ANL/NRIC-20/1 Rev. 1

National Demonstration Reactor Siting Study – Phase I

Energy and Global Security Directorate
Nuclear Science and Engineering Division
Decision and Infrastructure Sciences Division

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National Demonstration Reactor Siting Study – Phase I

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EXECUTIVE SUMMARY

In 2020, the Department of Energy Office of Nuclear Energy (DOE-NE) initiated the Advanced Reactor Demonstration Program (ARDP), with the goal of demonstrating two advanced reactor designs within the next five to seven years. When evaluating challenges in meeting this deadline, the newly established National Reactor Innovation Center (NRIC) determined that there was a limited number of well-characterized sites that could support this time-sensitive demonstration requirement. To close this gap, NRIC initiated a two-phase joint analytic effort including DOE, National Laboratory, and academic partners to examine demonstration reactor siting alternatives. The first phase of the study, which is documented in this report, describes the development of a methodology for site assessment and a preliminary assessment of a limited number of known siting alternatives. Revision 1 of this report includes 3 additional (13 total) siting alternatives and 2 additional (4 total) example scenarios.

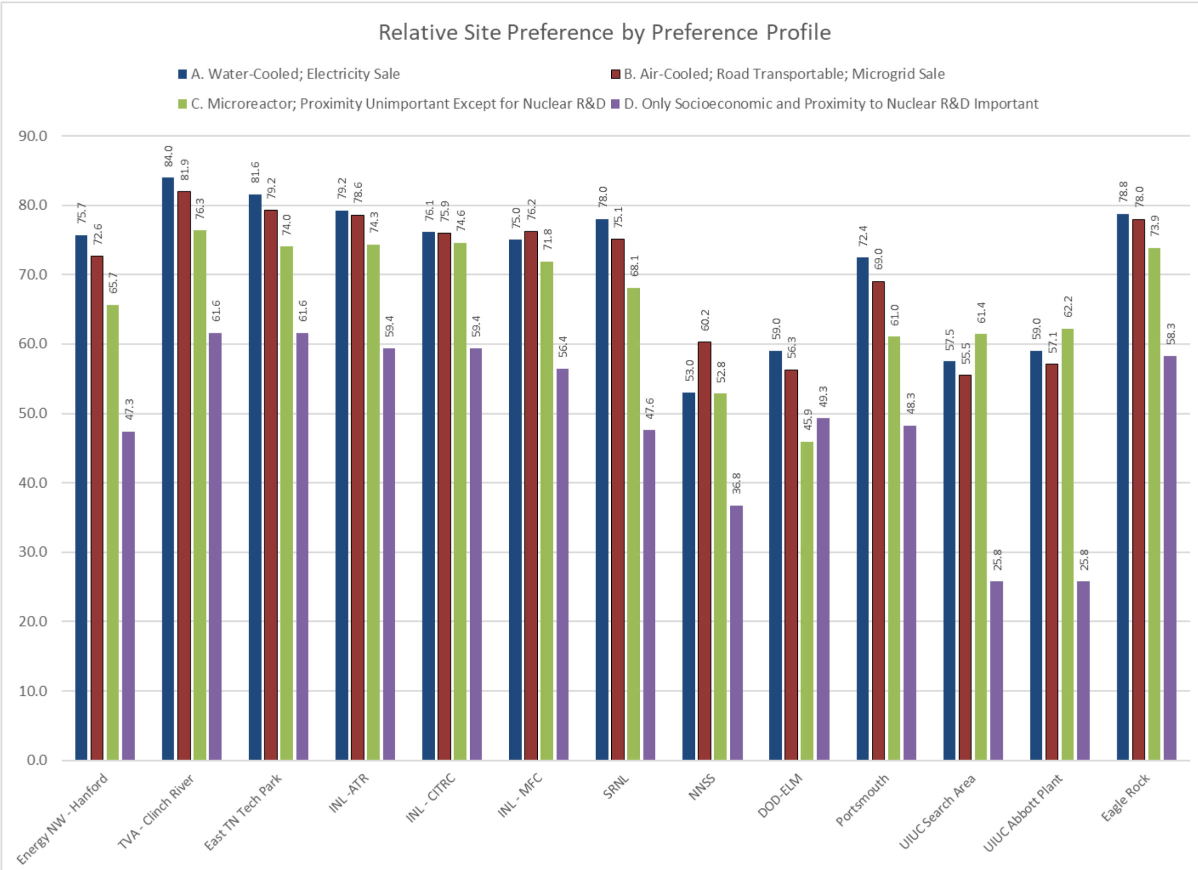
The Phase I analysis, led by Argonne National Laboratory (Argonne), leveraged an existing geographic information system (GIS) model developed at the Oak Ridge National Laboratory (ORNL) known as Oak Ridge Siting Analysis for power Generation Expansion (OR-SAGE) and a GIS model that is currently under development at the University of Michigan (UMich), known as "Janet." Collectively, these models incorporate attributes that cover Nuclear Regulatory Commission (NRC) technical siting guidelines as well as social and economic factors that may impact siting decisions. As a final quantitative assessment of the sites, and to allow for a cross-site comparison, the Argonne team developed a multi-attribute assessment model, incorporating the quantitative outputs from the OR-SAGE and "Janet" models. Though not included in the quantitative assessment, Argonne analysts also gathered information related to air quality and extreme weather for each location. These factors may be incorporated into future quantitative assessments. ***The goal of this preliminary assessment is not to rule out any individual site, but rather to provide a mechanism for stakeholders to compare across site options based on their assessment of importance/utility for each of the attributes included using a new developed methodology that leverages siting tools, multi-objective preference models, and data***.

