Siting Guide: Site Selection and Evaluation Criteria for an Early Site Permit Application

Technical Report

Siting Guide: Site Selection and Evaluation Criteria for an Early Site Permit Application

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EPRI Project Manager
E. Rodwell

EPRI • 3412 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com

ORGANIZATION(S) THAT PREPARED THIS DOCUMENT

McCallum-Turner, Incorporated

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This report was prepared by

McCallum-Turner, Incorporated
1153 Bergen Parkway, Suite M-472
Evergreen, CO 80439

Principal Investigator
K. Turner

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REPORT SUMMARY

As part of the Early Site Permit (ESP) Demonstration Program, the *Siting Guide: Site Selection and Evaluation Criteria for an Early Site Permit Application* was initially published in March 1993. It served as a roadmap and tool for applicant use in developing detailed siting plans to support an ESP application. This revision has been prepared to update the site selection process and criteria to reflect current regulatory requirements. The updated *Guide* also addresses the impact of significant changes in business conditions since 1993 because of electric utility deregulation.

Background

Applicants seeking to deploy new nuclear power facilities must obtain site permits and approval for construction and operation from the Nuclear Regulatory Commission (NRC). All existing nuclear power sites and facilities were licensed under requirements provided in 10 CFR Part 50. In 1989, NRC published requirements for a new licensing process in 10 CFR Part 52 to provide early resolution of siting and design issues and to enhance the stability and predictability of the regulatory environment. Subpart A of 10 CFR 52 provides requirements for an ESP, which allows for early resolution of site-related safety and environmental issues before a large commitment of resources is made.

Prior to preparing an application for an ESP, applicants must select a site. The site that is selected must be suitable for construction and operation of a standard plant design envelope that encompasses the range of specific designs contemplated for deployment. In addition, since deployment of a nuclear power facility is a major federal action, it is subject to the National Environmental Policy Act (NEPA). Therefore, a full NEPA analysis is conducted by NRC as part of the ESP process in accordance with 10 CFR Part 51. Changes in regulatory requirements resulted in modifying a number of siting criteria as well as introducing additional criteria, notably in the areas of geology/seismology, environmental justice, and cost. Furthermore, the siting process has been expanded to describe how existing nuclear power plant sites, industrial sites (sites with potential legacy contamination), and characterized sites (sites that have been previously studied) would be incorporated into the site selection process.

Objectives

- To provide a roadmap and tool for conducting a site selection process for advanced light water reactor (ALWR) designs and, in general, other designs, except for design-specific aspects of the site/facility interface and the application of individual siting criteria.

- To support identification of sites that conform with requirements for a site permit in Subpart A-Early Site Permits and a combined construction and operating license in Subpart C-Combined Operating License of 10 CFR Part 52.

Approach

The *Siting Guide* describes a four-step site selection process involving sequential application of exclusionary, avoidance, and suitability criteria, as well as incorporation of preferences (or weighting factors) that are applied to the suitability criteria. The exclusionary, avoidance, and suitability criteria address the full range of considerations important in nuclear power facility siting. These include health and safety aspects, environmental aspects, socioeconomic and land use aspects, and engineering and cost aspects. The criteria encompass construction, operations, transportation, and accident conditions.

Results

The *Siting Guide* provides an up-to-date framework for the site selection process. Steps 1 and 2 of the siting process are areal in nature; screening of a relatively large region of interest is performed to identify a number of discrete "site-sized" parcels for evaluation as a potential nuclear power facility site. These steps are accomplished using mappable information. Comparing individual sites based on their relative suitability is the focus of steps 3 and 4. This portion of the process begins with the use of mapped and other published information and concludes with detailed information collected through on-site investigations, as necessary. Step 4 culminates in selecting a preferred site for which an ESP application can be submitted.

EPRI Perspective

The site selection process for a nuclear power facility must consider all NRC, state, local, and other requirements as well as business, engineering and socioeconomic factors to provide confidence that the selected site will meet all of the applicant's objectives. As a result of the large number and variety of factors that must be considered in the site selection process, it is essential to develop and document the framework for conducting this process. In addition, since it is unlikely that applicants will have perfect sites available, it is important to develop an approach for weighing all factors and assessing sites based on the relative contribution of each factor to the applicant's overall objectives. The *Siting Guide* provides the methodology and framework for developing a detailed and specific process to meet the needs of ESP applicants for site selection.

Keywords

Advanced light water reactors (ALWRs)
Early site permit
Plant parameters envelope
Siting criteria

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1
INTRODUCTION

One task within the Early Site Permit Demonstration Program was the development of a guide for site selection criteria and procedures. "Siting Guide: Site Selection and Evaluation Criteria for an Early Site Permit Application" was initially published in March 1993 to serve as a roadmap and tool for applicants to use in developing detailed siting plans for their specific region of the country.

In the spring of 2001, an activity to update the Siting Guide to reflect current regulatory requirements and business conditions was initiated. This update to the Siting Guide also maintains three fundamental principles that, if used, ensure a high degree of success for an ESP applicant.

- First, the site selection process should consider environmentally diverse site locations within a given region of interest.
- Second, the process should contain appropriate opportunities for public input.
- Third, the process should be applied so that the results are clearly reasonable to an impartial observer, based on appropriately selected criteria, including criteria that demonstrate the site can host an advanced light water reactor (ALWR).

The Siting Guide provides for a systematic, comprehensive site selection process in which three basic types of criteria (exclusionary, avoidance, and suitability) are presented via a four-step procedure. It provides a checklist for criteria application at each step of the process and describes how criteria are applied, either qualitatively or quantitatively. The applicant should use this guide as a framework for site selection, customizing the overall approach, as appropriate, for individual siting situations. Use of the process described in the Siting Guide assumes that the applicant has:

1. made fundamental business decisions on the economic viability of a nuclear power facility,
2. determined that a market for the facility's output exists, and
3. identified the general geographic area for the facility to serve its market.

1.1 Background

In November 1990, the Nuclear Power Oversight Committee (NPOC) prepared a strategic plan for building new nuclear power facilities. An essential element in the strategy (Building Block 5) consisted of initiating a project to obtain Nuclear Regulatory Commission (NRC) approval through newly issued 10 CFR Part 52 (Early Site Permits; Standard Design Certifications and Combined Licenses for Nuclear Power Reactors). The plan was designed to be implemented either through attainment of an early site permit (ESP) or through the submission of, and NRC approval of, a combined construction and operating license (COL) application for a design certified ALWR under the NRC standardization rule. In 1990 Sandia National Laboratory issued a Request for Quotation to test the ESP process in a demonstration program. In early 1991, the Joint Contractors were formed and selected by the DOE through SNL to implement the Early Site Permit Demonstration Program. The Joint Contractors were assisted by the Electric Power Research Institute (EPRI) and the Nuclear Management and Resources Council (NUMARC) and developed the following phased approach to the preparation, review, and application to NRC for acceptance of an early site permit:

- Phase I - Regulatory Review and Technical Evaluation
- Phase II - Applicant Selection and Planning for Phase III
- Phase III - Site Specific Activities, Licensing, and Approval

Phase I included three tasks; Task 1 was a technical review and assessment of regulatory issues related to ESP, and Task 2 included plant parameters envelope (PPE) development for ESP. The original version of this guide was the subject of Task 3, site selection and evaluation criteria for ESP application. The product of Task 1, the "Regulatory Criteria Evaluation Report" (RCER) (Halliburton NUS, March 1993) and the Task 2 product, the "Plant Parameters Envelope" Volume 1 (Bechtel Corporation, March 1993) provided major input to the March 1993 version of this document. In addition to these Task 1 and 2 products, the "Advanced Light Water Reactor Utility Requirements Document" (EPRI, 1992), referred to in this report as the Utility Requirements Document or URD, was a key resource document for the March 1993 version of this guide.

1.2 Purpose and Goals

The Siting Guide is designed to be responsive to 10 CFR 52, 10 CFR 100, and related regulations and guidance, and form a framework or roadmap for an applicant to use in developing a detailed siting plan for a specific region of the country. The scope of work for this updated Siting Guide builds upon the work conducted in support of the March 1993 version and includes:

- Review of results of prior Early Site Permit Demonstration Program tasks;
- Evaluation of changes in relevant NRC regulations, Regulatory Guides, and other siting guidance;
- Modifications in standard or accepted technical approaches relevant to the structure or application of siting criteria;
- Review and revision of screening and evaluation (suitability) criteria and inclusion of additional criteria using present Federal siting requirements, the PPEs and the review of regulatory requirements applicable to ESP ;

- Technical review of all changes by subject matter experts;
- Procedures for applying the criteria in an overall siting methodology which:
  - Incorporates the opportunity for early and continued public participation;
  - Includes a mechanism to consider previously identified sites and industrial sites in the screening and evaluation process;
  - Incorporates consideration of electric utility deregulation in the siting process; and
  - Addresses the generic PPEs in the siting criteria and process.

The original version and this update of the Siting Guide are applicable to ALWR designs. The site selection process generally applies to other designs, however design specific aspects of the site/ facility interface and siting criteria need to be reconsidered for other designs.

The purpose of this guide is to define a procedure whereby an applicant can identify site(s) that can be the subject of a successful ESP application. The siting criteria developed require consideration of many of the environmental impacts addressed in the Environmental Report (ER) that is required to accompany the ESP application (see Regulatory Guide 4.2). Execution of the process outlined in this guide will also provide specific material required for Section 9.0 of the ER. However, ER preparation requires additional detailed environmental impact analyses beyond that undertaken in the siting process.

1.3 Report Structure

This section provides an overview of the balance of the report. Section 2.0 presents an overview of the proposed siting procedure including:

1. A discussion of the phased approach in Section 2.1;
2. Introduction to the siting criteria (in Section 2.2), which are organized in four groups:
   - Health and Safety;
   - Environmental;
   - Socioeconomic; and
   - Engineering and Cost;
3. Procedures for scoring criteria in Section 2.3; and
4. Procedures for developing criteria importance weightings in Section 2.4.

A detailed list of siting criteria and how they are applied in the siting process appears in Section 3.0. Section 4.0 discusses a number of additional aspects of site selection, including public participation, incorporation of industrial, characterized and existing sites into the siting process, and consideration of electric utility deregulation in the siting process. A discussion of applicable state requirements is presented in Appendix A. A description of the use of Geographic Information Systems (GIS) as a tool in modern siting studies is provided in Appendix B.

Appendix C illustrates how criterion scoring is established, using examples of utility functions and criteria from this guide. Appendix D is a Weighting Workshop Handbook that provides a framework for the process of assigning relative importance to each site suitability criterion. A description of recent examples of volunteer approaches to siting hazardous facilities is provided in Appendix E. The results of the review and analysis of changes to Federal regulations since 1993, which served as the basis for modifications to the siting criteria in Section 3.0, are provided in Appendix F.

2
SITING PROCEDURE

This section describes suggested elements of an overall siting procedure. It is a general guide to assist applicants in the development of region-specific siting plans. It also serves as a comprehensive checklist of siting criteria and methods for applying them. The full spectrum of siting issues should be "customized" for a specific region, through development of a detailed siting plan using this Guide as a roadmap.

The five primary components of the ESP siting procedure are defined and discussed in the following sections:

- ***Siting Procedure Overview - Section 2.1.*** Functional steps that are required to screen a region of interest down to sites which can be the subject of an ESP application.
- ***Siting Criteria - Section 2.2.*** Criteria that represent regulatory, facility design, and environmental requirements, which should be taken into account in site selection.
- ***Criterion Scoring - Section 2.3.*** Development of "utility functions" which quantify the relative suitability of a site with respect to a single criterion.
- ***Weighting/Composite Suitability - Section 2.4.*** Development of weight factors that reflect the relative importance of individual criteria in siting and development of a composite suitability value that reflects siting tradeoffs among criteria.
- ***Public Involvement - Section 2.1, Section 4.1.*** Development of a process for integrating public information and public participation in the siting process. Reference to interactions between the functional siting process and public involvement is made in Section 2.1; a more detailed discussion of the subject is provided in Section 4.1.

The discussion that follows requires some "forward referencing" as concepts are introduced before they are formally defined (e.g., siting criteria referenced in Section 2.1 defined in Section 2.2). It is strongly recommended that readers first review Section 2 in its entirety to become familiar with siting concepts, and then a second time to fully understand the overall siting procedure.

2.1 Siting Procedure Overview

Figure 2-1 provides a decision tree for ESP site selection. This decision tree illustrates the flow of the process, how the various steps incorporate and apply the three types of criteria (exclusionary, avoidance, and suitability), and points of opportunity for public participation. The elements of the procedure for ESP siting are tabulated in Table 2-1. For each of the steps, the starting point; the process employed at the step; the type of criteria to be used; the map scale likely to be most useful; the nature of the data sources; and the end product are indicated.

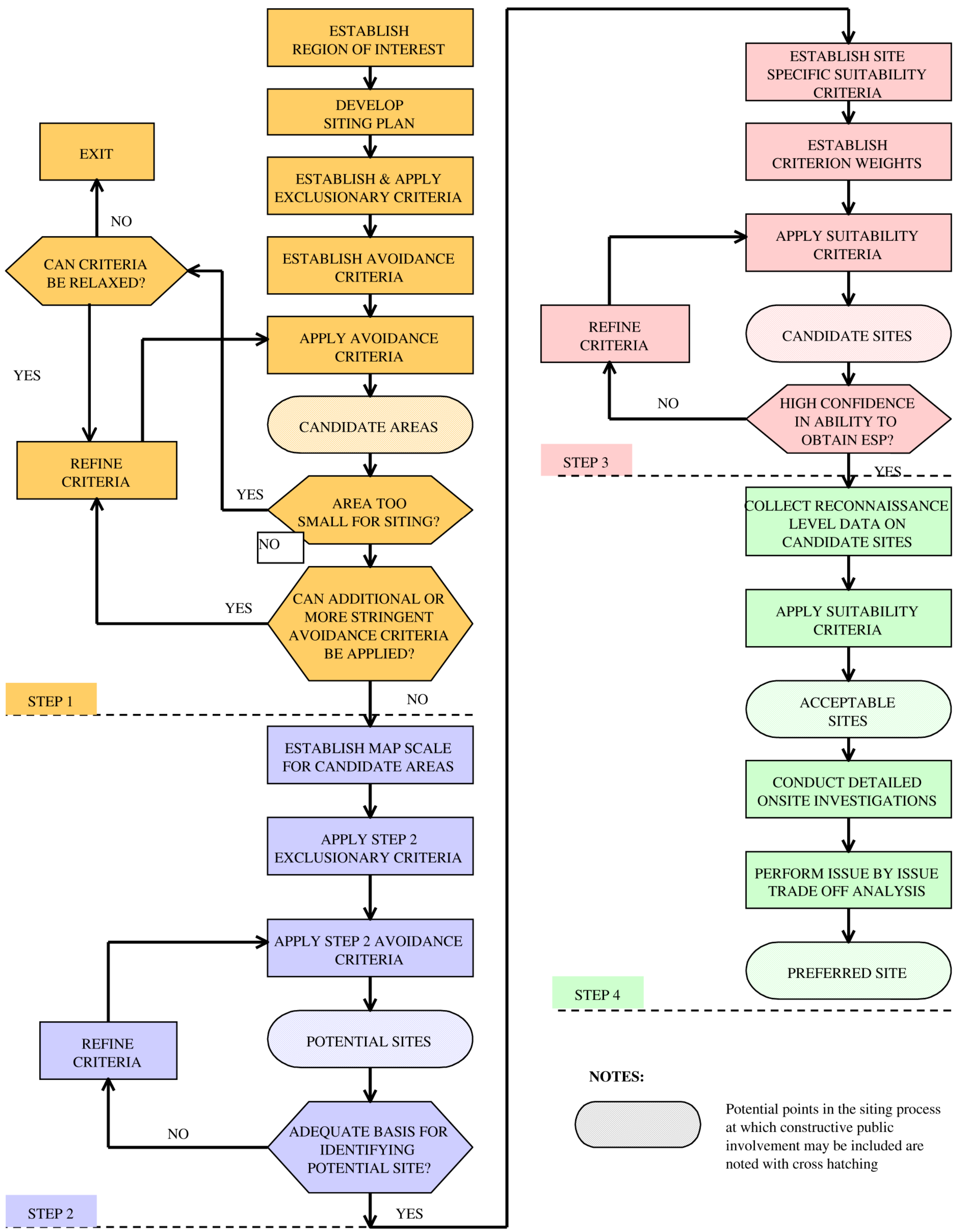

Figure 2-1
Early Site Permit Site Selection Comprehensive Decision Tree Process

Table 2-1
Outline of Phased ESP Siting Approach

STEP	1	2	3	4
STARTING POINT	Region of Interest	Candidate Areas	Potential Sites	Candidate Sites
PROCESS	Area Screening	Area Screening	Site Screening	Site Selection: Issue By Issue Analysis
CRITERIA E-Exclusionary A-Avoidance S-Suitability	E&A	E&A	Principally S Some Redefinition of E&A Boundaries	Principally S
RESULT	Candidate Areas	Potential Sites	Candidate Sites	Acceptable Sites or Preferred Sites
DATA SOURCES	Published 1:250,000 or Smaller	Published 1:125,000 to 1:24,000	Published and Reconnaissance 1:24,000	Detailed On-site Verification Surveys 1:24,000 or Larger

This Guide assumes that the need for obtaining an ESP has been established and the applicant has identified a Region of Interest (ROI), or geographic area within which a site must be located. The ROI will derive from the applicant's pre-existing fundamental business decisions on the economic viability of a nuclear power facility, the market for the facility's output, and the general geographic area where the facility should be deployed to serve its market.

In defining the public participation requirements for the siting process, it has also been assumed that the applicant has obtained tacit concurrence from the appropriate public/regulatory bodies on the need for a site and the ROI. Although assumptions regarding ROI and public participation have been made to provide a starting point for the Guide, the public may participate at earlier stages than indicated and the ROI definition and approval process and timing may vary among applicants.

Steps 1 and 2 of the process are areal in nature, since screening of a relatively large region of interest is performed to identify a number of discrete "site-sized" parcels for evaluation as a potential nuclear power facility site. These steps are accomplished using mappable information and can be greatly facilitated by employing a computerized Geographic Information System (GIS) as the mechanism for managing information. A more detailed description of this important analytical tool is provided in Appendix B.

Comparison of individual sites on the basis of their relative suitability is the focus of Steps 3 and 4. This portion of the process begins with the use of mapped and other published information and concludes with detailed information collected through on-site investigations, as necessary, culminating in the selection of a preferred site for which an ESP application can be submitted. As the siting process unfolds, the level of information detail and the corresponding level of confidence in site characterizations increase continuously. Accordingly, previous conclusions should be evaluated at each step of the process to ensure that they remain valid in light of new data. A summary description of each step follows (please see Section 2.2 for a discussion of the criterion types discussed below):

Step 1

The ROI is first screened using exclusionary criteria to eliminate those areas in which it is not feasible to site a nuclear power facility due to regulatory, institutional, facility design, and/or environmental constraints. Further screening is performed using avoidance criteria to eliminate feasible -- but less favorable -- areas, thus further reducing the area remaining under consideration. Should this process result in an area too small for identification of an adequate number of potential sites, the avoidance criteria can be relaxed and the process repeated. Conversely, if the area remaining is too large and additional avoidance criteria can be defensibly applied, the criteria may be made more stringent, and the process repeated. The avoidance screening process is repeated until the candidate areas identified are adequate (but not unreasonably large) to present multiple siting options or until no more restrictive avoidance criteria can be justifiably applied.

Step 2

Candidate areas identified in Step 1 are further screened using refined exclusionary and avoidance criteria to identify optimum areas for a facility. As in Step 1, screening is conducted as an iterative process with the application of refined criteria until an appropriate number of potential sites can be identified. A key difference in the application of exclusionary and avoidance criteria in Step 2 is the introduction of data that is at a more refined scale (1:24,000 versus 1:250,000); therefore, information at this scale may not have been considered in Step 1. A variety of protected lands, population features, ecologically protected resources (e.g., wetlands), and resources set aside for cultural or historical reasons are at such a scale that (because of their limited areal extent) they would not be considered as part of Step 1. These could, for example, include resources that are identified at the state, county, or local institutional levels. However, circumventing these “smaller” sized exclusionary and avoidance features is equally as valid as avoiding the larger features considered in Step 1. Accordingly, the consideration of these more detailed features in Step 2 will be essential to the process of reducing candidate areas to potential sites.

From the application of these exclusionary and avoidance features, potential sites are identified as discrete parcels of land approximating the size of an actual facility site (e.g., 2-5 times the minimum land area required). While areal screening is used to identify areas within which potential sites can be identified, professional judgment should be incorporated in defining potential sites to ensure that they are feasible, optimized to the degree possible, and allow some flexibility in the site layout process.

Steps 1 and 2 of the siting process are based on the philosophy of driving away from (or avoiding) those features and conditions that would not be consistent with requirements of obtaining a site permit. The emphasis is on ensuring that those areal features that should not and can not be associated with a site are no longer being considered; the focus is on eliminating large tracts of land because they do not exhibit conditions consistent with a potential site. The remaining land areas are presumed acceptable in terms of continued consideration, because these parcels do not contain the “undesirable” features. Once potential sites are identified (at the completion of Step 2), a transition in the selection approach takes place. The emphasis becomes one of evaluating, as integrated entities, the acceptability of discrete parcels of land that could be suitable sites. The process then becomes one of comparing sites and identifying a site that possesses the most favorable set of conditions for siting a nuclear power facility.

Step 3

The objective of Step 3 is to identify and rank a relatively small number of candidate sites (from the list of potential sites) for a more detailed study. This is principally performed using a series of suitability criteria based on published data and reconnaissance-level information. Application of these criteria is accompanied by the introduction of "quantified" judgements (or weights) regarding the relative importance of these suitability criteria to the siting process. As discussed in Section 2.4, incorporation of these judgments (weights) enables the applicant to incorporate preferences into the process. In addition, sensitivity analysis (to the process of applying criterion weights) is performed to help decision-makers understand the impact of these preferences on the siting process, provide the basis for making critical comparisons among sites, and enhance the confidence in the Step 3 results.

As a quality check, reconnaissance-level information can be examined at this step for a variety of reasons, including to ensure that no exclusionary or avoidance criteria appear which were not identified during application of the previous steps. For example, state, county, or local political institutions may be in the process of considering designation of additional protected features that did not appear at either the 1:250,000 or 1:24,000 scale of application. This quality check is part of considering the parcel as an integrated unit that must, in the final analysis, demonstrate compliance with all applicable laws and regulations.

The more detailed data used during Step 3 allows the applicant to identify a suite of sites (the highest ranked sites) that, based on the data, are acceptable candidates for an ESP application (e.g., any site that survives this step should be capable of obtaining an ESP).

Step 4

The purpose of step 4 is to select a preferred site from candidate sites identified in Step 3. To accomplish this objective, this step may involve conducting additional screening of the candidate sites and/or confirming the results of Step 3, at a higher confidence level, using more detailed site-specific data developed from on-site verification surveys (Step 4). The actual logistics of Step 4 should be designed based on the applicant's needs and the number of sites remaining after Step 3. Detailed on-site studies designed to provide verification of critical site suitability characteristics (which have been based up to this point on published data and reconnaissance information) should be conducted first. These studies should provide additional differentiation among the candidate sites, and in doing so, will provide the basis for an issue-by-issue analysis that will allow the applicant to identify the cost and environmental tradeoffs associated with developing each of the acceptable sites during Step 4. Costs for these verification studies have proven to be justified since they provide a higher level of assurance that the preferred site has no fatal flaws which could result in extended licensing delays and increased costs. This also the standard approach for siting low-level radioactive waste and similar facilities.

In contrast to the composite suitability analyses conducted in earlier steps which "roll up" all site suitability considerations into a single composite value, this analysis allows the decision-maker to consider actual tradeoffs in environmental impacts and site-specific costs quantitatively (e.g., acres of wetlands, miles of transmission line). This provides the decision-maker with a clear basis for differentiating among candidates, and thereby selecting, a preferred site. The trade-off information should be presented in a table, using Table 5 of Regulatory Guide 4.2 as a model.

2.2 Siting Criteria

This section contains a definition of the siting criteria types and specific criteria used in this Guide. A detailed description of the siting criteria and their application follows in Section 3.0.

2.2.1 Criteria Types

Three criteria types are defined based on the severity of constraints imposed by underlying requirements. Exclusionary criteria represent requirements that, if not satisfied by site conditions, would preclude an ESP. Examples include site PPE values that do not fall within applicable Plant Parameters Envelopes (PPEs), National Parks, and high population densities. Exclusionary criteria are used to eliminate areas based on consideration of go/no-go situations and are generally based on regulatory and/or plant design (e.g., PPE) requirements.

Avoidance criteria have the same site screening effect as exclusionary criteria but are more flexible in their application. They are utilized to identify broad areas with more favorable than unfavorable conditions, for example distance from population centers. Because the distinction between favorable and unfavorable areas is not well defined in regulation, application of avoidance criteria help ensure that the siting approach is effective. For example, one of the goals of an effective siting approach is to strike a balance between: 1) having a sufficient number and diversity of potential sites for further study in Step 3; and 2) having too large a number of potential sites to practically consider in Step 3. This balance is achieved in Steps 1 and 2 through application of avoidance criteria. Should the use of a suite of avoidance criteria combined with exclusion criteria in Steps 1 and 2 result in too few or too many potential sites for use in Step 3, the application of the avoidance criteria can be refined accordingly.

Finally, suitability criteria represent requirements that affect the relative environmental suitability or cost of developing the site, but do not represent unacceptable environmental stress, severe licensing problems, or excessive additional cost. Examples of suitability criteria are local topographic features, access considerations, important species habitat, impingement/entrainment effects, and optimizing location of the site with respect to the load center. Evaluation of sites with respect to suitability criteria requires assessing trade-offs among the various criteria, as described in Section 2.3.

2.2.2 Criteria Grouping

The site selection process utilizes three types of criteria: exclusionary, avoidance, and suitability. In addition, past practice and regulatory requirements have led to four groups of criteria based on characteristics and issues addressed:

- Health and Safety;
- Environmental;
- Land Use and Socioeconomics; and
- Engineering and Cost-related.

The criteria identified within each group are presented in Table 2-2 . These criteria groupings are also further subdivided to enable separate consideration of the specific aspects of facility development (e.g., construction versus operation). For example, the Health and Safety criteria are further divided into accident cause-related, accident effects-related, and operational effects-related criteria. The Environmental criteria are organized by construction and operation and are further sub-divided based on the consideration of effects to aquatic and terrestrial ecology. Health and safety; transportation and transmission; and land use/socioeconomics factors comprise the Engineering and Cost-Related criteria. Because detailed cost estimates cannot be developed for an ESP application, these criteria reflect site attributes that affect relative costs.

An overview of criteria grouping is provided in Table 2-2 , along with the context in which criteria are applied in the screening process. Disciplines that are used to apply each criterion are also identified. This criteria format provides a correlation with the typical discipline breakdown utilized in many environmental reports and related National Environmental Policy Act (NEPA) documents. It also facilitates the weighting of criteria.

2.3 Criterion Scoring

To evaluate the suitability of each Potential Site in Step 3 and each Candidate Site in Step 4, each criterion is first evaluated independently. This evaluation is accomplished by defining a utility function that translates quantifiable site characteristics into a common suitability scale expressing preferences for one site over another. A typical suitability scale ranges from 1 to 5, where the scale value of 1 is the lowest level of suitability (least preferable) and the scale value of 5 is the highest (most preferable). An example of this utility function translation might be distance to population centers (in which increasing preference is associated with increasing distance). In this example, a site at a distance "x" (in miles) could be assigned a suitability of 2 and a distance "y" (where $y > x$) would be assigned a suitability of 3. Using this utility function, sites at distances "y" from population centers are more preferable than those at distance "x".

With the exception of criteria that involve cost considerations, each suitability criterion is represented by a separate utility function. For cost-related criteria, the measure of dollars is universal; hence, a single utility function is established once an aggregate cost is developed arising from all cost-related criteria. This single utility function is then applied in concert with the remainder of the utility functions in executing Steps 3 and 4 of the process. Examples of utility functions can be found in the individual criteria discussions of Chapter 3.

Many utility functions relate attributes to the suitability scale using a linear function. However, nonlinear functions are appropriate for other situations and would be defined based on the professional judgment of the discipline specialist. Functions can be continuous when the suitability attribute can be represented by a quantitative continuum or can be discrete when the suitability attribute is grouped into classes or groups and scored by the professional according to increased suitability. It is important for applicants to ensure that utility functions defined in their Siting Plan properly reflect site conditions and technical concerns unique to their ROI. Appendix C provides further discussions on criterion scoring as well as examples using different types of utility functions.

Table 2-2
Siting Criteria

		STEPS			
Section	**Criteria**	**1**	**2**	**3**	**4**
3.1	**Health & Safety Criteria**				
3.1.1	Accident Cause-Related				
3.1.1.1	Geology/Seismology (GEOL)				
3.1.1.1.1	Vibratory Ground Motion	E	E	S	S
3.1.1.1.2	Capable Faults	E & A	E & A	S	S
3.1.1.1.3	Surface Faulting and Deformation	A	A	S	S
3.1.1.1.4	Geologic Hazards	A	A	S	S
3.1.1.1.5	Soil Stability		A	A & S	S
3.1.1.2	Cooling System Requirements				
3.1.1.2.1	Cooling Water Supply (HYDRO)	A	A	S	S
3.1.1.2.2	Ambient Temperature Requirements (MET)	E			
3.1.1.3	Flooding (HYDRO)	E	E	S	S
3.1.1.4	Nearby Hazardous Land Uses (LU, SOCEC)				
3.1.1.4.1	Existing Facilities		A	S	S
3.1.1.4.2	Projected Facilities			S	
3.1.1.5	Extreme Weather Conditions (MET)				
3.1.1.5.1	Winds	E&A		S	
3.1.1.5.2	Rainfall	E&A			
3.1.2	Accident Effects-Related				
3.1.2.1	Population (DEM)	E	E	S	S
3.1.2.2	Emergency Planning (DEM, LU, SOCEC)			S	S
3.1.2.3	Atmospheric Dispersion (MET)	E	E	S	
3.1.3	Operational Effects-Related				
3.1.3.1	Surface Water – Radionuclide Pathway				
3.1.3.1.1	Dilution Capacity			S	S
3.1.3.1.2	Baseline Loadings			S	S
3.1.3.1.3	Proximity to Consumptive Users			S	
3.1.3.2	Groundwater Radionuclide Pathway (HYDRO & RAD)	A	A	S	S
3.1.3.3	Air Radionuclide Pathway (MET, RAD)				
3.1.3.3.1	Topographic Effects			S	S
3.1.3.3.2	Atmospheric Dispersion	E	E	S	
3.1.3.4	Air-Food Ingestion Pathway (MET,RAD,LU)			S	
3.1.3.5	Surface Water-Food Radionuclide Pathway (HYDRO, RAD & LU)			S	S
3.1.3.6	Transportation Safety (MET, LU)			S	
3.2	**Environmental Criteria**				
3.2.1	Construction-Related Effects on Aquatic Ecology				
3.2.1.1	Disruption of Important Species/Habitats (ECOL)	E	A	S	S
3.2.1.2	Bottom Sediment Disruption Effects (HYDRO)				
3.2.1.2.1	Contamination			S	S
3.2.1.2.2	Grain Size			S	S
3.2.2	Construction-Related Effects on Terrestrial Ecology				
3.2.2.1	Disruption of Important Species/Habitats and Wetlands (ECOL)				
3.2.2.1.1	Important Species/Habitats			S	S
3.2.2.1.2	Ground Cover/Habitat			S	S

		STEPS			
Section	**Criteria**	**1**	**2**	**3**	**4**
3.2.2.1.3	Wetlands	E	E	S	S
3.2.2.2	Dewatering Effects on Adjacent Wetlands (ECOL)				
3.2.2.2.1	Depth to Water Table			A&S	S
3.2.2.2.2	Proximal Wetlands			S	S
3.2.3	Operational-Related Effects on Aquatic Ecology				
3.2.3.1	Thermal Discharge Effects (ECOL & HYDRO)				
3.2.3.1.1	Migratory Species Effects			S	S
3.2.3.1.2	Disruption of Important Species/Habitats			S	S
3.2.3.1.3	Water Quality			S	S
3.2.3.2	Entrainment/Impingement Effects (ECOL & HYDRO)				
3.2.3.2.1	Entrainment Organisms			S	S
3.2.3.3	Dredging/Disposal Effects (LU & HYDRO)				
3.2.3.3.1	Upstream Contamination Sources			S	S
3.2.3.3.2	Sedimentation Rates			S	S
3.2.4	Operational-Related Effects on Terrestrial Ecology				
3.2.4.1	Drift Effects on Surrounding Areas (ECOL)				
3.2.4.1.1	Important Species/Habitat Areas			S	S
3.2.4.1.2	Source Water Suitability			S	S
3.3	**Socioeconomics Criteria**				
3.3.1	Socioecomics-Construction-Related Effects (LU & SOCEC)			S	S
3.3.2	Socioecomics-Operation				S
3.3.3	Environmental Justice			S	S
3.3.4	Land Use				
3.3.4.1	Construction- and Operation-Related Effects	E	E&A	S	S
3.4	**Engineering & Cost – Related Criteria**				
3.4.1	Health and Safety-Related Criteria				
3.4.1.1	Water Supply (HYDRO)			S	S
3.4.1.2	Pumping Distance (ENG)	A	A	S	S
3.4.1.3	Flooding (HYDRO)			S	S
3.4.1.4	Vibratory Ground Motion (GEOL)				
3.4.1.5	Soil Stability (GEOL)			S	S
3.4.1.6	Industrial Site Remediation			S	S
3.4.2	Transportation or Transmission-Related Criteria (LU & ENG)				
3.4.2.1	Railroad Access			S	S
3.4.2.2	Highway Access			S	S
3.4.2.3	Barge Access			S	S
3.4.2.4	Transmission Cost and Market Price Differentials				
3.4.2.4.1	Transmission-Construction			S	
3.4.2.4.2	Electricity Market Price Differentials			S	S
3.4.3	Related to Socioeconomic – Land Use (LU & SOCEC)				
3.4.3.1	Topography (ENG)	E	A	S	S
3.4.3.2	Land Rights (LU)			S	S
3.4.3.3	Labor Rates (ENG-COST)			S	S

Key: E = Exclusionary A = Avoidance S = Suitability
DEM = Demography, ECOL = Ecology, GEOL = Geology, HYDRO = Hydrology, LU = Land Use, MET = Meteorology, SOCEC = Socioeconomics, ENG = Engineering

2.4 Criteria/Importance Weighting

In evaluating the inevitable tradeoffs between suitability criteria, it is necessary to assign a relative importance to each criterion in selecting a nuclear power facility site; the relative importance should be reflected as a numerical weight value. In a simple example, if thermal impacts are considered to be twice as important as entrainment effects, the former criterion might be assigned a weight twice as large as that for the latter. Assignment of weights is a sensitive issue in siting studies because the opinions and value judgments as to the relative importance of individual criteria vary with the perspectives of the individual stakeholder or group (e.g., utility, regulator, and public interest group).

There are a number of techniques for assigning importance weights to criteria. It is recommended that a ratio weighting technique be utilized. In this process, criteria are placed in rank order and a value of 1 is assigned to the least important criterion. The evaluator then assigns numerical weights such that each of the remainder of the criteria receive a weight value depicting how much more important it is relative to the other ranked criteria. These relative weights are then normalized to 1.0.

After determination of the criterion weights, these normalized weights are then multiplied by the utility scores (1-5) for each of the criterion-weight pairs and these products summed to get an overall weighted score (composite suitability value) for each site. These composite suitability values can then be used to rank or compare sites in terms of their overall suitability.

A possible variation on the use of a single consensus weighting for each criterion is the determination of separate site rankings using the consensus weightings of various stakeholder groups. These groups and their resulting site rankings can be brought together in an open, moderated group discussion to find common ground for an agreed-upon identification of the top few sites to be analyzed further in Steps 3 and 4.

This process of criterion weighting and composite suitability scoring can be applied at both site screening and site selection stages (i.e., Steps 3 and 4), although a GIS application is required for the former because of the volume of information and data that is involved. Sensitivity studies using different criterion weight sets (thereby reflecting different viewpoints) can be conducted to assess their effect on the selection of a preferred site and thereby lend additional credibility to the decision process.

There are a variety of methods for developing criterion weight values (e.g., nominal group technique, modified Delphi, and Kepner-Tregoe). While detailed discussion of these techniques is beyond the scope of this Guide, a summary of one (the modified Delphi technique) is provided in the Weighting Workshop Handbook located in Appendix D.

3
DETAILED DISCUSSION OF SITING CRITERIA

This section provides a detailed description of each siting criterion and its application in the siting process. These criteria descriptions have been designed to be generic so that they can be applied to an ESP application anywhere in the continental United States. Accordingly, some "customization" of utility functions may be appropriate for specific regions; and some criteria may not be applicable for some siting applications.

