within the limits established in 40 CFR 423, no alternative treatment systems would need to be considered if the established cutoff approach is expanded to non-radiological waste systems.

In addition to meeting BPT and BAT limitations, the URDs for passive and evolutionary ALWRs commit to implementing a "Good Neighbor Policy." This policy establishes goals limiting hazardous and toxic chemical wastes in accordance with Environmental Protection Agency standards. According to Volume I of the URD for ALWRs, chemical releases to the environment are "inherently minor in a nuclear plant." Therefore, it is not expected that ALWR chemical waste systems will have difficulty meeting the established limits or obtaining and maintaining a NPDES permit.

4.0 CONCLUSIONS AND SUMMARY

Through development of an alternate approach for evaluating design alternatives and expanded application of one of the approaches already included in regulatory guidance, the issue regarding the ability to consider adequately station design alternatives, while avoiding costly design development, is resolved. If use of established cutoff limits for systems other than radwaste is not acceptable without rulemaking or other lengthy proceedings, the Composite Suitability Approach could be successfully applied to the systems which this report treats with this approach.

Use of the methods and process described in this report allow an ESP applicant to quantitatively compare alternatives based on environmental factors by having only basic site information and minimal detail regarding specific design features of the various system alternatives.

The ultimate selection from among those alternatives which have no significantly different impacts can be based on monetary cost and any discretionary factors the applicant may wish to use.

The effort to apply the process once site data is gathered will be focused on the weighting and scoring of the various factors for the comparison worksheets not design development. Cost estimates can be taken from currently operating plants or similar industrial sites. Since there is no requirement to propose only one preferred alternative in the ER, actual selection could take place nearer the time of site use. The permit holder would need only to validate the selected option is within the range of impact described in the application ER.

The overall conclusion is that the portion of an ER dealing with station design alternatives can be developed to a sufficiently detailed level at the ESP application stage to allow the NRC to fulfill its obligation under NEPA.

5.0 REFERENCES

- 1 Title 10, Code of Federal Regulations, Part 52 (10 CFR 52), Subpart A - Early Site Permits.
- 2 10 CFR 52.17(a)(2).
- 3 Regulatory Guide 4.2; *Preparation of Environmental Reports for Nuclear Power Stations*, Revision 2, dated July 1976.
- 4 40 CFR 423, *Steam Electric Power Generating Point Source Category*.
- 5 HALLIBURTON NUS Environmental Corporation. 1992. Early Site Permit Demonstration Program Regulatory Criteria Evaluation Report; Technical Review of Documentation Related to Site Permitting for Advanced Light Water Reactors.
- 6 National Environmental Policy Act (Title 42, United States Code, Section 4330 *et seq.*).
- 7 *Ibid.* §102(2)(E).
- 8 *Ibid.* §102(2)(C)(iii).
- 9 Executive Order 11514, *Protection and Enhancement of Environmental Quality*, Section 2(b), 3 CFR 902 (1966-70); as amended by Executive Order 11991, 3 CFR 123 (1978).
- 10 *Ibid.*, Section 2(g).
- 11 40 CFR Pts. 1500-1508, *Council on Environmental Quality NEPA Regulations*, Section 1502.(c).
- 12 *Ibid.*, Section 1502.14: "This section is the heart of the environmental impact statement. Based on the information and analysis presented in the sections on Affected Environment (§ 1502.15) and the Environmental Consequences (§ 1502.16), it should present the environmental impacts of the proposal and the alternatives in a comparative form, thus sharply defining the issues and providing a clear basis for choice among options by the decisionmaker and the public. In this section agencies shall:
 - (a) Rigorously explore and objectively evaluate all reasonable alternatives and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated.

- (b) Devote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits.
- (c) Include reasonable alternatives not within the jurisdiction of the lead agency.
- (d) Include the alternative of no action.
- (e) Identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such a preference...."