The sites considered in this assessment are listed in the table below and shown in the map that follows. Given timeline constraints for this preliminary assessment, the assessment team did not conduct outreach to the individual sites. This activity may be undertaken as part of future assessments which would allow for more detailed site assessments where appropriate. More important than the individual site results is the methodology proposed using a combination of the tools and data from UMich, ORNL, and Argonne.

Upon review of the sites considered, using example attribute weights for four scenarios that are described in more detail in the report, summary results of relative preference values are provided below. The four scenarios considered include a small modular reactor scale unit requiring water cooling that generates electricity to be sold to a grid, two microreactor scale unit scenarios with different considerations for proximity considerations, and a scenario that only considers socioeconomic considerations and proximity to nuclear research and development support. These four scenarios represent a range of factors and preference weightings that demonstrate the ability of the proposed methodology to evaluate potential reactor sites.

Analyzed Demonstration Reactor Sites
Joint Base Elmendorf-Richardson, AK (Elmendorf)
Energy Northwest (Hanford, WA)
Clinch River – (Tennessee Valley Authority (TVA)) – Area covered by Clinch River Early Site Permit No. ESP-006
East Tennessee Technology Park
Idaho National Laboratory (INL) – Areas surrounding Advanced Test Reactor (ATR)
Idaho National Laboratory (INL) – Areas surrounding Critical Infrastructure Test Range Complex (CITRC)
Idaho National Laboratory (INL) – Areas surrounding Materials and Fuels Complex (MFC)
Eagle Rock, Idaho
Savana River National Laboratory (SRNL) – H-2 Site
Nevada National Security Site (NNSS)
Portsmouth Site, Portsmouth, OH
The University of Illinois, Urbana-Champaign (UIUC) –Search Area
The University of Illinois, Urbana-Champaign (UIUC) – Abbott Power Plant

Proposed Demonstration Reactor Sites



Summary observations based on this preliminary assessment are as follows:

A. For each scenario, multiple sites emerge as viable candidates based on the parameters considered while others have challenges that would require further investigation.

B. Sites such as TVA-Clinch River, East Tennessee Technology Park, the four sites in Idaho, SRNL, and Energy Northwest-Hanford scored favorably overall. Most of these sites have hosted nuclear facilities in the past, are reasonably well characterized with few apparent technical challenges, and are located in close proximity to support infrastructure that may help ensure success in advanced reactor demonstrations.

C. Further assessment of cooling water availability should be completed for the INL-ATR and INL-CITRC sites given that both sites did not meet the Phase I threshold criterion used in the OR-SAGE model for cooling water availability.

D. An additional assessment of socioeconomic factors, specifically the high social vulnerability and labor costs would be advisable if siting is considered at the Energy Northwest – Hanford location.

E. If the Portsmouth, OH site is considered for siting, additional review would be necessary to further characterize landslide risk noted in the OR-SAGE screening.

F. The NNSS location is primarily impacted (from a technical perspective) by cooling water availability, which may not be a constraining factor. It may be a viable option for an air-cooled demonstration design where there is no intent to eventually license for sale of electricity. However, the location also has one of the lowest ratings for public acceptability and may pose challenges for development of a larger design with a long-term business model that envisions grid tie-in due to its remote location.

G. The two UIUC sites have challenges related to proximity (distance to airport, population centers, and cooling water) which may be less of a concern for a microreactor design. However, the site also scored low due to the current moratorium for building new nuclear facilities in the state of Illinois and other factors related to the electricity market. If a demonstration reactor at these sites intended to generate heat for uses other than electricity generation, some of these challenges could be removed, however, the challenge associated with the current moratorium for building new nuclear in Illinois would still be a factor.