Many of these criteria have been modified from the original issuance of this document due to (1) changes in Federal regulations (see Appendix E), (2) advances in thinking regarding how certain criteria are to be applied in facility siting, or (3) emerging conditions that applicants may need to address (e.g., consideration of industrial sites and deregulation). Changes in state-specific requirements were not updated from the original issuance of this guide; users will need to examine and incorporate any changes in those regulations into the process.

Each applicant should conduct a review of the materials in this Guide; the state siting, emergency planning, and environmental regulations applicable to the region of interest; and the physical characteristics of the region of interest as the first step in the siting process. Based on this review, the applicant will be able to design a detailed Siting Plan.

A summary of the criterion categories was previously presented in Table 2-2. This table provides the presentation order for the criteria in this section. Also indicated in this table are the disciplines that are employed in evaluating each of the criteria. This presentation allows the applicant to correlate the discipline-criterion association with the typical disciplines evaluated in many ERs and related NEPA documents. The structure of these table also supports the criteria weighting process that is required as part of the suitability evaluations in Steps 3 and 4.

One product of Early Site Permit Demonstration Program, Task 2, was the development of Plant Parameters Envelopes for the individual ALWR evolutionary and passive plant designs. (Bechtel Corporation, 1993). These PPEs define the envelope of the facility/site interface conditions that, if not satisfied by the site, may preclude locating an ALWR facility on the selected site. Composite envelopes that provide bounding values for any evolutionary design and also any ALWR are also provided. An ESP applicant can utilize PPEs to represent a bound for the range of facility designs to be considered for the site.

Because of the complexity of evaluating many of the PPE sections and because detailed site-specific data are often required, a site's ability to fall within the envelopes cannot be explicitly determined, in most cases, until Step 4. Where data are likely to allow PPE evaluations earlier in the process, a discussion of these applications is included. However, a detailed parameter-by-parameter evaluation should be conducted prior to completion of Step 4 to ensure that ALWRs can be accommodated at selected sites.

A composite ALWR PPE for any ALWR plant design, based on the limiting values for the PPEs of individual ALWR designs as of 1993 was developed for the Plant Parameters Envelope Report of the Early Site Permit Demonstration Program (Bechtel Corporation, 1993). The discussions in the following subsections use individual PPE values from this composite ALWR PPE as examples.

During the development of this revision of the Siting Guide, an activity was initiated with plant designers to update the ALWR PPEs and also to add additional PPEs for other prospective designs. These updated PPEs are to be provided in the report, "Industry Guideline For Preparing An early Site Permit Application - 10 CFR part 52, Subpart A" (NEI, 2001). Thus applicants wishing to implement the Siting Guide should obtain the most current set of PPEs from this NEI report or plant designers. In addition, applicants who consider only particular ALWR designs or other designs should utilize specific PPEs for these designs and adjust the criteria accordingly.

3.1 Health and Safety Criteria

3.1.1 Accident Cause-Related Criteria

3.1.1.1 Geology/Seismology

Current NRC regulations identify three geologic, seismologic, and soil parameters that must be evaluated to determine the suitability of prospective sites. First, the Safe Shutdown Earthquake (SSE) must be determined to establish a vibratory ground motion design basis, and detailed information regarding capable tectonic structures and sources are needed to determine the SSE. Second, the occurrence of, or potential for, surface faulting or deformation must be identified and evaluated to permit evaluation of site conditions with respect to standard facility designs. Third, other geologic conditions (e.g., geologic hazards and soil characteristics) that could affect the safety of a facility must also be evaluated.

In general, the regulations and guidance pertaining to ESP promulgated since 1993 are less specific in defining what will be an acceptable (or unacceptable) site as compared to the criteria that were in effect when existing nuclear facilities were sited. No deterministic exclusionary geologic conditions were identified in the current regulations. The requirements for the scope and level of detail of investigations necessary to demonstrate site suitability are much more flexible. To some extent, the required investigations may vary depending on the extant geologic and seismic conditions, and some investigative areas can be asymmetrical (i.e., not only the distance from, but the spatial relationship to, seismic and geologic features must be taken into account).

This change in license application review policy provides the applicant with broad flexibility in "making the case" that a site is seismically acceptable for a nuclear power facility. However, whereas previous license requirements were more specifically defined in the regulations and guidance, decisions on the level of detail that will be needed and to some extent what investigations need to be addressed are now within the purview of the applicant. Because these determinations are specific to individual sites, this change also has the effect of leaving the applicant with little guidance for screening large areas and comparing sites without the kinds of information that would be developed from detailed site-specific investigations.

The following site identification process and siting criteria are intended to provide applicants with general guidance on incorporating seismic concerns into ESP site selection planning. However, because of the highly interpretive nature of the site suitability evaluation and because interpretations will be specific to the region of interest and the sites under consideration, technical experts in seismic, vibratory ground motion, and foundation engineering should be involved throughout the applicant's site selection process. This evaluation team would provide the applicant with guidance on incorporating seismic hazards into the siting decisions at each step of the process, ensuring that the logic of screening decisions and site comparisons is technically sound, defensible, and will result in a suitable site.

The reasonably available geologic and seismologic literature, maps, and other sources of information on the region of interest should be identified for Step 1. At this stage, the evaluation team of earth scientists and engineers can evaluate the information and outline potential feasible areas for further study (in subsequent steps). Also, unfavorable areas can be identified and avoided if possible. Even at early stages of the siting, an experienced evaluation team may be able to identify potentially highly suitable general candidate areas (or candidate-size areas to avoid).

The criteria discussed in the following geology/seismology sections provide an initial set of conditions and issues that should be examined.

Acquisition of the geologic and seismologic information needed to fully address siting concerns requires extensive and detailed investigations. Accordingly, an overarching siting criterion for this section relates to the fact that an area with relatively simple, non-complex geologic and seismic conditions will be easier to license, less expensive, require less time to investigate, and will be subject to less uncertainty than an area with complex conditions. Similarly, areas for which high-confidence data exist will be more favorable than areas for which the data is vague or lacking.

The Geology/Seismology criteria and their application in the various siting steps are as follows:

Report Section	Criteria	Step 1	2	3	4
3.1.1.1.1	Vibratory Ground Motion	X	X	X	X
3.1.1.1.2	Capable Tectonic Structures or Sources	X	X	X	X
3.1.1.1.3	Surface Faulting and Deformation	X	X	X	X
3.1.1.1.4	Geologic Hazards	X	X	X	X
3.1.1.1.5	Soil Stability		X	X	X

3.1.1.1.1 Vibratory Ground Motion

Step 1 – The URD provides for a maximum Safe Shutdown Earthquake (SSE) of 0.30g. Areas where regional hazard mapping shows peak ground accelerations (PGAs) exceeding 0.30g at a probability of exceedance of 2% in 50 years should be excluded. The Probability of Exceedance of 2% in 50 years roughly corresponds to a return period of 2,500 years (or a frequency of occurrence of once in 2,500 years) in approximating the SSE. Maps of seismic hazards in the conterminous United States, Hawaii and Alaska, such as those developed by the U.S.G.S as part of the National Earthquake Hazards Reduction Program (Frankel, A. et al, National Seismic Hazard Maps, Documentation, June, 1996, U.S. Geological Survey Open File Report 96-532), are appropriate for this exercise. In certain areas of the United States, evaluations of a certain site parameter, such as the SSE, may demonstrate that the overall facility design is not compromised, even when a higher SSE must be considered. The applicant should consider schedule delays and other additional costs when pursuing such a program. Specific, non-standard ALWR design(s) may be required under such scenarios.

Step 2 – Exclusionary areas should be plotted at sufficiently large scales such that boundaries are easily defined in the mapped areas. No further analysis is required at this level of mapping.

Step 3 – The applicant should develop a joint utility function based on the range of values of PGA derived from Step 1 data represented by the potential sites identified in Step 2 along with soil stability (Section 3.1.1.1.4). While site specific investigations will be required to define the ultimate static and dynamic engineering properties of a particular site's soils, there are certain soil properties that, in association with vibratory ground motion, have unfavorable characteristics, such as high water table, grain size distribution, and low density. Sites with the highest values of PGA in combination with deleterious site soils would receive a low rating of 1 while those sites with lowest values of PGA and no known deleterious site soil conditions would receive a utility function rating of 5.

Step 4 – At this detailed level of investigation, the applicant should perform seismic hazard analysis using currently acceptable guidance [i.e. those studies completed by Lawrence Livermore National Laboratory (LLNL) and EPRI]. A utility function should be developed in conjunction with detailed and site-specific information relating to geologic and geotechnical site verification investigations and the sites rated accordingly. Those sites scoring highest at this level should be evaluated using methodology outlined in USNRC Regulatory Guide 1.165. Any of the sites not meeting the appropriate standard should be eliminated from further consideration.

3.1.1.1.2 Capable Tectonic Structures or Sources

With regard to capable tectonic structures (including capable faults), no absolute exclusionary criteria have been identified. Therefore, capable tectonic structures are addressed as an avoidance criterion.

The existence of capable tectonic structures can impact determination of the SSE, and extensive detailed investigations may be required. Accordingly, the presence of capable tectonic structures within the investigative area (in general within 200 miles of a site), especially near a site, will seriously increase the time required for licensing, the cost of licensing, the risk of license denial, and possibly construction costs.

Step 1 - The concept of avoiding areas based upon consideration of the size (length) of faults (which may be capable, and hence capable tectonic structures) and their distance to a site is a valid criterion for initial characterization of site suitability. Previously, NRC provided specific guidance for determining which faults would be considered of significance in determining the SSE by identifying minimum fault lengths for various distances out to 200 miles from a site. Faults of lesser length, at the given distances, were considered non-significant and would not require detailed investigations to determine if they were capable (except as discussed in Section 3.1.1.1.3). In addition, capable faults with lengths less than those identified in Table 3-1 (taken from 10 CFR 100, Subpart A) were not to be considered for determining the SSE, unless unusual conditions or circumstances were identified. While not specifically addressed in current regulations for ESP, use of the Table 3-1 methodology, as outlined below, would likely be found acceptable and is considered a valid initial approach.

Table 3-1
Capable Tectonic Source/Distance Relationships

Distance from the site (miles)	Minimum Fault Length (miles)
0 to 20	1
Greater than 20 to 50	5
Greater than 50 to 100	10
Greater than 100 to 150	20
Greater than 150 to 200	40

From Table 3-1 it can be seen that the significance of faults is proportional to their length and inversely proportional to their distance from a site. Areas containing faults exceeding the length shown for a given distance should be avoided, if feasible. If subsequent siting factors and analysis are such that adequate candidate sites are identified, no further effort will be required. If the cumulative effects of the process do not allow adequate delineation of candidate areas, this and other avoidance criteria can be reexamined as discussed in Section 2.1.

Step 2 - In general, no further analysis may be required for Step 2, beyond more detailed delineation of the avoidance boundaries at the larger scale (greater detail) maps of Step 2.

Step 3 - If faults or other potentially capable structures were identified in Steps 1 and/or 2, an evaluation team of earth scientists can provide preliminary ranking of candidate sites based upon the available data (other criteria in this section for surface faulting and deformation, geologic hazards, and soil and rock properties should also be evaluated during this step). Of particular concern is the orientation of any nearby faults or other structures, and the propagation characteristics of relevant earthquakes.

Step 4 - The results of site-specific geologic studies conducted in this step will be integrated into the seismic risk analysis and evaluation (see also Step 4 of Criterion 3.1.1.1.1, Vibratory Ground Motion). This analysis is used to provide an overall suitability for the Geology/Seismology criterion as part of the selection of the preferred site, including consideration of whether capable structures are present on the site.

3.1.1.1.3 Surface Faulting and Deformation

With regard to surface faulting and deformation, no absolute exclusionary criteria have been identified. Therefore, surface faulting and deformation are addressed as avoidance criteria.

The potential for, or the occurrence of, surface faulting or deformation primarily concerns facility design, although the SSE may also be affected. The final design must enable the facility to withstand the effects of any site or near-site surface faulting or deformation. Surface deformation can be due to tectonic or non-tectonic structures; deformation related to non-tectonic structures or conditions are, in general, considered less serious than tectonic-related structures or conditions. Further, the occurrence of subsurface or "blind" tectonic structures must also be evaluated to establish their potential to cause surface deformation.

Appendix D to Regulatory Guide 1.165 (D.2.1) states that (1) in general, any tectonic surface deformation within 25 miles of a site will require detailed investigation to determine its significance, (2) engineering solutions may not be adequate to mitigate the effects of ground surface deformation or displacement, and (3) it is prudent to select an alternative site when a potential for permanent ground displacement exists at a proposed site. Therefore, site locations that are within 25 miles of a tectonic structure that has exhibited, or has the potential to exhibit, surface displacement or deformation should be avoided. If such a site is considered, it must be determined, through detailed investigations, whether the structure is capable (e.g., the presence of surface or near-surface deformation of a recurring nature during the last approximate 500,000 years or at least once in the last approximate 50,000 years). If the investigations demonstrate that the structure is not capable, then additional considerations relative to surface displacement or deformation would not be required.

Section D.2.1 also indicates that more extensive investigation will be needed for any faults or other tectonic structures located within 5 miles of a site to determine if they are capable tectonic sources. Accordingly, sites without such structures are more favorable.

Depending on the geologic and seismic regime , a suitable ranking system can be developed for the surface faulting and deformation criteria, and applied to identify the more favorable (or less favorable) sites in the latter steps of the siting process.

Step 1 - At a regional scale (in general, a 200 mile radius around the area of interest), and based upon texts and available geologic reports and maps, identify all tectonic and non-tectonic structures and faults with a potential for surface deformation or displacement. Map unfavorable areas using professional judgement and guidance from the evaluation team.

Step 2 - Apply appropriate more detailed mapping to identify potentially favorable siting areas.

Step 3 - Document the occurrence of surface faulting and tectonic and non-tectonic structures in and within 25 miles of the areas identified in Step 2. Select tentative candidate sites by avoiding:

1. Any such structures altogether (most favorable);
2. Potential non-capable structures;
3. Potential capable structures (less favorable).

Sites with potential capable structures within 25 miles should be avoided unless there are no reasonable alternatives.

Step 4 - Document the occurrence of surface faulting and tectonic and non-tectonic structures that are within 5 miles of the candidate sites identified in Step 3. Select preferred sites that avoid:

1. Any such structures altogether (most favorable);
2. Potential non-capable structures;
3. Potential capable structures;
4. Faults exceeding 1,000 feet in length;
5. Capable faults exceeding 1,000 feet in length (least favorable).

Sites with structures as identified in 3), 4), and 5) above will require significantly more detailed and extensive investigation (and increasing respectively with the numerical order), with commensurate expense and risk of license denial. The flexibility for addressing these features through facility design is limited, because applicants will be considering ALWR standard designs in selecting a site under the ESP process. Only sites whose characteristics fall within the PPE values for seismic qualification can be considered. Accordingly, the evaluation team should address whether the identified geologic features would result in earthquake design requirements inconsistent with ALWR designs. This evaluation should be made at each step of the siting process, and any areas or sites that are incompatible with the standard design requirements excluded from further study.

3.1.1.1.4 Geologic Hazards

With regard to geologic hazards, no absolute exclusionary criteria have been identified. Therefore, geologic hazards are addressed as an avoidance criterion. The following geologic and related man-made conditions should be avoided in locating a facility:

- Areas of active (and dormant) volcanic activity;
- Subsidence areas caused by withdrawal of subsurface fluids such as oil or groundwater, including areas which may be effected by future withdrawals;

- Potential unstable slope areas, including areas demonstrating paleolandslide characteristics;
- Areas of potential collapse (e.g., karstic areas in limestone, salt, or other soluble formations);
- Mined areas, such as near-surface coal mined-out areas, as well as areas where resources are present and may be exploited in the future;
- Areas subject to seismic and other induced water waves and floods.

Step 1 - These areas should be mapped as avoidance areas based upon texts, reports, maps and professional judgment.

Step 2 - The boundaries of these avoidance areas should be further defined based on the more detailed information available at the Step 2 scale.

Step 3 - Utility functions should be developed and related to distance from such adverse features based on professional judgment and regional conditions. Sites furthest away from these feature would be scored 5 and areas closest would be scored 1.

Step 4 - The utility functions and analysis of Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information developed for Step 4.

3.1.1.1.5 Soil Stability

With regard to soil stability, no absolute exclusionary criteria have been identified. Therefore, soil stability is addressed as an avoidance criterion.

Sites with competent bedrock generally have suitable foundation conditions. If bedrock areas are not available, areas with competent and stable solid soils such as dense sands and glacial tills should be selected. Areas that contain uniform, consistent, and non-complex soil conditions are considered to be more favorable than areas that do not, because of the less rigorous investigations that will be needed. Areas with soils that might be unstable because of their mineralogy, lack of consolidation, water content, or potentially undesirable response to seismic or other events should also be avoided. Further, areas that may contain soils subject to liquefaction, thick layers of soft soil, anomalous soil conditions, a high ground water table, subsurface cavities (natural or manmade), or rock that is subject to solutioning should be avoided.

While detailed on-site investigations will be required to determine the static and engineering properties of the site soils, initial screening can be conducted based on available information about related soil properties to guide the selection toward sites with a higher likelihood of having suitable soil characteristics.

Step 1 - This step is not applicable to this criterion.

Step 2 - Soil data of sufficient detail may not be available at a regional scale. However, if relevant information exists, areas containing poor soil conditions can be identified using avoidance criteria and an appropriate ranking applied. The evaluation team should be consulted on the determination of whether data available at this scale is adequate to support mapping avoidance areas and how the avoidance criteria should be defined.

Step 3 - Soil mapping at the series level is generally not available at scales smaller than National Resources Conservation Service (NRCS, formally SCS) county soil maps (1:20,000 scale). In some areas, such as glaciated areas, where detailed mapping of glacial deposits has been conducted and correlations can be made to general soil suitability characteristics, avoidance mapping of unfavorable areas may be possible at larger map scales used. Identifying avoidance areas would be dependent upon available data and the ability to exercise reasonable professional judgment.

For Step 3, avoidance areas would be identified and a utility function defined to relate the range and combination of unsuitable soil properties to mappable series areas. This utility function would be based on professional judgment and the nature of the soil properties characterizing the potential sites. Scores of 5 would relate to the most suitable soils among the potential sites and a score of 1 would relate to the least suitable soils. If sites are characterized by areal variation on the soil suitability categories, areal average scores can be determined through GIS mapping and analysis capabilities. If areal data allow, an evaluation of liquefaction potential for soils should be conducted at this step; any area that shows liquefaction potential at the site-specific SSE should be excluded from further consideration.

Step 4 - Based on site-specific geotechnical investigations conducted in this step, candidate sites would be evaluated by a utility function for soil stability, based on professional judgment using a similar approach as outlined above for Step 3.

3.1.1.2 Cooling System Requirements

The Cooling System Requirements criteria and their application in the siting steps are as follows:

Report Section	Criteria	Step	1	2	3	4
3.1.1.2.1	Cooling Water Supply		X	X	X	X
3.1.1.2.2	Ambient Air Requirements		X			

3.1.1.2.1 Cooling Water Supply

Guidance on cooling water requirements has been developed as part of the PPEs; specifics are as follows:

PPE Section	Requirement	Composite 1993 ALWR Value
2.7.15 2.8.18 2.10.10	Makeup Flow Rate (Closed Cycle Systems)	20,600 (34,500) GPM
2.7.16 2.8.15 2.10.11	Maximum Consumption of Water (Closed Cycle System)	17,700 GPM
2.7.17 2.8.16 2.10.12	Monthly Average Consumption of Raw Water (Closed Cycle Systems)	15,400 GPM
2.9.2	Cooling Water Flow Rate (Once-through)	1,100,000 GPM

Sites that are incapable of providing these levels of water supply within applicable physical and regulatory constraints should be excluded from further consideration. The evaluation of water supply capability should include both the effects on water quantity left in the source water body and the effects on water quality as a result of reduced waste assimilation capacity.

The allocation policies and laws operable at the state level govern the use and consumption of cooling water. In some cases, federal regional agencies such as the River Basin commissions may also have jurisdiction. Evaluations of the ability to supply the facility water requirements must take such allocations for other uses into account. For an ESP, this would require projections of use and consumption into the future not only at the initiation of operations but through the operating period as well (up to 65 years). This timeframe may be beyond the range of periods typically addressed in state water supply plans. Information on projected uses should be incorporated into the siting analysis as early as possible, consistent with the applicant's institutional and public relations program. In the preamble to the final 10 CFR 52, the Commission addressed the question of adequate data for such future information requirements. The NRC stated that it is confident that there will be information adequate to support site approvals. They go on to indicate that where adequate information is not available, ESPs will not be issued. This would suggest that the approach to evaluating water supply requirements set forth in the PPEs should be conservative to allow for the uncertainties related to projecting such future use and consumption constraints.

Step 1 - The evaluation of water supply adequacy involves the comparison of (1) site supply characteristics associated with low-flow conditions as modified by other use allocations as projected into the period of facility operations with (2) the design basis facility water consumption rate. As noted above, the allowance for non-facility future allocations should be based on conservative assumptions developed in consultation with state water supply planning officials. The US Geological Survey compiles data on the 7-day average low-flow for a recurrence interval of 10 years for streams and rivers throughout the United States. This data source should be utilized for the analysis of low-flow supply. A common assumption used in siting studies is that states would not permit more than 10 percent of the dependable flow to be withdrawn for a consumptive use. Criteria that apply to the unique physical and regulatory characteristics of the ROI under study should be defined, using the PPE sections outlined above as the measure of facility requirements.

Using such data, stretches of rivers or streams that indicate a minimum flow of record of less than the total of the facility consumption rate and the future non-facility consumption rate would be mapped as avoidance areas. Areas along segments of streams or rivers which meet the criteria and which are located beyond realistic pumping distances as outlined in the discussion of Engineering and Cost-Related Issues (Section 3.4) will also be avoided. It is assumed that an adequate water supply can be provided at estuarine and ocean sites with similar pumping distance constraints. For lakes, the supply capacity would be evaluated considering the lake capacity and lake levels, as well as historic low levels and refill (inflow) rates, together with the potential for conflict with lake usage, such as recreation.

If this analysis results in inadequate availability of areas for further analysis, groundwater supply sources can be included in the evaluation as independent sources or as supplemental sources to the surface water supply. The same conservative approach to future projections of non-facility consumptive use would be applied for groundwater use. Assuming the existence of reasonably sized well fields based on cost considerations, the groundwater supply component can be estimated based on the aquifer yield characteristics. As with the surface water supply, the areas that do not meet the total of the facility consumption rate and projected future non-facility consumptive uses would be mapped as avoidance areas. Groundwater source areas that meet the supply requirements will be bounded by the aquifer areal distribution plus reasonable pumping distances from the margin of the aquifer. In cases where both surface and groundwater sources are considered, the source and pumping constraints would be overlain and combined.

Step 2 - The avoidance areas outlined in Step 1 would be further defined at the more detailed map scale of Step 2.

Step 3 - The potential sites should be evaluated and scored with regard to the degree with which the supply at low-flow conditions, based on 7-day, 10-year low-flows and historical drought stages or water surface elevations, exceeds the design basis consumption rate and the projected future use requirements. The potential effects of cooling water withdrawals on water quality will be evaluated on the basis of the likelihood of conflicts, based on minimum flow availability, in areas with existing or expected wastewater discharges or other potentially significant water quality constraints.

The supply exceedance value would form the basis for a utility function with a score of 5 for sites with the highest degree of excess supply and/or the least potential for water quality effects, and a score of 1 for the lowest degree of excess supply and/or the greatest potential for water quality effects. The related pumping distance suitability evaluation would be treated as a utility function in Step 3 as described in Section 3.4 as an Engineering and Cost-Related Issue.

Step 4 - The suitability analysis developed for Step 3 would be reevaluated in the light of site-specific data developed in Step 4.

3.1.1.2.2 Ambient Temperature Requirements

Step 1 - PPE Section 2.1 lists a variety of ambient air requirements that must be met at prospective sites to meet the design envelope for the Normal Plant Heat Sink. These requirements are as follows:

PPE Section	Requirement	Composite 1993 ALWR Value
2.1.1	Normal Shutdown Max Ambient Temp (1% Exceed) Coincident	100 F DB/77 F WB
2.1.2	Normal Shutdown Max Wet Bulb Temp (1% Exceed) Non-coincident	80 F WB
2.1.3	Normal Shutdown Min Ambient Temp (1% Exceed)	-10 F
2.1.5	RX Thermal Power Max Ambient Temp (0% Exceed) Coincident	115 F DB/80 F WB
2.1.6	RX Thermal Power Max Wet Bulb Temp (0% Exceed) Non-coincident	81 F WB
2.1.7	RX Thermal Power Min Ambient Temp (0% Exceed)	-40 F
2.7.3 2.8.2 3.6.3	Approach Temperature	10 F

Areas that do not meet one or more of these requirements should be mapped a scale of 1:250,000 and these areas are to be excluded from further consideration.

Data for the analyses to establish these statistical, or surrogate, measures of meteorological temperatures are generally available from National Oceanic and Atmospheric Administration (NOAA), states, universities, and private sources (e.g., meteorological observations acquired for power generation or industrial facilities, private airfields). Applicable statistical evaluations or studies may also be available from these same sources or in the general literature. Review of available studies, or analyses of available meteorological data are needed to define the dry bulb and wet bulb temperature parameters for the regions, areas, and possibility sites of interest.

The ambient air criteria are generally appropriate for Step 1, and possibility Step 2, of the site evaluation process, depending on the spatial distribution and detail of meteorological data. If the data show that all locations within the region of interest satisfy the PPE values, then all potential sites will be acceptable, and the ambient air requirements are not important in the siting evaluations. In this case, other, suitability temperature parameters may be considered (e.g., dry bulb temperatures with various wet bulb temperature depressions) to identify more favorable regions or potential sites.

It should be noted that meteorological data are applicable only for the location of the measurement station. Actual site-specific data for candidate sites will only be available once the site is selected for development. Extrapolation of available data to other areas or potential site locations should be undertaken to support temperature mapping. The extrapolation should be made considering a number issues (e.g., topography, meteorological data acquisition design and location) and is best left to the judgment of professional meteorologist.

Steps 2, 3, and 4 – No further analysis is required. Extrapolation of available data to areas and sites of interest may be possible; depending on specificity of data available, applicants may wish to map the excluded areas at a more detailed scale in Step 2.

3.1.1.3 Flooding

10 CFR 100 (December 1996) and Regulatory Guide 4.7 (April 1998, Revision 2) provide additional requirements/guidance regarding physical characteristics of site that shall be considered in the design and construction of any facility. These references also indicate that site parameters (such as design basis flood conditions or tornado wind loading) be established for use in evaluating any facility to be located on a site to ensure that the occurrence of physical phenomena would pose no undue hazard.

10 CFR 100.20(c)(3) requires that:

> "Factors important to hydrological radionuclide transport (such as soil, sediment, and rock characteristics, adsorption and retention coefficients, ground water velocity, and distances to the nearest surface body of water) must be obtained from on-site measurements. The maximum probable flood along with the potential for seismically induced floods discussed in §100.23 (d)(3) must be estimated using historical data."

10 CFR 100.23(d)(3) states:

> "Determination of design bases for seismically induced floods and water waves. The size of seismically induced floods and water waves that could affect a site from either locally or distantly generated seismic activity must be determined."

Finally, NRC Regulatory Guide 4.7 offers the following guidance on consideration of flooding.

> "Criteria for evaluation of seismically induced floods are provided in 10 CFR 100.23. Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants," describes an acceptable method of determining the design basis floods for sites along streams or rivers and discusses the phenomena producing comparable design basis floods for coastal, estuary, and Great Lakes sites. The effects of a probable maximum flood (as defined in Regulatory Guide 1.59), seiche, surge, or seismically induced flood such as might be caused by dam failures or tsunamis on station safety functions can generally be controlled by engineering design or protection of the safety-related structures, systems, and components identified in Regulatory Guide 1.29, *Seismic Design Classification*. For some river valleys, flood plains, or areas along coastlines, there may not be sufficient information to make the evaluations needed to satisfy the criteria for seismically induced

flooding. In such cases, study of the potential for dam failure, river blockage, or diversion in the river system or distantly and locally generated sea waves may be needed to determine the suitability of a site. In lieu of detailed investigations, Regulatory Guide 1.59 and Section 2.4 of Regulatory Guide 1.70 present acceptable analytical techniques for evaluating seismically induced flooding.

Step 1 - Using USGS 1:250,000-scale topographic maps exclude major floodplain areas, based on professional judgment of topographic expression of floodplain areas. This exclusionary mapping will overlap to a large degree the Step 1 exclusionary mapping of major wetlands as described in Section 3.2.2.1.3. PPE Section 1.8.1 requires that the maximum flood must be at least one foot below grade. Any areas incapable of meeting this standard should also be excluded.

Step 2 - Using FEMA flood hazard maps, refine the exclusion areas developed in Step 1 and exclude areas within the 100-year floodplain.

Step 3 - Using FEMA flood hazard maps and related data on the elevations and areas associated with the 100- and 500-year flood levels, together with topographic information of the potential sites, develop a utility function related to the degree of exceedance of the 100-year flood level elevations on an areal percentage basis. Sites that minimally exceed flood-level elevations would be scored a 1, and those that have the highest degree of exceedence of flood level elevations would be scored a 5.

This function would be modified based on a number of considerations. First, the potential for ice jam flooding would be evaluated through a review of historical data for the areas downstream of the site. Second, at coastal, estuary, or Great Lake sites, considerations must include storm-related flooding (if these conditions are not considered as part of generating the 100-year and 500-year floodplain maps -- see Note below) and locally or distantly generated seismically induced flood levels. Previous studies addressing these considerations have been conducted for many coastal areas and could form the basis for the utility function evaluations at this step in coastal areas. Third, an additional consideration with regard to coastal sites, which will likely require evaluation, is the effect of potential sea level rise or instances of tsunamis (if these conditions are not considered as part of generating the 100-year and 500-year flood plain estimates -- see Note below). Finally, for riverine sites, the potential for flooding effects from upstream dam failure would be evaluated.

Each of these additional considerations (i.e., downstream ice jam flooding, storm-related flooding, seismically induced flooding, and upstream dam failure) would be used to modify the original utility function as follows. The utility function score for a site would decreased by 1 increment for each consideration that a site exhibits (i.e., downstream dams that could cause ice jam flooding, likelihood of storm induced flooding, likelihood of seismically induced flooding, and upstream dams that could cause flooding) when the frequency of occurrence of the consideration exceeds $1x10^{-6}$ per year.

NOTE: It will likely be necessary to contact FEMA to understand the full range of parameters and site conditions that are incorporated into the flood level estimates for individual sites.

Step 4 - Update the suitability utility functions from Step 3, based on site-specific data.

3.1.1.4 Nearby Hazardous Land Uses

The purpose of this criterion is to incorporate NRC guidance on site suitability considerations regarding the nature and proximity of man-related hazards (e.g., airports, dams, transportation routes, and military and chemical facilities) into the site selection process. The final rule at 10 CFR 100.21(e) codifies this guidance as "Potential hazards associated with nearby transportation routes, industrial and military facilities must be evaluated and site parameters established such that potential hazards from such routes and facilities will pose no undue risk to the type of facility proposed to be located at the site." NRC rules also address mitigation of such hazards via modification of activities at these facilities, evaluation of accident frequencies and impacts, and incorporation of design features to mitigate impacts on the NPP from accidents at hazardous facilities.

Regulatory Guide 4.7 provides additional guidance on consideration of nearby hazardous land uses, and specifies identification of potentially hazardous facilities and activities within 5 miles (8 km) of a proposed site and major airports within 10 miles (16 km). For facilities within these distances, the Regulatory Guide further states:

> "If a preliminary evaluation of potential accidents at these facilities indicates that the potential hazards from shock waves and missiles approach or exceed those of the design basis tornado for the region, or there are potential hazards such as flammable vapor clouds, toxic chemicals, or incendiary fragments, the suitability of the site should be determined by a detailed evaluation of the degree of risk imposed by the potential hazard.
>
> The acceptability of a site would depend on establishing that (1) an accident at a nearby industrial, military, or transportation facility would not result in radiological consequences that exceed the dose specified in 10 CFR 50.34(a)(1), or (2) the accident poses no undue risk because it is sufficiently unlikely to occur (less than about 10^{-7} per year), or (3) the nuclear power station can be designed so its safety will not be affected by the accident."

Thus, significant analyses and demonstrations of fact may be required for sites where hazardous land uses are located within the specified distances.

The Nearby Hazardous Land Uses criteria and their application in the various siting steps are as follows:

Report Section	Criteria	Step 1	2	3	4
3.1.1.4.1	Existing Facilities	X	X	X	X
3.1.1.4.2	Projected Facilities			X	

3.1.1.4.1 Existing Facilities

Step 1 - This Step is not applicable to this criterion.

Step 2 - Map as avoidance areas lands within 10 miles of major airports and/or within 5 miles of hazardous facilities, including the following:

- Military bases, munitions storage areas and ordnance test ranges, missile bases, firing or bombing ranges
- Oil pipelines
- Oil or gas wells
- Oil and gas storage areas
- Significant manufacturing facilities
- Chemical facilities
- Refineries
- Mining and quarrying operations
- Dams
- Land and water transportation routes for hazardous materials
- Docks and anchorages for hazardous materials

Step 3 - Develop a utility function assigning a 5 to sites having the largest number of hazardous facilities within the specified distances and sites with the lowest number (or none) a 1.

Step 4 - For sites with hazardous facilities within the specified distances, confirm site suitability by conducting a detailed evaluation of the degree of risk imposed by each potential hazard. The acceptability of a site depends on establishing that:

1. An accident at a nearby industrial, military, or transportation facility would not result in radiological consequences that exceed the dose specified in 10 CFR 50.34, or

2. The accident poses no undue risk because it is sufficiently unlikely to occur (less than about 10^{-7} per year), or

3. The nuclear power station can be designed so its safety will not be affected by the accident.

Eliminate any sites for which acceptability cannot be established.

Develop a utility function based on predicted impacts at the candidate sites. Assign a suitability value of 1 to sites with no impacts, a 5 to the site with the highest impacts, and intermediate values based on the magnitude of predicted impacts from hazardous facilities.

3.1.1.4.2 Projected Facilities

Two considerations can form the basis for projecting the likelihood for future potentially hazardous facilities to be located within 5 miles of the facility: 1) suitability and compatibility of land use plans and zoning; and, 2) projected economic growth related to the particular type of facility.

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - For each of the categories of facilities noted above, conduct an evaluation of the projected growth potential in the site area, based on historical trends and the presence and abundance of physical and socioeconomic attributes typically required for such growth. Develop a utility function to relate growth potential from 5, for high potential, to 1, for low potential, based on the results of the analysis and professional judgment. In a similar fashion, evaluate the compatibility of land use plans and zoning ordinances for each category of facility and develop a utility function with a score of 5 for cases where the type of facility is not allowed and a score of 1 for cases where the plans and ordinances allow or encourage such facilities. The two utility functions would then be combined by averaging the scores for a composite evaluation of the potential for such facilities to be located near the facility.

3.1.1.5 Extreme Weather Conditions

The following PPE sections and values define the extreme weather conditions of interest for site selection:

PPE Section	Requirement	Composite 1993 ALWR Value
1.11	Tornado (Design Bases)	
1.11.1	Maximum Pressure Drop	1.46 PSID
1.11.2	Maximum Rotational Speed	240 MPH
1.11.3	Maximum Translational Speed	57 MPH
1.11.4	Maximum Wind Speed	260 MPH
1.11.6	Radius of Maximum Rotational Speed	150 FT
1.11.7	Rate of Pressure Drop	1.2 PSI/SEC
1.12	Wind	
1.12.1	Basic Wind Speed	110 mph
1.12.2	Importance Factors	1.0 (NSR)/1.11 (SR)
1.4	Precipitation	
1.4.1	Maximum Rainfall Rate	19.4 in/hr (6.2 in/5 min)
1.4.2	Snow Load	50 lbs/sq ft

These PPE sections are addressed in the Extreme Weather Conditions criteria, which are as follows:

Report Section	Criteria	Step	1	2	3	4
3.1.1.5.1	Winds		X		X	
3.1.1.5.2	Precipitation		X			

3.1.1.5.1 Winds

In addition to the above exclusionary extreme weather events considered in the development of PPEs, extreme weather avoidance and suitability criteria can be developed from available meteorological data and studies.

Step 1 - Where data are available to characterize the ROI with respect to these plant parameters, any areas that are characterized as having severe weather characteristics in excess of the associated ALWR parameters should be excluded from further consideration. For example, the URD for passive plants indicates that the wind loading on structures is based on an extreme wind design of 110 mph for a 50-year return interval. Based on the 1970 National Atlas , only the southern portion of Florida and coastal portions of Washington and Northern Oregon have expected winds with a 50-year return interval exceeding the 110 mph PPE value. If these areas are included in the applicant's ROI, they should be mapped as exclusionary areas.