- 13 35 FR 5463, dated April 2, 1970.
- 14 10 CFR 51 - Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions.
- 15 Fogleman, V. M. 1990. Guide to the National Environmental Policy Act.
- 16 U.S. Atomic Energy Commission. February 1971. Draft Guide to the Preparation of Environmental Reports for Nuclear Power Plants: Issued for Comment and Interim Use (Notice of Availability 36 FR 5150, March 17, 1971).
- 17 U.S. Atomic Energy Commission. August 1972. Guide to the Preparation of Environmental Reports for Nuclear Power Plants: Issued for Comment .
- 18 37 FR 16035, dated August 9, 1972.
- 19 38 FR 8013, dated March 27, 1973 (Regulatory Guide 4.2; Preparation of Environmental Reports for Nuclear Power Plants; March 2, 1973).
- 20 RG-4.2, Section A.2, also discusses the Federal Water Pollution Control Act (FWPCA), but only to point out that the United States Environmental Protection Agency may collect information pursuant to the FWPCA that is similar to information collected by NRC pursuant to NEPA.
- 21 "...the guide in Section 10.7 and 10.8 on Page 36 and 37 allows a cutoff point such that discussions and descriptions of radwaste systems need not be detailed if compliance with Appendix I can be shown. A similar approach should be taken in other areas of the guide; for example, chemical and thermal effluent limits; and environmental impact limits for radiation, chemicals, and heated effluents below which no further consideration is required...." letter, G.L. Gleason, Vice President, Atomic Industrial Forum, Inc. to L. Rogers, Director of Regulatory Standards, U.S. Atomic Energy Commission, *Atomic Industrial Forum Comments on AEC's Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Plants,"* April 26, 1973, page 3.

APPENDIX A: TABLE 5 RG-4.2

Environmental Factors To Be Used In Comparing Alternative Station Systems (Page A-1 of A-13)

Primary Impact	Population or Resources Affected	Description	Unit of Measure ^a	Method of Computation
1. NATURAL SURFACE WATER BODY	(Specify natural water body affected)			
1.1 Impingement or entrapment by cooling water intake structure	1.1.1 Fish ^b	Juveniles and adults are subject to attrition.	Percent of harvestable or adult population destroyed per year for each important species	Identify all important species as defined in Section 2.2. Estimate the annual weight and number of each species that will be destroyed. (For juveniles destroyed, only the expected population that would have survived naturally need be considered.) Compare with the estimated weight and number of the species population in the water body.
1.2 Passage through or retention in cooling systems.	1.2.1 Phytoplankton and zooplankton.	Plankton population (excluding fish) may be changed due to mechanical, thermal, and chemical effects.	Percent changes in production rates and species diversity	Field studies are required to estimate (1) the diversity and production rates of readily recognizable groups (e.g., diatoms, green algae, zooplankton) and (2) the mortality of organisms passing through the condenser and pumps. Include indirect effects ^c which affect mortality.
	1.2.2 Fish	All life stages (eggs, larvae, etc.) that reach the condenser are subject to attrition.	Percent of harvestable or adult population destroyed per year for each important species	Identify all important species as defined in Section 2.2. Estimate the annual weight and number of each species that will be destroyed. (For larvae, eggs, and juveniles destroyed, only the expected population that would have survived naturally need be considered.) Compare with the estimated weight and number of the species population in the water body.

^aApplicant may substitute an alternative unit of measure where convenient. Such a measure should be related quantitatively to the unit of measure shown in this table.

^bFish as used in this table includes shellfish and other aquatic invertebrates harvested by man.

^cIndirect effects could include increased disease incidence, increased predation, interference with spawning, changed metabolic rates hatching of fish out of phase with food organisms.

Environmental Factors To Be Used In Comparing Alternative Station Systems (Page A-2 of A-13)