Additional observations and more recent studies should be reviewed to supplement these observations. Data and studies to establish these criteria in the regions and areas of interest are generally available from NOAA, states, universities, and private sources (e.g., meteorological observations acquired for power generation or industrial facilities, and private airfields) or in the general literature.

Step 2 - No further analysis would be required for Step 2.

Step 3 - Additional avoidance and suitability criteria related to extreme weather conditions may be defined to distinguish among potential sites. Data on severe storms has been complied since the 1950's and is available through the NOAA's National Climatic Data Center. The frequency of severe storms and events over various regions has been complied. The likelihood of extreme weather events that could possibly cause a PPE exceedance or add costs to the design or operation of a facility are appropriate avoidance and suitability criteria for siting evaluation for Step 3. For those sites where severe weather frequencies differ, utility functions can be defined where the sites with lowest frequency for each identified event type would be assigned a 5 and the site with the highest frequency a 5. A utility function would be established for each weather event type for which these differences exist among the sites under consideration.

Step 4 - No further evaluations would be conducted in Step 4.

3.1.1.5.2 Precipitation

Step 1 - Precipitation data and statistical studies and evaluations for extreme precipitation events are available from NOAA's National Climatic Data Center. An example is the probable maximum precipitation (PMP) provided for various regions and areas of the country. Other sources of precipitation data and information are state and universities and local building design codes/accepted practices. These data should be used to identify areas that may be subject to precipitation events in excess of the PPE values for rainfall and snow loading; these areas would be mapped as exclusion areas and eliminated from further consideration.

Steps 2 though 4 - No further analysis is required.

3.1.2 Accident Effects-Related

3.1.2.1 Population

In selecting a site for a nuclear power station, the applicant must demonstrate that the proposed site meets the following conditions codified at 10 CFR 100.21:

- An exclusion area surrounding the reactor in which the reactor licensee has the authority to determine all activities, including exclusion and removal of personnel and property,
- A low population zone (LPZ) which immediately surrounds the exclusion area, and,
- A population-center distance of at least 1.33 times the distance from the reactor to the outer boundary of the LPZ, where a populated center contains more than about 25,000 residents.

In addition, Regulatory Guide 4.7 provides guidance that:

> "A reactor should preferably be located such that, at the time of initial site approval and within about 5 years thereafter, the population density, including weighted transient population, averaged over any radial distance out to 20 miles (cumulative population at a distance divided by the circular area at that distance), does not exceed 500 persons per square mile."

The Regulatory Guide also indicates that "Areas of low population density are, in general, preferred." Under this guidance, a population center of about 25,000 or more residents should be no closer than 4 miles from the reactor because a density of 500 persons per square mile within this distance would yield a total population of 25,000 persons. Similarly, a city of 100,000 or more should be no closer than about 10 miles; a city of 500,000 or more should be no closer than about 20 miles; and a city of 1,000,000 or more should be no closer than about 30 miles.

The transient population should be included in the population figures for those sites where a significant number of people (other than those just passing through the area) work, reside part-time, or engage in recreational activities and are not permanent residents of the area. The transient population should be weighted according to the fraction of time the transients are in the area.

If the population density of the proposed site exceeds, but is not well in excess of the above, preferred value, the applicant should consider alternative sites having a lower population density. However, consideration will be given to other factors such as safety, the environment, or economics (e.g., superior seismic characteristics, better rail or highway access, shorter transmission line requirements, and less impacts on sensitive environmental resources), which may result in the site with the higher population density being found acceptable.

Projected changes in population within about 5 years after initial site approval should be evaluated for the proposed site and any alternative sites considered.

Application of the Population criterion is as follows:

Step 1 - Using U.S. Census data, map areas within the following distances from population centers as exclusionary.

Population Center Size	Exclusionary Distance (miles)
25,000	4
100,000	10
500,000	20
1,000,000	30

Step 2 – Refine boundaries of the exclusion areas identified in Step 1, as appropriate, based on additional data, if any, available at the more refined map scale.

Step 3 – Determine the total population density within 20 miles of each candidate area as described above; a GIS approach, coupled with electronic population data available from the Census, may be useful in these computations. Develop a utility function that assigns a scale value of 5 to the site with the lowest cumulative population density and a value of 1 to the highest. Sites with intermediate densities would be given values proportional to the calculated densities.

Step 4 – Refine the analysis described in Step 3 based on more detailed site location mapping.

3.1.2.2 Emergency Planning

NRC regulations (10 CFR 50, 52, and 100) require that nuclear power facility sites have characteristics such that adequate plans to protect members of the public in emergencies can be developed. Guidance in Regulatory Guide 4.7 indicates that applicants must identify and consider site characteristics, such as egress limitations from the area surrounding the site, that could pose a significant impediment to the development of emergency plans. Special population groups (e.g., those in hospitals, prison, or other facilities with special emergency situation needs) should also be taken into account. Sites with such emergency planning impediments, or with special population groups in the emergency planning zones, should be considered less suitable than sites that do not.

Steps 1 and 2 - These steps are not applicable to this criterion.

Step 3 - Potential sites should be reviewed to identify the number and type of "significant impediments" to emergency plan effectiveness that are present. Site characteristics to be considered in this analysis include:

- Traffic capacity
- Number of egress alternatives
- Network type: 1) freeway or expressway; 2) urban streets, or 3) rural roads
- On ramp capacities for freeways
- Number of traffic control points per network segment
- Terrain characteristics (curves, steep slopes)
- Climatic conditions.

A utility function should be defined that ranks sites according to the level of evacuation difficulty, as reflected in the identified constraints. At the most basic level, sites would be characterized by the number of emergency planning constraints identified; sites with the largest number would be assigned a score of 1 and those with the smallest number a 5. These ratings could be refined to reflect the relative magnitude of difficulty associated with the identified constraints. For example, physical features (e.g., topographic constraints) might be ranked "higher" than climatic conditions, because the latter feature affects egress only if an accident occurs coincident with a severe weather event, whereas the topographic constraints are permanent.

The analysis could also incorporate an evaluation of natural hazard damage scenarios such as earthquakes or floods that might affect both the nuclear power facility and the evacuation routes and evacuation network.

Step 4 - The suitability analysis of Step 3 could be enhanced using site parameters at an increased level of detail to compare emergency planning characteristics of potential sites. For example, an Evacuation Time Estimate (ETE), developed in accordance with NUREG-0654/FEMA-REP-1, Revision 1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," (NRC/FEMA, November 1980) could be prepared for each of the sites under consideration. Based on these ETE estimates, a utility function would be defined that assigns the largest ETE a value of 1 and the smallest a 5; intermediate values would be scaled between these extremes.

3.1.2.3 Atmospheric Dispersion

PPE sections applicable to this criterion are:

PPE Section	Requirement	Composite 1993 ALWR Value
9.1	Atmospheric Dispersion (Chi/Q) - Accident	
9.1.1	0.5 mile, 0-2 hr	1.0E-3 sec/m^3
9.1.2	2 mile, 0-8 hr	1.35E-4 sec/m^3
9.1.3	2 mile, 1-4 day	5.4E-5 sec/m^3
9.1.4	2 mile, 4-30 day	2.2E-5 sec/m^3
9.1.5	2 mile, 8-24 day	1.0E-4 sec/m^3

Use of the X/Q as a measure of a site's atmospheric dispersion characteristics is discussed in Section 3.1.3.3.2 (Operational Effects – Related: Atmospheric Dispersion). Because only short-term exposures are of concern during accidents, worst-case (e.g., 5 or 10 percentile) short-term X/Q estimates are of concern for this siting criterion. Guidance on appropriate dispersion models for estimating accident scenario X/Qs is provided in Regulatory Guide 1.3 (Assumptions Used for the Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Boiling Water Reactors) and Regulatory Guide 1.4 (Assumptions Used for the Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors).

Data for the development of representative accident X/Q values for regions of interest and candidate areas are generally available from National Oceanic and Atmospheric Administration (NOAA), states, universities, or private sources (e.g., meteorological observations acquired for power generation or industrial facilities, and private airfields). Because exclusionary criteria are provided for two distances and five accident averaging periods, the expected X/Q values can only be determined from hourly meteorological observations. Although extrapolating annual average X/Q values to other locations is possible, extrapolating the shorter accident periods is more problematic. In the absence of hourly observations, joint frequency distributions (JFD) of wind speed and directions by stability class can be used to develop surrogate X/Q values (e.g., median, 5 percent, and 10 percent) for use in identifying exclusionary and avoidance areas and evaluating site suitability.

Steps 1 and 2 - To the degree allowed by available meteorological data and using professional judgement, identify any areas of the region of interest where short-term dispersion characteristics do not satisfy the PPE values above. Map these areas as exclusionary and eliminate them from further consideration in the siting process.

Step 3 - Estimates of short-term X/Qs corresponding to the PPE values above would be developed for each of the candidate sites. In addition to the analysis discussed above, this evaluation should also take into account site-specific characteristics (e.g., topography and coastal effects) that could affect dispersion of accidental releases. In the absence of on-site meteorological data, professional judgement will be required to adopt regional data to account for these local effects. Any sites whose estimated dispersion characteristics do not satisfy the PPEs would be eliminated from further consideration.

Step 4 - No further analysis would be conducted in Step 4.

3.1.3 Operational Effects-Related

3.1.3.1 Surface Water – Radionuclide Pathway

Two PPE sections are applicable to this criterion. Each deals with dose standards codified in Title 10 of the Code of Federal Regulations that facility discharges must meet:

PPE Section	Requirement	Composite 1993 ALWR Value
10.1.1	Dose Consequences - Normal	10 CFR 50, Appendix I 10 CFR 20
10.1.2	Dose Consequences - Post Accident	10 CFR 20 10 CFR 100

Liquid pathway dose consequences depend primarily on source terms (PPE Section 10.3) and on dilution in the receiving water body. The latter parameter can only be accurately estimated with detailed analysis and site-specific data. Utility functions described below have been derived to provide a surrogate for the liquid pathway dose consequence requirements for siting purposes. Detailed dose consequence calculations should be performed to confirm site suitability at Step 4 of the process.

The Surface Water – Radionuclide Pathway criteria are as follows:

Report Section	Criteria	Step	1	2	3	4
3.1.3.1.1	Dilution Capacity				X	X
3.1.3.1.2	Baseline Loadings				X	X
3.1.3.1.3	Proximity to Consumptive Users				X	

3.1.3.1.1 Dilution Capacity

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - The EPA employs the Probabilistic Dilution Model as an analytical tool in the screening of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites to determine which sites have the potential to cause unacceptable health risks to downstream users and would thus require a detailed environmental fate analysis. The model is applicable to rivers and streams, but not to estuaries. The model is based on the fact that, in general, the most important process affecting a contaminant's concentration in a surface water body is the degree of dilution. The model uses stream flow data from a sub-basin and contaminant loading data to predict health-based effects for persons using the water body (EPA, 1988).

Information on the radioactive source term dilution at a new power facility will be site -specific. For siting consideration where such information is not available, however, surrogate parameters, representing the dilution capacity of a stream, can be used. The greater the dilution capacity of a stream, the shorter will be the mixing length downstream defined as the zone within which complete mixing of a discharge contaminant occurs. Mixing length varies approximately in proportion to the product of the stream velocity and the square of the stream width and inversely to the product of the stream depth and the shear velocity. The shear velocity is the square root of the product of the acceleration of gravity, the hydraulic radius (cross-section area divided by the wetted perimeter) and the energy gradient of the stream (slope of the channel). A utility function would be developed using the stream characteristics listed above and an approved analytical estimate for mixing length. EPA (EPA,1988) suggests an equation adapted from a number of sources for use in estimating stream-mixing length. The shortest mixing lengths among the potential sites would be scored 5 and the longest mixing length sites would be scored 1.

Step 4 - Based on site-specific verification studies in Step 4 the utility function developed in Step 3 would be reevaluated. If adequate data is available, the dose consequences specified in the PPE sections listed above should be estimated and compared to standards referenced therein.

3.1.3.1.2 Baseline Loadings

The capacity of a stream to impact health and safety of downstream consumers is also related to the existing, or baseline loadings of, radionuclides that are present in the system or can be anticipated in the future.

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Using data collected and reported by the USGS, the variation in radionuclide loading to streams can be evaluated for the potential sites. Where such data is not available for the potential sites, or as a supplement to this database, the upstream radionuclide discharge data from state and/or federal discharge permit information can be utilized to estimate pollutant loads from upstream sources. This information would be incorporated into a utility function to score each potential site with regard to existing radionuclide stream loadings. These scores would be modified based on the potential for future land uses, which could release additional radionuclide discharges. Sites with lowest levels of existing and projected radionuclide loadings would be scored 5 and those with highest levels would be scored 1.

Step 4 - Based on site specific information, the evaluation of radionuclide loadings would be updated in this step.

3.1.3.1.3 Proximity to Consumptive Users

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Identify the downstream locations of public water supply withdrawals and recreational contact uses for each potential site and develop a combined utility function related to the distance to these uses, with greater scoring reflective of greater avoidance of consumptive users. Sites with the greater pathway lengths to these users would be scored 5 and those with the closest pathways would be scored 1.

Step 4 - No further analysis would be required in Step 4.

3.1.3.2 Groundwater Radionuclide Pathway

The EPA issued its Groundwater Protection Strategy in August 1984 and provided Guidance for Groundwater Classification in December 1986 (EPA, 1986) under its responsibilities as outlined in the SDWA. The Strategy established three general classes of ground water representing a hierarchy of groundwater resource values to society as follows:

- Class I - Special groundwater
- Class II - Groundwater currently and potentially a source of drinking water
- Class III - Groundwater not a source of drinking water.

Class I ground waters are resources of unusually high value. They are highly vulnerable to contamination and are (1) irreplaceable sources of drinking water and/or (2) ecologically vital. Many states have adopted their own system based on the EPA strategy and have mapped the locations of groundwater classes.

Steps 1 and 2 - Map as avoidance areas the location of Class I ground waters.

Step 3 - Within a two-mile area of the potential sites, develop a utility function based on the percentage of Class II and Class III groundwaters. If these groundwaters have not been designated, utilize the procedures and data outlined in EPA guidance to evaluate the groundwaters within two miles of the site. For example, the considerations to be evaluated for a designation of Class I includes the following:

- Highly vulnerable groundwater
- Irreplaceable source of drinking water
- Ecologically vital groundwater.

The EPA (EPA, 1987) has developed a numerical ranking system called DRASTIC, using readily available information on the following seven hydrogeologic characteristics to evaluate vulnerability:

- D - Depth to the water table
- R - Net Recharge
- A - Aquifer media
- S - Soil media

- T - Topography
- I - Impact of the vadose zone
- C - Hydraulic conductivity of the subject ground-water flow system

DRASTIC provides a standardized technical basis for evaluating the relative vulnerability of shallow aquifers to groundwater pollution. The higher an area scores on the index, the more susceptible to groundwater contamination. The numerical value obtained is related to two broad climatic regions in the country, based on whether the annual evapotranspiration exceeds mean annual precipitation. These seven criteria can be evaluated and utilized to rank the potential sites over the scoring range of 1 to 5.

Step 4 - Site-specific information developed in Step 4~~,~~ will be used to revise the utility function developed in Step 3 to develop a ranking of sites for suitability.

3.1.3.3 Air Radionuclide Pathway

The Air Radionuclide Pathway criteria are as follows:

Report Section	Criteria	Step 1	2	3	4
3.1.3.3.1	Topographic Effects	X	X	X	X
3.1.3.3.2	Atmospheric Dispersion	X	X	X	X

3.1.3.3.1 Topographic Effects

Topography of a region or area has an effect on both the dispersion characteristics of a site and on the impacts of the facilities' operation on the environment. In general, the rougher the terrain, the more likely that complex transport and dispersion conditions would not be appropriately represented in the X/Q dispersion estimates described in Sections 3.1.2.3 and 3.1.3.3.2. Channel flows, up/down valley flows, and sea breeze recirculation are examples of topographically induced dispersion and transport conditions that cannot be properly assessed if the meteorological data are not measured in locations representative of these conditions. These same complex transport and dispersion conditions could alter fogging and icing frequencies used in the assessment of transportation safety.

Steps 1 and 2 - These steps are not applicable to this criterion.

Steps 3 and 4 - Topographic features of the siting regions/areas should be considered qualitatively in the evaluation of atmospheric dispersion, transportation safety, and site preparation. Significant topographic features involving significant local meteorological effects, resulting in significant potential for fogging/icing impacts, and/or requiring extensive land preparation will make the site less suitable. For example, sites located in valleys or with other topographic restrictions to free atmospheric transport and dispersion would be less favorable locations for a facility. Applicants should incorporate the effects of topographic features into the utility functions defined for criteria that reflect these impacts (e.g., 3.1.2.3 - Atmospheric Dispersion, 3.1.3.6 - Transportation Safety, 3.4.3.2 - Topography (Cost)). Topographic data required for this assessment can be obtained from a number of sources (e.g., U.S. Geologic Survey topographic in maps of various scales and in electronic media).

3.1.3.3.2 Atmospheric Dispersion

The PPE section defining the dispersion meteorological envelope that must be satisfied for successful ALWR siting is as follows:

PPE Section	Requirement	Composite 1993 ALWR Value
9.2	Atmospheric Dispersion (X/Q) (Annual Average)	0.5 mile 7.2E-5/ 1.0 mile 1.5E-5 sec/M3

The dispersion parameter used to evaluate and distinguish exclusionary and avoidance areas and, where possible, suitability criteria is an estimated ambient concentration normalized by the emission rate (X/Q in units of sec/m^3). The X/Q values are independent of emission rate and are, therefore, a measure of the dispersion qualities of the atmosphere at the location of measurement and at other locations where the data can be considered representative. The application of meteorological data measured at one location to other areas and sites should be based on professional judgment considering a number of factors (e.g., topography, proximity of locations, and exposure). Guidance on the appropriate dispersion model to use in this assessment is provided in Regulatory Guide 1.111 (Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors).

Data for the development of representative annual average X/Q values for regions of interest and candidate areas are generally available from National Oceanic and Atmospheric Administration (NOAA), states, universities, or private sources (e.g., meteorological observations acquired for power generation or industrial facilities, and private airfields). It is important to note that these data are characteristic only of the location of the measurement station. Actual site-specific data for a candidate sites will only be available once a site is selected. However, extrapolation of available data to other areas or potential site locations is possible considering a number issues (e.g., topography, meteorological data acquisition design and location) and incorporating the judgment of a professional meteorologist. Such extrapolations allow use of existing data for siting evaluations.

Steps 1 and 2 - To the degree allowed by available meteorological data and using professional judgement, identify any areas of the region of interest where annual average dispersion characteristics do not satisfy the plant parameter values above. Map these areas as exclusionary and eliminate them from further consideration in the siting process.

Step 3 - Using methods and data outlined above, develop annual average X/Q estimates for each candidate area. Develop a utility function in which the site with the lowest X/Q receives a 5 and the highest a 1; sites with intermediate X/Q values would be given proportionate intermediate scores.

Step 4 - No further analysis would be conducted in Step 4.

3.1.3.4 Air-Food Ingestion Pathway

A potential human exposure pathway is airborne radionuclides emissions from the power station through the food chain for adjacent crops and pasture operations.

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - The amount of crop and pasturelands in the areas surrounding potential sites would be determined and used to develop a utility function related to the potential for impacts via the air-food pathway. Using a GIS, the acreage of crop and pasturelands within the following annuli would be measured: (1) 0 to 10 miles; (2) 10 to 20 miles; and, (3) 20 to 30 miles. The acreage would be weighted on a graduated scale with the nearer areas receiving a greater emphasis. The cumulative weighted average for each potential site would form the basis for the utility function, with the highest acreage sites receiving a score of 1 and the lowest acreage sites a score of 5.

Step 4 - The site-specific studies to be conducted in Step 4 would not allow site-specific determination of the annual wind sector data such as will be needed at the preferred site for ESP. Therefore, no additional analysis would be conducted.

3.1.3.5 Surface Water – Food Radionuclide Pathway

In addition to the potential pathways addressed in Section 3.1.3.1 Surface Water, and Section 3.1.3.2, Groundwater Radionuclide Pathway, use of irrigation waters in downstream areas is a potential pathway for radionuclides.

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Potential sites would be evaluated based on the proximity in the downstream direction to stream withdrawal locations and the acreage of the irrigation usage. A utility function would be developed to reflect these combined variables and sites with the greatest potential for this irrigation pathway would be scored a 1 and those will the lowest potential would be scored a 5.

Step 4 - The utility function and analysis developed for Step 3 would be updated based on the site-specific information from Step 4.

3.1.3.6 Transportation Safety

Potential impacts from facility operations on transportation safety could occur as a result of increased hazards such as fog and ice from the operation of cooling systems (e.g., cooling towers and cooling reservoirs). Cooling systems operations could increase fogging or icing occurrences in the facility area or increase the intensity of naturally occurring fogging or icing events. Sites with greater potential for naturally-occurring fogging and/or icing conditions will generally be more likely to be affected by facility cooling systems operations. Therefore, regions, areas, and sites with greater historical frequency of fogging and icing conditions will be less suitable for facility development.

Data on the historical occurrence of fogging and icing conditions can be obtained from NOAA, states, universities, and private sources (e.g., meteorological observations acquired for power generation or industrial facilities, and private airfields). Applicable statistical evaluations or studies may also be available from these same sources or in the general literature. Review of available studies, or analyses of available meteorological data, will be required to establish the historical fogging and icing conditions for regions, areas, and sites of interest.

Steps 1 and 2 - These steps are not applicable to this criterion.

Step 3 - Frequencies of fogging and icing would be developed by extrapolating data from existing meteorological measurements. A utility function would be developed based on the frequency of icing and fogging occurrence at each of the potential sites. Sites with low occurrences would be scored a 5 and sites with high occurrences would be scored a 1; intermediate values would be scored in proportion to the fogging/icing frequency data estimate.

Step 4 - No further analysis would be required in Step 4.

3.2 Environmental Criteria

3.2.1 Construction-Related Effects on Aquatic Ecology

3.2.1.1 Disruption of Important Species/Habitats

Regulatory Guide 4.7 points out that proper siting of nuclear power stations should consider effects on populations of important species or ecological systems. The Regulatory Guide defines important species as follows:

> "A species, whether animal or plant, is important (for the purpose of this guide) if a specific causal link can be identified between the nuclear power station and the species and if one or more of the following criteria applies:
>
> 1. If the species is commercially or recreationally valuable,
> 2. If the species is endangered or threatened,

3. If the species affects the well-being of some important species within criteria (1) or (2) or if it is critical to the structure and function of a valuable ecological system or is a biological indicator of radionuclides in the environment."

Applicants should also note that the Endangered Species Act, 16 USC §§ 1531 et seq requires that any action authorized, funded, or carried out by a federal agency in the US must not likely jeopardize the continued existence of any listed endangered or threatened species or result in the destruction or adverse modification to critical habitat.

Of particular concern are the following habitat areas that are utilized by the significant important species, including considerations of seasonal use:

- breeding and nursing
- nesting and spawning
- wintering, and
- feeding.

Important considerations regarding the evaluation of disruptive effects include the uniqueness of the habitat within the region and the amount of habitat that would be destroyed or disturbed relative to the total amount in the region, considering also the effects on the reproductive capacity of the important species.

Step 1 - Map designated critical habitats of endangered species as exclusionary.

Step 2 – Screen the area remaining after application of Step 1 for the likely presence of threatened or endangered (T&E) species. Avoid sites where T&E species are known to be present (e.g., nesting or feeding areas).

Step 3 - Evaluate the remaining sites identified in Step 2 for presence of important species habitats such as marine grasses, commercial shellfish beds, spawning, nursing, and feeding areas. Based on an evaluation of the relative proportion of comparable habitat at the site to the surrounding region, and considering the importance of reproductive capacity, develop a utility function with a rating of 5 assigned to sites where no potential impact is expected, 3 assigned to sites where a potential moderate impact is expected, and 1 where potential severe impact is expected. Intermediate ratings will be based on professional judgment.

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information.

3.2.1.2 Bottom Sediment Disruption Effects

Potential short-term impacts to aquatic resources may occur as a result of dredging and related operations that disturb bottom sediments. Two considerations can be used to evaluate the degree of impact which might occur from these activities: (1) the extent of contamination or potential for contamination; and, (2) the grain size of sediments. Based on a number of studies by EPA's Office of Water Studies (EPA, 1986 and 1987) and a report by the National Academy of Science, "Contaminated Marine Sediments -- Assessment and Remediation," EPA indicated that sediments in all types of water bodies, at hundreds of locations across the country, are contaminated at levels that harm benthic and other aquatic communities and that potentially threaten human health and wildlife. The sediment contaminants of greatest concern appear to be heavy metals and persistent, toxic, bioaccumulative organic compounds.

Based on this finding, the EPA formulated and issued for public comment in March 1992 a strategy for contaminated sediment management. EPA initially focused attention on developing chemical-specific sediment contaminate level guidelines to protect benthic organisms from the following organic contaminants: acenapthene, dieldrin, endrin, fluoranthene, and phenanthrene.

In general, fine-grained sediments (muds) have higher water content and higher concentrations of contaminants than coarser (sandy) sediments, due to their capacity for adsorbing contaminants.

The following Bottom Sediment Disruption Effects criteria and their application in the various siting steps are as follows:

Report Section	Criteria	Step 1	2	3	4
3.2.1.2.1	Contamination			X	X
3.2.1.2.2	Grain Size			X	X

3.2.1.2.1 Contamination

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Using data compiled by EPA, NOAA, and state agencies as part of EPA's Contaminated Sediment Strategy, the level of sediment contamination for areas within the potential sites where dredging may occur would be identified. Scoring would be based on professional judgment and/or related guidance from EPA or state agencies.

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information. Detailed site information and ecological investigations would be used to score the candidate sites.

3.2.1.2.2 Grain Size

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - The range of sediment grain sizes for the potential sites identified in Step 2 would be identified. Potential data sources include the USGS stream database, state publications, and NOAA studies. Develop a utility function to score the sites with the highest percentages of silt and clay as 1 and the sites with the lowest percentages of silt and clay as 5. Where sediment grain size data are not available, the scoring would be made on the basis of professional judgment based on stream morphology information at the site. The use of grain-size data would provide a supplement to the contamination evaluation discussed above.

Step 4 - The utility functions and analysis completed in Step 3 will be updated and reevaluated for the remaining candidate sites, based on site-specific information.

3.2.2 Construction-Related Effects on Terrestrial Ecology

3.2.2.1 Disruption of Important Species/Habitats and Wetlands

The Disruption of Important Species/Habitats and Wetlands criteria and their application in the various siting steps are as follows:

Report Section	Criteria	Step	1	2	3	4
3.2.2.1.1	Important Species/Habitats		X	X	X	X
3.2.2.1.2	Ground Cover/Habitat				X	X
3.2.2.1.3	Wetlands		X	X	X	X

3.2.2.1.1 Important Species/Habitats

Steps 1 - Map designated critical habitats of endangered species as exclusionary.

Step 2 - Screen the areas remaining after Step 1 for the likely presence of threatened or endangered (T&E) species. Avoid areas where T&E species (either flora or fauna) are known to be present.

Step 3 - Score the remaining sites according to the potential presence of all important species habitats, including feeding, wintering, or nesting areas, relative to the surrounding region. Develop a utility function with a rating scale of 5 to 1. A score of 5 would be assigned to sites that are outside the known range of important species; 4 would be assigned to sites within the known range of important species but where no suitable habitat is present; 3 would be assigned to sites within the known range of important species, where suitable habitat is present, but where no sightings have been recorded; 2 would be assigned to sites within the known range of important species, where suitable habitat is present, and where there are reports of such species in transit through the area; and 1 would be assigned to sites within the known range of important species and where there are reports of the species present in the general area.

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information.

3.2.2.1.2 Groundcover/Habitat

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Two factors, consisting of the ecological value and acreage of each ground cover type (e.g., woodlands, scrub, and grasslands) covering the site, would serve as a surrogate for the impact that construction would have on terrestrial ecology.

- Ecological Value. The potential sites identified in Step 2 would be scored by a biologist, according to the ecological value of the ground cover present. The ecological value of each habitat type is dependent on several factors, including type of vegetation, the successional stage, the uniqueness of the species (both flora and fauna), and the ecological function. Based on professional judgment, sites will be scored from 1 (highest) to 5 (lowest) in respect to their ecological value.
- Acreage of Ground Cover Covering Site. For each of the potential sites identified in Step 2, the acreage of each habitat type/ground cover would be determined. An overall weighted average score for each site would be determined based on the value category score weighted by its acreage, summed over the whole site. Sites with the highest weighted average score would be assigned a rating of 1, sites with the lowest weighted average score a rating of 5; those with intermediate scores would be given a proportional intermediate rating. Alternatively, an expert in the field of terrestrial ecology would assign an overall rating according to the distribution and functional value of the habitat mix.

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information.

3.2.2.1.3 Wetlands

Applicants should note that Executive Order, E.O. 11990, “Protection of Wetlands” requires that each federal agency “avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative…”

Step 1 - Exclude major wetlands shown on USGS topographic maps and land use and land cover maps (1:250,000 scale).

Step 2 - No further analysis; simply transpose exclusions to larger scale maps for better definition of boundaries. National Wetlands Inventory maps (1:24,000 scale) could be utilized, if available.

Step 3 - Site scores would range from a 5 for those with no or minimal wetlands of value to a 1 where a substantial amount of valuable wetlands is affected. USGS and wetland inventory maps (1:24,000 scale), or other locally available mapping sources, should be used to determine the amount of wetlands present at each of the potential sites identified in Step 2.

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites based~~,~~ on site-specific information, including wetland delineation mapping.

3.2.2.2 Dewatering Effects on Adjacent Wetlands

The Dewatering Effects on Adjacent Wetlands criteria and their application in the various siting steps are as follows:

Report Section	Criteria	Step	1	2	3	4
3.2.2.2.1	Depth to Water Table				X	X
3.2.2.2.2	Proximal Wetlands				X	X

3.2.2.2.1 Depth to Water Table

Steps 1 and 2 - These Steps are not applicable to this criterion. The ALWR PPE prescribes that the groundwater level must be at least two feet below grade. Areas with groundwater less than two feet below grade should be avoided. Initial screening can be conducted by using an environmental data base such as DENIX (Department of Defense Environmental Network and Information eXchange) and SCS maps. Because detailed information regarding the water table is not available at scales smaller than SCS county soil maps (1:20,000), it is not possible to utilize water table depths as a criterion in Step 1 or 2.

Step 3 - The potential sites identified in Step 2 would be evaluated using the DENIX database and the soils analysis data mapped as a part of the soil stability criteria (see Section 3.1.1.1.4). Sites where the water table is less than two feet above grade would be mapped as avoidance areas.

A utility function would also be developed to score the remaining sites according to the depth of the water table. A score of 5 would be assigned to sites where the maximum depth to the water table occurs. A score of 1 would be assigned to sites where the depth of the water table is closest to 2 feet below grade. Intermediate scores will be based on professional judgment.

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites based on site-specific information.

3.2.2.2.2 Proximal Wetlands

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Develop a utility function to score the potential sites according to their relative proximity to wetlands. Areas farthest away from wetlands would be scored 5 and areas closest would be scored 1. An overall site average distance to wetlands score would be developed using GIS.

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information; sites proximal to wetlands with high functional value for wildlife and/or water quality would receive a relatively lower numerical score (would be less suitable) than those sites not proximal to such wetlands.

3.2.3 Operational-Related Effects on Aquatic Ecology

3.2.3.1 Thermal Discharge Effects

The Thermal Discharge Effects Criteria and their application in the various siting steps are as follows:

Report Section	Criteria	Step 1	2	3	4
3.2.3.1.1	Migratory Species Effects			X	X
3.2.3.1.2	Disruption of Important Species/Habitats			X	X
3.2.3.1.3	Water Quality			X	X

3.2.3.1.1 Migratory Species Effects

Applicants should note that the Migratory Bird Treaty Act, 16 USC §§ 703 et seq., makes it unlawful to pursue, take, or kill migratory birds or the nest or eggs of such birds. Also, the Bald and Golden Eagle Protection Act, 16 USC §§ 668 et seq., makes it unlawful to pursue, molest, or disturb bald and golden eagles, their nests, or their eggs in the US. Golden eagle nests that interfere with resource development or recovery operations may be relocated if a permit is obtained from the US Department of Interior.

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Four factors – the stream capacity flow, the width of the stream, the size of ponds or lakes, and the abundance of migratory species – will determine the effect that a thermal discharge will have on migratory species.

- Stream Capacity Flow. Develop a utility function to score the potential sites according to the stream capacity flows. High flows would be scored 5 and low flows would be scored 1, using the methods outlined in Section 3.1.3.1.
- Width of the Stream. Develop a utility function to score the potential sites according to the width of the streams that flow past the site. Sites with the largest widths would be scored 5 and those with the smallest widths would be scored 1.
- Size of Ponds or Lakes. Develop a utility function to score the potential sites according to the size (dilution capacity) of the ponds or lakes on the site that may be affected by thermal discharges. Sites with the largest size (volume) would be scored 5 and those with the smallest size would be scored 1.
- Species Abundance. Develop a utility function to score the potential sites according to the relative abundance of migratory species present at the site. Sites with small numbers of migratory species would be scored 5 and sites with large numbers of migratory species would be scored 1.

The migratory species scores would be an appropriate combination of the scores for the four factors discussed above. The highest combined scores would be assigned to sites that have high volumes of water available and low migratory species abundance. For example, a final score of 5 would correspond to a site that either does not have migratory species or a site that contains migratory species but a minimal impact is expected as a result of a thermal discharge to a large capacity stream or lake. A final score of 1 would be assigned to sites where potentially severe impacts to migratory species would occur as a result of a thermal discharge.

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information.

3.2.3.1.2 Disruption of Important Species/Habitats

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Following the methods and considerations outlined in Section 3.2.1.1, a utility function would be developed, based on the potential effects on these resources, beyond those identified due to construction, which may result from operational activities.

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information.

3.2.3.1.3 Water Quality

The PPEs establish values, which bound the chemical, thermal and flow characteristics of blowdown from ALWR cooling systems. They are as follows:

PPE Section	Requirement	Composite 1993 ALWR Value
2.7.4 2.8.3 2.10.2 3.6.4 3.8.2	Blowdown Constituents and Concentrations	See table directly below
2.7.5 2.10.3	Blowdown Flow Rate (Mechanical Draft & Pond)	5,200(17,700) GPM
2.8.4	Blowdown Flow Rate (Natural Draft)	5,200(17,700) GPM
2.7.6 2.8.5 2.10.4	Blowdown Temperature (Closed Cycle)	100 F
2.7.9 2.8.8 2.10.7	Cycles of Concentration (Closed Cycle)	4
2.9.1	Cooling Water Discharge Temp (Once-through)	118 F
2.9.3	Cooling Water Temperature Rise (Once-through)	18 F
2.9.5	Heat Rejection Rate (Once-through)	9.7E9 BTU/hr

Blowdown Constituents and Concentrations			
	Concentration (ppm)[1]		
Constituent	River Source	Well/Treated Water	Envelope
Chlorine demand	10.1	--	10.1
Free available chlorine	0.5	--	0.5
Chromium	--	--	--
Copper	--	6	6
Iron	0.9	3.5	3.5
Zinc	--	0.6	0.6
Phosphate	--	7.2	7.2
Sulfate	599	3,500	3,500
oil and grease	--	--	--
Total dissolved solids	--	17,000	--(1)
Total suspended solids	49.5	150	150
BOD, 5-day	--	--	--

(1) Assumed cycles of concentration equals 4

These parameters define the thermal and water quality impacts that cooling system blowdown effluents will have on the receiving water body for the various cooling system configurations. For a site to be acceptable, it must be possible for the ESP applicant to obtain permits for these discharges. This, in turn, will depend on the applicable state and Federal Clean Water Act, regulations, existing water quality, existing thermal loading, and, in some cases, biological sensitivity of the receiving water body. Due to the current regulatory atmosphere for once-through (open-cycle) cooling systems, applicants should specifically consult with permitting agencies to ensure that this option remains viable before eliminating sites based on values 2.9.1, 2.9.3, or 2.9.5.

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - The following factors should be considered in determining the effect that thermal discharges will have on overall water quality: baseline thermal loadings (from upstream facilities), baseline ambient water temperature, expected stream flow rate, stream width, the sensitivity of the species present, and baseline concentrations of dissolved oxygen, dissolved solids, and nutrients. An expert in the field of aquatic ecology will score the potential sites according to the magnitude of the potential impacts to water quality by taking into account all of the factors named above, at a minimum, and considering applicable state standards regarding thermal pollution. Sites would be scored from 5 (low impact) to 1 (high impact) according to the overall expected impacts to water quality.

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information.

3.2.3.2 Entrainment/Impingement Effects

3.2.3.2.1 Entrainable Organisms

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Develop a utility function to score the potential sites according to the expected density of potentially entrainable organisms such as phytoplankton and zooplankton. Particular emphasis should be given to the possibility of high seasonal densities of significant zooplankton species. Lowest densities would be scored 5 and highest densities would be scored 1.

Step 4 - The utility function and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information.

3.2.3.3 Dredging/Disposal Effects

The Dredging/Disposal Effects criteria and their application in the various siting steps are as follows:

Report Section	Criteria	Step	1	2	3	4
3.2.3.3.1	Upstream Contamination Sources				X	X
3.2.3.3.2	Sedimentation Rates				X	X

3.2.3.3.1 Upstream Contamination Sources

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Develop a utility function to score the potential sites according to the amount of contamination that is released from facilities upstream. The scoring would range from 5 for sites with a low potential for upstream contamination sources to a score of 1 for sites with a high potential for upstream contamination.

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information.

3.2.3.3.2 Sedimentation Rates

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Using data from sediment and hydrology studies, an assessment will be made on the range of sedimentation rates for each of the potential sites for areas which may require maintenance dredging around intake structures. Scores would range from 1 for sites with high sedimentation rates to 5 for sites with low sedimentation rates.

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information.

3.2.4 Operational-Related Effects on Terrestrial Ecology

3.2.4.1 Drift Effects on Surrounding Areas

The Drift Effects on Surrounding Areas criteria and their application in the various siting steps are as follows:

Report Section	Criteria	Step 1	2	3	4
3.2.4.1.1	Important Species/Habitat Areas			X	X
3.2.4.1.2	Source Water Suitability			X	X

3.2.4.1.1 Important Species Habitat Areas

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Areas within 10 miles of the site where habitats of important species or habitats of high ecological value occur (including wetland areas) would be mapped based on 2-, 4-, 6-, 8-, and 10-mile annuli. The acreage of these important habitats within each annulus would be measured and weighted as a function of distance to provide an overall distance-weighted measure of nearby important habitats. A utility function would be developed for this data to score sites, ranging from a high-weighted acreage of important habitats as 1 to those with low values as 5. This evaluation may be delayed to Step 4 for sites where drift problems are unlikely (e.g., non-coastal sites).

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information.

3.2.4.1.2 Source Water Suitability

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Several factors should be considered in evaluating the magnitude of the potential drift effects as a result of variations in the chemical character of source water. Such factors vary regionally and include evaporation rate and concentrations of dissolved solids. Using data characterizing the potential concentrations of dissolved solids for various potential water sources, an expert in the field of water resources would score the potential sites according to the expected magnitude of the potential impacts to water quality from cooling tower drift. Sites would be scored from 5, for sites with lowest levels of dissolved solids and evaporation rates, to 1 for sites with highest levels of dissolved solids.

Step 4 - The utility functions and analysis completed in Step 3 would be updated and reevaluated for the remaining candidate sites, based on site-specific information.

3.3 Socioeconomics Criteria

The siting, construction and operation of a nuclear power station can place stresses on the local labor supply, transportation facilities, and community services. An evaluation of suitability of nuclear power station sites should include an assessment of impacts of construction and operation, including transmission and transportation corridors, and potential problems relating to community services (e.g., schools, police and fire protection, water and sewage, and health facilities). In addressing such impacts in site selection, applicants should note that NRC places special emphasis on impacts to communities "… that possess notably distinctive cultural character, i.e., towns that have preserved or restored numerous places of historic interest, have specialized in an unusual industry or avocational activity, or have otherwise markedly distinguished themselves from other communities."

Siting decisions should also reflect fair treatment and meaningful involvement of all people, regardless of race, ethnicity, culture, income or educational level to assure equitable consideration and to minimize disproportionate effects on minority and low-income populations. NRC has committed to carrying out the measures set forth in Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (50 FR 7629), to ensure that effects of its actions do not disproportionately impact minority and low-income communities.

- Socioeconomic criteria related to siting a nuclear power facility are defined by a number of socioeconomic factors including:
- Impacts on local labor supply
- Impacts of importing labor
- Impacts to local infrastructure and community services such as fire protection, police protection, utilities, health care, education, recreation and transportation
- Impacts on local taxes and community expenditures
- Impacts on community culture and character
- Impacts on minority and low-income populations (environmental justice).

Incompatible land uses, referred to as "nearby hazardous land uses," are discussed in Section 3.1.1.4. The following sections discuss the socioeconomic and environmental justice criteria associated with construction and operation of a nuclear power facility.

3.3.1 Socioeconomic - Construction Related Effects

The PPE section relevant to this criterion is the construction workforce requirement.

PPE Section	Requirement	Composite 1993 ALWR Value
29.4.1	Facility workforce - construction	2,600 – 6,410 People

The facility construction workforce is likely to be available at any location that is found suitable for a nuclear power facility. The issue in siting, therefore, is the potential socioeconomic impact associated with the temporary influx of construction workers who live too far away to commute daily from their residence. The criterion described below is designed to consider sites from this perspective; no other application of this PPE section to the siting process is required.

The construction of a nuclear power facility is very labor-intensive. For the ALWR, skilled and unskilled construction workers would likely be needed over a 4 to 5 year period. Socioeconomic impacts of nuclear power facility construction are directly related to two factors:

- The number of construction workers who will move into the facility site vicinity with their families; and
- The capacity of the communities surrounding the facility site to absorb this new (immigrant) population.

The number of immigrant workers is dependent upon labor availability within commuting distance of the facility site. If an adequate supply of workers is available within reasonable commuting distance of the job site, few (if any) workers would choose to relocate to the site vicinity. The capacity of communities to absorb an increase in population depends on the availability of sufficient resources, such as adequate housing and community services (e.g., schools, hospitals, police, transportation systems, and fire protection) to support the influx without straining existing services. Impacts to a small community located along the commuter route(s) (e.g., food, lodging, gas, and congestion) can also be significant and should be considered when siting a facility.

The trigger for adverse socioeconomic impacts is the need to relocate construction workers and their families into local communities. The severity of socioeconomic impacts is proportional to the level of stress placed on the community services by the relocated workers and their families. A highly populated urban area would probably have a sufficient labor pool to accommodate the demands of nuclear power facility construction. It is also more likely to have the required mix of skilled and unskilled laborers, and the more urbanized areas can more readily absorb the influx of workers and their families. By contrast, a sparsely populated area is not as likely to have, or be able to support, an adequate labor pool. In such instances, workers migrating into the area, frequently with their families, can severely impact the available housing market and community services. An indirect effect that could also occur with the temporary relocation of a large construction workforce, the construction of new housing, and the expansion of existing social services to meet the demands of a high influx of workers, is the potential for additional immigrants (non-construction workforce) coming to the area to take advantage of the improvements. In addition, there is the potential for induced growth from certain industries that may choose to relocate to the area because of the availability of a major new source of electrical power. Such an influx could alter the character of the local community, and fiscal impacts of this growth may be disruptive.

A site having minimal socioeconomic impact would either be (1) located within a reasonable commuting distance from a major town, city, or metropolitan area that has an adequate and available labor force, and an appropriate mix of skilled and unskilled workers or (2) located within a reasonable commuting distance from a major town, city, or metropolitan area that can absorb much of the influx of construction workers with little disruption to services and lifestyle. Such information is available in Census Bureau data. Careful planning on the part of the applicant and the community can help to minimize these impacts.

From a socioeconomic perspective, the information that should be considered in rating sites from the perspective of construction impacts includes:

- Labor requirements
- Location of labor pool
- Number of immigrants
- Fiscal assessment of affected communities.

It is important to understand the inverse interrelationship among socioeconomic impacts and health and safety/emergency planning criteria. From a socioeconomic perspective, proximity of a facility site to a major urban center is advantageous in terms of finding an adequate labor supply. However, from a health and safety perspective, a large population in the facility vicinity results in greater public health and safety concerns (e.g., radiological impacts and emergency planning). Population and emergency planning considerations are discussed in Section 3.1.2 of this Siting Guide.

In addition to avoiding protected and/or sensitive land uses in siting a nuclear facility (Section 3.3.4), there is a need to consider the direct and indirect economic impact of nuclear power facility construction on the value of surrounding land uses. First, nuclear power facilities can preempt large areas, especially when large cooling lakes are constructed. The land requirement is likely to be an issue when a proposed site is on productive land (e.g., agricultural land) that has limited local availability and is important to the local economy, or which may be needed to meet foreseeable national demands for products.

Second, it has also been argued that construction of a nuclear power facility may create a "stigma effect" (or indirect effect) on the value of adjacent land uses, based on perceived effects. According to this argument, residential properties would decline in value and agricultural lands would become less valuable as a result of nuclear power facility construction. Interestingly, even though the concern expressed is related to nuclear power facility *operation*, proponents of this view believe that this type of socioeconomic impact actually occurs during construction (in anticipation of operation). Little data exist as to whether this perceived socioeconomic condition translates into an actual, measurable impact. Nevertheless, it is an important public concern that relates to siting.

From a siting perspective, consideration of the "stigma effect" is appropriate at the Candidate Site evaluation phase (Step 4) and is as much a public participation concern as a quantitative socioeconomic one.

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - The suitability analysis for Step 3 would include development of utility functions for (1) availability of an adequate labor force with commuting distance and (2) the ability of the community to absorb the influx of workers should they relocate. Information to be utilized includes Census Bureau data, information from state and local planning agencies, and from state economic development agencies (e.g., zoning and land use planning categories). Potential sites with an adequate labor force within a reasonable commuting distance would be scored 5; sites with on inadequate labor pool and potentially significant impacts due to labor force influx would be scored 1. Communities without a labor force within a reasonable commuting distance, but with a lesser degree of potential impact would be scored intermediate values based on professional judgment.

Step 4 - Using the utility scoring function prepared in Step 3, the applicant would refine site ratings based on more detailed site-specific data, as available.

3.3.2 Socioeconomics – Operation

The operation of an ALWR requires a labor force of about 800 skilled workers. Thus, the greatest socioeconomic impacts occur during construction rather than operation. The socioeconomic impacts of operation tend to be a function of negotiations between the utility and affected communities regarding benefits that the utility might provide during the life of the facility. Such benefits can include special tax plans, support to local emergency planning efforts, and educational programs. These can be viewed as income provided to affected communities by the utility. Such benefits are typically the subject of negotiations between the applicant and local communities late in the siting process and are not appropriate for inclusion in the process itself. However, applicants who identify significant site specific community benefits may wish to design a qualitative utility function to allow such factors to be taken into account in identifying a preferred site.

3.3.3 Environmental Justice

The purpose of an environmental justice evaluation is to identify and address, as appropriate, disproportionately high and adverse human health and environmental effects on minority and low-income populations. These populations may be present in scattered small groups or may have unusual customs, practices, or dependencies on specific resources (e.g., fish) that would be overlooked in a reconnaissance level analysis that focuses on the majority population. As a result, it is necessary to evaluate impacts for each such population(s) and to more carefully examine unusual environmental pathways and unique lifestyles and practices (subsistence activities or dependence on specific water supplies) that could result in disproportionately high and adverse impacts on them.

With respect to environmental justice, the evaluation is a two-step process. The first step is to identify whether any minority and low-income populations exist that may be impacted by nuclear power facility construction and operation. The area to be evaluated for such populations would coincide with the area within a 50-mile radius of the site. If any minority or low-population groups are identified, the second step is to assess the degree to which each minority or low-income population would disproportionately experience adverse human and environmental impacts and/or would disproportionately be deprived of benefits. Guidelines for specific information requirements for environmental justice determinations are described in Attachment 4 to NRR Office Letter No. 906, Revision 1: "Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues" (1996).

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 - Minority and low-income populations would be identified in relation to the reactor site and site vicinity. Potential sites with a low population of minorities and low-income populations (weighted by distance from the site) would be scored a 5. Potential sites with high such populations would be scored 1, with intermediate values based on professional judgement. Bureau of Census data (US and State level) are particularly useful repositories for mapping environmental justice data; other good sources include State and County government agencies, as well as local university departments of economics and sociology.

Step 4 - Using the utility scoring function prepared in Step 3, refine site ratings based on more detailed site-specific data, as available.

3.3.4 Land Use

The purpose of this criterion is to assess site suitability with respect to compatibility of a NPP site with existing and planned land uses. This criterion is also structured to take into account visual impacts of site development. Land uses that are incompatible with nuclear power facilities because of the hazards they pose to safe operation are categorized as "nearby hazardous land uses;" these are discussed in Section 3.1.1.4.

Regulatory Guide 4.7 identifies three general land use issues that should be addressed in nuclear power facility siting: consistency with land use plans adopted by Federal, state, regional or local agencies; specialty crop production, and aesthetic effects. Specific suitability issues identified in Appendix B of the Regulatory Guide include existing and prospective designated amenity areas, public planning (land use planning and zoning), and visual amenities.

Many site factors (e.g., zoning, visual impacts) that are necessary to assess these suitability issues can be evaluated only in the context of discrete land parcels that are identified in Steps 3 and 4 of the siting process. Issues important in suitability determinations can also be highly localized; for example, farmland may be important at one site, public amenities at another, and visual impacts at a third.

To focus the evaluation of land use compatibility in site selection, this criterion is structured to avoid sensitive land uses in the early stages (Steps 1 and 2) of the process and to focus on tailored evaluation of individual sites, taking into account both local issues and site-specific conditions, in the latter stages (Steps 3 and 4).

Land use criteria also relate to public amenity areas, such as national parks, preserves, or ecologically sensitive areas (e.g., historic property or site on the National Register of Historic Places). The evaluation of site suitability in the vicinity of public amenity areas is dependent, in part, on consideration of a specific facility design and station layout in relation to potential impacts on the public amenity areas. However, public amenity areas that are distinctive, unique, or rare in a region should be avoided as sites for nuclear power stations. In applying the land use criterion, applicants should also note the requirements codified in Federal laws listed in Table 3-3.

Table 3-2
Phase 1 Factors for Existing Site Evaluations

- Organic Act of the National Park Service, 16 USC § 1, under which construction activities within the national park system (including national parks, monuments, reservations, recreation areas, conservation areas, and cemeteries) are subject to the US Department of Interior regulations and must be conducted so as to prevent or minimize damage to the environment and other resource values. Activities inconsistent with the purpose for which a national park system land was established (to leave the areas unimpaired for future generations) would be precluded.
- Wild and Scenic Rivers Act, 16 USC §§ 1271 et seq., which prohibits development that would have a direct and adverse effect on federally designated wild and scenic rivers without approval by the US Secretary of Interior or US Secretary of Agriculture, as appropriate.
- Costal Zone Management Act, 16 USC § 1451 et seq., which requires that facilities located in the coastal zone or that would directly affect the coastal zone are consistent with approved state coastal zone management programs.
- National Wildlife Refuge System Administration Act, 16 USC §§ 668dd et seq., which prohibits industrial activity in a national wildlife refuge without receipt of a permit or easement from the US Fish and Wildlife Service, upon a determination that such use is compatible with the purpose for which the refuge was established (to protect and conserve wildlife and their habitat).
- Wilderness Act, 16 USC §§ 1131 et seq., which generally prohibits the conduct of any commercial enterprise within a wilderness area. Wilderness areas exist in national forest, national parks, national wildlife refuges, and on Bureau of Land Management land. Some non-obtrusive activity may be permissible.
- National Forest Organic Legislation, 16 USC §§ 471a et seq.; Multiple-Use Sustained-Yield Act of 1960, 16 USC §§ 528 et seq.; Forest and Rangeland Resources Planning and Research Acts, National Forest Management Act, and Renewable Resources Extension Act, 16 USC §§ 1600 et seq. Under these Acts, exploratory activities within a national forest require a special use permit from the US Department of Agriculture. Facilities cannot be located within a national forest unless they are determined by the US Department of Agriculture to be consistent with the national forest system land and resource management plan (outdoor recreation, range, timber, watershed, and fish and wildlife purposes).
- National Trails Systems Act, 16 USC §§ 1241 et seq., which prohibits the conduct of activities on or in the vicinity of federally designated national trails that are compatible with the purposes for which the trails were established.
- Farmland Protection Policy Act, 7 USC §§ 4201 et seq., which seeks to minimize the extent to which federal activities contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses. The adverse effects of facilities on the preservation of farmland are required to be evaluated using criteria developed by the US Department of Agriculture, Soil Conservation Service (7 CFR Part 658).
- Floodplain Management, E.O. 11988, which requires federal agencies to minimize adverse effects from development in a 100-year floodplain.
- Cultural resource protection statutes: National Historic Preservation Act of 1966, 16 USC §§ 470 et seq.; Historic Sites, Buildings and Antiquities Act, 16 USC §§ 461 et seq.; Archaeological and Historic Preservation Act amended by the Resource Salvage Act, 16 USC §§ 469 et seq.; Archeological Resources Protection Act of 1979, 16 USC §§ 470aa et seq.; American Antiquities Act, 16 USC §§ 432 and 433. These Acts protect historic districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology, and culture that are included in or eligible for inclusion in the National Register of Historic Places. Historic and prehistoric ruins, monuments, and objects of antiquity located on federal lands are also protected.
- American Indian Religious Freedom Act, 16 USC §§ 1996 et seq., which protects sites associated with native American religious practices.

Step 1 - Using USGS 1:250,000-scale maps, identify land use areas that are protected by a Federal, state, or local agency; to the degree feasible, proposed public amenity areas should also be identified at this scale. Regulatory Guide 4.7 (Section B) identifies the areas of public use that should be considered in this Step, along with the cognizant Federal agency. State agencies should be contacted to identify similarly protected land uses at the state level.

Typical protected land uses important at this stage include, but are not limited to:

- National Parks
- Wild and Scenic Rivers
- Designated coastal-zone areas
- Wildlife Refuges
- Wilderness Areas
- Native American Reservations
- National Recreation Areas
- National Forests
- National Wildlife Reserves or Preserves
- National Recreation Areas
- National Historic Landmarks or Monuments.
- National Trails

Once these have been identified and mapped, exclude these areas from consideration.

Step 2 - Additional data on protected land uses should be obtained and mapped at this stage. As mentioned in Section 2, protected lands at the State and local level are often of such a size that they are not mappable at the scale used for application of Step 1. For example, individual states and local governments administer parks, recreation areas, and other public use and benefit areas. Information on these areas should also be obtained from cognizant state agencies. Using regional and state land use maps, soils maps, vegetation maps, historical maps, and any other sources of land use/land cover information or archaeological information, refine the map prepared in Step 1 and map the following land uses as avoidance or exclusionary areas, as appropriate:

- Hospitals
- Correctional facilities
- Schools
- Prime agricultural lands
- Historic, Cultural, and Archaeological sites
- Commercially exploitable mineral resources

- Transportation and utility corridors
- Recreational areas (e.g., golf courses, swimming, fishing, boating)
- Designated visually sensitive areas or viewsheds.

Step 3 – At this stage in the siting process, applicants should begin to address local land use issues and individual site conditions. Actual definition and application of utility functions should be designed in consideration of these site-specific conditions. However, the following example suitability functions illustrate the kinds of evaluations that should be considered for implementation. For each factor listed below, the applicant should establish distances from the site to which the listed features will be evaluated, based on the potential for impacts. For example, public amenity areas from which the site cannot be seen should not be included in visual impact evaluations. Conversely, applicants may find it necessary to adjust numerical scoring suggested below to properly reflect impacts on especially important or sensitive resources.

Proximity to Designated Amenity Areas. Develop a utility function in which the number of existing and planned amenity areas in the site vicinity is weighted by their distance from the potential site. Assign a value of 5 to the site with the lowest aggregate score and a 1 to the site with the highest.

Land Use Compatibility. For on-site and adjacent land uses, a utility function would be developed to relate the suitability of adjacent existing and future land use, based on type and proximity to the site. Perform an evaluation of the number of acres of alternative land uses (e.g., prime farmland) that would be pre-empted by a nuclear power facility site and its support facilities (including substations, transmission lines, pipelines, roads, and railroads). If off-site land uses would be affected, these lands should be included in the analysis. Land uses identified but not excluded in Step 2 should also be considered in this analysis. Construct a utility function in which sites with the lowest (adjacent existing and future land use) acreage would be assigned a 5 and the highest acreage sites a 1.

Consistency with Land Use Plans. Land use plans include all types of formally adopted documents for land-use planning, zoning, and related regulatory requirements. Local general plans are included, even though they are subject to future change. Proposed plans should be included if they have been formally proposed by the appropriate government body in written form, and are being actively pursued by officials of the jurisdiction. Staged plans, which must go through phases of development, should also be included even if they are incomplete. A utility function would be defined, with sites characterized by their proximity to boundaries of land use plans; sites with actual overlap would be assigned a value of 1 and those with no nearby land covered by such plans would be assigned a 5.

Potential for Visual Impacts. Sites would be evaluated on the basis of the number of viewsheds from public amenity areas or other sensitive areas from which the nuclear power facility could be seen. A distance or visibility weighting of these raw counts may be appropriate to reflect actual visual impacts. A utility function would be defined so those sites having the highest visibility would be assigned a rating of 1 and the lowest a 5.

Step 4 - Refine the utility functions prepared in Step 3, using more detailed site-specific data, as available.

3.4 Engineering and Cost-Related Criteria

This section addresses those criteria that are cost-sensitive.. Consideration of these criteria allows important site-related cost differentials to be considered in the site selection process. Because site selection under the ESP process will occur prior to detailed design evaluations it is not possible to apply detailed cost estimates to the engineering and cost-related criteria. Site attributes that are cost-sensitive will be outlined, based on the general nature of the cost-attribute function, and treated accordingly. Where cost-related factors have been considered in other sections, such as in Health and Safety, a cross-reference is made to that analysis.

In previous sections, each suitability criterion is represented by a separate utility function. For the cost criteria described in this section, however, the criterion measure is cost in dollars, which is a universal metric. Accordingly, utility functions are not developed for these criteria. Rather, costs developed for each criterion in this section are summed for each site; this total of site-related costs represents site-specific cost differentials among the potential and candidate sites. Composite site-specific costs would then be examined against the other criterion results from Steps 3 and 4 of the siting process (Sections 3.1 through 3.3). That is, costs would be balanced against the results arising from the application of the Health & Safety, Environmental, and Socioeconomic criteria.

Cost estimates specified in these criteria should be developed in constant-year dollars, taking into account timing of each expense and a consistent discount rate. For example, a "present value" for operational costs such as water pumping and transmission losses should be developed so these costs can be directly compared with construction costs. All costs should be discounted to a single year; for applicants whose construction and operation dates have not been established, the year of the ESP application submission should be used.

3.4.1 Health and Safety Related Criteria

A number of these issues are also addressed in Section 3.1 and from a site suitability perspective, it may be helpful to revisit these evaluations as part of the development of the Engineering and Cost-Related criteria. Correlation with the health and safety utility functions may be helpful in evaluating cost.

3.4.1.1 Water Supply

Steps 1 and 2 – Steps 1 and 2 are not applicable to this criterion.

Steps 3 and 4 - Water supply was initially treated in Section 3.1.1.2 from the standpoints of availability and competing uses. The analysis in this section addresses the costs associated with supplying the facility water requirements, in light of future, competitive, non-facility consumption rates. Cost estimates should be derived based on the cost of purchasing water (and any associated required water rights) for each site. Estimates should consider any additional costs (e.g., escalated prices) associated with meeting facility requirements during low-flow periods or droughts that could reasonably be estimated from historical information.

3.4.1.2 Pumping Distance

Step 1 - Areas beyond a practical pumping distance would be mapped as avoidance areas. For example, a maximum distance of 20 miles from the water source or 20 miles upstream from the points of required minimum flow represent reasonable cutoff distances. The avoidance distance could also be set using a statistical analysis of the distribution of region-wide pumping distances compiled from a GIS and using chosen a percentile such as the 75^{th} percentile of distances, based on professional judgment as to cost effects.

Step 2 - The avoidance distances developed in Step 1 would be transposed to the Step 2 scale maps and boundaries delineated.

Steps 3 and 4 - The cost of constructing pumping stations and infrastructure developments necessary to transport water from the source to the site would be estimated. In addition, any offsite right-of-way or land lease costs associated with water transport would be included in the cost estimate. If known, the present value of operational costs (e.g., pumping power) should also be included.

3.4.1.3 Flooding

Steps 1 and 2 – Steps 1 and 2 are not applicable to this criterion.

Steps 3 and 4 - Flooding was initially treated in Section 3.1.1.3 from the standpoint of avoidance of major floodplains, the degree of exceedance of the 100-year floodplain levels, and proximity to major dams. The analysis for this criterion involves estimating the cost of additional engineered features that are required for flood protection. Also included would be any additional flood insurance costs associated with a floodplain (or near floodplain) location.

3.4.1.4 Vibratory Ground Motion

For the Advanced Light Water Reactor, which has a Safe Shutdown Earthquake of 0.3g, site cost increments that are a function of Peak Ground Acceleration do not exist as a result of standardization. Thus, cost differentials associated with designing for the site Safe Shutdown Earthquake are not applicable to siting for standardized light water reactor designs.

3.4.1.5 Soil Stability

Soil stability was initially treated in Section 3.1.1.1.4 from the standpoint of soil properties and their relationship to the suitability of foundation conditions.

Steps 1 and 2 - Steps 1 and 2 are not applicable to this criterion.

Steps 3 and 4 – For this criterion, the applicant should estimate the cost of site-specific foundation design features and associated construction requirements that might arise from soil conditions (e.g., slope stability). Basic foundation engineering and construction costs that would be applicable to all site locations are not part of this criterion. Site preparation costs arising from topographic features are considered in Section 3.4.1.3.

3.4.1.6 Industrial Site Remediation

The purpose of this criterion is to capture costs associated with any environmental cleanup activities, that may be required at industrial sites before they can be developed for a nuclear power facility. Remediation costs incurred in developing such sites should be added to other costs identified in Section 3.4 to allow an equitable and systematic cost comparison among alternative sites. As discussed in Section 4.4, which provides additional discussion on considering industrial sites in site selection, costs included in evaluating this criterion should include only those cleanup costs for which the applicant is directly responsible.

Steps 1 and 2 - See Step 3 below.

Step 3 - Based on the history of site activities, a scoping-level estimate of environmental cleanup costs should be prepared. This estimate may derive from engineering judgement, experience with cleanup actions at similar sites, and/or previous studies for the site being considered, as available. The estimate should focus only on those cleanup activities for which the applicant is directly responsible, e.g., they should exclude any legacy contamination remediation activities for which previous owners/users of the site are legally responsible.

Step 4 - Cleanup cost estimates should be refined based on detailed characterization of the extent and nature of site contamination. Applicants may wish to negotiate a due diligence discovery of information with site owners to ensure that the full scope of cleanup activities can be understood and that the associated costs are known to an adequate level of confidence.

3.4.2 Transportation or Transmission-Related Criteria

The following PPE sections have been identified which pertain to access routes:

PPE Section	Requirement	Composite 1993 ALWR Value
29.1.1	Construction Module Dimensions	22(H)x21(W)x67(L)
29.1.2	Heaviest Construction Shipment	1,546,000 lbs.

Applicants should review areas/sites under consideration to confirm that access routes capable of accommodating these requirements (either under existing conditions or with appropriate improvements) are available. Any sites that fail this review should be excluded from further consideration in Step 1. This review should be coordinated with the applicant's future options for selecting a facility design. For example, the AP600 and AP1000 designs are modularized and are fully rail transportable; other designs may require barge access(e.g., pressure vessel delivery). Thus, the review of access route constraints should take into account the transportation modes required to support facility designs that may be eventually constructed.

3.4.2.1 Railroad Access

Steps 1 and 2 - Steps 1 and 2 are not applicable to this criterion.

Steps 3 and 4 - The cost of constructing a railroad spur from the nearest access location to the site boundary would be estimated, given site conditions as revealed in USGS topographic and related land use maps. This estimate would include all costs attendant to the spur's development and include land acquisition or land leasing costs, relocation costs, and construction costs. Construction costs can be estimated using standardized "construction cost-per-mile" data, augmented for conditions that may be specific to each site (e.g., labor costs).

3.4.2.2 Highway Access

Steps 1 and 2 - Steps 1 and 2 are not applicable to this criterion.

Steps 3 and 4 - As with railroad access, the cost of constructing roads from the nearest access location to the site boundary would be estimated, given site conditions as revealed in USGS topographic and related land use maps. This estimate would include all costs attendant to the access road's development and include land acquisition or land leasing costs, relocation costs, and construction costs. Construction costs can be estimated using standardized "construction cost-per-mile" data, augmented for conditions that may be specific to each site (e.g., labor costs).

3.4.2.3 Barge Access

Steps 1 and 2 - Steps 1 and 2 are not applicable to this criterion.

Steps 3 and 4 - There two components of this cost evaluation. The first is an estimate of the cost of constructing a barge terminal. This estimate would include all costs attendant to the barge facility including land and port acquisition or leasing costs, relocation costs, dredging costs, and costs associated with infrastructure development (e.g., load transfer equipment) at the barge location. The second component is derived by estimating the cost of any additional road or railroad development necessary to provide access from the barge terminal to the site. The estimates in this step would be developed consistent with the process described in Sections 3.4.2.1 and 3.4.3.2.

3.4.2.4 Transmission Cost and Market Price Differentials

Criteria discussed in this section are designed to rank sites based on site-specific differences in transmission cost or electricity market price considerations. Potential cost components are transmission construction and market price differentials Applicability of these criteria will depend on individual applicant's geographic and business environment (e.g., construction costs may not apply because separate business entities would build transmission lines). Thus, each applicant should "customize" the application of these criteria to accurately reflect its unique business considerations.

3.4.2.4.1 Transmission Construction

This criterion applies only if the applicant is responsible for construction of transmission connections at one or more of the sites under consideration. In a deregulated business environment, it is anticipated that a Regional Transmission Operator (RTO) would be responsible for construction and operation of lines connecting a nuclear power facility to the transmission grid. In such cases, transmission cost differentials between sites would not apply to evaluation of alternative sites, and this criterion would be omitted from the applicant's site selection process.

Steps 1 and 2 - These Steps are not applicable to this criterion.

Step 3 Estimate the total miles of transmission line required to connect each site to the existing transmission grid, by line voltage. Using standard costs per mile for construction and acquisition costs for each voltage, develop a total transmission construction cost for lines at each site. If significant additional costs would be incurred at individual sites due to especially difficult construction conditions or high cost (e.g., rough terrain, urban areas, long spans, and water crossings), the total construction estimates should be adjusted accordingly.

Step 4 – No further analysis is required in Step 4.

3.4.2.4.2 Electricity Market Price Differentials

This criterion would apply only if the applicant can identify differences in market price for produced electricity among sites under consideration. If no such differences are identified, or if defensible estimates of the differences cannot be developed, this criterion should be omitted from the applicant's site selection process.

Steps 1 and 2 - These Steps are not applicable to this criterion.

Steps 3 and 4 – A cost penalty should be computed for sites where the applicant can document it would receive lower prices for electricity produced than would be obtained at other sites (e.g., because of local oversupply or transmission services costs). The cost penalty would be estimated by computing the present value of the price differential (i.e., $/MW (highest price site) - $/MW (lower price site)) over the design life of the facility. The computed cost would be added to the other site-specific cost differentials, as described in Section 3.4, above.

3.4.3 Criteria Related to Land Use and Site Preparation

3.4.3.1 Topography

Step 1 - Large areas characterized by mountainous terrain would be mapped as exclusion areas because of the excessive relief.

Step 2 - Areas with slopes greater than 12% mean slope, or greater than 400 feet relief within the minimum site area, would be mapped as avoidance areas.

Steps 3 and 4 - The intent of this criterion is to establish the costs associated with any topographic features that would translate into site-specific differences in site preparation costs. For example, extensive cutting and filling, grading, and blasting could be factors that differentiate among sites. Basic construction costs common to all sites are not part of this criterion. In addition, site preparation activities that relate to unique foundation engineering design considerations are discussed under Criterion 3.4.1.5.

3.4.3.2 Land Rights

Steps 1 and 2 - Steps 1 and 2 are not applicable to this criterion.

Steps 3 and 4 – The intent of this criterion is to assess the identifiable costs associated with land acquisition. Under deregulation, applicants may not have the power of eminent domain and the applicant may not own even existing sites. This criterion provides for an estimate of the cost of acquiring the necessary land area and buffer zones; it would include any costs of relocating existing site structures or facilities. In addition, for industrial sites, costs that would arise from performing due diligence and any attendant regulatory-mandated cleanup activities should also be considered (see Criterion 3.4.1.6 and Section 4.3).

3.4.3.3 Labor Rates

Steps 1 and 2 - Steps 1 and 2 are not applicable to this criterion.

Steps 3 and 4 - The intent of this criterion is to quantify any local labor conditions that might translate into cost differentials between sites. The labor pool of interest is that associated with facility construction. Application of this criterion would be a two-step process. The first step is to identify site labor rates and to identify if there are any significant differences across potential and candidate sites. If such differences exist, then an estimate of costs associated with labor rate differences (i.e., labor rate difference combined with estimated level of effort for each labor category) should be prepared. Overall labor availability is discussed in Section 3.3.3.

4
CONSIDERATIONS DURING SITE SELECTION

This Chapter provides coincident and special-circumstance considerations that applicants should consider in planning and executing the site selection process. Important aspects of coordinating an applicant's siting process with a public information and involvement program is discussed in Section 4.1. Incorporation of three special-case sites: existing nuclear facility, industrial and characterized sites, are discussed in Sections 4.2 through 4.4.

Three types of candidate sites, which are distinguished by their regulatory history and use, may be identified by applicants in the site selection process. They are defined in Table 4-1. Also included in the Table are considerations that must be addressed for each site type in the site selection process described in this Guide. Specifically, an applicant should process a "greenfield" site through the site evaluation and selection process as described in Section 2.0. In contrast, existing, characterized and industrial sites each bring distinct advantages and disadvantages that should be addressed explicitly; processes for dealing with the unique character of these site types are described in Sections 4.2 through 4.4.

Table 4-1
Candidate Site Types

Site Type	Description	Siting Considerations
New or Greenfield	Undeveloped sites that were not used previously for any industrial purpose.	No history of legacy contamination. No previous NRC approval; limited site characterization data available.
Existing	Sites that have received a previous formal approval from the NRC as a nuclear power facility site, including sites that: Are contiguous with operating nuclear power facility sites. Previously received a construction permit and/or operating license (whether or not the permit or license has expired).	Previously approved by NRC as being a site for which no "obviously superior" alternative exists. A wealth of site characterization data exists.
Characterized	Sites for which documented studies have been conducted pursuant to applying for a nuclear power facility construction permit or operating license but for which no formal NRC approval has been obtained.	Site characterization data and analyses exist. Applications may exist and formal or informal NRC comments may have been obtained.
Industrial	Sites that have previously been the location of industrial facilities (either privately or publicly owned).	Legacy contamination may exist, with associated cleanup liabilities and costs.

4.1 Public Involvement and Acceptance

Public involvement is a necessary and desirable part of the ESP site selection process and enables the applicant to consult with and include interested and affected individuals (or stakeholders) in the decision process. The public involvement process provides a means by which the public's questions and concerns (if they exist) can be identified in advance of decisions, so that those decisions consider and reflect the views of the public to the extent possible. The critical element is that all stakeholders (e.g., the applicant's own employees; Federal, state, and local officials; public interest groups and the general public in the vicinity of the candidate sites) should be involved early, substantively, and frequently in the site selection process, as depicted in Figure 2-1. A generic matrix of public involvement activities and steps in the site selection process described in Chapter 2 appears in the following paragraphs; however, the specific nature and timing of an applicant's public involvement activities should be developed in concert with the siting plans.

Step 1 - This early stage of siting, involving identification of broad candidate areas, primarily includes public information activities such as:

- Providing regional media releases and background reports periodically and at key decision points.
- Informal networking (e.g., small meetings and briefings.) with state and local officials, educational institutions, industry groups, media, and other opinion makers should be initiated to inform these organizations as to the overall intent of the process. In addition, this is the point at which a public participation plan should be developed.

Step 2 - As avoidance and exclusionary criteria are being applied in this stage, it is important to continue preparation of general media releases and to increase efforts to establish local and regional networks of expertise. These networks may be composed of technical experts in health, regional planning, land-use, and other fields. Such networks may contribute to the effectiveness of the siting process by identifying and further refining important criteria to be applied in subsequent steps. In addition, these networks may become future communication resources as the project reaches the site-specific stage. Other activities may include:

- Building communication channels with local and regional elected officials so that formal relationships are established before the announcement of candidate sites.
- Identifying other interested and affected parties that will need/want to be contacted immediately upon announcement of candidate sites.
- Creating a technical review group (e.g., composed of local and regional technical experts from universities, planning commissions, consulting organizations) that can be used to verify the implementation of complex choices through the use of Delphi and other decision-aiding techniques.