Primary Impact	Population or Resources Affected	Description	Unit of Measure ^a	Method of Computation
1.3 Discharge area and thermal plume	1.3.1 Water quality, excess heat	The rate of dissipation of the excess heat, primarily to the atmosphere, will depend on both the method of discharge and the state of the receiving water (i.e., ambient temperature and water currents).	Acres and acre-feet	Estimate the average heat in Btu's per hour dissipated to the receiving water at full power. Estimate the water volume and surface areas within differential temperature isotherms of 2, 3, and 5°F under conditions that would tend, with respect to annual variations, to maximize the extent of the areas and volumes.
	1.3.2 Water quality, oxygen availability	Dissolved oxygen concentration of receiving waters may be modified as a consequence of changes in the water temperature, the translocation of water of different quality, and aeration.	Acre-feet	Estimate volumes of affected waters with concentrations below 5, 3, and 1 ppm under conditions that would tend to maximize the impact.
	1.3.3 Fish (nonmigratory)	Fish ^b may be affected directly or indirectly because of adverse conditions in the plume.	Net effect in pounds per year (as harvestable or adult fish by species of interest)	Field measurements are required to establish the average number and weight (as harvestable or adults) of important species (as defined in Section 2.2). Estimate their mortality in the receiving water from direct and indirect effects. ^c
	1.3.4 Wildlife (including birds and aquatic and amphibious mammals and reptiles)	Suitable habitats (wetland or water surface) may be affected	Acres of defined habitat or nesting area	Determine the areas impaired as habitats because of thermal discharges, including effects on food resources. Document estimates of affected population by species.
	1.3.5 Fish (migratory)	A thermal barrier may inhibit migration, both hampering spawning and diminishing the survival of returning fish.	Pounds per year (as adult or harvestable fish by species of interest)	Estimate the fraction of the stock that is prevented from reaching spawning grounds because of station operation. Prorate this directly to a reduction in current and long-term fishing effort supported by that stock. Justify estimate on basis of local migration patterns, experience at other sites, and applicable State standards.

Environmental Factors To Be Used In Comparing Alternative Station Systems (Page A-3 of A-13)

Primary Impact	Population or Resources Affected	Description	Unit of Measure ^a	Method of Computation
1.4 Chemical effluents	1.4.1 Water quality, chemical	Water quality may be impaired.	Acre-feet %	The volume of water required to dilute the average daily discharge of each chemical to meet applicable water quality standards should be calculated. Where suitable standards do not exist, use the volume required to dilute each chemical to a concentration equivalent to selected lethal concentration for the most important species (as defined in Section 2.2) in the receiving waters. The ratio of this volume to the annual minimum value of the daily net flow, where applicable, of the receiving waters should be expressed as a percentage and the largest such percentage reported. Include the total solids if this is a limiting factor. Include in this calculation the blowdown from cooling towers and other closed-cycle cooling systems.
	1.4.2 Fish	Aquatic populations may be affected by toxic levels of discharged chemicals or by reduced dissolved oxygen concentrations.	Pounds per year (by species of fish)	Total chemical effect on important species of aquatic biota should be estimated. Biota exposed within the facility, as well as biota in receiving waters, should be considered. Supporting documentation should include reference to applicable standards, chemicals discharged and their toxicity to the aquatic populations affected.
	1.4.3 Wildlife (including birds and aquatic and amphibious mammals and reptiles)	Suitable habitats for wildlife may be affected.	Acres	Estimate the area of wetland or water surface impaired as a wildlife habitat because of chemical contamination, including effects on food resources. Document the estimates of affected population by species.

APPENDIX A: TABLE 5 RG-4.2 (con'd)

Environmental Factors To Be Used In Comparing Alternative Station Systems (Page A-4 of A-13)

Primary Impact	Population or Resources Affected	Description	Unit of Measure ^a	Method of Computation
	1.4.4 People	Recreational water uses (boating, fishing, swimming) may be inhibited.	Lost annual user days and area (acres) or shoreline miles for dilution	The volume of the net flow to the receiving waters required for dilution to reach accepted water quality standards must be determined on the basis of daily discharge and converted to either surface area or miles of shore. Cross-sectional and annual minimum flow characteristics should be incorporated where applicable. The annual number of visitors to the affected area or shoreline must be obtained. This permits estimation of lost user-days on an annual basis. Any possible eutrophication effects should be estimated and included as a degradation of quality.
1.5 Radionuclides discharged to water body	1.5.1 Aquatic organisms	Radionuclide discharge may introduce a radiation level that adds to natural background radiation.	Rad per year	Sum dose contributions from radionuclides expected to be released.
	1.5.2 People, external	Radionuclide discharge may introduce a radiation level that adds to natural background radiation for water users.	Rem per year for individual, man-rem per year for estimated population at the midpoint of station operation	Sum annual dose contributions from nuclides expected to be released.
	1.5.3 People, ingestion	Radionuclide discharge may introduce a radiation level that adds to natural background radiation for ingested food and water.	Rem per year for individuals (whole body and organ); man-rem per year for population at the midpoint of station operation	Estimate biological accumulation in foods and intake by individuals and population. Calculate doses by summing results for expected radionuclides.