Step 3 - As suitability criteria are being applied at this stage, key activities may include:

- Conducting community interviews to identify interested and affected parties and to identify membership for a potential community advisory group (e.g., composed of elected and appointed officials, and leaders of community, environmental, and neighborhood groups) that could provide useful input to the process and input that would be viewed as not necessarily influenced by the applicant's views. Developing a draft public participation plan for each candidate site.
- Establishing information repositories within each community that hosts a candidate site.
- Conducting small meetings, workshops, and open houses at the information repositories.
- Organizing and supporting a speaker's bureau composed of project staff members, and advisory and technical review group members, who would be trained to make presentations to local civic and community groups.
- Arranging tours of and/or visits from similar nuclear facilities for selected parties. Arrange for applicant staff, government personnel, and/or private citizens to be available to answer questions.
- Beyond activities associated with the community in which each candidate site is located, identifying and implementing communication mechanisms for surrounding communities commensurate with their interest(s) and the impact of the site on their community.

Step 4 - At this site-specific stage, the public participation process should become even more interactive and activities and programs should be tailored to the characteristics and features of the site. Some enhancements to earlier plans may occur as the final preferred site is identified. Networks should be refined, and more formalized mechanisms for soliciting public input should be devised and implemented. Activities should include the initiatives resulting from Step 3 above, as well as additional efforts such as:

- Formally designating a site-specific advisory or working group
- Tailoring the public participation plan to the site
- Starting a site-specific newsletter, hotline, web site, and other communication devices

Public involvement in siting is a continuum with increased effort and emphasis at each step of the process. A public participation process that is sensitive to the local culture and understands the values of local stakeholders will provide appropriate opportunities for these values to be incorporated into decision-making.

During the late 1980s and 1990s, one of the emerging developments in the process of siting controversial facilities was the formal consideration of volunteer sites in the siting process. A volunteer site is defined as one that is put forth by a government entity (e.g., State, county, local) or private concern for purposes of being considered as the location for a potentially controversial facility. This phenomenon (the provision of volunteer sites) has had a much longer history in the siting of other types of facilities, notably multipurpose public facilities such as arenas or athletic stadiums. A summary of some previous actual volunteer site experience for controversial facilities is provided in Appendix D.

Translation of previous experience with volunteer sites to the Early Site Permit Process suggests the following:

- Obtaining public acceptance at the earliest stage possible is always preferable (whether it is in the form of a volunteer site or in general support for a rigorous siting process).
- Any volunteer site must be subject to the rigors of the siting process and must be treated in an equivalent fashion to all other land units being considered. It must be possible to demonstrate that a volunteer site would successfully emerge from whatever stage of the siting process during which it is being offered (i.e., if a volunteer is offered during application of the first step, only exclusionary and avoidance criteria would be applied). Like any other site, volunteer sites must be capable of surviving NRC's "no obviously superior alternative site" test.
- The earlier in the application of the siting process that a volunteer site is identified and offered, the simpler will be its incorporation into the process from both operational and cost perspectives.
- For volunteer sites that are not “owned” by a governmental entity (e.g., State, County, Town), a due diligence examination should be conducted so that the applicant thoroughly understands the history and uses of the site, as well as any technical and institutional risks.
- It is likely that many volunteered sites will have minimal data available; a significant effort will be necessary to gather information, especially if the site is not offered until the later stages of the process. Any data that is provided in association with an offer of a volunteer site should be carefully and thoroughly reviewed for accuracy.
- If a volunteer site is offered late in application of the siting process, a “cost-benefit” analysis should be considered to examine the trade-off associated with incorporating the volunteer site and essentially suspending the balance of the siting process while this new site is examined. This includes not only evaluating the effort necessary to gather technical information on the suitability of the site, but includes consideration of the activities associated with establishing the institutional mechanisms that are detailed above under the discussions of each step of the siting process.
- If a site is volunteered, it will be critical to first understand the institutional framework under which the site is being offered as well as the views of other stakeholders. Any condition(s) under which the site is being volunteered must be established and universally understood. This framework and these conditions may well translate into the application of additional site selection criteria for the particular volunteer site.

4.2 Consideration of Existing Sites

By virtue of the fact that they have been previously shown to be favorable sites in NRC licensing actions, existing sites present attractive opportunities for Early Site Permits. In addition to enjoying acceptance by the local population, existing sites also possess a wealth of site data that will support both the ESP and future COL actions. As described in Revision 0 of this Guide, existing sites can be included as part of Step 3 of the site comparison process, along with other identified candidates. This approach, which is also applicable to consideration of applicant-owned, but undeveloped sites, is described in Section 4.2.1.

An alternative approach involves capitalizing on favorable characteristics of, and data about, an existing site to demonstrate that no "obviously superior" site exists. This streamlined approach, which does not require formally executing all steps of the process described in Section 2.0, is described in Section 4.2.2.

4.2.1 Consideration as Candidate Sites

This section provides a discussion of one approach for considering existing sites within the site selection process. The ESP applicant must fulfill obligations under NEPA and as such, cannot limit site screening to only existing sites. The process within the Siting Guide provides a framework to objectively include these sites.

If an existing site is screened out based on application of exclusionary criteria in Step 1, the site should be excluded from further consideration. The site would not be acceptable for either regulatory or technical reasons. The application of avoidance criteria in Step 2 may show an existing site to have undesirable characteristics. It is probable that most existing sites would still be under consideration at this stage because such site(s) were most likely identified considering many of the same criteria as outlined in Chapter 3.0. However, if the site is found to have significant unfavorable characteristics at this stage, attempting to "force fit" a site may make defense of it as having "no obviously superior alternative" difficult.

As the avoidance criteria and the suitability criteria become less restrictive in Step 3, the merits of existing sites should become more apparent. For example, the regulatory history and the degree of available technical information should favor areas that include the existing site over others. As the evaluation progresses through Step 4, all of the identified sites should be acceptable, based on exclusionary, avoidance, and suitability criteria. At this point in the process, assuming that existing sites are still under consideration, their merits, as compared to other sites, should become apparent for the reasons stated earlier.

Therefore, even though this approach does not afford existing sites any special consideration, the process outlined in the Guide allows the additional merits of these sites to be fully considered at the appropriate stages of the siting decision process.

4.2.2 Demonstration That No Obviously Superior Site Exists

Existing nuclear power facility sites have previously been reviewed by NRC and found to satisfy the principle that no obviously superior site existed at the time of original licensing. The approach described in this section capitalizes on this licensing history and on the wealth of technical and environmental data available at previously licensed sites

NRC recognition of existing site status is found in the fact that the agency has noted that a full-scale, systematic siting process may not be necessary to justify selection of an existing site for an ESP. For example, guidance provided to NRC staff on their review of alternative site analyses (NUREG-1555, Section 9.3, III (8)) states, in part (emphasis added):

> "*Recognize that there will be special cases in which the proposed site was not selected on the basis of a systematic site-selection process.* Examples include facilities proposed to be constructed on the site of an existing nuclear power facility previously found acceptable on the basis of a NEPA review and/or demonstrated to be environmentally satisfactory on the basis of operating experience…"

The streamlined approach described in this section for satisfying the NEPA alternative site requirements is designed to take full advantage of existing sites as just such a special case. The two-phases of this process are:

1. Ensure development of an ESP at the existing site will not pose technical, regulatory, or institutional risks for the existing NPP(s); such risks might derive from changes in regulatory requirements or site conditions (e.g., seismic evaluation, population growth, water availability), and (assuming no unacceptable risks are identified),

2. Using the criteria in Chapter 3 of the Guide as a "suitability framework," demonstrate that no other site in the surrounding region is "obviously superior" to the existing NPP site.

These steps are described in detail in the following paragraphs.

<u>Phase 1 - Evaluate Site Licensing Risks and Suitability Issues</u>

The objective of this step is to identify any potential negative impacts on the "apparent" suitability of the existing site, when judged against current standards and conditions. Because of the proprietary nature of issues being considered, Phase 1 evaluations should be conducted internal to the applicant's organization and would not become part of the ESP application itself.

This "down-side" risk analysis should address changes (since the original license was issued) in regulatory technical requirements, financial regulation (e.g., deregulation), site conditions, and the site licensing and permitting history. Future plans for the existing units (e.g., license extension) should also be taken into account. The evaluation should address potential impacts on existing units of initiating a new licensing action, as well as the suitability of the proposed new site itself.

Table 4-2 provides a preliminary list of issues that should be evaluated in this phase, along with examples of how these issues may affect the decision to seek an ESP at an existing site. Specific considerations applicable to this analysis (as well as how they will affect the siting decision) will be unique to individual facility sites

Table 4-2
Phase 1 Factors for Existing Site Evaluations

Factor	Description
Seismic Evaluation	Seismic design of the existing units should be evaluated against seismic reactor site criteria in 10 CFR 100, Appendix B, and the earthquake engineering criteria in 10 CFR 50, Appendix S. Since these criteria differ from those in effect when the current fleet of nuclear power facilities was licensed, situations could arise where new facilities must be designed to more stringent seismic criteria than existing operating facilities. Because the new requirements are applicable only for applications filed on or after January 10, 1997, they have no direct regulatory impact on existing facilities. However, there is a risk that opponents would use such information to allege that the operating facilities are "unsafe" because they do not meet current requirements. Such potentialities may not discourage applicants from seeking ESPs at existing sites, but, in any case, they should be aware of this issue prior to proceeding with a new ESP application.
Demographic Changes	Because population distributions have changed markedly since the current fleet of nuclear facilities was licensed, an existing site should be evaluated against both new commercial/residential patterns and NRC's current demographic site suitability guidance. These considerations are described in Regulatory Guide 4.7 Appendix A, Item A.4 as: 20-mile population density less that 500 persons/square mile; distance from LPZ boundary to nearest population center (>25,000) at least 1 1/3 times the distance from reactor to LPZ boundary. Population growth near the existing site may affect the ability of existing units to meet these criteria. Although regulatory compliance for existing facilities would not be affected, the same kinds of public concerns and institutional risks as listed for Seismic Evaluations, above, could apply.
Emergency Planning	Although maintaining conformance with emergency planning requirements is an ongoing process at operating nuclear facilities, EP requirements applicable to any proposed new ESP should be reviewed in light of existing data and plans to ensure that no major new EP issues, for either the new application or existing units, would be raised by licensing a new site.
Exclusion Area	Applicants must ensure that there is adequate land area at the existing site so that an exclusion area can be established for the new unit(s) which satisfies the requirements of 10 CFR 100.
Transmission Access	Applicants must be assured that adequate transmission capability is available to deliver power from both existing and new units to customers, and that transmission charges will allow delivered electricity to be competitive in the open marketplace. The existing site should be evaluated in accordance with Criterion 3.4.2.4 to ensure that existing sites are not significantly less favorable than alternative locations from a transmission perspective. Existing sites with adequate transmission capacity for both existing and new units have significant advantages for the new ESP, because there will be no need to incur environmental impacts of constructing additional transmission lines.
Power Pricing	In a deregulated environment, electricity supplied from both existing and new units will depend on a complex mix of market factors (e.g., number, size and location of customers; pre-existing long term supply contracts; facility ownership) all of which may vary over time. Under some circumstances, further concentration of generating units at a single physical location may produce a local "oversupply" which could affect prices generators can obtain for the output of both new and existing units. While predicting price impacts years into the future is at best a speculative matter, applicants should evaluate such potential effects to minimize the possibility of being put at a pricing disadvantage because of the large concentration of generating capacity at a single location.
Water Availability	Applicants must ensure that adequate cooling or make-up water is available from the water source, taking into account both existing and potential new units. Water supply availability and cost evaluations are described in Criteria 3.1.1.2.1 and 3.4.1.1, respectively; these should be applied using total water requirements for existing and planned units as the basis for evaluation. Results of this analysis will identify whether significant constraints in water availability (which would affect all units at the site and could hamper operations in times of low flow) exist.

Factor	Description
Permitting/Licensing Status	This factor is included to focus on any outstanding or problematic ongoing regulatory issues involving existing units that provide insights into potential problems facing approval of an ESP. For example, a history of regulatory concerns about discharges from the existing facility would point to potential problems in obtaining withdrawal or discharge permits for new units. In evaluating this factor, applicants should consider the full spectrum of interfaces with regulators and the public to ensure that the existing site does not carry institutional risks that could affect approval of an ESP.
Plans for Existing Units	Applicants should ensure that developing an ESP is consistent with plans for existing units . Issues such as license extension, major maintenance (e.g., steam generator replacement), and decommissioning should be considered to ensure that an ESP and future units would not interfere logistically or from a regulatory posture with these plans.
Spent Fuel Storage	Because it is not clear when a central spent fuel repository will be available, facility operators are providing on-site storage in the form of interim spent fuel storage facilities. Land requirements analysis for an ESP should also take into account any additional space required to provide interim spent fuel storage for both new and existing units. Any site-specific issues identified in recent NRC reviews of applications for on-site spent fuel storage facilities should also be examined for relevance tot he ESP application.

The purpose of these evaluations is to ensure that financial, technical, or institutional challenges associated with an existing site are identified and taken into account in the applicant's decision process. Once it has been determined that the existing site can be developed consistent with the objectives for both the existing power facilities and the new site, the Phase 2 demonstration, below, should be completed.

Phase 2 - Demonstrate No Alternative Sites Are "Obviously Superior"

The objective of this phase is to demonstrate that no sites "obviously superior" to the proposed new site exist. Guidance on the approach for making this determination is provided in NUREG-1555, Section 9.3:

> "The review should also include the staff's independent comparison of alternative sites with the applicant's preferred site to determine if there are any alternatives sites that are environmentally preferable to the proposed site. When one or more environmentally preferable alternative sites are identified, the scope of this review should be extended, using benefit-cost techniques and other procedures to determine if any environmentally preferable site can be shown to be obviously superior to the applicant's proposed site."

Criteria described in Sections 3.1.2, 3.1.3, and 3.2 provide an objective framework for evaluating and ranking the environmental suitability of nuclear power facility sites. In particular, metrics defined for applying Steps 3 and 4 of the respective criteria establish bases for objective comparison of the relative environmental suitability of alternative sites. Thus, these criteria can be used to establish, first, whether any sites in the ROI are environmentally preferable to the proposed location, and, if necessary, whether any of these alternatives constitute "obviously superior" sites.

Given the applicant's ROI (see Section 2.1), utility functions for each of the environmental criteria can be defined. Using the range of conditions extant in the ROI, the suitability ratings for the proposed site can be developed. If the proposed site is shown to be highly suitable for all of the environmental criteria and/or if there are no criteria for which it is highly unsuitable, it can be argued that no environmentally preferable site exists. Site comparisons beyond this stage may not be necessary.

If the analysis shows that the proposed site ranks low in suitability for one or more environmental criteria, it may be necessary to identify alternative sites (see NUREG-1555, Section 9.3 (1)) against which to perform a comparative overall suitability evaluation. The objective of this evaluation is to demonstrate that, on balance and taking all criteria into account, sites available in the ROI are not environmentally preferable to the proposed site. The evaluation itself should be conducted in accordance with guidance provided in Section 2.1, Steps 3 and 4.

If the comparative suitability evaluation indicates that environmentally preferable sites do exist, economic, technological, and institutional factors must be compared in a benefit-cost evaluation among the alternative sites to determine whether one or more of the environmentally preferable sites is obviously superior. Given that there are environmentally preferable sites, it must be possible to identify advantages from the cost, technical, and/or institutional perspectives that favor the preferred site. The Engineering and Cost-Related Criteria that are provided in Section 3.4 constitute an initial framework for this evaluation. Additional institutional constraints or opportunities are site-specific and must be identified by the applicant. In terms of the regulatory guidance for the obvious superiority determination, NRC lists three component factors (NUREG-1555, Table 9.3-2): facility costs; institutional constraints, as they affect site availability; and additional public concerns. The following guidance on demographic criteria for identifying obviously superior sites is also found in NUREG-01555, Section 9.3, Appendix B:

> "In terms of a review of demographic aspects of the site-selection process, the population density guidelines of Regulatory Guide 4.7 have been interpreted by the staff in the following manner:
>
> - If, on balance, there are alternative sites of approximately equal merit regarding issues other than population density,
> - If the proposed site has a population density substantially greater than one of the alternative sites, and
> - If that density is in excess of the stated Regulatory Guide 4.7 values, there does exist a site obviously superior to the proposed site."

If the proposed new site at an existing nuclear power station cannot be shown to satisfy the obvious superiority test described above, there is a high likelihood that NRC would not approve it for an ESP. In such cases, an alternative site, identified in accordance with the process described in Chapter 2 should be proposed, instead.

4.3 Consideration of Characterized Sites

In addition to existing nuclear power facility sites there are sites in the contiguous US that have been investigated with the intent of developing a construction permit application. In contrast to existing sites (which, by definition, have received some level of formal NRC approval), active consideration of these sites was suspended at a stage prior to completion of NRC's review. The stage at which pursuit of approval was terminated varies considerably among these sites. For example, applications were prepared and submitted for some sites, while for others site selection studies were performed and data was gathered but no formal submittal was made to NRC. In each case, formal or informal feedback from NRC on site suitability may have been obtained.

Incorporation of characterized sites in the site selection process should recognize the level of data availability and the degree to which suitability had been determined at the time consideration was suspended. Because no formal approval was obtained, these sites, applicants should carefully review the level of data collection and analysis available on such sites to determine how they should be addressed. For example, for sites with essentially "application-ready" data, it may be possible to justify selection using the process outlined for existing sites in Section 4.2. Conversely, it may be necessary to incorporate previously studied sites with minimal data and analyses into the site selection process along with other candidate and potential sites in Steps 3 and 4 of the process.

While a body of site characterization data exists for sites that have been previously studied for development of a nuclear power facility, formal concurrence on suitability has not been obtained from NRC, and a formal determination that no obviously superior site exists has not been made. Thus, in the "burden of proof" sense, previously studied sites fall somewhere between greenfield and existing sites. Whether the full site decision process must be executed to justify selection of these sites, or whether a more streamlined approach (Section 4.2) will be adequate, will depend on the detail and level of formality of previously developed site documentation. Questions applicants should consider in conducting a siting study for such sites include:

- Was a site selection (decision) study conducted to identify the site?
- Did previous site selection studies include consideration of the full spectrum of environmental issues?
- What was the level of stakeholder involvement and public participation in the siting process?
- Were alternative sites considered and the basis for selection of the characterized site documented?
- At what level of detail were site characterization data developed?
- Were on-site data collection programs conducted? Are they still in operation (e.g., meteorology)?
- Was an application filed with NRC?
- Were comments were received from NRC review?

Answers to these questions will determine the level of additional site selection detail necessary to complete the ESP application. For ESP applications involving previously studied sites, early discussions should be initiated with NRC to obtain concurrence on the applicant's approach for the considering alternative sites.

4.4 Consideration of Industrial Sites

Industrial sites refer to sites that have been previously developed and utilized for some purpose other than a nuclear power facility; such sites may be owned by the applicant or by another party. These sites may present opportunities for an ESP in that they are already disturbed ecologically and are typically characterized as industrial land use. However, there may be a history of environmental contamination, environmental compliance problems (e.g., discharges), and/or public opposition to activities at the site.

Requirements and responsibilities for cleanup at such sites are established as matters of law and regulatory requirements; they may also be affected by legal agreements reached in real estate transactions. Post-remediation cleanup goals depend on the nature and extent of contamination and on regulations and legal documents. Thus, for example, even if legacy contamination exists, use of the site for industrial purposes may obviate or mitigate the need for cleanup actions. Discussions in this section are based on the assumption that cleanup actions may be required prior to developing a nuclear power facility at such sites.

Equitable comparison of industrial sites with other alternatives in the siting process requires that the full import of dealing with such problems be considered. Factors discussed in this section should be addressed to the degree that cleanup requirements apply to sites under consideration and to the degree that the applicant is responsible for cleanup actions. For example, most of the issues discussed below would not apply if existing contamination levels are compatible with industrial (nuclear power facility) land uses. Similarly, remediation costs should only be incorporated to the degree that the applicant (versus another entity, e.g., a previous site owner) is legally liable for legacy contamination. The possibility of schedule delays should be considered for any previously utilized and potentially contaminated site.

To accurately address these issues, applicants must establish the cleanup goals to be achieved (i.e., what is the target residual contamination level). Cleanup requirements for contaminated sites are generally dictated by risks to site users and to the public and by the intended post-cleanup land use. Assuming an industrial or equivalent land use category for development of a nuclear power facility, cleanup requirements will include protecting both construction and operations workers, as well as eliminating risks to the public (e.g., intercepting a contaminated ground water plume). Applicants should consult the cognizant Superfund agencies to understand the required target cleanup levels, especially if these requirements have already been the subject of regulatory action.

To include industrial sites in the process, applicants must ensure that these potential problems do not present cost or schedule impediments that either preclude or hinder development of a nuclear power facility such that other sites would be obviously superior. In particular, extremely high remediation costs, lengthy cleanup schedules, and/or cleanup scope uncertainties would be cause for avoiding an industrial site. Provision for including such costs in the site comparison is provided in Criterion 3.4.1.6; however, applicants must also address cleanup schedules and uncertainties in light of the objectives of their ESP application. At the later stages of the siting process, applicants should engage a professional engineer to provide an independent assessment of the cleanup schedule and cost to provide assurance that these parameters are achievable.

An important element in addressing industrial site issues is the amount and accuracy of information available characterizing existing contamination. Particularly in the case of sites not owned by the applicant, a due diligence examination should be conducted so that the applicant thoroughly understands the history and uses of the site, as well as any technical and institutional risks. The level of detail for such information requests should be commensurate with the stage of the siting process. Before any decision is made to propose an industrial site as the applicant's proposed site, the liabilities and responsibilities of the applicant and the current owner should be formalized legally.

Finally, applicants must ensure that any cleanup activities planned for a industrial site, once an ESP has been issued, are consistent with the allowed use of the licensed site as provided in 10 CFR 50.10 (e)(1). In such cases, a site redress plan may be required as part of the ESP application.

5
REFERENCES

Bechtel Corporation, March 1993, Plant Parameters Envelope Document, Volumes I and II, Early Site Permit Demonstration Program, Revision 2.

Electric Research Power Institute (EPRI), May 1992, Advanced Light Water Reactor Utility Requirements Document (URD), Revision 3.

Environmental Protection Agency (EPA), December 1986, Guidelines for Ground-Water Classification Under the EPA Ground-Water Protection Strategy, Final Draft, Office of Ground-Water Protection.

Environmental Protection Agency (EPA), December 1987, Drastic: A Standardized System For Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings, (EPR-600/2-87-035).

Environmental Protection Agency (EPA), April 1988, Probabilistic Dilution Model.

Halliburton NUS, March 1993, Regulatory Criteria Evaluation Report (RCER), Revision 0.

Nuclear Energy Institute (NEI), NEI 01-XX, 2001(Expected), Industry Guideline For Preparing AN Early Site Permit Application - 10 CFR Part 52, Subpart A

NRC/FEMA, November 1980, Criteria for Preparation and Evaluation of Radiological Emergency Plans and Preparedness in Support of Nuclear Power Plants, (NUREG - 0654 - Revision 1).

A
RESULTS OF REVIEW OF STATE REQUIREMENTS

Note to Readers: The previous version of this document (dated March 1993) contained state power facility siting regulations and environmental regulations that could impact the site selection process. The power facility siting statutes and implementing regulations of each State, excluding Alaska, were examined, and telephone interviews of key regulatory personnel were conducted to provide supplemental information. Table A.1 from the March 1993 document provides a synopsis of the regulatory analysis.

In addition, nine states were chosen for a more detailed review by determining which states had the highest number of nuclear power facilities and a sample was selected, which represented the geographic regions of the United States. The nine states included: Alabama, California, Connecticut, Florida, Illinois, Michigan, New York, North Carolina, and Pennsylvania. The examination of these states focused on state regulations such as land use, air quality and water quality, which could restrict siting, as well as the siting regulations.

These analyses were not updated for this version of the document. Just as changes to applicable Federal requirements since 1993 were evaluated as part of developing this document, applicants should evaluate changes in state regulations in designing site selection processes and criteria.

B
GEOGRAPHIC INFORMATION SYSTEMS

Geographic Information Systems (GIS) are computerized hardware and software systems that facilitate the entry, analysis, display, and overall management of mappable information. GIS originated in the early 1970s as rudimentary map-drawing programs. They have since evolved into powerful tools that perform sophisticate analyses on mapped data and create high-quality cartographic products. GIS technology has experienced phenomenal growth in acceptance and usage since its inception in the early 1970's, and today is used on a widespread basis worldwide.

Typical users of GIS today include government agencies (at all administrative levels); universities and centers of research; special interest groups (e.g. political parties and environmental groups); utility companies and energy development companies; engineering and environmental consultants; and various segments of the manufacturing, retailing, and service industries. As a result of this demand, several ancillary GIS support services abound: software and hardware manufacturers, data conversion services, GIS management consulting, educational and training services, GIS conferences, and industry publications. Clearly, GIS is no longer an arcane or exotic technology; it is a fundamental data analysis tool that is used for a variety of applications, in a variety of settings throughout the world.
Several GIS packages are available commercially or in the public domain. In addition, several GIS databases, including elevation, transportation, hydrography, and population distributions, are available for many areas in the U.S. from government agencies. The easy availability of GIS packages and digitized data, along with decreasing costs and increasing performance of hardware, contribute to today's interest in the technology.

B.1 Data Structure

GIS packages store geographic information as a set of data layers (also called "coverages"), where each layer represents a specific data theme, such as transportation, surface hydrology, or topography. Map layers are typically stored in two principal formats: vector and raster. Vector data structures represent geographic features as an ordered set of X,Y coordinate pairs in standard real-world coordinate systems, such as UTM or State Plane. In many systems, vector data files can be related to tabular attribute files that contain specific characteristics related to the mapped features; for example, a map coverage of county boundaries could be accompanied by an attribute table containing population, number of households, tax revenue, etc. Rasterized GIS data represent features in a regularly spaced grid of sample locations called grid cells. Both types of data structures are acceptable for supporting site screening and evaluation projects.

B.2 GIS Analytical Operations

The true power of GIS lies in its analytical capabilities, because it allows data computations that would be difficult and laborious, if possible at all, by using manual methods. Typical GIS operations that can be performed on mapped data include the following:

- Arithmetic - Addition, subtraction, division, and multiplication of maps;
- Logical/Boolean - Comparison of two or more maps to return maximum, minimum, intersection, union, or other results.
- Spatial Operations - Distance buffering, network modeling, and least-path modeling.
- Topographic Operations - Slope, aspect, visibility, precipitation runoff, and other models that consider changes in terrain elevation.

The individual analytical operations or commands in most modern GIS packages can be logically arranged into powerful models that yield valuable decision-making information. The results of the operations can be portrayed as high quality color maps and statistical reports to assist decision-makers in evaluating sites.

B.3 GIS Application in Site Screening and Evaluation

Because of the map overlay and analytical operations available in modern GISs, they are excellent tools for conducting site screening and evaluation. In fact, since the early 1970s, GIS has been applied toward site selection for nuclear and coal-fired power facilities.[1]
GIS-based approaches to site evaluation often emulate the McHargian[2] method of overlaying several map themes to arrive at a composite suitability map. A common, generalized process is outlined in the sections below.

B.3.1 Identify Factors of Concern

The factors that will influence the siting decision are identified. These factors include legal requirements, professional judgements, and economic factors that will affect the permitting, licensing, construction, operation, and decommissioning of the facility. Typical factors of concern include, but are not limited to: biological sensitivity; health and safety; land use suitability; site preparation costs; and cooling costs. It is possible that one "issue" map may detail exclusionary categories, representing areas that are eliminated for siting due to one or more legal or practical considerations.

B.3.2 Data Base Construction

Mapped data are identified to support the development of issue maps. Data are compiled onto standard base maps for the area of concern, and entered into the GIS through digitization or reformatting of existing digital data.

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[1] For example, *A Report on Data Management For Power Facility Siting: Delmarva Interface Study*, Dames & Moore, 1975.

[2] McHarg, Ian L. *Design with Nature*. Garden City, NY, Doubleday, 1969.

B.3.2.1 Data Analysis

A flow diagram is prepared to illustrate the analytical techniques used to create issue maps (see Figure B-1). GIS operations are performed on map layers in a systematic, predetermined sequence. A typical GIS operation would be to create a buffer zone at some defined distance from wetlands. The result of this step is the creation of a set of issue maps, where each map evaluates potential sites relative to a specific siting issue. (Suitability evaluation techniques are described in Section B.3). Typically, suitability is expressed as an index on a relative scale, for example, 1 to 5. Issue maps are combined through a logical map overlay to create a composite site suitability map, through weighted or unweighted methods (weighting techniques are described in Section 2.4).

B.3.2.2 Presentation of Results

Issue maps and composite suitability maps are presented as hard-copy GIS products, accompanied by statistical reports that show the distribution and statistical parameters (e.g., mean, median, and standard deviation) of map values.

B.3.2.3 Selection of Candidate Sites

Candidate siting areas can be identified with the assistance of GIS statistical techniques, such as: percentile ranking (for example, displaying those areas in the top ten percentile of suitability ratings); identifying contiguous areas larger than a defined threshold size and shape.

B.3.3 Site Specific Applications

The site screening procedure described above assumes the development of a regional database of various screening criteria. Large regional databases typically generalize features in order to save storage space and to speed data computations. Once a set of candidate sites is identified, it is possible to construct GIS databases for the sites with more resolute and detailed information to support detailed site-specific applications. The results of these applications can then be used to help differentiate the suitability of individual sites.

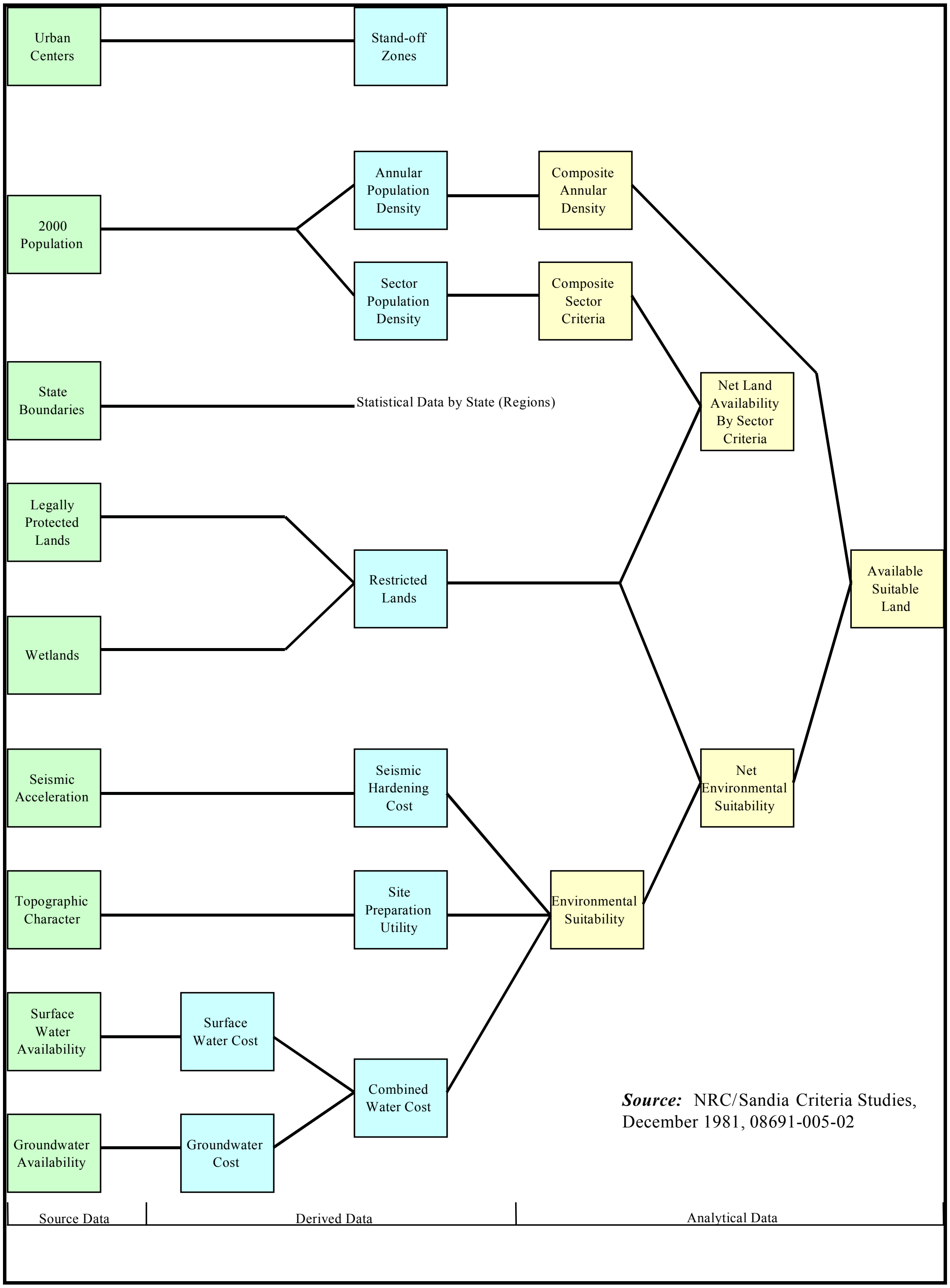


Figure B-1
Data Structure Diagram

C

EXAMPLES OF CRITERION SCORING FOR SITE SUITABILITY EVALUATION

An essential component of the ESP Siting Guide process involves translating site characteristics into a common suitability scale and then scoring sites for each site selection criterion. These scales express preferences for one site over another and are used, with weighting factors, to develop composite site ratings. The suitability scale suggested in the Siting Guide ranges from 1 to 5, where a scale value of 1 represents the lowest level of suitability (least preferable) and a scale value of 5 represents the highest (most preferable). The Siting Guide uses the term "utility function" to describe the process or rationale for converting from site data to the suitability scale.

Utility functions may take a variety of forms, depending on data availability and the criterion being evaluated; examples include:

- Relating site attributes to the suitability scale using a linear function.
- Using nonlinear functions that are defined based on the professional judgment of the discipline specialist.
- Using continuous utility functions when the suitability attribute is represented by a quantitative continuum (e.g., distance to a feature).
- Using discrete translations from site attributes to suitability where data is aggregated into classes or groups (e.g., number of features within a distance).

The purpose of this Appendix is to illustrate how suitability scales can be established and scale values assigned to score sites, using examples of utility functions and criteria from the Siting Guide.

Examples are provided that illustrate a variety of data availability (e.g., quantitative, qualitative) situations and a range of relationships between data and suitability scales (i.e., utility functions) that may be encountered in executing the process described in the Siting Guide.

While the examples below provide guidance for specific criteria, it should be stressed that actual suitability scales and scores for a given criterion, as well as the rationale for developing them, will depend on the region of interest and sites under consideration. Subject Matter Experts (SME) in the relevant technical disciplines should be consulted to ensure that utility functions produce suitability values that accurately represent variations between sites.

Also, more than one of the scoring concepts may be relevant to an individual criterion. For example, both the "Qualitative Data and Discrete Scoring" and " Integration of Multiple Utility Functions" approaches might be applied to a single criterion.

C.1 Quantitative Data - Linear Scoring

Case Scenario: There is quantitative information available on the relevant site characteristic and site suitability can be characterized as varying directly with it.

Example Criterion 1: Population (see Section 3.1.2.1 of the Siting Guide).

Site Attribute to Suitability Translation: The utility function is established by estimating the aggregate population density within 20 miles for each of the candidate sites. The site with the lowest population density would be scaled as a 5. The site with the highest population density would be scaled as a 1. Sites with intermediate densities would be given values proportional to the calculated densities.

Site Suitability Value Example:

SITE	POPULATION DENSITY	SCORE
A	400 persons per square mile	1
B	100 persons per square mile	4
C	50 persons per square mile	4.5
D	120 persons per square mile	3.8
E	300 persons per square mile	2

Example Criterion 2: Proximity to Consumptive Users (see Section 3.1.3.1.3 of the Siting Guide).

Site Attribute to Suitability Translation: The utility function is established by determining the combined distance to the downstream locations of public water supply withdrawals and recreational contact uses for each candidate site. Sites with the greatest pathway lengths to these users would be scored 5 and those with the closest pathways would be scored 1.

Site Suitability Value Example:

SITE	COMBINED DISTANCE TO PUBLIC WATER SUPPLY WITHDRAWALS AND RECREATIONAL CONTACT USE	SCORE
A	20 miles	4
B	10 miles	2
C	5 miles	1
D	15 miles	3
E	30 miles	5

C.2 Quantitative Data - Proportional Scoring

Case Scenario: Suitability varies proportionately with the quantitative site characterization data, for instance, as a proxy for impact.

Example Criterion: Criterion 3.1.1.4, Nearby Hazardous Land Uses. Hazardous facilities in the vicinity of sites are to be identified and, in applying Step 4 of that criterion, sites are to be ranked according to the potential impact of these facilities on a nuclear power plant at the site.

Site Attribute to Suitability Translation: Impacts of certain hazardous facilities (e.g., chemical plants) will be affected by atmospheric diffusion as well as by their distance from the site. To more accurately represent suitability in such cases, the utility function could be scaled according to the impact measure (dispersion) rather than the measured variable (distance). In the case of hazardous facilities, assume for simplicity that dispersion varies inversely with the square of distance to the site (Impact proportional to $1/[\text{distance}]^2$).

Site Suitability Value Example: (It is implicitly assumed in this example that no impact would occur for facilities beyond 20 miles.)

SITE	DISTANCE TO HAZARDOUS FACILITY	SCORE
A	20 miles	5
B	10 miles	1.25
C	1 mile	1
D	15 miles	2.8
E	17 miles	4.5

C.3 Quantitative Data - Discrete Scoring

Case Scenario: Suitability is based on distance from and/or direction to a feature in the site vicinity (e.g., volcanic activity) based on professional judgment and regional conditions.

Example Criterion: Geologic Hazards (see Section 3.1.1.1.4 in the Siting Guide).

Site Attribute to Suitability Translation: In general, suitability would decrease with greater numbers of such features and increase with increasing distance from them. However, from an impact perspective, the suitability scale could also depend heavily on the type, nature, orientation and size of such features. In such cases, a representative proportional relationship for the utility function between distance and suitability cannot be derived, and discrete suitability values would be assigned based on SME analysis and professional judgement.

Site Suitability Value Example: A site with volcanic activity 20 miles distant is given a rating of 2, while a second site with a different type of volcanic feature within 5 miles, that has less impact is assigned a 4. These hypothetical ratings assume, of course, that the SME has identified specific characteristics that support these differences in ratings; these characteristics would be documented in the site selection record.

C.4 Qualitative Data - Discrete Scoring

Case Scenario: Quantitative information is not available. Qualitative information, in conjunction with professional judgement applied by a SME, must be applied to derive suitability ratings

Example Criterion: Land Use, archeological resources, (Siting Guide Section 3.3.4).

Site Attribute to Suitability Translation: The value of archeological resources (and therefore the impact of a nuclear power plant on them) cannot be directly related to the extent, depth, location, or even age of deposits or relics. Accordingly, it would necessary for an SME to assign site ratings for the utility function based on an overall judgement of the significance of impacts on archeological resources using qualitative information.

Site Suitability Value Example: While the actual framework for these ratings assignments would be unique to each siting study and to the resources affected, the following table provides a hypothetical example of a rationale for how these discrete suitability ratings could be assigned.

SITE	CHARACTERIZATION OF ARCHEOLOGICAL RESOURCE	SCORE
A	No identified resources on site	5
B	Significant resources on site; mitigation not feasible. Not unique; similar to many other regional resources.	2
C	Unique on-site resources; mitigation not feasible.	1
D	Significant resources on site; can be preserved via mitigation or avoided.	3
E	Some resources on site; not unique to region and can be preserved via mitigation or avoidance	4

C.5 Integration of Multiple Scoring Considerations

Case Scenario: Two elements, data sets, impacts or other suitability measures must be taken into account in evaluating a single criterion.

Example Criterion: Socioeconomic – Construction Related Effects (see Section 3.3.2 of the Siting Guide).

Site Attribute to Suitability Translation: Under this criterion, two socioeconomic concepts are applied:

1. availability of an adequate labor force with commuting distance, and,

2. ability of the community to absorb the influx of workers should they relocate.

The utility function is established by assigning candidate sites with an adequate labor force within a reasonable commuting distance a score of 5 and sites with on inadequate labor pool and potentially significant impacts due to labor force influx a score of 1. Communities without a labor force within a reasonable commuting distance, but with a lesser degree of potential impact would be scored intermediate values, which are tradeoffs between the two concepts, based on professional judgment.

Site Suitability Value Example:

SITE	ADEQUACY OF LABOR FORCE	ADEQUACY OF INFRASTRUCTURE	SCORE
A	Insufficient labor pool within commuting distance	Sufficient infrastructure to adsorb labor force	3
B	Sufficient labor pool within commuting distance	Sufficient infrastructure to adsorb labor force	5
C	Some minor relocation of labor pool likely	Sufficient infrastructure to absorb labor force	4
D	Insufficient labor pool within commuting distance	Insufficient infrastructure to absorb labor force	1
E	Some relocation of labor pool likely	Insufficient infrastructure to absorb labor force	2

D
WEIGHTING WORKSHOP HANDBOOK

Applicants seeking to deploy new nuclear power facilities must obtain site permits and approval for construction and operation from the Nuclear Regulatory Commission (NRC). Subpart A of 10 CFR 52 provides the requirements for an early site permit (ESP), which allows for early resolution of site-related safety and environmental issues. This handbook is an appendix of the Siting Guide, and serves as a roadmap and tool for applicants to use in developing detailed siting plans to support an ESP application

The Siting Guide describes a four-step site selection process involving sequential application of exclusionary, avoidance, and suitability criteria, as well as incorporation of preferences (or weighting factors) that are applied to the suitability criteria. The exclusionary, avoidance, and suitability criteria address the full range of considerations important in nuclear power plant siting, including health and safety aspects, environmental aspects, socioeconomic and land use aspects, and engineering and cost aspects. The criteria encompass construction, operations, transportation, and accident conditions. In addition to providing applicants with a process for identifying suitable ESP sites, this approach is designed to satisfy National Environmental Policy Act (NEPA) requirements for the consideration of alternate sites.

Handbook Objective

To provide a logical and systematic framework for eliciting, assigning, and incorporating value judgments for the relative importance of individual site selection criteria.

Steps 3 and 4 of the siting process involve evaluation of suitability criteria. In evaluating the inevitable trade-offs between suitability criteria, it is necessary to assign a relative importance to each criterion in selecting a nuclear power plant site. Assignment of weights is a sensitive issue in siting studies because the opinions and value judgments as to the relative importance of distinct criteria vary with the perspectives of the individual stakeholder or group (e.g., utility, regulator, and public interest group). The objective of this handbook is to provide a logical and systematic framework for eliciting, assigning, and incorporating such value judgments for use in Steps 3 and 4 of the siting process. This handbook addresses the use of the Delphi process to obtain individual and group preferences on the relative importance of criteria.

In conducting group exercises to assign judgments (weights) to represent the relative importance of siting criteria, there are several overarching elements to consider.

1. It is essential to recognize that such judgments reflect not only the intrinsic value of the individual criterion, but the quality, depth, and reliability of the characterization information on the sites being evaluated. It is not unreasonable to assume that the uncertainty associated with the data profile for a specific criterion may have as much influence on its importance (as judged by those assigning weights) as what the data convey about the suitability of one site versus another. These notions demand that the applicant understand and communicate information on data quality and reliability to all who are involved in the process of assigning weights.

2. Although an applicant may chose to conduct a weighting exercise internally without the participation of any external stakeholders, the overall siting process is inherently linked to the applicant's public information program. Accordingly, the applicant should adopt as an operating assumption that the outcome of such weighting exercises could be requested by and made available to external stakeholders.

Organization of This Handbook

Section D.1 outlines the entire weighting process in a step-by-step systematic fashion from introductory remarks, to presentation of information, to establishing workshop expectations, to execution of the process steps, to time management.

Section D.2 addresses the guidelines for establishing and communicating the overall process and expectations, distributing information prior to the workshop, and addressing questions and concerns in advance of group activities.

Section D.3 describes the facilitator's roles, responsibilities, and performance expectations, including the need to set (and maintain) clear ground rules and protocols, and to ensure that pre-existing relationships (e.g., supervisors and subordinates in the same group) do not limit, inhibit, or otherwise impact the effectiveness of the process.

Section D.4 discusses factors important to participant selection (technical expertise, comfort level with group dynamics) as well as the notion of incorporating external (to the applicant organization) views.

Section D.5 outlines the (statistical analysis) options that can be used as the basis for initially establishing groups, for subsequently determining if "movement" has occurred with respect to group positions, and for determining when "closure" has been achieved.

Section D.6 provides guidance on basic requirements of and content for weighting process documentation, including, where appropriate, examples of the types of information that should be included to meet these objectives.

Section D.7 provides an example workshop and agenda and worksheets.

Section D.8 identifies examples of potential circumstances that could arise during and/or following workshop execution, and indicates strategies for resolution.

D.1 Weighting Process

It is recommended that the weighting process be conducted using the Delphi technique. The intent of applying the technique is to establish, through the collective judgment of a group of siting and energy experts or other interested parties, the relative importance of each suitability criterion for nuclear power plant site selection. In evaluating the trade-offs between suitability criteria, it is necessary to assign a relative importance to each criterion in selecting a nuclear power plant site; the relative importance should be reflected as a numerical weight value. For example, if thermal impacts are considered to be twice as important as entrainment effects, the former criterion might be assigned a weight value twice as large as that for the latter. Assigning weights is a sensitive issue in siting studies because opinions and value judgments as to the relative importance of distinct criteria vary with the perspectives of the individual or interest group (e.g., utility, regulator, and public interest group).

The Delphi technique described herein to solicit, document, and establish judgments of relative importance is a modified form of the traditional Delphi procedure that has been used successfully in numerous applications on site selection projects. As with all Delphi techniques, it is characterized by an iterative methodology as shown in Figure D-1 that begins with autonomous assessments or value assignments by each participant. The value assignments are statistically summarized providing a group-based measure to which each participant can respond. A group discussion is then conducted, which completes the first iteration. The next iteration is initiated with the reassignment of values based on feedback from the discussion process.

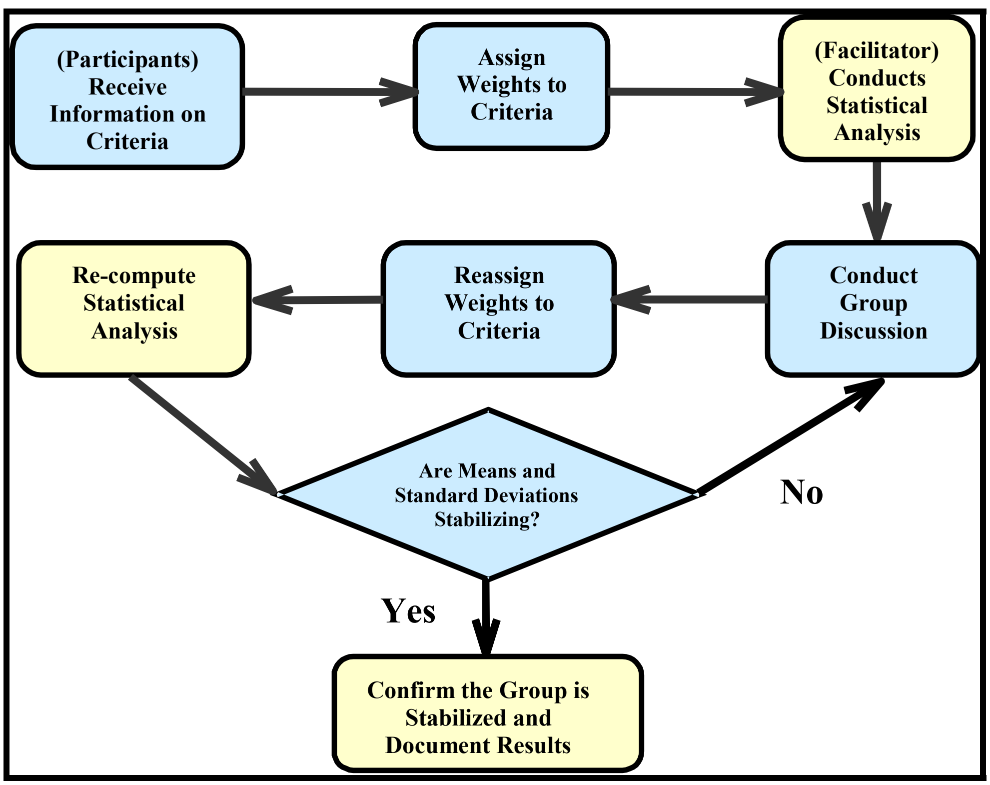


Figure D-1
Simplified Weighting Process Diagram

There are a number of techniques for assigning weights to criteria. For purposes of this handbook, a point allocation weighting technique is described. In this process, a pool of points (generally 100 or 1,000) is provided to each participant for purposes of distribution across all criteria. The participant assigns points to each individual criterion, with those that are judged more important receiving a greater proportion of the available points. An alternative process is a ratio weighting technique, under which suitability criteria are placed in rank order and a value of 1 is assigned to the least important criterion. The participant assigns numerical weights such that each of the remainder of the criteria receive a weight value depicting how much more important it is relative to the other ranked criteria. These relative weights are then normalized to 1.0. Although this technique is not explicitly discussed here, in concept the two techniques yield the same type of information (participant preferences) and can be used with equal effectiveness to support the weighting process.

The Overall Procedure is Conducted in Eight Major Steps

- Define process objectives
- Select participant group
- Describe suitability criteria
- Assign individual importance weights
- Conduct statistical analysis
- Conduct group discussion
- Achieve group stability
- Incorporate results into the site selection process

Define Process Objectives. Defining the objectives of the Delphi process involves establishing criteria to be evaluated. It is assumed that all (non-engineering) suitability criteria identified in the Siting Guide would be subject to the Delphi process. It is essential that information on each suitability criterion be documented and provided to participants in advance of the workshop. (Note: See Section D.2 of this handbook for additional information on pre-planning.)

Incorporation of Engineering Criteria

As described in Section 3.4 of the Siting Guide, the measure for all engineering criteria is cost in dollars, which is a universal metric. Accordingly, utility functions and weights are not developed for these criteria. Rather, costs developed for each engineering criterion are summed for each site. The total of site-related costs represents site-specific cost differentials among the potential and candidate sites. Composite site-specific costs are examined against the other criterion results from Steps 3 and 4 of the siting process. That is, costs would be balanced against the results arising from the application of the Health and Safety, Environmental, and Socioeconomic criteria and their associated weights.

Select Participant Group. After the objectives of the Delphi have been established and the criterion set documented, a participant group is selected. The participant group may be formed in several ways. It may be a multidisciplinary group, a multi-interest group, or both.

- **Multidisciplinary groups**, including geotechnical, hydrological, engineering, demographic and ecological experts, to list a few, might explore the assignment of relative importance, primarily from a technical viewpoint.
- **Interested groups** (such as the conservation groups, utility associations, and elected officials) might perform the evaluation from a socioeconomic or socio-environmental perspective.

- A typically **balanced group** might include professionals in different applied sciences, planners, managers, lawyers, and the lay public representing specific interests.

The group must include participants who can address each of the suitability criteria and impart their specific knowledge to the group. In addition, it may be beneficial to include generalists (people who may have come from a specific area of application and have, through their experience, developed general knowledge within the area of power plant siting). (Note: See Section D.4 of this handbook for additional information on participant selection.)

Describe Suitability Criteria. At a suitable meeting place, the facilitator begins the first group meeting. (Note: See Section D.3 for additional information on the role of the facilitator and sample agenda attachment at end of handbook.) The principal investigators and/or subject matter experts from the project team present information on each of the suitability criteria that are being evaluated. Having been made aware of a general definition and scope of each criterion, each participant gains a detailed understanding of how source data is collected, developed, and translated into information on the specific suitability criteria. The presentation/discussion of each suitability criterion continues until the group feels that it has achieved a common understanding. This does not imply that the group has a common view as to the relative importance of the individual criteria, but that the participants have achieved a basic understanding of each criterion, its definition, and how suitability is measured (scaled). The objective of this activity is to assure that all participants are operating from a common information base. Each participant will be able to express his or her feelings about the importance of each criterion by assigning weights during the iterative assessment process.

Assign Importance Weights. Each participant assigns a point value to each of the suitability criteria from among the total points provided (i.e., typically 100 or 1,000 total points). The number of points assigned represents the weighting or importance value of each criterion and is a measure of its level of contribution to the composite evaluation of nuclear power plant site suitability. These values are assigned confidentially and at the conclusion of each participant's assessment, the facilitator collects the participant's ballot so that the values can be aggregated into a group statistical summary. (Note: See Section D.7 for an example form to be used in assigning weights.)

Conduct Statistical Analysis. Once all participants have finished value assignments, the facilitator performs a statistical analysis of the results. The analysis results are reported to the participants, including each individual's values which are normalized to a common scale and the group averages. By comparing the group average results from every iteration, it is apparent how the group values are changing as a result of the interactive discussion process. In addition to the group average, the standard deviation for each suitability criterion is computed and reported to the group to show the group how it may be converging or diverging for any particular criterion.

After the statistics have been computed and reported to the participants, each participant reviews the values that he or she assigned (which have been normalized to a common sum total for comparative purposes) and compares them with the group average values. During a short period of review, each participant determines if he or she believes that the group average should be higher or lower, and, if so, prepares arguments to present to the other participants with the intent of persuading them to change their value assignments during the next iteration. (Note: See Section D.5 of this handbook for additional information on the statistical analysis process.)

Conduct Group Discussion. The group discussion is conducted in two parts.

1. During the first part, each participant has the opportunity to speak, without interruption, to **present specific views or arguments** concerning each suitability criterion.

2. Once each participant is given the opportunity to speak, an open discussion is held where **additional information may be presented**. When the open discussion is concluded, the process is iterated.

Each participant is asked to assign new values based on the information or the learning that has occurred during the group discussion. If one participant is particularly convincing in his presentation, then others may change their values, although there is no requirement to change weights. At the conclusion of the next value assignments, the statistics are computed again and reported to the group. After review of the group statistics, each individual is aware of the degree to which the group position has changed with respect to each suitability criterion and can develop additional arguments or restate previous arguments to persuade the group to move a value in a desired direction. Alternatively, participants may decide to change their own weight values. The group discussion is reconvened, and the entire process is repeated.

Achieve Group Stability. The first iteration of the procedure is primarily considered to be a learning iteration; that is, individuals who are conversant with only some of the suitability criteria will learn a great deal about the remainder. In the second iteration, a greater exploration of siting trade-offs begins to take place. As the participants learn more about the challenge of the siting process and the impact of the suitability criteria on this decision, new ideas occur, new concepts are presented, and a greater exploration or a more comprehensive view of the siting process and the influence of individual criterion is achieved. After several iterations of the entire process, as the facilitator continually monitors several key statistical indicators, the group-normalized weights tend to stabilize. Upon achieving a stabilized group opinion or value for each criterion, the Delphi process is complete and the final group averages are considered the collective group judgment concerning the relative importance of each of the suitability criteria.

Incorporate Results into Site Selection Process. Once a final set of group normalized weights is established, these weights are then multiplied by the suitability scores (1-5) for each of the criterion-weight pairs and these products summed to get an overall weighted score (composite suitability value) for each candidate site. These composite suitability values can then be used to rank or compare sites in terms of their overall suitability and are used, in concert with the site cost differentials, as the basis for identifying a preferred site. (Note: See Section 2.4 of the Siting Guide and Section D.6 of this handbook for additional information on process closure.)

D.2 Pre-Planning Activities

The objectives of pre-planning activities are to establish expectations, to communicate these expectations, and to ensure that these expectations are understood and accepted by the participants. While the nature and formality of the pre-planning activities will vary to some degree depending upon the composition of the workshop (e.g., presence or absence of external stakeholders), the following activities should be conducted prior to the workshop.

- Establish and transmit workshop expectations and process (protocols)
- Provide additional information on the overall decision (site selection) process
- Conduct a pre-meeting to ensure common understanding of expectations and process.

It is essential that all participants come to the workshop with a comparable understanding of expectations and the overall process. Ideally, several weeks before conduct of the workshop, materials describing objectives and the sequencing of steps should be provided to participants either via mail, email, or a secure Website. Objectives could include the following:

- Establish relative importance of suitability criteria to the overall siting process;
- Determine which suitability criteria are deemed most importance to the siting process; or
- Identify which suitability criteria should play the most important role in siting.

The process description should include the information presented in Section D.1 of this handbook augmented by information in the Siting Guide (i.e., Section 3.0), which describes in detail the site selection criteria. Once transmitted, the facilitator should contact each participant to ensure receipt, address initial questions, establish a time for a pre-meeting to field questions from participants, and understand each participant's background and motivation for involvement. If, as part of the workshop process, it is intended to augment the criterion list by adding specific suitability criteria or to understand the impact of removing criteria from consideration, then these permutations should be communicated to the participants as part of the process description.

Beyond these basic materials on the workshop process and siting criteria, it may be useful to provide the participants with information on how the final weights are used to identify preferred site(s). This interplay of scaling values and weights is a concept that is often misunderstood, and all participants should have a realistic view of the way in which the outcome of the workshop will influence the overall site selection decision.

At least one week before the workshop, the facilitator should chair a pre-meeting to entertain questions on the workshop objectives and process. (Note: If participants are in several geographic locations, a conference call will be sufficient.) It will likely be important to have subject matter experts available if detailed technical questions are asked, which are outside of the facilitator's area of expertise. A full participant pre-meeting has several benefits.

- Addressing questions prior to workshop conduct allows more time at the workshop to be **dedicated to group discussion and interaction**.
- It ensures that participants are **receiving consistent information** from the facilitator and subject matter experts.
- It serves as a **safety mechanism,** if a question on process, protocols, or criteria arises, which has not been considered by the facilitator or subject matter experts.

As a method of closure, all questions, answers, and participant background information should be documented and provided to participants before their arrival at the workshop.

D.3 Role of the Facilitator

The facilitator is essential to the success of the process of assigning value judgements and eliciting group preferences regarding the relative importance of siting criteria. An effective facilitator must be knowledgeable, a catalyst, and inquisitive, yet at the same time dispassionate, objective, and unaffected by the results. In order to ensure that such success is achieved, the facilitator must play a number of roles in the execution of the Delphi workshop process. The facilitator's roles include:

- Dispensing information
- Serving as an arbiter, and
- Identifying when closure is achieved.

Dispensing Information (Setting the Stage). The facilitator's initial function is to ensure that the entire process is clear, unambiguous, and well understood by all participants. This includes delineating the role of the facilitator in the workshop (see sample agenda attachment at end of handbook). Although all participants will have received materials in advance of the workshop, the facilitator should review the information with the group. All participants must accept the overall ground rules for execution of the workshop. It is important for the participants to understand that while their opinions and judgements are crucial, the end result is to converge upon a "group view" that is reflective of each of the participant's views. The participants should also be made aware that it is highly likely that as the process unfolds, individual views (including their own) may well change. Finally, there is an expectation that participants will be open to accepting the positions of others and recognize that the objective of the process is to identify as much common ground as possible among all participants.

In addition to process-specific information, the facilitator at the outset must clearly establish "code of conduct" expectations for the group. Participants must be clear regarding what is acceptable interactive behaviour with their fellow participants. Technical disagreements and differences are to be expected. The facilitator should distinguish between facts (information that can ultimately be determined to be true or accurate) and opinions (judgments which are not inherently right or wrong but are a reflection of one's views). The objective of this overall "stage setting" is to ensure that each and every participant understands the workshop objectives, process, and expectations. As a constant reminder, it will be useful for the facilitator to capture these notions on a flip chart or board that is readily visible to the group.

Serving As Mediator (Managing the Process). Once the workshop process begins to unfold, the facilitator's role transitions to one of ensuring that the process is being implemented as prescribed. This function has several dimensions.

1. The facilitator must **lead the group** through each process step and monitor the time increment associated with each. In this function, the facilitator serves as a guide, but does have ultimate decision authority regarding process execution, agenda, and schedule.

2. The facilitator must **ensure that all participants have a basic understanding** of technical elements, which is not the same as saying all participants are in agreement. In this function,

the facilitator "checks" with each individual and determines whether there is a common information base or framework to use as a point of departure for discussions.

3. The facilitator must **mediate disagreements among participants**. This essential function requires that the facilitator help the participants to delineate and fully understand their differences on particular aspects. The facilitator's role is not to force the participants to agree; the participants will make that determination when they reassign weight values through subsequent iterations of the process.

Identifying When Closure Is Achieved (Achieving Consensus or Stability). As indicated in Section 2.0, the weighting process is an iterative one of assigning weights – conducting statistical analysis – presenting individual views – conducting open discussion – and then reassigning weights, and so on. The first iteration of the process can be characterised as essentially a learning iteration in that most participants have a detailed understanding of a subset of the siting criterion and a limited understanding of the balance. As the process iterates, the participants become individually more conversant in the full range of siting criteria and more detailed and insightful group discussions may occur. Generally over a number of iterations, the participant weights will tend to converge and/or stabilize. The function of the facilitator is to gauge the stability of the group values and assess the extent to which additional convergence is possible or likely. The facilitator can accomplish this through the use of some statistical tests (see Section 6.0) as well as by "checking" with the group. The decision rests on two elements:

1. Is there any **additional technical information** that can be brought forward for the group's benefit to enhance individual and collective understanding?

2. Are there any participants who believe that their **positions or views may change further**?

If the answer to both questions is "no," then a stabilized group position has been achieved.

D.4 Participant Selection

Although the participant group may be formulated in a number of different ways, there are generally two dimensions to any participant group.

- The collective area(s) of expertise, and
- The range of viewpoints

Selection of Internal and External Participants

Basic objectives that should be addressed in selecting participant groups include obtaining representation, where feasible, of the breadth of technical disciplines, the range of viewpoints, and the spectrum of stakeholder constituencies. Beyond these objectives, very different challenges are presented when establishing internal participants versus external participants. In establishing an internal participant group, one must recognize the influence of organizational issues, such as existing supervisory-subordinate relationships, responsibility for major elements of the ESP program, and work history. These elements may impact both who is selected to participate and how they react in a group setting. For example, if Sam and Joe are candidate participants, and Sam is Joe's aggressive supervisor and Joe is known to be passive and non-confrontational, including both individuals in the weighting workshop may impact the effectiveness of the participant group. Beyond interpersonal issues, the project organizers (and/or facilitator) need to be mindful of each individual's interest level in the process. For example, if Harry is a knowledgeable, yet not highly motivated technical resource, his contribution to the group process may be limited.

In establishing an external participant group, each individual should have some "standing" with respect to the program/project (e.g., they are elected or appointed officials, they represent potentially affected individuals, they represent a group that has recognized status as representing the public interest, or they are a nearby resident). It must be recognized that the process of selecting external participants is in some measure being ceded to the external group(s). That is, once the issue is in the public domain, external stakeholder entities will tend to self-identify and will certainly self-appoint their representative(s) for a group process. As a point of reference, it may be useful to determine if group weighting activities have been conducted to address local or regional issues and, if so, determine how such groups were constituted. For external group participants, it may be particularly important to have a pre-meeting to ensure that all participants understand and accept the workshop protocols. For example, if it becomes apparent that Bill will likely not accept the workshop framework, and may use the event as a forum for advocating a position, the project team may need to inform his organization that they need to appoint another representative.

In selecting participants from among groups of similar or competing interests, the project team should be mindful of the political dynamics and long-term ramifications that may result from selecting one organization's representative for workshop participation over another similar organization's prospective participant. The weighting process may benefit from conducting similar workshops with other participant groups; an attachment to this appendix highlights the value of multiple workshops.

Areas of expertise include those disciplines associated with the scope of the siting criteria, including geo-technical, hydrology, engineering, radiological, transportation, demography, ecology, land use, and cultural resources practitioners. Ranges of viewpoints are reflective of one's view of the relative importance of the respective criterion as well as one's view of the need, safety, and effectiveness of nuclear power. The participant group should be constituted with individuals representing both a range of technical disciplines and a range of viewpoints.

Beyond participants who have identifiable areas of expertise and points of view, the participant group can also benefit from the presence of generalists (i.e., individuals who can knowledgeably provide input in several of areas and in the siting process). Generalists can serve two functions. They provide a technical check for many of the technical specialists. They also have some ability to weigh and balance a number of technical aspects and place multiple notions in context.

For the weighting process to be effective, each participant must be comfortable with the dynamics of group interactions, which will require each participant to be able to effectively articulate their positions and viewpoints as well as to contribute to group discussions and deliberations. Individuals who are reluctant or not comfortable with such processes should not be considered, even if they are recognised as a technical expert.

There is no ideal number of participants; however, some boundary parameters to consider are:

1. There must be a sufficient number of participants so that, collectively, there is a **knowledge base that spans the full range of technical disciplines**. This would indicate a minimum of 8-10 persons. While it is possible to use non-voting "resource" personnel to supplement a small participant group, it is preferable to have all attendees participate in the entire process.

2. The size of the group must be such that all participants can **effectively share their views within the allotted schedule and that meaningful group discussion can be conducted**. This would suggest that a group size not in excess 20-25 participants. Larger groups become difficult to manage and are susceptible to a small number of group members exerting a disproportionate influence on the other participants.

If the applicant elects to include external participants in the weighting process, several additional notions are important:

- Understand the full range of viewpoints associated with external stakeholders;
- Recognize the range of external stakeholder entities (e.g., governmental bodies, elected officials, public interest groups, and lay persons);
- Select a representative of each stakeholder group; and
- Emphasize communication and pre-planning activities to ensure stakeholder representatives understand overall process and expectations.

The applicant should recognize that once a participant group has been constituted, the applicant may have some obligation to inform the group as to the progress of the siting process. Continued involvement of this group may also be of benefit to the project.

D.5 Statistical Analysis and Software

The approach used to calculate group statistics is somewhat dependent upon the size of the participant group. For groups of 15-20 or less, it is suggested that, after each iteration of allocating points among the suitability criteria, two measures be calculated for each criterion – the mean and the standard deviation.

The Mean and Standard Deviation

The **mean** represents the numerical average of weight values for each criterion and is the group's collective measure of the importance of that criterion with respect to the balance of the criteria.

The **standard deviation** reflects the degree to which group consensus or agreement exists for each criterion.

These statistics are recalculated for each iteration (i.e., each time the participants reallocate points among the suitability criteria). The facilitator then reviews the sets of statistics to determine if the following trends are occurring:

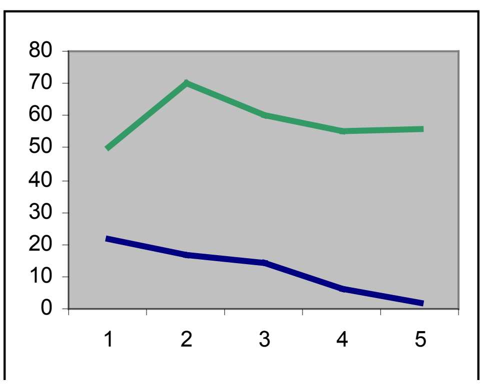
- If the mean for a criterion **continues to change significantly** (whether higher or lower), it is a reflection that the participants are continuing to adjust their view of the relative importance of the specific criterion with respect to the other criteria.
- If the standard deviation for a criterion **increases over iterations**, it is a reflection that the participants are exhibiting a greater divergence of views regarding the specific criterion.
- If the standard deviation for a criterion **decreases over iterations**, it is a reflection of increasing consensus of the group regarding the specific criterion.

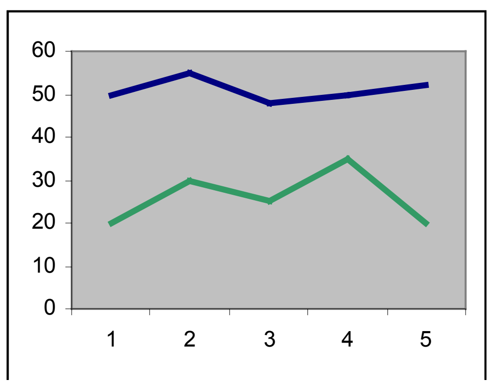
What Is Stability?

Group stability is the point in the process when there are no additional changes in the participant's views (as reflected in their weight values) regarding the relative importance of the site selection criteria. The facilitator can monitor the output of each round of voting to determine if stability is being achieved. The first chart is a hypothetical example of five rounds of voting where the mean for a criterion (the top line) is changing minimally and the standard deviation (the bottom line) is decreasing. These patterns suggest a criterion for which the group has reached consensus on its importance and there is minimal, if any, disagreement or change from round to round. Clearly, the group has reached stability on this criterion.

The second chart is a hypothetical example of five rounds of voting where the mean for the criterion (the bottom line) is showing some, but not significant change, yet the standard deviation (the top line) is constant and high. These patterns suggest that while the group's mean has not changed much, there is not unanimity of opinion regarding the importance of this criterion. In this case, the facilitator should pulse the group to understand the nature of the differences among participants (i.e., why do some feel the criterion is relatively important and others do not) and determine if any additional movement, resolution, or change is likely. If there is none, then the group has reached stability for this criterion.

If wide variations in the views of importance persist, the facilitator may recommend to the project team that a sensitivity analysis be conducted, using importance values representative of various opinions. These sets of values would be used to calculate composite suitability scores for each site. Comparison of the "scores" would indicate the affect of the various opinions on the siting decision.





As with any group there will not be total unanimity. The objective is to determine when stability is being exhibited. Accordingly, the statistical evidence to look for includes minimal change (from iteration to iteration) in the individual criterion mean values and evidence of stability in the individual standard deviations. When both those conditions have been met, the group process has reached closure. (Note: A spread sheet at the end of this handbook enables tracking of iteration-by-iteration weighting point allocation and calculation of statistical measures.)

For larger groups (30-40 and above), an alternative approach is suggested, which involves establishing subgroups – each of which has a somewhat common view of the relative importance of the suitability criteria. These subgroups would be established statistically by calculating a series of standard deviations and assigning individuals to groups who have a common portfolio of allocated points (e.g., geologic features most important). Once these groups are established, they would operate independently, but in a fashion as described above to facilitate achievement of consensus within each subgroup. When the subgroups achieved stability, preferred sites (site rankings) would be identified for each.

How to Form Subgroups

If the number of participants is approaching 30, it may be necessary to split the group into subgroups. This is accomplished by reviewing the first round of weight assignments and clustering individuals with similar views. Recognizing the large number of site selection criteria, it is unlikely that two participants will ever vote identically. However, there are statistical methods, as outlined below, which can be applied for reasonable and defensible identification of subgroups for later rounds of voting. Subgroups are established by calculating a series of standard deviations that indicate similarity of views (software programs exist to perform these calculations). In layman's terms, subgroups are established based on individuals whose portfolio of preferences is most similar. Beyond identifying similarities, the facilitator must also decide when reviewing the initial balloting what constitutes a group (e.g., two persons, at least four persons, no more than 10 persons). The table below is a hypothetical ballot from eight participants in a weighting exercise, each of whom has allocated 100 points across 10 site selection criteria.

	P1	P2	P3	P4	P5	P6	P7	P8
C1 - HS	10	5	10	15	20	5	10	10
C2 - HS	15	5	5	10	10	5	15	5
C3 - HS	20	0	5	15	10	5	10	0
C4 - HS	10	5	5	15	10	5	10	5
C5 - E	5	20	20	5	5	25	5	10
C6 - E	5	15	15	0	5	15	10	10
C7 - E	0	20	20	0	5	15	10	15
C8 - E	5	20	10	0	5	15	10	20
C9 - S	15	5	5	20	20	5	5	15
C10 - S	15	5	5	20	10	5	15	10
	100	100	100	100	100	100	100	100

From a visual review of the information one could make the following observations/groupings:

- Participants 1, 4, and 5 could constitute a group on the basis of each allocating over 50 points to the health and safety criteria, over 30 points to the socioeconomic criteria, and no more than 20 points to the environmental criteria.
- Participants 2, 3, and 6 could constitute a group on the basis of each allocating over 60 points to the environmental criteria, no more than 25 points to the health and safety criteria, and no more than 10 points to the socioeconomic criteria.
- Participant 7 allocated weights evenly, and could join either of the above groups, although he/she may not find another participant who supports his/her evenly weighted preferences.
- Participant 8 voted like the second subgroup (55 points to environmental criteria) and somewhat like the first subgroup (25 points to socioeconomic criteria). Matching participants based on their strongest preferences would result in this participant being assigned to the second subgroup.

Sophisticated mathematical models are available to analyze participant voting and develop statistical measures of voting "likeness." Applicants should use such models when (1) participants exceed 30 or more, (2) rigorous documentation of decisions is required (because of institutional sensitivities), and (3) expert mathematical consultation is available to support data analysis.

D.6 Document Closure

After completion of the workshop process, it is important to ensure that the results are documented. These records are of several types and include the elements identified below.

Checklist of Records to be Retained from Workshop Process

- **Final Group (Mean) Weights.** This represents the ultimate end result and is a critical input to the site selection process in order to establish an overall preferred site.
- **Final Group Standard Deviation.** This is a measure of the degree of consensus of the final group weights.
- **Individual Iteration Group Weights and Standard Deviations.** This information will provide an indication of the extent to which the Group evolved or changed during the course of the workshop.
- **Individual Raw Scores.** This information should be kept for purposes of being able to demonstrate quality and integrity of the process.
- **Lessons Learned.** If, during the course of the workshop, issues or suggestions are raised that may be of value, these should be documented for consideration in the conduct of future weighting exercises.