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APPENDIX A: TABLE 5 RG-4.2 (con'd)

Environmental Factors To Be Used In Comparing Alternative Station Systems (Page A-5 of A-13)

Primary Impact	Population or Resources Affected	Description	Unit of Measure ^a	Method of Computation
1.6 Consumptive use	1.6.1 People	Drinking water supplies drawn from the water body may be diminished.	Gallons per year	Where users withdraw drinking water supplies from the affected water body, lost water to users should be estimated. Relevant delivered costs of replacement drinking water should be included.
	1.6.2 Agriculture	Water may be withdrawn from agricultural usage, and use of remaining water may be degraded.	Acre-feet per year	Where users withdraw irrigation water from the affected water body, the loss should be evaluated as the sum of two volumes: the volume of the water lost to agricultural users and the volume of dilution water required to reduce concentrations of dissolved solids in station effluent water to an agriculturally acceptable level.
	1.6.3 Industry	Water may be withdrawn for industrial use.	Gallons per year	
1.7 Plant construction (including site preparation)	1.7.1 Water quality, physical	Turbidity, color, or temperature of natural water body may be altered.	Acre-feet and acres	The volume of dilution water required to meet applicable water quality standards should be calculated. The areal extent of the effect should be estimated.
	1.7.2 Water quality, chemical	Water quality may be impaired.	Acre-feet, %	To the extent possible, the applicant should treat problems of spills and drainage during construction in the same manner as in Item 1.4.1.
1.8 Other impacts				The applicant should describe and quantify any other environmental effects of the proposed station that are significant.
1.9 Combined or interactive effects				Where evidence indicates that the combined effect of a number of impacts on a particular population or resource is not adequately indicated by measures of the separate impacts, the total combined effect should be described.
1.10 Net effects				See discussion in Section 5.7.

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Environmental Factors To Be Used In Comparing Alternative Station Systems (Page A-6 of A-13)

Primary Impact	Population or Resources Affected	Description	Unit of Measure	Method of Computation
2. GROUNDWATER				
2.1 Raising/lowering of groundwater levels	2.1.1 People	Availability or quality of drinking water may be decreased, and the functioning of existing wells may be impaired	Gallons per year	Volume of replacement water for local wells actually affected should be estimated
	2.1.2 Vegetation	Trees and other deep rooted vegetation may be affected	Acres	Estimate the area in which groundwater level change may have an adverse effect on local vegetation. Report this acreage on a separate schedule by land use. Specify such users as recreational, agricultural, and residential
2.2 Chemical contamination of groundwater (excluding salt)	2.2.1 People	Drinking water of nearby communities may be affected	Gallons per year	Compute annual loss of potable water
	2.2.2 Vegetation	Trees and other deep rooted vegetation may experience toxic effects	Acres	Estimate area affected and report separately by land use. Specify such uses as recreational, agricultural, and residential
2.3 Radionuclide contamination of groundwater	2.3.1 People	Radionuclides that enter groundwater may add to natural background radiation level for water and food supplies	Rem per year for individuals (whole body and organ); man-rem per year for population at the midpoint of station operation	Estimate intakes by individuals and populations. Sum dose contributions for nuclides expected to be released
	2.3.2 Vegetation and animals	Radionuclides that enter groundwater may add to natural background radiation level for local plant forms and animal population	Rad per year	Estimate uptake in plants and transfer to animals. Sum dose contributions for nuclides expected to be released
2.4 Other impacts on groundwater				The applicant should describe and quantify any other environmental effects of the proposed station that are significant

APPENDIX A: TABLE 5 RG-4.2 (con'd)

Environmental Factors To Be Used In Comparing Alternative Station Systems (Page A-7 of A-13)