D.7 Example Agenda and Worksheets

Example Workshop Agenda

Step	Topic	Participation	Time (min)	Comments
1	Introductions	All	10	
2	Discussion of Process and Ground Rules	Facilitator	15	
3	Presentation of Information on Suitability Criteria	Subject Matter Experts	90	Could be somewhat variable
4	Assign Importance Weights	Participants	20	
5	Break	All	20	
6	Compute Statistical Analysis	Facilitator	20	During Break
7	Review Statistical Results and Prepare for Group Discussion	Participants	20	
8	Group Discussion/Each Individual Speaks	Participants	60	Varies with group size
9	Group Discussion/Open	Participants	30	
10	Reassign Importance Weights	Participants	15	
11	Break	All	75	Lunch
12	Recompute Statistical Analysis	Facilitator	20	During Break
13	Review Statistical Results and Prepare for Group Discussion	Participants	20	
14	Group Discussion/Each Individual Speaks	Participants	60	Varies with group size
15	Group Discussion/Open	Participants	30	
16	Reassign Importance Weights	Participants	15	
17	Break	All	20	As needed when iterating
18	Recompute Statistical Analysis	Facilitator	20	During Break
19	Review Statistical Results and Determine if Group Stabilized	Facilitator and Group	20	If stabilized, adjorn; if not, repeat steps 14 -18

ASSIGNMENT OF WEIGHTING POINTS WORKSHEET				
Participant Identifier:		**Date:**		
Criteria	**Iteration 1 Points**	**Group Average**	**Iteration 2 Points**	**Group Average**
Health and Safety				
Vibratory Ground Motion				
Capable Faults				
Surface Faulting and Deformation				
Geologic Hazards				
Soil Stability				
Cooling Water Supply				
Flooding				
Existing Facilities				
Projected Facilities				
Winds				
Population				
Emergency Planning				
Atmospheric Dispersion				
Dilution Capacity				
Baseline Loadings				
Proximity to Consumptive Users				
Groundwater Radionuclide Pathway				
Topographic Effects				
Atmospheric Dispersion				
Air-Food Ingestion Pathway				
Surface Water-Food Radionuclide Pathway				
Transportation Safety				
Environmental				
Disruption of Important Species/Habitats				
Contamination				
Grain Size				
Important Species/Habitats				
Ground Cover/Habitat				
Wetlands				
Depth to Water Table				
Proximal Wetlands				
Migratory Species Effects				
Disruption of Important Species/Habitats				
Water Quality				
Entrainment Organisms				
Upstream Contamination Sources				
Sedimentation Rates				
Important Species/Habitat Areas				
Source Water Suitability				
Socioeconomics				
Socioeconomics-Construction-Related Effects				
Socioeconomics-Operation				
Environmental Justice				
Land Use				

WORKSHOP CALCULATION WORKSHEET

CRITERIA / PARTICIPANT NUMBER	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	MEAN	STDEV
Health and Safety												
Vibratory Ground Motion												
Capable Faults												
Surface Faulting and Deformation												
Geologic Hazards												
Soil Stability												
Cooling Water Supply												
Flooding												
Existing Facilities												
Projected Facilities												
Winds												
Population												
Emergency Planning												
Atmospheric Dispersion												
Dilution Capacity												
Baseline Loadings												
Proximity to Consumptive Users												
Groundwater Radionuclide Pathway												
Topographic Effects												
Atmospheric Dispersion												
Air-Food Ingestion Pathway												
Surface Water-Food Radionuclide Pathway												
Population												
Transportation Safety												
Environmental												
Disruption of Important Species/Habitats												
Contamination												
Grain Size												
Important Species/Habitats												
Ground Cover/Habitat												
Wetlands												
Depth to Water Table												
Proximal Wetlands												
Migratory Species Effects												
Disruption of Important Species/Habitats												
Water Quality												
Entrainment Organisms												
Upstream Contamination Sources												
Sedimentation Rates												
Important Species/Habitat Areas												
Source Water Suitability												
Socioeconomics												
Socioeconomics-Construction-Related Effects												
Socioeconomics-Operation												
Environmental Justice												
Land Use												
TOTAL = 1000												

Total row only applicable if Point Allocation Rating Technique used; it is not applicable for the Ratio Weighting Technique.

Location:

Date:

Signature:

D.8 Other Weighting Process Case Study Scenarios

Appendix D outlines a logical and systematic framework and set of protocols for eliciting, assigning, and incorporating value judgments regarding the relative importance of site selection criteria. Beyond these process steps, the overall effectiveness and success of the weighting exercise and implementation of its results often requires the facilitator and/or project team to make challenging and difficult decisions. The objectives of this section are to:

- Identify examples of potential circumstances that could arise during and/or following workshop execution, and
- Indicate strategies for resolution.

Some of the scenarios selected for illustration reflect circumstances that have been encountered in the execution of a weighting workshop process and in the implementation of its results. Each of these situations would require deft and effective leadership and direction on the part of the facilitator and/or the project team. The scenarios include the following:

1. During the weighting process, a small number of participants submits random weights that vary widely from round to round negatively impacting the statistical results (the means and standard deviations) as well as the cohesion of the group.
2. A limited number of criteria are judged by the participants as meaningless to the exercise and a recommendation is made to remove these criteria from consideration.
3. The participant group prefers to assign weights at a higher level of aggregation rather than across all of the selection criteria (i.e., they wish to assign weights to groups rather than to individual criteria).
4. The participant group prefers to simply rank order the criteria rather than to assign weight values to each.
5. The applicant conducts only a single workshop comprised of internal participants, which yields a single set of weights that could be viewed as limited in terms of the diversity of views it represents.
6. As a result of one or more workshops, a number of weight sets are developed, the application of which leads to inconclusive or contradictory site rankings.
7. A stakeholder group, not involved in the workshop process, voluntarily submits its own set of weights for incorporation.

Each scenario is presented using a common format; its elements are as follows:

- **Scenario Description:** This section describes the situation and identifies the vulnerabilities to the weighting exercise from the conditions outlined.

- **Examples of Scenario in Practice:** This section provides examples of where or how the scenario could be encountered.
- **Possible Strategies for Resolution:** This section describes a number of strategies or approaches for addressing the scenario, indicating what steps or actions the facilitator/project team should implement to effect resolution.

Advantages/Disadvantages of Strategies: This section outlines the advantages and disadvantages associated with each of the alternative strategies described in the prior section.

WEIGHTING PROCESS CASE STUDY – SCENARIO 1

Scenario 1 Description: A small number of participants submits weights that vary widely from round to round negatively impacting the statistical results (the means and standard deviations) as well as the cohesion of the group.

Examples of Scenario in Practice: As part of a now-defunct Federal (i.e., Department of Energy) program to locate a geologic repository for high-level nuclear waste in crystalline rock formations, a weighting workshop was conducted for external participants (stakeholders) only. The workshop was attended by approximately 40-50 individuals, and its purpose was to solicit views on the relative importance of a number of geologic, engineering, environmental, and socioeconomic "screening variables" that were being used to discriminate among candidate locations across 17 eastern, north central, and southeastern States.

The screening variables were constructed much like the avoidance criteria in the Siting Guide. That is, they were intended to "drive" away from areas or conditions that were not compatible or desirable from the standpoint of locating a geologic repository. As a result, by knowing the conditions associated with a particular location of interest, one could theoretically "drive" the siting decision away from that location by allocating a large fraction of the available weighting points to those screening variables that had the most relevance for the location of interest.

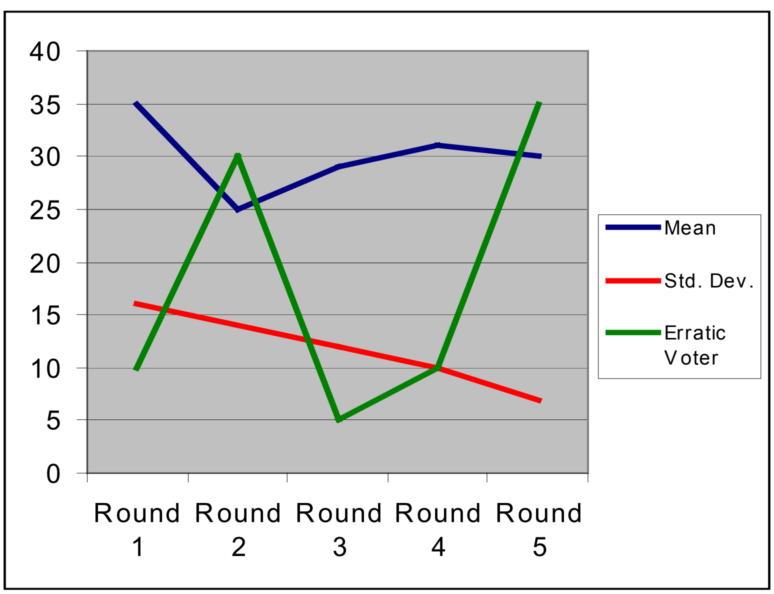
Due to the large number of invitees to the workshop, a decision was made prior to the workshop to split the participants into smaller groups after the initial vote. Subgroups were formed by clustering persons who had common views of the importance of particular screening variables (or whose portfolio of preferences had a degree of uniformity). Each of the stakeholders was representing one of the 17 States, and all the stakeholders had a working knowledge of the program, the specific screening variables, and the protocols for the weighting process (including how sub-groups would be formed).

A review of the initial vote revealed that a small number of participants (2 or 3) had allocated all their points to 1 or 2 of the (approximately 17) screening variables. All other participants had allocated points across most of the variables. This strategy of allocating all points to 1 or 2 variables did not changes from round to round, although the participants did periodically change the variables to which they allocated their points. (Note: Although this voting practice was not prohibited by the protocols, there was a belief on the part of some participants that this was a deliberate attempt to compromise the weighting workshop process.)

These individuals were statistically clustered in the same subgroup for the balance of the workshop. Each of the 4 subgroups operated independently, but in a fashion to facilitate achievement of consensus weights within each. When each subgroup achieved stability, the consensus weights for each subgroup were used to identify preferred (candidate) areas.

WEIGHTING PROCESS CASE STUDY – SCENARIO 1
Possible Strategies for Resolution: If it is clear that one or more of the participants is allocating points to only a small number of variables, the facilitator must first determine (during the initial individual discussions) the rationale for this decision. If the participant appears to have genuine technical reasons for his/her decisions, then the process should continue. However, if it becomes apparent (through, for example, random changing of the assignment of weighting points) in subsequent rounds that there is no rationale technical explanation for the voting behavior or if the individuals do not appear to be genuine in their approach, then the facilitator has 3 options: 1. Continue to allow the individual(s) to vote and include their inputs into the group statistical results. 2. Separate the “erratic” voters from the balance of the participants and form a second group. Under this strategy, there would be 2 group results. 3. Remove the individuals from the workshop process and do not include any of their inputs in the group statistical results
Advantages/Disadvantages of Strategies: (Note – It is recognized that this scenario would not occur in a weighting process that was attended by only internal, i.e., applicant personnel.) The advantage of the first strategy is that no participant can allege that he/she was not able to provide their input and have it considered as part of the weighting process. The disadvantages are that (1) intentional, erratic voting intrinsically devalues the importance of the other votes and, hence, the group product, and (2) other participants may allege that the process was not being applied genuinely and may challenge the legitimacy of the weighting results and its application to the selection of sites. The advantage of the second strategy is that the erratic voters can provide their input, but it does not directly affect the input of the other participants. The disadvantages are that (1) some participants might perceive that this solution provides erratic voters with a more significant platform (i.e., their own group) than afforded other participants, and (2) the solution introduces the challenge of applying two sets of group results to the final site selection process. (Note – For example, under this method one might have two sets of site rankings – one ranked set of sites based on the erratic voters final weight results and a second set of ranked sites arising out of the final weights developed by the balance of the participants.) The advantage of the third strategy is that the remaining (majority of) the participants do not have their inputs impacted by the inputs of those whose intent is unclear. The disadvantages (in an external workshop setting) are that (1) a stakeholder or stakeholder group is being removed from providing input to the process and (2) an implicit decision is being made about the intentions of selected participants that may be difficult to substantiate. The ultimate choice of strategy should be based on an assessment of the extent to which the facilitator believes that the erratic voters are intentionally attempting to subvert the process combined with consideration of the extent to which the balance of the participants believe that their input is being compromised. (See attached table for examples of potential erratic voting.)

Scenario 1: Examples of Potentially Erratic Voting for Hypothetical Participant				
Example A				
Criteria	**Round 1**	**Round 2**	**Round 3**	**Round 4**
C1 – Health & Safety	50	0	0	0
C2 – Health & Safety	50	0	0	0
C3 – Health & Safety	0	0	50	0
C4 – Health & Safety	0	0	50	0
C5 – Environmental	0	0	0	50
C6 – Environmental	0	0	0	50
C7 – Environmental	0	50	0	0
C8 – Socioeconomic	0	50	0	0
Example B				
Criteria	**Round 1**	**Round 2**	**Round 3**	**Round 4**
C1 – Health & Safety	13	0	25	0
C2 – Health & Safety	13	0	25	0
C3 – Health & Safety	13	0	25	0
C4 – Health & Safety	13	0	25	0
C5 – Environmental	12	34	0	0
C6 – Environmental	12	33	0	0
C7 – Environmental	12	33	0	0
C8 – Socioeconomic	12	0	0	100
Participants are allocating 100 points across the site selection criteria.				



The graphic displays conditions that might indicate erratic voting for a particular criterion. The group mean for the criterion is becoming constant and the standard deviation is decreasing; these patterns are indicative of group stability. However, the voting pattern for one participant bears little resemblance to the group trend and is to some degree erratic in and of itself. Because participants have a fixed number of points to allocate, it is likely that this hypothetical participant's erratic voting pattern may be exhibited for other criteria as well.

WEIGHTING PROCESS CASE STUDY – SCENARIO 2

Scenario 2 Description: A limited number of criteria are judged by the participants as meaningless to the exercise and a recommendation is made to remove these criteria from consideration.

Examples of Scenario in Practice: Frequently, when participants make judgments about the relative importance of site selection criteria (and assign weights), they consider one or more of the following in their decision process:

1. What is the significance of the criterion to the process of selecting a site that achieves its intended objectives (i.e., is the criterion inherently important)?

2. Does the description of the criterion adequately describe those concepts that are embodied within the criterion (i.e., is the criterion appropriately defined and understood)?

3. Does the information exist that allows that criterion to be applied in practice (i.e., is the data available at an appropriate scale and level of precision)?

If, in the mind of the participant, one of more of the above characteristics does not exist for a specific criterion, then they may use that condition as a basis to assign minimal (or no) weight to the criterion. If, for a specific criterion, such a view is pervasive across a group of participants, then a basis may exist to reconsider the application of the criterion in the entire siting process.

An example of the first condition might be that a number of participants believe that the notion of "Projected Facilities" is so intrinsically uncertain in its application as to be of limited value because one is being asked to judge the importance of one future and uncertain condition on another.

An example of the second condition might be that a number of participants believe that the concept of "Capable Faults" requires a significant number of assumptions to be made about the proximity, characteristics, and extent of a (three-dimensional) faulting pattern, and their impact on the viability of a site. The establishment and integration of these concepts may not be judged as compatible with the application of a scaling variable.

An example of the third condition might be that a number of participants believe that the concept of "wetlands" can not be readily applied using literature-based sources of information because field information and measurements would be needed to establish the precise location, aerial extent, and seasonality of marsh land areas.

What is important to recognize is that for the same decision (i.e., establishing site preferences) and using the same set of site selection criteria, different participant groups might have contrasting views inclusion or elimination of criteria (i.e., Group 1 – All criteria will be used; Group 2 – Criteria A and B should be removed from consideration; Group 3 – Criteria C should be removed from consideration).

WEIGHTING PROCESS CASE STUDY – SCENARIO 2

Possible Strategies for Resolution: If some of the participants raise questions about the value and/or application of certain screening criteria (and therefore their inclusion in the process), then the facilitator must first determine the basis for and pervasiveness of the concern. It will be important to have the subject matter experts available during this dialogue to address technical, definitional, and data adequacy questions. Subject matter expert clarifications may resolve participant concerns. If this exchange does not satisfy those participants who have concerns about selected criterion, then the facilitator has three options:

1. Include all criteria in the weighting process; make no process changes. Advise participants to assign low weights to the criteria of concern.

2. Modify the process to have participants vote with and without the “controversial” criteria; modify the process to enable the participants to see the impact of the controversial criteria.

3. Remove the controversial criteria from the process; have participants vote only on the balance.

Advantages/Disadvantages of Strategies: The advantage of the first strategy is that it preserves the original set of criteria as a standard. This may be particularly important if the weighting process is to be conducted a number times with several participant groups, and the concept of a fixed set of criteria is methodologically beneficial to compare and contrast results. In addition, the concerned participants could be instructed to assign a value of “0” to the subject criteria. The disadvantages are that (1) the facilitator could be perceived as not being responsive to the group (or at least to some participants), and (2) if the concerns are pervasive, the group could question the legitimacy of the results.

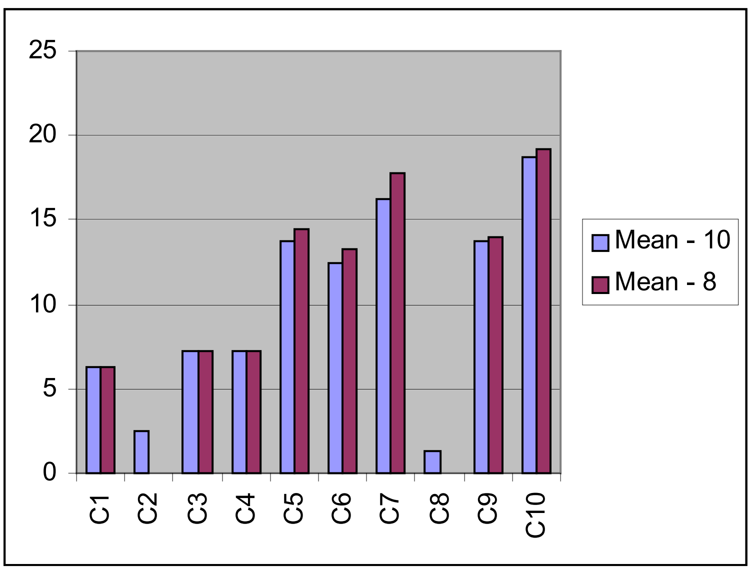
The advantage of the second strategy is that the participants can see the impact of removing the “suspect” criteria on the process, and the ability to perform a comparison may alleviate concerns (see table and graphic below). The disadvantages (especially if only a few participants have concerns) are that (1) the protocols and methods have been adjusted to accommodate a few participants, and (2) the modification introduces additional time into the workshop process.

The advantage of the third strategy (especially if a group consensus exists) is that it focuses the participants’ attention on what the group believes to be important. The disadvantage is that if the weighting process is to be conducted with a number of participant groups, the concept of a fixed set of criteria may be methodologically beneficial to compare and contrast results (i.e., other groups may not agree with the criteria elimination).

The ultimate choice of strategy should be based on the degree of group consensus regarding the “suspect” criteria and the potential for conducting similar weighting processes with other groups.

Note: A scenario of considering the introduction of additional criteria would be subject to the same types of strategies, issues to address (e.g., modifying the process), and advantages and disadvantages and, hence, has not been discussed separately in this material.

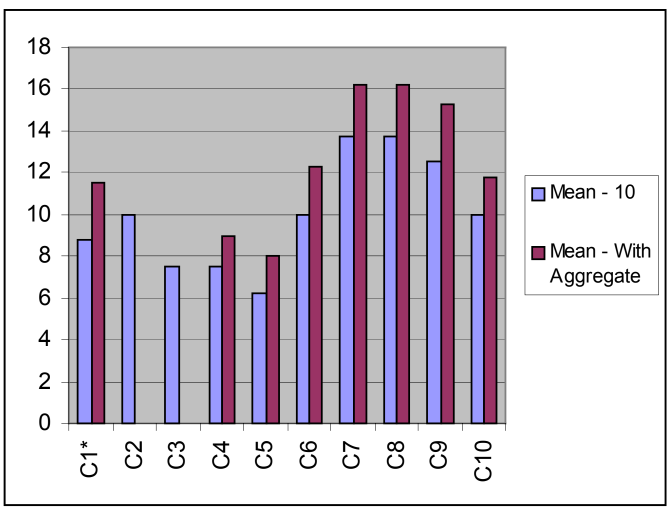
Scenario 2: Comparison of Weighting All Criteria Versus Weighting Without "Controversial Criteria"					
Participant Group – All Criteria					
Criteria	**P1**	**P2**	**P3**	**P4**	**Mean (Rank)**
C1	10	5	5	5	6.25 (8)
C2	5	5	0	0	2.5 (9)
C3	10	5	5	10	7.25 (6)
C4	5	10	5	10	7.25 (6)
C5	10	20	10	15	13.75 (3)
C6	5	20	10	15	12.5 (5)
C7	20	15	5	25	16.25 (2)
C8	0	0	0	5	1.25 (10)
C9	15	10	25	5	13.75 (3)
C10	20	10	35	10	18.75 (1)
Participant Group – Without "Controversial" Criteria					
Criteria	**P1**	**P2**	**P3**	**P4**	**Mean (Rank)**
C1	10	5	5	5	6.25 (8)
C3	10	5	5	10	7.25 (6)
C4	5	10	5	10	7.25 (6)
C5	10	22	10	16	14.5 (3)
C6	5	22	10	16	13.25 (5)
C7	22	16	5	28	17.75 (2)
C9	16	10	25	5	14 (4)
C10	22	10	35	10	19.25 (1)
Participants are allocating 100 points across the site selection criteria.					



The graphic displays the slight differences in mean values for the case where participants allocate points among all 10 criteria versus a case where points are allocated among 8 criteria (excluding controversial criteria, the points originally allocated to which were minimal).

WEIGHTING PROCESS CASE STUDY – SCENARIO 3
Scenario 3 Description: The participant group prefers to assign weights at a higher level of aggregation rather than across all of the selection criteria (i.e., they wish to assign weights to groups rather than to individual criteria.
Examples of Scenario in Practice: Often times recommendations are made to combine site selection criteria prior to conducting the weighting process. This is generally due to a belief that the criteria have some commonality or overlap and it is not necessary to distinguish between or among the criteria. This is typically associated with the knowledge that the data or information supporting the criteria is limited, and while the concepts are important, application of the site selection criteria in practice will be challenging. For example, participants may propose that "vibratory ground motion," "capable faults", and "surface faulting and deformation" be considered as a single criterion because all address stability of the underlying geologic formation, and impact the seismic design of the facilities. Typically, these recommendations are provided by individuals having some level of understanding of the criteria and the underlying data. Accordingly, such recommendations will likely come with some level of credence with the other participants.
Possible Strategies for Resolution: Similar to the previous scenario, the facilitator must first determine the pervasiveness of the concern. It will be important to have the subject matter experts available during this dialogue to address technical and definitional questions. If, after this dialogue is complete, and the recommendation remains on the table, there are two options. 1. Include all criteria in the weighting process; make no process changes. 2. Allow the process to be executing using the "aggregated" criteria.
Advantages/Disadvantages of Strategies: The advantage of the first strategy is that it preserves the original set of criteria as a standard. This may particularly important if the weighting process is to be conducted with several groups, and the concept of a fixed set of criteria is methodologically beneficial to compare and contrast results. The disadvantages are that (1) the facilitator could be perceived as not being responsive to the group (or to some participants), and (2) if the concerns are pervasive, the group could question the legitimacy of the results. The advantage of the second strategy (especially if a group consensus exists) is that it focuses the participants' attention on what the group believes to be relevant, and it still enables participants to consider the all the original criteria, only for some, in a composite format. If the weighting process is to be conducted with a number of participant groups, this strategy could be a disadvantage because the concept of a fixed set of criteria may be methodologically beneficial. However, the strategy can be accomplished (see attached table and graphic). The ultimate choice of strategy should be based on the degree of group consensus regarding the benefits of "aggregating" criteria and the potential for conducting similar weighting processes with other participant groups.

Scenario 3: Comparison of Weighting All Criteria Versus Weighting of Aggregated Criteria					
Participant Group – All Criteria					
Criteria	**P1**	**P2**	**P3**	**P4**	**Mean (Rank)**
C1	5	10	5	15	8.75 (7)
C2	5	10	10	15	10 (4)
C3	5	10	0	15	7.5 (8)
C4	10	5	10	5	7.5 (8)
C5	5	5	10	5	6.25 (10)
C6	15	5	10	10	10 (4)
C7	20	5	20	10	13.75 (1)
C8	15	20	15	5	13.75 (1)
C9	10	20	10	10	12.5 (3)
C10	10	10	10	10	10 (4)
Participant Group – Aggregated Criteria					
C1 Aggregate = C1, C2, and C3	6	11	6	23	11.5 (6)
C4	11	7	11	7	9 (7)
C5	6	7	11	7	8 (8)
C6	17	7	11	14	12.25 (4)
C7	21	7	23	14	16.25 (1)
C8	17	25	16	7	16.25 (1)
C9	11	25	11	14	15.25 (3)
C10	11	11	11	14	11.75 (5)
Participants are allocating 100 points across the site selection criteria.					



The graphic displays the differences in mean values for the case where participants allocate points among all 10 criteria versus a case where points are allocated among 8 criteria, one of which is an aggregated criterion (C1 is a composite of C1, C2, C3 from the base case). Although there are noticeable changes in mean values, the relative positioning (importance) of criteria 4-10 essentially remains the same. Composite criterion 1 is judged to be the sixth most important criterion (out of 8), which is consistent with the relative ranking of its constituent criteria (i.e., Criteria 1, 2, and 3 were ranked as the seventh, fourth, and eighth most important criteria, respectively, out of 10).

WEIGHTING PROCESS CASE STUDY – SCENARIO 4

Scenario 4 Description: The participant group prefers to simply rank order the criteria rather than to assign weight values to each.

Examples of Scenario in Practice: Participants may decide that the process of allocating (e.g., 1,000 points) across 30-40 variables is too onerous. The reasons for this may be several:

1. They assert that the distribution of the points ascribes a level of precision and analysis that is not consistent with their limited understanding or evaluation precision of the individual criterion. They are saying, in essence, that assigning a detailed portfolio of points exceeds their awareness of the impact of specific selection criteria.

2. They do not want to entertain discussions of "how much more important" one criterion is than another, only that one is more important. In this case, they are saying that they do not believe it is necessary to distinguish numerically among criteria to achieve a valid workshop result.

3. They believe that the process will be made more efficient by simply rank ordering the criteria. This is also an implicit statement that the rigor and/or validity of the process will not be impacted and that time will be saved.

If these points are raised during the pre-meeting prior to the actual workshop, the facilitator has the benefit of time and being able to discuss the workshop protocols and methods as part of an open and meaningful dialogue that does not compress the workshop schedule. If not, then the facilitator has a much greater challenge.

Possible Strategies for Resolution: In understanding and attempting to address any one or all of these conditions, it is necessary for the facilitator to understand the underlying concerns. There will likely be two principal reasons:

1. There is a belief that not being a "technical expert" prevents the participants from confidently or capably discriminating among 30-40 criteria.

2. There is not a "buy-in" that it is methodologically necessary to execute the process as described; and a simpler approach will yield an equally valid result.

If the first reason is overriding, then the facilitator can do a number of things. First, the facilitator can remind the participants that in this process there is no right, wrong, or correct answer only a consensus as derived from the group. Second, the facilitator can ask the subject matter experts to clarify for participants any particular areas of concern or areas for which there may be a misunderstanding or a lack of understanding. Third, the facilitator can remind the group that after each round of voting a series of discussions and interactions will occur, which generally enhances the understanding of criteria among every participant.

If the second reason is overriding, then the facilitator has two options. First, the facilitator can remind the group that it is essential to judge "how much more important" (i.e., quantify) one criterion is than another. This ultimately allows one to determine if one site is viewed as significantly (or marginally) preferable to another, and might even change criterion preferences (see attached table). Second, the facilitator can accede to the group's desires and allow rank ordering of criteria, recognizing that this will provide a group consensus result, but will "mask" the degree of difference among criteria, and, therefore, among sites. (Note: A group consensus based on ordinal ranking of site selection criteria could be used to develop an overall assessment of site favorability; however, such a result might not be consistent with one derived from application of weights.)

WEIGHTING PROCESS CASE STUDY – SCENARIO 4
Advantages/Disadvantages of Strategies: Whenever possible, it is always advantageous to conduct the process as proposed, especially if there multiple workshops are planned or envisioned. Accordingly, if the concern is one of understanding the criteria and this concern arises before the acting workshop voting stage, there are opportunities to provide information to the participants that should alleviate their reluctance. Conversely, modifying the process to allow rank order voting of the criteria may be the only option if the concerns are pervasive, and if it appears that completion of the workshop is being jeopardized. However, the downstream impacts may be significant in terms of the conduct of subsequent workshops and the ability to develop a true (or consistent) measure of overall or composite favorability (and effectively differentiate or discriminate among candidate sites).

Scenario 4: Comparison of Ordinal Ranking of Criteria Versus Weighting of Criteria

Criteria	Ranking				Weighting			
	P1	P2	P3	Mean (Rank)	P1	P2	P3	Mean (Rank)
C1	2	1	2	1.7 (6)	10	2	8	6.7 (5)
C2	1	4	1	2 (5)	5	10	2	5.7 (6)
C3	3	2	3	2.7 (4)	15	4	15	11.3 (4)
C4	4	3	4	3.7 (3)	18	6	20	14.7 (3)
C5	5	6	5	5.3 (2)	24	50	25	33 (1)
C6	6	5	6	5.7 (1)	28	28	30	28.7 (2)

For purposes of this example, in ordinal ranking 6 is judged to be the most important criterion and 1 is the least important. In weighting, the more important criteria are allocated with a larger proportion of the available (100) points. This concept of "how much more important", which is a critical distinction between ordinal ranking and weighting, can be demonstrated on an individual basis by examining "complex" decisions that we make in our everyday lives. Selection of a job, purchase of a home, and identification of a college each involve thoughtful consideration number of criteria addressing: cost, value, quality, location, lifestyle, flexibility, compensation, growth potential, future earnings, resale, and undoubtedly others. Invariably, when a final decision is made in such matters, the individual reduces the selection process to a vital few (i.e., "what it boils down to is…"). This is equivalent to valuing a subset of the overall criteria as "more important" than the balance. When this individual process is extrapolated across a group of 10 people all contemplating a common set of decisions, one can envision how the group decision might be influenced by whether the process used in one of ordinal ranking versus weighting.

WEIGHTING PROCESS CASE STUDY – SCENARIO 5

Scenario 5 Description: The applicant conducts only a single workshop comprised of internal participants, which yields a single set of weights that could be viewed as limited in terms of the diversity of views it represents.

Examples of Scenario in Practice: When an applicant conducts a single (internal) workshop for the purposes of assigning weights to the site selection criteria, there are several conditions to monitor (and potentially avoid) to ensure that the process has been fully and appropriately exercised and that a meaningful result has been achieved. Situations to be avoided are:

1. Only a limited number of rounds of voting are conducted (i.e., one or two), specifically because participants are not either thoughtfully considering the views of others or aggressively or thoroughly re-examining their own positions based on information provided by other participants.

2. The backgrounds of the participant group span only a limited range of technical disciplines suggesting that critical insights and understanding may be lacking with respect to a number of site selection criteria.

3. Participants default to a narrow set of views or are not thoughtfully considering a diverse range of opinions, resulting in a distribution of weights that is focused on an extremely small proportion of the site selection criteria.

Possible Strategies for Resolution: None of the above conditions, in and of themselves, are direct evidence that the workshop process is not meaningful has not been professionally conducted. However, in a public and institutional environment in which all elements of the applicant's decision process are likely to be thoroughly scrutinized, it is incumbent on the applicant to ensure that it does not place itself in a situation that unnecessarily comprises the site selection process or leaves it open to criticism.

Accordingly, in the event any of the above conditions were to occur, it would be prudent for the applicant to examine the entire workshop process and adopt one of more of the following strategies:

1. Take no further action beyond documenting why it believes that workshop process was thorough and credible.

2. Conduct sensitivity analyses to determine to what extent alternative weight sets would significantly alter (if at all) the final site ranking results (see attached table for example alternative weight sets).

3. Request that an external stakeholder representative review the workshop process and its results. Conduct sensitivity analyses to determine the impact, if any, this review has on site rankings.

It is also possible that these strategies could be implemented in combination. For example, the applicant could document its position and conduct a series of sensitivity analyses.

Advantages/Disadvantages of Strategies: The advantage of the first strategy is that it requires the applicant to thoughtfully re-examine the workshop process as part of a self-assessment evaluation (a tool that is commonly used in the technology development and application arena). The disadvantage of the first strategy is that, regardless of intent or thoroughness, it has the potential to be viewed as a non-objective evaluation, which is not sufficiently comprehensive in its approach.

The advantage of the second strategy is that it may indicate the site rankings are relatively insensitive to the range of weight sets applied and, hence, would support the conclusion that the internal workshop did not "intentionally skew" the results. The disadvantage of the second strategy is that, if the results vary dramatically with weight set, it has the potential to suggest the need for additional siting perspectives and

WEIGHTING PROCESS CASE STUDY – SCENARIO 5

workshop processes. This condition also places the applicant in a challenging position with respect to asserting that it has picked the "best site."

The advantage of the third strategy is that offers the opportunity for an independent, external evaluation, which may provide for the necessary process credibility to be established. The disadvantage of the third strategy is that it may lead directly to a firm recommendation to reconvene or conduct additional weighting workshops. Similar to above, this also places the applicant in a challenging position with respect to asserting that it has picked the "best site."

Scenario 5: Example Alternative Weight Sets to be Incorporated into Sensitivity Analysis

Criteria	Internal Weights	Alternative Weight Set 1	Alternative Weight Set 2	Alternative Weight Set 3
C1 – Health & Safety	20	8	5	13
C2 – Health & Safety	30	8	5	13
C3 – Health & Safety	20	8	5	13
C4 – Health & Safety	10	8	5	13
C5 – Environmental	5	20	5	12
C6 – Environmental	5	20	5	12
C7 – Environmental	5	20	5	12
C8 – Socioeconomic	5	8	65	12

Participants are allocating 100 points across the site selection criteria.

WEIGHTING PROCESS CASE STUDY – SCENARIO 6

Scenario 6 Description: As a result of one or more workshops, a number of weight sets are developed, the application of which leads to inconclusive or contradictory site rankings.

Examples of Scenario in Practice: If several weights sets are derived from the conduct of one or more workshops, it is conceivable that the application of these weight sets to the site selection criteria could yield site rankings for which different sites emerge as the preferred site.

As depicted in the example shown in the table below, seven candidate sites have been ranked based on the application of five weight sets. Five different sites (Sites A, C, D, E, and F) are ranked as most favorable (i.e., preferred) for one of the weight sets. Each of the these five sites also ranks somewhat unfavorably (in comparison to the other six sites) as a result of applying one or more of the balance of the weight sets. Site G does not rank as the most favorable after application of any of the weight sets, and generally appears in the lower half of the site rankings. Site B does not rank as the most favorable site after application of any of the weight sets, but is consistently ranked high for all cases (i.e., second most favorable site).

Possible Strategy for Resolution: If, from inspection, a preferred site is not immediately apparent, the project team should carefully examine the collection of site rankings to determine if there is a logical and systematic way to distinguish or discriminate among the candidate sites – based upon the information presented. In further examining Sites A, B, C, D, E, and F, the following patterns emerge, which do enable such a determination to be made.

- Site F ranks relatively low for all weight sets other than weight set 5.
- Site C is always superior to Site A, except for weight set 1.
- Site C is always superior to Site E, except for weight set 3.
- Site C is superior to Site D for weight sets 1-3.
- Site D is superior to Site C for weight sets 4 and 5.
- Site B is superior to Site C for all weight sets other than weight set 2.
- Site B is superior to Site D for all weight sets other than weight set 4.
- Other than for weight set 4, Site D appears in the lower half of the site rankings for all other weight sets.

It would appear that of the seven candidate sites, Sites B and C are generally more favorable than the balance based on application of all weights sets and would both appear to be worthy of being designated as preferred sites.

At this advanced stage of the site selection process, it is important to recognize that comparisons are being made among sites with a preponderance of favorable characteristics. That is, the applicant presumably believes that these are all good (potentially licensable) sites. Accordingly, the project team is evaluating technical aspects to determine marginal (i.e., not significant) differences among the sites (especially in the case of Sites B and C). As a result, to achieve a final recommendation of a preferred site, it may be prudent to examine a host of business conditions that may differentiate or discriminate between Sites B and C. Such conditions include favorable geographic placement with respect to expected electric loads, proximity to existing transmission capacity, expectations for high electricity prices, and a high degree of public acceptance.

Scenario 6: Hypothetical Site Rankings Based on Multiple Weight Sets					
Site Rank	**Weight Set 1**	**Weight Set 2**	**Weight Set 3**	**Weight Set 4**	**Weight Set 5**
1	Site A	Site C	Site E	Site D	Site F
2	Site B	Site B	Site B	Site B	Site B
3	Site C	Site A	Site C	Site C	Site G
4	Site D	Site E	Site D	Site A	Site D
5	Site E	Site G	Site A	Site F	Site C
6	Site F	Site F	Site G	Site E	Site E
7	Site G	Site D	Site F	Site G	Site A
A ranking of 1 is the highest overall site ranking for a site. Rankings are based on the application of the site selection criteria combined with the indicated weighting set values.					

WEIGHTING PROCESS CASE STUDY – SCENARIO 7

Scenario 7 Description: A stakeholder group, not involved in the workshop process, voluntarily submits its own set of weights for incorporation.

Examples of Scenario in Practice: Given the high level of interest in the ESP program, it is conceivable that a stakeholder group or groups not directly involved in the applicant's siting process (or weighting workshops) could conduct its own weighting workshop as a mechanism to "insert" itself into the site selection process. The stakeholders could request that results of such workshop (a stakeholder set of weights) be considered by the applicant.

Possible Strategies for Resolution: If such a situation arises, the project team needs to first ask a number of critical questions:

1. Does the stakeholder group have standing?
2. Was the process used similar to that conducted by the applicant (e.g., criteria set, data, subject matter experts, facilitated process) and is process documentation used by the stakeholders available (e.g., individual weight assignments, calculation of means and standard deviations) for review?
3. Will acceptance of such a weight set(s) set either establish a precedent or set in motion development of even more external weight sets?

With the answers to these questions, three strategies for resolution are possible:

1. Do not consider or incorporate the stakeholder weights into the process.
2. Conduct a sensitivity analysis or otherwise incorporate the information to determine the impact on the site selection decision process.
3. Convene a separate workshop with the stakeholder group to establish weights (i.e., use applicant facilitator and subject matter experts).

Advantages/Disadvantages of Strategies: The advantage of the first strategy is that it avoids the potential for other groups to generate and submit weights in an ad hoc fashion, thereby placing the applicant in a problematic position. The disadvantage of the first strategy is that it has the potential to negatively impact stakeholder and institutional relations.

The advantage of the second strategy is that it the applicant is being responsive to the data generated by the stakeholders. The disadvantage of the second strategy is that it may result in changes to the site selection process and/or produce site selection results that are not in concert with applicant objectives for the facility.

The advantage of the third strategy is that the applicant is both being responsive and ensuring process consistency. Similar to the above, the disadvantage of the second strategy is that it may result in changes to the site selection process and/or produce site selection results that are not in concert with applicant objectives for the facility.

E

VOLUNTEER APPROACHES TO CONTROVERSIAL FACILITY SITING

During the late 1980s and 1990s, one of the emerging developments in the process of siting controversial facilities was the formal consideration of volunteer sites in the siting process. A volunteer site is defined as one that is put forth by a government entity or private concern for purposes of being considered as the location for a potentially controversial facility. The examples described below provide insights into how the siting process and concepts presented in Section 4.0 would be adjusted to address the offer of a volunteer site. Detailed recommendations for incorporating a volunteer site appear in Section 4.1.

One of the first applications of the volunteer approach to the siting of a controversial waste facility was in locating state-identified sites for disposal of low-level nuclear waste (under the provisions of *The Low-Level Radioactive Waste Policy Amendments Act of 1985*). Under this Act, States were encouraged to form partnerships or compacts under which one state would host a site, allowing low-level wastes from the other compact members to be disposed at the host State's site for a negotiated fee. The host State would self-identify a location and work with either NRC or its own state-regulating body (if it were an NRC Agreement State) to ensure compliance with the provisions of 10 CFR 61 and appropriate state and local regulations.

For example, the State of Illinois (which was in a compact with the State of Kentucky to dispose of that State's low-level waste) embarked upon an integrated "volunteer-traditional siting approach" to locating a low-level waste disposal facility. The approach first solicited interest on the part of all counties in the State of Illinois; land areas within those counties that expressed interest were subject to the application of a series of exclusionary and favorability factors. Critical to implementation was the notion that land units within any "volunteering" county had to undergo application of the technical siting process and demonstrate compliance with all applicable regulations. The essence of the Illinois approach was to reach some initial level of public acceptance at the start of the process, then apply all technical criteria to all land areas, and finally demonstrate compliance.

A contrasting approach within the Department of Energy involved selection of locations for disposal of high-level nuclear waste. This program (governed by *The Nuclear Waste Policy Act of 1984* and *The Nuclear Waste Policy Amendments Act of 1986*) differed from the Illinois application in that a "volunteer" component of the siting process was not implemented until a technically based national site selection process was well underway. This staged approach required that any State, County, or Tribal entity providing a land unit for consideration needed to demonstrate that the particular land unit would be equivalent (or not obviously inferior) to other land units that remained in consideration at that point in the national search process. As a enticement for States, Counties, or Tribes to participate, the government would provide funds to the State, County, or Tribe to study and evaluate the proposed land unit to determine if its suitability or favorability were comparable to that of the other land units being considered. The essence of the Department of Energy approach was that until its national search had reached a certain geographic stage, solicitation and incorporation of volunteer sites was not practical. However, at such time as volunteer sites might emerge, they must demonstrate that they would have emerged from initial steps of the siting process.

Frequently, the concept of "volunteering" is accompanied by the notion of what is the "*quid pro quo"* (or benefit) for taking on this potential additional risk. In some facility siting applications, this has involved tax relief. In others, this has involved infrastructure improvements (e.g., roads, utilities). Other concepts discussed have included removing some existing risk to which the local stakeholders are subject (e.g., closing a landfill) as a condition of volunteering. This idea of risk trading (or conversion) assumes that in return for accepting a potential public risk, another potential public risk will be removed. The critical point is that the entity "volunteering" a site or location for a facility may not necessarily represent the interests of all local stakeholders, and these other stakeholders could well have conditions upon which their acceptance of the facility is based.

F

ANALYSIS OF FEDERAL REGULATORY CHANGES

This appendix presents the methodology used to update the regulatory basis for the NRC siting criteria as well as presenting the results of the analysis (summarized in Table F-1). Efforts focused on identifying changes to the following NRC related documents that historically provided the regulatory basis for the siting criteria:

Code of Federal Regulations

- 10 CFR Part 50 (Domestic Licensing of Production and Utilization Facilities)
- 10 CFR Part 51 (Environmental Protection Regulations for Domestic Licenses and Related Regulatory Functions)
- 10 CFR Part 52 (Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants)
- 10 CFR Part 100 (Reactor Site Criteria).

NRC Regulatory Guides

- Regulatory Guide 1.101, Emergency Planning and Preparedness for Nuclear Power Reactors
- Regulatory Guide 1.183, Alternative Radiological Source Terms for Evaluating Design Basis Accidents
- Regulatory Guide 4.2, Preparation of Environmental Reports for Nuclear Power Stations
- Regulatory Guide, 4.7, General Site Suitability Criteria

NUREG Documents

- NUREG-0654, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants
- NUREG-0800, Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants
- NUREG-1555, Standard Review Plans for Environmental Reviews of Nuclear Power Plants

Changes were tracked since March 1993, when the original Siting Guide was issued. The major change affecting siting guidance since 1993 was the 1996 amendments to NRC's regulations to update the criteria used in decisions regarding power reactor siting, including geologic, seismic, and earthquake engineering considerations for future nuclear power facilities (see 61 *Federal*

Register (FR) 65157, December 11, 1996). The updated criteria apply to stationary power reactor site applications on or after January 10, 1997.

In response to these changes, NRC has revised its existing, and developed new, regulatory guidance to provide prospective licensees with the necessary guidance for implementing the final regulations. Affected relevant NRC Regulatory Guides and standard review plans (NUREG) are identified in Sections II and III, respectively.

F.1 Code of Federal Regulation (CFR) Searches

F.1.1 Methodology

The methodology included a four-step process as follows:

1. Electronic Federal Register Search 1994-2001 (by year), specifying "Final Rule" and using key words: "10 CFR Part 50", "10 CFR Part 51", "10 CFR Part 52", "10 CFR Part 100"; and a combination of "Nuclear Regulatory Commission" AND "environmental", "siting" and "criteria".

2. Electronic search of 10 CFR on NRC web site to identify which sections were affected between 1993 and 1997); search results also included the FR citation for affected 10 CFR Sections.

3. Electronic search of Federal Register for "Notices Affecting Title 10 of the CFR" (only available for years 1997 through 2001); search results generated listing of affected sections and FR citation (Volume and page number).

4. Manually reviewed latest version of relevant CFR Sections (10 CFR Parts 50, 51, 52, and 100) in their entirety to identify source (i.e., most recent update) at end of each section. All updates to FR subsequent to March 1993 were noted.

Using search results in steps 1-4 above, referenced FR notices were identified, collected, and reviewed (starting with summary text) to determine relevance to siting criteria. Where relevant, the entire FR notice was reviewed, particularly the introductory, background, and supplementary information sections, etc. to clarify which sections changed and to understand the rationale behind the changes.

F.1.2 Search Results

Reactor Site Criteria (including Seismic and Earthquake Engineering Criteria for Nuclear Power Plants)

NRC Regulations 10 CFR Parts 50, 52, and 100 (61 FR 65157, December 11, 1996) – effective January 10, 1997. Impacted sections: Subpart B in 10 CFR 100; 10 CFR 50.34(a) – dose calculations; 10 CFR 50 Appendix S (earthquake engineering criteria); 50.49(b)(1); 50.65(b)(1); 52.17(a)(1); and 54.4(a)(1)(iii).

The major change affecting siting guidance was the 1996 amendments to NRC's regulations to update the criteria used in decisions regarding power reactor siting, including geologic, seismic, and earthquake engineering considerations for future nuclear power facilities (see 61 FR 65157, December 11, 1996). New requirements apply to applicants who apply for a construction permit, operating license, preliminary design approval, final design approval, manufacturing license, early site permit, design certification, or combined license on or after effective date of final regulations. For those operating license applicants and holders whose construction permits were issued prior to January 10, 1997, reactor site criteria in 10 CFR Part 100 and seismic and geologic siting criteria and earthquake engineering criteria in Appendix A to 10 CFR 100 would continue to apply in all subsequent proceedings, including license amendments and renewal of operating licenses pursuant to 10 CFR 54. Criteria not associated with selection of site or establishment of the Safe Shutdown Earthquake Ground Motion (SSE) have been placed in 10 CFR 50. Revised reactor site criteria were added as Subpart B in 10 CFR 100 and apply to site applications received on or after January 10, 1997.

F.1.3 Major Changes in Siting Criteria

The rule allows NRC to benefit from the experience gained in the application of the procedures and methods set forth in the current regulation and to incorporate the rapid advancements in the earth sciences and earthquake engineering. The rule primarily consists of two separate changes: the source term and dose considerations (non-seismic), and the seismic and earthquake engineering considerations of reactor siting. These are summarized in more detail below.

NRC's overall approach is to establish the revised requirements in new sections to 10 CFR 100 and relocate facility design requirements to 10 CFR 50 while retaining the existing regulation. Changes in source term and dose considerations, and the seismic and earthquake engineering considerations of reactor non-seismic and seismic reactor site criteria for current facilities, are retained as Subpart A and Appendix A to 10 CFR Part 100, respectively. The revised reactor site criteria are added as Subpart B in 10 CFR Part 100 and apply to site applications received on or after effective date of the final regulations. Non-seismic site criteria are added as a new 100.21 to subpart B in 10 CFR Part 100. The dose calculations and the earthquake engineering criteria are located in 10 CFR Part 50 (50.34(a) and Appendix S, respectively).

Changes relate to the following parameters:

Reactor Siting Criteria (Nonseismic) - Subpart B (Evaluation Factors for Stationary Power Reactor Site Applications on or After January 10, 1997 – 10 CFR Part 100.21

Exclusion Area. The use of different doses for the whole body and thyroid gland is now replaced by a single value of 25 rem, total effective dose equivalent (TEDE). Also, there is a change in time period that a hypothetical individual is assumed to be at the exclusion area boundary; it is no longer fixed in regard to the appearance of fission products within containment. *Final rule*: The dose to an individual located at the nearest exclusion area boundary over any two-hour period after the appearance of fission products in containment, should not be in excess of 25 rem total effective dose equivalent.

Site Dispersion Factors. The final rule now requires that atmospheric dispersion characteristics of a site be evaluated, and that site dispersion factors based upon this evaluation be determined and used in assessing radiological consequences of normal operations as well as accidents.

Low Population Zone (LPZ). The final rule retains the requirement that dose consequences be evaluated at the outer boundary of the LPZ over the course of the postulated accident, and that these not be in excess of 25 rem TEDE. The final rule considers that siting functions intended for the LPZ, namely, a low density of residents and the feasibility of taking protective actions have been accomplished by other regulations or can be accomplished by other guidance.

Physical Characteristics of the Site. The final rule requires that physical characteristics of the site (such as geology, seismology, hydrology, meteorology) be considered in the design and construction of any facility proposed to be located there; AND that site parameters, such as design basis flood conditions or tornado wind loadings be established for use in evaluating any facility to be located on that site in order to ensure that the occurrence of such physical phenomena would pose no undue hazard.

Nearby Transportation Routes, Industrial and Military Facilities. As for natural phenomena, it has been a long-standing NRC staff practice to review man-related activities in the site vicinity to provide assurance that potential hazards associated with such facilities or transportation routes will pose no undue risk to any facility proposed to be located at the site. The final rule codifies this practice.

Adequacy of Security Plans. The final rule requires that characteristics of the site be such that adequate security plans and measures for the facility could be developed. The Commission envisions that this will entail a small secure area considerably smaller than that envisioned for the exclusion area.

Emergency Planning. Language in the final rule is consistent with that in Section 52.17 of the Commission’s regulations regarding early site permits. Appropriate sections of the rule (100.21(g)) have been modified to state that “physical characteristics unique to the proposed site that could pose a significant impediment to the development of emergency plans must be identified.” (Phrase “such as egress limitations from the area surrounding the site” has been deleted). The language is identical to that in 52.17(b)(1). It is included primarily to assure that a range of protective actions have been developed for a plume exposure pathway emergency planning zone for emergency workers and the public as stated in planning standards.

Siting Away from Densely Populated Centers. Next generation reactors are expected to have risk characteristics sufficiently low such that the safety of the public is reasonably assured by the reactor and facility design and operation itself, resulting in a very low likelihood of occurrence of a severe accident. The Commission is incorporating a two-tier approach with regard to population density and reactor sites: (1) locate reactor sites away form very densely populated centers, and (2) that areas of low population density are, generally, preferred. The Commission believes that a site not falling within these two categories, although not preferred, can be found acceptable under certain conditions. The Commission is not establishing specific numerical criteria for the evaluation of population density in siting future reactor facilities because acceptability of a specific site from the standpoint of population density must be considered in the overall context of safety and environmental considerations. Regulatory Guide 4.7 provides effective separation from population centers of various sizes. Under this guide, a population center of about 25,000 or more residents should be no closer than 4 miles from a reactor because a density of 500 persons per square mile within this distance would yield a total population of about 25,000 persons. Similarly, a city of 100,000 or more should be no closer than about 10 miles; a city of 500,000 or more should be no closer than about 20 miles, and a city of 1,000,000 or more should be no closer than about 30 miles.

Change to 10 CFR 50: The change relocates from 10 CFR 100 the dose requirements for each applicant at specified distances. The reason for the move is that requirements affecting reactor design are more appropriately located in 10 CFR Part 50.

Seismic and Earthquake Engineering Criteria - Changes to Appendix A to 10 CFR Part 100

The following changes are noted:

- Separate Siting from Design. Criteria not associated with site suitability or establishment of Safe Shutdown Earthquake Ground Motion have been placed in 10 CFR 50 (separates siting from design)
- Remove Detailed Guidance from the Regulation. Detailed guidance is removed from the regulation; the final regulation is streamlined, becoming a new section in Subpart B to 10 CFR Part 100 (100.23) rather than a new appendix to Part 100.
- The level of detail presented in the final regulation is reduced considerably. Thus, the final regulation contains:
  - Required definitions
  - Requirements to determine the geological, seismological, and engineering characteristics of the proposed site, and
  - Requirements to determine the Safe Shutdown Earthquake Ground Motion (SSE), to determine the potential for surface deformation, and to determine the design bases for seismically induced floods and water waves.

The key elements of the approach to determining the SSE are the guidance described in Regulatory Guide 1.165 (see Section II).

- Uncertainties and Probabilistic Methods. The final regulations explicitly recognize there are inherent uncertainties in establishing seismic and geologic design parameters and allows for the option of using a probabilistic seismic hazard methodology capable of propagating uncertainties as a means to address these uncertainties. The Rule further recognizes the nature of uncertainty; the appropriate approach to account for it depends greatly on the tectonic regime and parameters, such as, the knowledge of seismic sources, the existence of historical and recorded data, and the understanding of tectonics. Therefore, a method other than the probabilistic methods, such as sensitivity analysis, may be adequate for some sites to account for uncertainties.

- Safe Shutdown Earthquake. The final regulation moves the location of the seismic input motion control point form foundation-level to the free field at the free ground surface. It also requires that the horizontal component of Safe Shutdown Earthquake Ground Motion in free-field at the foundation level of structures must be an appropriate response spectrum considering the site geotechnical properties, with a peak ground acceleration of at least 0.1 g.
- Value of the Operating Basis Earthquake Ground Motion (OBE) and Required OBE Analysis. The final regulation allows the value of the Operating Basis Earthquake Ground Motion (OBE) – to be set at (i) one-third or less of the SSE, where OBE requirements are satisfied without an explicit response or design analyses being performed, or (ii) a value greater than one-third of the SSE, where analysis and design are required.
- Required Plant Shutdown. The final rule treats plant shutdown associated with vibratory ground motion exceeding the OBE or significant plant damage as a condition in every operating license. A new 50.54 (ff) is added to regulations to require a process leading to facility shutdown for licensees of nuclear power facilities that comply with the earthquake engineering criteria in Paragraph IV(a)(3) of Appendix S to 10 CFR 50.
- Clarify Interpretations. Section 100.23 resolves questions of interpretation.

F.2 NRC Regulatory Guides

F.2.1 Methodology

1. Reviewed Regulatory Guide Index for Divisions 1 (Power Reactors) and 4 (Environmental and Siting (Active and Draft listings)) to identify relevant guides and their corresponding publication dates. Those that were revised and/or issued new since 1993 and considered to be potentially relevant to the siting criteria were downloaded in their entirety for more detailed review. [Source: NRC website]

2. General search of NRC website for any information relevant to specific Regulatory Guide (as specified in search)

F.2.2 Search Results

The following new regulatory guides have been developed by the Commission to provide prospective licensees with the necessary guidance for implementing the final regulation (10 CFR Part 100; published 61 FR 65157, December 11, 1996):

Regulatory Guide 1.165, Identification and Characterization of Seismic Sources and Determination of Shutdown Earthquake Ground Motion. This Guide provides general guidance and recommendations, describes acceptable procedures, and provides a list of references that present acceptable methodologies to identify and characterize capable tectonic sources and seismogenic sources.

Regulatory Guide 1.12, Revision 2, Nuclear Power Plant Instrumentation for Earthquakes This Guide describes seismic instrumentation type and location, operability, characteristics, installation, actuation and maintenance that are acceptable to NRC staff.

Regulatory Guide 1.166, Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post-Earthquake Actions. This Guide provides guidelines that are acceptable to NRC staff for the timely evaluation of recorded seismic instrumentation data and to determine whether or not plant shutdown is required.

Regulatory Guide 1.167, Restart of a Nuclear Power Plant Shut Down by a Seismic Event. This Guide provides guidelines that are acceptable to NRC staff for performing inspections and tests of nuclear power plant equipment and structures prior to restart of a plant that has been shut down because of a seismic event.

A review of the existing Regulatory Guides historically providing the basis for siting criteria revealed the following results:

Regulatory Guide 1.70, Standard Format and content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition), November 1978. There has been no change since 1993; however,

Regulatory Guide 1.181, Content of Updated Final Safety Analysis Report in accordance with 10 CFR 50.71(e), September 1999, may be relevant (Draft DG-1082 issued 3/99). Regulatory Guide 1.181 provides additional guidance based on lessons learned from Millstone experience and other initiatives related to UFSARs; Revision 1 of NEI 98-03, “Guidelines for Updating Final Safety Analysis Reports,” dated June 1999, provides methods acceptable to NRC staff for complying with provisions of 10 CFR 50.71(e).

Regulatory Guide 1.101, Emergency Planning and Preparedness for Nuclear Power Reactors, August 1992 (Draft DG-1075, Proposed Revision 4, published 3/2000). Relates to 10 CFR 50.47 (Emergency Plans) and NUREG-0654 (see also Section III)

Background: Onsite and offsite emergency response plans must meet the standards that are listed in 10 CFR 50.47 in order for staff to make a positive finding that there is reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. One of these standards, 10 CFR 50.47(b)(4), pertains to the development of emergency action levels (EALs). Section IV, “Content of Emergency Plans” of Appendix E to 10 CFR 50 also contains requirements for the development and review of EALs. This guide provides guidance to licensees and applicants on methods acceptable to NRC staff for complying with NRC’s regulations for emergency response plans and preparedness at nuclear power reactors. Information contained in the regulatory guide is covered by requirements of 10 CFR 50.

A Draft Regulatory Guide (March 2000) is being revised to indicate that guidance contained in the recent Nuclear Energy Institute guidance (NEI 99-01), Draft Final Revision 4 (February 2000), “Methodology for Development of Emergency Action Levels”, is acceptable to NRC staff as an alternative method to that described in Appendix 1 to NUREG 0654/FEMA-REP-1

(Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, November 1980), and NUMARC/NESP-007 (Nuclear Utilities Management and Resource Council, Revision 2, January 1992), "Methodology for Development for Emergency Action Levels", for developing EALs required in Section IV of Appendix E to 10 CFR Part 50 and 10 CFR 50.47(b)(4). [Note that all methods are acceptable, although Rev 3 to Regulatory Guide 1.101 stated that licensees may use either NUREG 0654/FEMA-REP-1 or NUMARC/NESP-007 in developing their EAL scheme, but may not use portions of both methodologies."]

Regulatory Guide 1.183, Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors, July 2000 (Draft DG-1081 issued 12/99). Applies to 10 CFR 50.67 (64 FR 71990, December 23, 1999, Use of Alternative Source Terms at Operating Reactors) and Section 15.0.1 of NUREG-0800.

Regulatory Guide 1.183 provides guidance to licensees of operating power reactors on acceptable applications of alternative source terms; the scope, nature and documentation of associated analyses and evaluations; consideration of impacts on analyzed risk; and content of submittals. The Guide establishes an acceptable alternative source term (AST) and identifies significant attributes of other ASTs that may be found acceptable by NRC staff. Technical Information Document (TID) 14844, "Calculation of Distance Factors for Power and Test Reactor Sites," is cited in 10 CFR 100 as a source of further guidance on these analyses. This Guide presents advances since TID-14844 in understanding the timing, magnitude, and chemical form of fission product releases from severe nuclear power plant accidents. Many of the traditional methods used are not consistent with ASTs and with the total effective dose equivalent (TEDE) criteria provided in 10 CFR 50.67.

Regulatory Guide 4.2S1, Supplement 1 to Regulatory Guide 4.2, Preparation of Supplemental Environmental Reports for Applications to Renew Nuclear Power Plant Operating Licenses, September 2000 (proposed supplement 1, DG-4002, published 8/91; second proposed supplement 1, DG-4005, published 7/98). This Supplement is not applicable to siting criteria since it pertains to license renewals only.

Regulatory Guide 4.7, General Site Suitability Criteria for Nuclear Power Stations, April 1998 (DG-4003, Proposed Revision 2, published 11/1992; DG-4004, Second proposed Revision 2, published 2/1995). This Guide incorporates changes to 10 CFR 100 relating to siting criteria. Specifically, it discusses major site characteristics related to public health and safety and environmental issues that NRC staff considers in determining the suitability of a site.

F.3 NUREGs (Staff Technical Reports)

F.3.1 Methodology

1. Reviewed Listing of NRC Technical Reports in the NUREG series that includes reports updated and/or issued new since 1997. Downloaded (revised sections or reports as appropriate) those considered to be potentially relevant to the siting criteria for more detailed review. [Source: NRC website]

2. Conducted electronic search of Federal Register for period 1993 through 1996 using key words "Nuclear Regulatory Commission" and "NUREG" to identify potential revisions/updates to reports within this time period.

3. Reviewed Federal Register "hits" from Step 2 to identify any revisions to relevant NUREG documents between 1993 and 1996; FR review helped identify specific changes in NUREG documents relevant to siting criteria and why change was made

4. General search of NRC website for any information pertaining to specific NUREG document (as specified in search)

F.3.2 Search Results

NUREG-0396. This document was identified prior to the search as potentially relevant to the siting criteria. The only "hit" that came up was the following:

"Results of Evaluation of Emergency Planning for Evolutionary and Advanced Reactors", January 27, 1997 Memo, to inform the Commission of results of staff's effort to develop recommendations for technical criteria and methods to use to justify simplification of existing emergency planning (EP) requirements for evolutionary and advanced reactor designs.

NUREG-0625, "Report of the Siting Policy Task Force" (August 1979). This document was also identified prior to the search as potentially relevant. Only the Abstract of this document is available on-line. This document was prepared to support the site suitability issues reflected in modifications to regulations promulgated at 10 CFR Part 100 (61 FR 65157, December 11, 1996).

NUREG-0654/FEMA-REP-1, Rev 1, Addenda, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants" (Draft Report for Comment, February 2001). For early site permit applications, NRC and FEMA jointly developed criteria. This supplement contains guidance for writing, reviewing, and approving emergency plans and information to be submitted with an early site permit application. It relates to Emergency Planning under 10 CFR Part 52. Related document identified in search: Response Technical Manual (NUREG/BR-0150, Vol.1, Rev. 4) – 12/10/99; 11/17/00.

NUREG-0800, 'Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants". The following chapters were identified as having been revised; no revision dates were identified for Chapters 7 or 13:

- Chapter 7 (Instrumentation and Controls) – no date specified
- Chapter 13, Section 13.1.1 (Management and Technical Support Organization)
- Chapter 13, Sections 13.1.2-13.1.3 (Operating Organizations); and
- Chapter 15, Section 15.0.1 (Radiological Consequence Analyses Using Alternative Source Terms; July 2000) and
- Chapter 15, Section 15.0.2 (Review of Analytical Computer Codes – Draft, December 2000).
- None of these revisions appear to be relevant to the siting criteria.

NUREG-1555, Standard Review Plans for Environmental Reviews for Nuclear Power Plants (October 1999). Supplement 1, "Operating License Renewal" (not relevant to siting criteria for new plants). This Plan has been updated and revised to guide reviews for a range of applications including "green field" (first time) reviews of CP and OL applications in 10 CFR 50; reviews of applications for early site permits (ESPs) in 10 CFR 52, Subpart A; It also incorporates guidance for NRC's evaluation of new technical issues, such as environmental justice (see also below) and severe- accident mitigation design alternatives.

The following new Standard Review Plan Sections were developed for the final regulations:

– Standard Review Plan Section 2.5.1, Rev 3, Basic Geologic and Seismic Information This Plan describes procedures to assess the adequacy of geologic and seismic information cited in support of applicant's conclusions concerning suitability of a facility site.
– Standard Review Plan Section 2.5.2, Rev 3, Vibratory Ground Motion. This Plan describes procedures to assess the ground motion potential of seismic sources at the site and to assess the adequacy of the SSE.
– Standard Review Plan Section 2.5.3, Rev 3, Surface Faulting. This Plan describes procedures to assess the adequacy of applicant's submittal related to the existence of potential for surface faulting affecting the site.

F.4 Other Regulatory Requirements

Executive Order 12898 (59 FR 7629)

This relates to impacts on minority and low-income populations (Environmental Justice).

NRR Office Letter 906 (1996) contains guidance to NRC staff on conducting environmental justice reviews. This guidance is reflected by the addition of three new ESRPs in NUREG-1555, NUREG-1555, which incorporates procedures to identify and describe minority and low-income populations that could be impacted by siting a nuclear power facility. Section 2.5.4 contains procedures for identifying and describing minority and low-income populations that could be impacted by proposed action. ESRPs 4.4.3 and 5.8.3 cover subsequent staff assessment and evaluation of specific impacts for facility construction and operation, respectively. Wording changes in other ESRPs now reflect NRC's commitment to address environmental justice issues.

Environmental Justice considerations now need to be incorporated into the siting criteria

Safe Drinking Water Act Amendments of 1996

Redefinition of Public Water System in SDWA Section 1401(4) as Amended by 1996 SDWA Amendments (63 FR 41939, August 5, 1998). A public water system was previously defined to include only piped water systems (if such system has at least 15 service connections or regularly serves at least 25 individuals). The definition has now been broadened to include systems providing water for human consumption that deliver this water by "constructed conveyances", such as irrigation canals.

Siting criteria relating to "distance from public water system" appear to be more state-specific and are therefore not addressed in this siting criteria update which is based on Federal regulations only.

[Note: Information requested by FERC for pipeline projects is distance from Group A water supply wells (defined as federally-regulated public water supply wells that have 15 or more connections or service 25 or more people). Applicant has to note whether wells are within 150 feet of areas to be disturbed during construction. Group B water supply wells are regulated by States (state-specific).]

National Primary Drinking Water Regulations, Radionuclides; Final Rule (EPA) 65 FR 76707, December 7, 2000. This Rule finalizes maximum contaminant level goals, maximum contaminant levels, and monitoring, reporting, and public notification requirements for radionuclides; it is only applicable to community water systems. The final rule includes requirements for uranium, which is not currently regulated, and revisions to monitoring requirements for combined radium-226 and radium-228, gross alpha particle radioactivity, and beta particle and photon radioactivity. [EPA, SDWA]

Table F-1
Summary of Changes in NRC Siting Criteria Regulatory Basis since March 1993

Regulatory Basis	Change since March 1993	Relate to Siting Criteria	Affected Citation(s)	Date(s)/ Reference	Notes
NRC Regulations					
10 CFR Part 50	YES	NO See Note	50.34(a); Appendix S; 50.49(b)(1); 50.65(b)(1)	12/11/96 (61 FR 65157)	NRC revisions to 10 CFR in December 1996 included a reorganization to group design-related requirements in 10 CFR 50 and site-suitability requirements in 10 CFR 100.
10 CFR Part 51 NEPA regulations	YES	NO – Changes relate only to license renewals.		6/5/96 (61 FR 28467) and 12/18/96 (61 FR 66537) 9/3/99 (64 FR 48495)	License renewal provisions promulgated. Supporting analysis in NUREG 1437 – does include guidance on Environmental Justice (EJ) review. Amended to update generic characterization of impacts due to transport of fuel and waste (Tables S-3 and S-4).
10 CFR Part 52	YES		52.17(a)(1)	12/11/96 (61 FR 65157)	Modifications affect introductory text only (paragraph (a)(1) and paragraph (a)(1)(vi); these reflect the reorganization of related CFRs (see comment on 10 CFR 50, above).
10 CFR Part 100	YES	YES - Geology Seismology Flooding, Nearby Hazardous Land Use, Winds, Population, Emergency Planning, Atmospheric Dispersion	Subpart B	12/11/96 (61 FR 65157)	Promulgates evaluation factors for Power Reactor Site applications submitted on or after January 10, 1997 (includes both non-seismic and geologic/seismic siting criteria – see Note 1)
NRC Regulatory Guides					
Reg. Guide 1.70 Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants	NO	NO			Regulatory Guide does not provide site suitability criteria explicitly. Note: Regulatory Guide 1.181, September 1999, relates to content of Final SARs in accordance with 10 CFR 50.71(e)
Reg. Guide 1.101 Emergency Planning and Preparedness for Nuclear Power Reactors	YES	NO	50.47(b)(4)	March 2000	DG-1075 was issued as draft Revision 4 to Regulatory Guide 1.101; see also NUREG-0654.

Regulatory Basis	Change since March 1993	Relate to Siting Criteria	Affected Citation(s)	Date(s)/ Reference	Notes
Reg. Guide 1.165 Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion	YES	YES	10 CFR 100.23	March 1997	Provides general guidance on procedures acceptable to the NRC staff for (1) conducting geological, geophysical, seismological, and geotechnical investigations, (2) identifying and characterizing seismic sources, (3) conducting probabilistic seismic hazard analyses, and (4) determining the SSE for satisfying the requirements of 10 CFR 100.23.
Reg. Guide 1.183 Alternative Radiological Source Terms for Evaluating Design Basis Accidents	YES	NO	50.67	July 2000	Applies to operating nuclear power plans. Updates guidance in TID 14844 (cited in 10 CFR 100); also relates to Section 15.0.1 of NUREG-0800
Reg. Guide 4.2 Preparation of Environmental Reports for Nuclear Power Stations	YES	NO		September 2000 (Supplement 1)	Supplement 1 addresses applications to renew Nuclear Power Plant Operating Licenses. See also NUREG-1437 (August 1999); and NUREG-1555, Supplement 1 (March 2000)
Reg. Guide 4.7 General Site Suitability Criteria	YES	YES - Geology Seismology Flooding, Nearby Hazardous Land Use, Winds, Population, Emergency Planning, Atmospheric Dispersion Socioeconomics	10 CFR 100	April 1998 (Rev 2)	In general, Rev. 2 of the Regulatory Guide reflects the site suitability changes to 10 CFR 100 promulgated at 61 FR 65157, 12/11/96. Appendix A - Revised to reflect changes in site safety considerations promulgated as above. Appendix B - Additional issue, B.17, Environmental Justice has been added to environmental protection considerations.
			NUREGs		
NUREG-0396 [Title?]	NO	TBD Emergency Planning			A January 27, 1997 memo to inform Commission of efforts to develop recommendations for technical criteria and methods to use to justify simplification of existing emergency planning requirements was identified; this change relates to Reg. Guide 0396.
NUREG-0625, Report of the Siting Policy Task Force	NO	See Note at right.			This NUREG document was prepared to support the site suitability issues reflected in modifications to regulations promulgated at 10 CFR Part 100 (61 FR 65157, 12/11/96).

Regulatory Basis	Change since March 1993	Relate to Siting Criteria	Affected Citation(s)	Date(s)/ Reference	Notes
NUREG- 0654, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants	YES	YES Emergency Planning; Air-Food Ingestion Pathway	10 CFR 52	February 2001	Addenda; draft report for comment (updated citations only)
NUREG-0800, Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants	YES, certain sections	NO	Sections 7; 13.1.2; 13.1.3; 15.0.1; and 15.0.2	15.0.1 (July 2000); 15.0.2 (December 2000, Draft)	Chapter 7 relates to Instrumentation and Controls; Chapter 13 sections relate to Management and Technical Support Organization and Operating Organizations; Chapter 15 sections relate to Radiological Consequence Analyses Using Alternative Source Terms and Review of Analytical Computer Codes.
NUREG-1555, Standard Review Plans for Environmental Reviews for Nuclear Power Plants	YES	YES Socioeconomics	10 CFR Parts 50 and 52	October 1999	Incorporates guidance for NRC's evaluation of new technical issues – Environmental Justice and severe-accident mitigation design alternatives
OTHER REQUIREMENTS					
Executive Order 12898, Environmental Justice	YES	YES Socioeconomics			NUREG-1555 incorporates procedures to identify and describe minority and low-income populations that could be impacted by siting a nuclear power plant.

Note 1: Major changes in siting criteria promulgated at 61 FR 65157 include:

Exclusion Area – Use of different doses for whole body and thyroid gland is now replaced by a single value of 25 rem, total effective dose equivalent (TEDE). Also there is a change in the time period that a hypothetical individual is assumed to be at the exclusion area boundary (no longer fixed in regard to appearance of fission products within containment). Final rule: The dose to an individual located at the nearest exclusion area boundary over any two-hour period, after the appearance of fission products in containment, should not be in excess of 25 rem total effective dose equivalent.

Site Dispersion Factors - The modified rules requires that atmospheric dispersion characteristics of the site be evaluated, and that site dispersion factors based upon this evaluation be determined and used in assessing radiological consequences of normal operations as well as accidents.

Low Population Zone - The rules retain the requirement that dose consequences be evaluated at the outer boundary of the LPZ over the course of the postulated accident and that these not be in excess of 25 rem TEDE. (The rule is based on the consideration that siting functions intended for LPZ, namely, a low density of residents and the feasibility of taking protective actions, have been accomplished by other regulations or can be accomplished by other guidance).

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Nearby Transportation Routes, Industrial and Military Facilities - The final rule codifies NRC's long-standing practice for review of man-related activities in the site vicinity to provide assurance that potential hazards associated with such facilities or transportation routes will pose no undue risk to any plant proposed to be located at the site.

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EPRI creates science and technology solutions for the global energy and energy services industry. U.S. electric utilities established the Electric Power Research Institute in 1973 as a nonprofit research consortium for the benefit of utility members, their customers, and society. Now known simply as EPRI, the company provides a wide range of innovative products and services to more than 1000 energy-related organizations in 40 countries. EPRI's multidisciplinary team of scientists and engineers draws on a worldwide network of technical and business expertise to help solve today's toughest energy and environmental problems.

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EPRI • 3412 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com