Primary Impact	Population or Resources Affected	Description	Unit of Measure ^a	Method of Computation
3 AIR				
3.1 Fogging and icing (caused by evaporation and drift)	3.1.1 Ground transportation	Safety hazards may be created in the nearby regions in all seasons	Vehicle hours per year	Compute the number of hours per year that driving hazards will be increased on paved highways by fog and ice due to cooling towers and ponds. Documentation should include the visibility criteria used for defining hazardous conditions on the highways actually affected.
	3.1.2 Air transportation	Safety hazards may be created in the nearby regions in all seasons	Hours per year, flights delayed per year	Compute the number of hours per year that commercial airports will be closed to visual (VFR) and instrumental (IFR) air traffic because of fog and ice from cooling towers. Estimate number of flights delayed per year.
	3.1.3 Water transportation	Safety hazards may be created in the nearby regions in all seasons	Hours per year, number of ships affected per year	Compute the number of hours per year ships will need to reduce speed because of fog from cooling towers or ponds or because of warm water added to the surface of the river lake, or sea.
	3.1.4 Vegetation	Damage to timber and crops may occur through introduction of adverse conditions	Acres by crop	Estimate the acreage of potential plant damage by crop.
3.2 Chemical discharge to ambient air	3.2.1 Air quality, chemical	Pollutant emissions may diminish the quality of the local ambient air	% and pounds or tons	The actual concentration of each pollutant in ppm for maximum daily emission rate should be expressed as a percentage of the applicable emission standard. Report weight for expected annual emissions.
	3.2.2 Air quality, odor	Odor in gaseous discharge or from effects on water body may be objectionable	Statement	A statement must be made as to whether odor originating in station is perceptible at any point offsite.

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APPENDIX A: TABLE 5 RG-4.2 (con'd)

Environmental Factors To Be Used In Comparing Alternative Station Systems (Page A-8 of A-13)

Primary Impact	Population or Resources Affected	Description	Unit of Measure ^a	Method of Computation
3.3 Radionuclides discharged to ambient air and direct radiation from radioactive materials (in plant or being transported)	3.3.1 People, external	Radionuclide discharge or direct radiation may add to natural background radiation level	Rem per year for individuals (whole body and organ), man-rem per year for population at the midpoint of station operation	Sum dose contributions from nuclides expected to be released.
	3.3.2 People, ingestion	Radionuclide discharge may add to the natural radioactivity in vegetation and in soil	Rem per year for individuals (whole body and organ), man-rem per year for population at the midpoint of station operation	For radionuclides expected to be released, estimate deposit and accumulation in foods. Estimate intakes by individuals and populations and sum results for all expected radionuclides.
	3.3.3 Vegetation and animals	Radionuclide discharge may add to natural background radioactivity of local plant and animal life	Rad per year	Estimate deposit of radionuclides on and uptake in plants and animals. Sum dose contributions for radionuclides expected to be released.
3.4 Other impacts on air				The applicant should describe and quantify any other environmental effects of the proposed plant that are significant.

APPENDIX A: TABLE 5 RG-4.2 (con'd)

Environmental Factors To Be Used In Comparing Alternative Station Systems (Page A-9 of A-13)

Primary Impact	Population or Resources Affected	Description	Unit of Measure ^a	Method of Computation
4 LAND				
4.1 Site selection	4.1.1 Land, amount	Land will be preempted for construction of nuclear power station, station facilities, and exclusion zone	Acres	State the number of acres preempted for station, exclusion zone, and accessory facilities such as cooling towers and ponds. By separate schedule, state the type and class of land preempted (e.g., scenic shoreline, wet land, forest land, etc.)
4.2 Construction activities (including site preparation)	4.2.1 People (amenities)	There will be a loss of desirable qualities in the environment due to the noise and movement of men, material, and machines.	Total population affected, years	The disruption of community life (or alternatively the degree of community isolation from such irritations) should be estimated. Estimate the number of residences, schools, hospitals, etc., within area of visual and audio impacts. Estimate the duration of impacts and total population affected.
	4.2.2 People (accessibility of historical sites)	Historical sites may be affected by construction.	Visitors per year	Determine historical sites that might be displaced by generation facilities. Estimate effect on any other sites in plant environs. Express net impact in terms of annual number of visitors.
	4.2.3 People (accessibility of archaeological sites)	Construction activity may impinge upon sites of archaeological value.	Qualified opinion	Summarize evaluation of impact on archaeological resources in terms of remaining potential value of the site. Referenced documentation should include statements from responsible county, State, or Federal agencies, if available.
	4.2.4 Wildlife	Wildlife may be affected	Qualified opinion	Summarize qualified opinion including views of cognizant local and State wildlife agencies when available, taking into account both beneficial and adverse affects.

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APPENDIX A: TABLE 5 RG-4.2 (con'd)

Environmental Factors To Be Used In Comparing Alternative Station Systems (Page A-10 of A-13)

Primary Impact	Population or Resources Affected	Description	Unit of Measure ^a	Method of Computation
4.3 Station operation	4.2.5 Land (erosion)	Site preparation and station construction will involve cut and fill operations with accompanying erosion potential	Cubic yards and acres	Estimate soil displaced by construction activity and erosion. Beneficial and detrimental effects should be reported separately.
	4.3.1 People (amenities)	Noise may induce stress	Number of residents, school populations, hospital beds	Use applicable State and local codes for offsite noise levels for assessing impact. If there is no code, consider nearby land use, current zoning, and ambient sound levels in assessing impact. The predicted sound level may be compared with the published guidelines of the Environmental Protection Agency (EPA), American Industrial Hygiene Association and the Department of Housing and Urban Development (HUD).
	4.3.2 People (esthetics)	The local landscape as viewed from adjacent residential areas and neighboring historical, scenic, and recreational sites may be rendered esthetically objectionable by station structures	Qualified opinion	Summarize qualified opinion, including views of cognizant local and regional authorities when available
	4.3.3 Wildlife	Wildlife may be affected	Qualified opinion	Summarize qualified opinion, including views of cognizant local and State wildlife agencies when available, taking into account both beneficial and adverse effects.
	4.3.4 Land, flood control	Health and safety near the water body may be affected by flood control	Reference to Flood Control District approval	Reference should be made to regulations of cognizant Flood Control Agency by use of one of the following terms: <i>Has No Implications</i> for flood control, <i>Complies</i> with flood control regulation.

APPENDIX A: TABLE 5 RG-4.2 (con'd)

Environmental Factors To Be Used In Comparing Alternative Station Systems (Page A-11 of A-13)

Primary Impact	Population or Resources Affected	Description	Unit of Measure ^a	Method of Computation
4.4 Salts discharged from cooling towers	4.4.1 People	Intrusion of salts into groundwater may affect water supply	Pounds per square foot per year	Estimate the amount of salts discharged as drift and particulates. Report maximum deposition. Supporting documentation should include patterns of deposition and projection of possible effect on water supplies.
	4.4.2 Vegetation and animals	Deposition of entrained salts may be detrimental in some nearby regions	Acres	Salt tolerance of vegetation in affected area must be determined. That area, if any, receiving salt deposition in excess of tolerance (after allowance for dilution) must be estimated. Report separately an appropriate tabulation of acreage by land use. Specify such uses as recreational, agricultural, and residential. Where wildlife habitat is affected, identify populations.
	4.4.3 Property resources	Structures and movable property may suffer degradation from corrosive effects	Dollars per year	If salt spray impinges upon a local community, property damage may be estimated by applying to the local value of buildings, machinery, and vehicles a differential in average depreciation rates between this and a comparable seacoast community.
4.5 Transmission route selection	4.5.1 Land, amount	Land will be preempted for construction of transmission line systems	Miles, acres	State total length and area of new rights-of-way. Estimate current market value of land involved.
	4.5.2 Land use and land value	Lines may pass through visually sensitive (that is, sensitive to presence of transmission lines and towers) areas, thus impinging on the present and potential use and value of neighboring property	Miles, acres, dollars	Total length of new transmission lines and area of rights-of-way through various categories of visually sensitive land. Estimate minimum loss in current property values of adjacent areas.

Environmental Factors To Be Used In Comparing Alternative Station Systems (Page A-12 of A-13)

Primary Impact	Population or Resources Affected	Description	Unit of Measure ^a	Method of Computation
	4.5.3 People (esthetics)	Lines may present visually undesirable features.	Number of such features	Estimate total number of visually undesirable features, such as number of major road crossings in vicinity of intersection of interchanges; number of major waterway crossing; number of crest, ridge, or other high point crossings, and number of "long views" of transmission lines perpendicular to highways and waterways.
4.6 Transmission facilities construction	4.6.1 Land adjacent to rights-of-way	Constructing new roads for access to rights-of-way may have environmental impact.	Miles	Estimate length of new access and service roads required for alternative routes.
	4.6.2 Land, erosion	Soil erosion may result from construction activities.	Tons per year	Estimate area with increased erosion potential traceable to construction activities.
	4.6.3 Wildlife	Wildlife habitat and access to habitat may be affected.	Number of important species affected	Identify important species that may be disturbed (Section 2.2).
4.7 Transmission line operation	4.6.4 Vegetation	Vegetation may be affected.		
	4.7.1 Land use	Land preempted by rights-of-way may be used for additional beneficial purposes such as orchards, picnic areas, nurseries, and hiking and riding trails.	%, dollars	Estimate percent of rights-of-way for which no multiple-use activities are planned. Annual value of multiple-use activities less cost of improvements.
	4.7.2 Wildlife	Modified wildlife habitat may result in changes.	Qualified opinion	Summarize qualified opinion including views of cognizant local and State wildlife agencies when available.
4.8 Other land impacts				The applicant should describe and quantify any other environmental effects of the purposed station that are significant.

APPENDIX A: TABLE 5 RG-4.2 (con'd)

Environmental Factors To Be Used In Comparing Alternative Station System (Page A-13 of A-13)

Primary Impact	Population or Resources Affected	Description	Unit of Measure ^a	Method of Computation
4.9 Combined or interactive effects				Where evidence indicates that the combined effects of a number of impacts on a particular population or resource are not adequately indicated by measures of the separate impacts, the total combined effect should be described. Both beneficial and adverse interactions should be indicated.
4.10 Net effects				See discussion in Section 5.7.

APPENDIX B - GLOSSARY OF TERMS

Advanced Boiling Water Reactor (ABWR): A 1300-MWe boiling water reactor (BWR) which uses innovative designs and systems. It contains improvements over current BWRs in plant availability, operating capacity factor, safety, and reliability - while reducing power generation costs, construction duration, occupational radiation exposure, and radwaste.

ALARA: ALARA or "As Low As Is Reasonably Achievable" numerical limits are established in 10 CFR 50.34a and 50.36a. Appendix I of 10 CFR 50 sets numerical limits for design objectives and limiting conditions for operation of liquid and gaseous radwaste systems based on ALARA criteria.

AP600: A simplified, standard 600 MWe nuclear power plant design being developed which combines proven pressurized water reactor technology with innovative passive safety systems.

Council on Environmental Quality: The council established by NEPA to formulate and recommend national policies to promote the improvement of the quality of the environment.

Early Site Permit (ESP): The permit which provides evidence of the acceptability of a proposed site for future ALWR nuclear plant siting.

Early Site Permit Application: An application completed by nuclear industry for an ESP. The application presents information which demonstrates a comprehensive and well-documented site selection process and presents environmental impact and other information required for a NRC assessment of the suitability of the proposed site for an ALWR at some time in the future.

Early Site Permit Demonstration Program (ESPDP): A joint DOE/U.S. nuclear industry initiative for demonstrating the early resolution of siting-related issues before the detailed design proceedings of the combined operation license review. The ESPDP consists of three phases: Phase I, *Regulatory Review and Technical Evaluations*, Phase II, *Site Selection and Planning for Phase III*, and Phase III, *Site-Specific Activities, Licensing, and Approval*.

Environmental Impact Statement (EIS): A document prepared in accordance with the requirements of section 102(2)(C) of the National Environmental Policy Act (NEPA).

Environmental Report (ER): Sections 51.20 and 51.21 of 10 CFR Part 51 require the ESP applicant to submit two ERs. The first in the Construction Permit Stage and the second in the Operating License Stage. ERs contain information needed by the NRC to complete an EIS for a proposed plant.

Evolutionary ALWR Plant: Contains systems which shall be simplified relative to current LWRs so as to make them less complex and to minimize the number of active components.

Geographic Information Systems (GIS): A computer-based application which allows rapid identification of geographic information pertinent to evaluation of subsystem design alternatives (e.g., alternate corridors for transmission facilities).

Good Neighbor Policy: A policy which states that the ALWR plant be a good neighbor to its surrounding environment and population, and that requirements to limit radioactive releases from normal operation shall be defined. These radioactive release limitations apply to solid waste shipment quantities and radioactive liquid and radioactive gaseous release quantities to the environment. (URD, Vol. III, Ch. 12, section 1.5.1)

National Environmental Policy Act (NEPA): A Federal legislative act enacted in 1969 declaring a national policy to promote efforts which would prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man.

National Pollutant Discharge Elimination System (NPDES) Permit: Any ALWR plant which intends to discharge waste water or material into a body of water must obtain this permit. Limits for discharge of pollutants will be established by EPA or regulated by the state on a case-by-case basis.

New Source: Any building, structure, facility, or installation for which there is or may be the discharge of pollutants. The construction of which commenced after the publication of proposed Pretreatment Standards under section 307(c) of the Clean Water Act of 1977 which will be applicable to such source if such standard is thereafter promulgated in accordance with that section of the Clean Water Act.

New Source Performance Standards: Standards of performance which establish the quantity or quality of pollutant or pollutant properties which may be discharged by a new source.

Nuclear Regulatory Commission (NRC): The regulatory body responsible for implementing obligations under NEPA, the NRC is required to assess the potential environmental effects of a facility to ensure that issuance of an ESP permit will be consistent with NEPA goals. In 1989, NRC revised its regulations by adding provisions for ESPs and COLs (10 CFR Part 52). NRC guidance states that ERs accompanying nuclear power plant license applications should include discussion of station design alternatives.

Passive ALWR Plant: Contains systems which are essentially self-contained or self-supported which rely on (1) natural forces, such as gravity or natural circulation; (2) stored energy, such as batteries, rotating inertia, and compressed fluids; or (3) an energy inherent to the system itself for its motive power. These systems also contain

check valves and non-cycling powered valves which may change state to perform their intended functions but do not require a subsequent change of state nor continuous availability of power to maintain their intended functions.

Plant Parameter Envelope (PPE): Addresses the generic review of applicable Federal regulations and develops criteria for safety and environmental assessment of potential sites. The PPE identifies parameters that characterize the interface between an ALWR design and a potential site and quantify the interface through values selected from the URD, vendor design information, or engineering assessments.

Simplified Boiling Water Reactor (SBWR): Smaller version of the ABWR (640 MWe). The only differences between the SBWR and the ABWR are the power rating, core-flow recirculation (10 internal pumps for the ABWR and natural circulation for the SBWR), and the extent to which some of the safety systems use active versus passive features.

Standard Safety Analysis Report (SSAR): A report which systematically identifies the hazards of an ALWR operation; describes and analyzes the adequacy of measures taken to eliminate, control, or mitigate identified hazards; and analyzes and evaluates potential accidents and their associated risks.

Station Design Alternatives (SDA): Chapter 10 of RG 4.2 requires an applicant to include in the ER a study of station (subsystem) design alternatives. Alternatives for the following systems must be considered: circulating water system, intake system, discharge system, chemical waste treatment, biocide treatment, sanitary waste system, liquid radwaste and gaseous radwaste system, transmission facilities, and other systems.

System 80+ (Sys 80+): A 1300-MWe advanced pressurized water reactor (PWR). It is based on evolutionary improvements (e.g., improved safety systems) to the standard Sys 80 nuclear steam supply system.

Utility Requirements Document (URD): A design requirements document issued by EPRI that contains the nuclear industry's goals for advanced designs and defines the technical basis for improved and standardized future light water reactor designs, so that the nuclear option will be fully viable and able to meet its share of the nation's energy demands when new electricity generating plants are needed.

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