H. If further consideration of siting at Joint Base Elmendorf-Richardson is deemed desirable, a re-assessment of the site central location to mitigate technical challenges noted in this analysis is recommended. Results show that the site has technical challenges that are safety related (ground acceleration and proximity to faults).

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ACRONYMS AND ABBREVIATIONS

ACS	American Community Survey
AF	Air Force
AFB	Air Force Base
AIAN	American Indian and Alaskan Native
API	Application Programming Interface
AQI	Air Quality Index
ARDP	Advanced Reactor Demonstration Program
Argonne	Argonne National Laboratory
ATR	Advanced Test Reactor
BLS	Bureau of Labor Statistics
CDC	Centers for Disease Control
CEI	Climate Extreme Index
CES	Clean Energy Standard
CFR	Code of Federal Regulations
CONUS	Continental United States
CITRC	Critical Infrastructure Test Range Complex
DOE	U.S. Department of Energy
DOE-NE	U.S. Department of Energy Office of Nuclear Energy
DSIRE	Database of State Incentives for Renewables and Efficiency
EAB	Exclusion Area Boundary
EIA	U.S. Energy Information Administration
ELM	Elmendorf
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ESP	Early Site Permit
ETL	Extract, Transform, and Load
ETTP	East Tennessee Technology Park
FPTZ	Fastest Path to Zero
GIS	Geographical Information System
GPM	Gallons Per Minute
HVAC	Heating, Ventilation, and Air Conditioning
INL	Idaho National Laboratory
LACE	Levelized Avoided Cost of Electricity
LCOE	Levelized Cost of Electricity
LNG	Liquid Natural Gas
LWR	Light Water Reactor
MFC	Materials and Fuels Complex
MIT	Massachusetts Institute of Technology
MOPM	Multi-Objective Preference Model

MWth	Megawatts Thermal
NEIMA	Nuclear Energy and Innovation Modernization Act
NNSS	Nevada Nuclear Security Site
NRC	U.S. Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
NRIC	National Reactor Innovation Center
NUREG	U.S. Nuclear Regulatory Commission Regulatory Report
OR-SAGE	Oak Ridge Siting Analysis for power Generation Expansion
ORNL	Oak Ridge National Laboratory
ORR	Qak Ridge Reservation
PAD	Protected Areas Database
RG	Regulatory Guide
RPG	Renewable Portfolio Goal
RPS	Renewable Portfolio Standard
SECY	Commission Papers (U.S. Nuclear Regulatory Commission)
SEDS	State Energy Data System
SMR	Small Modular Reactor
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
SSE	Safe Shutdown Earthquake
SVI	Social Vulnerability Index
TVA	Tennessee Valley Authority
UAMPS	Utah Associated Municipals Power Systems
UIUC	University of Illinois-Urbana Champaign
UMich	University of Michigan
USGS	U.S. Geological Survey
ZEC	Zero Emissions Credit

1 Introduction and Background

Proactive alignment and integration of advanced reactor technology research, development, and demonstration is required to promote American leadership in nuclear energy development. Recognizing this, the fiscal year 2020 U.S. Federal Budget initiated a new development effort within the Department of Energy (DOE) Office of Nuclear Energy (DOE-NE) – the Advanced Reactor Demonstration Program (ARDP). This program, supported by the National Reactor Innovation Center (NRIC), included appropriations supporting the demonstration of two advanced reactor designs, coupled with risk reduction research funding for two to five additional designs. Additionally, NRIC supports reactor demonstration projects outside of the ARDP.

As part of the ARDP, industry teams must meet a DOE goal of demonstrating their technologies in a five- to seven-year time frame. This will require that reactor vendors not only determine the technical viability of their reactor designs to meet this challenging timeline, but will also need access to viable demonstration plant sites. These sites may need to support a range of designs to include thermal power from 3 megawatts thermal (MWth) up to 630 MWth, peak electrical loads of 1.5 kilowatts electrical up to 272 megawatts electrical, and pressures from atmospheric to high pressure. The majority of potential developers have also indicated to NRIC that they intend to use DOE-provided site services (if available) to include Emergency Services, Fire Response, and Water Resources. In a recent survey, NRIC found that there is a gap in the number of well-characterized sites that could support these known demonstration requirements.

In order to close the identified gap, NRIC initiated a two-phase joint analytic effort including DOE, national laboratory, and academic partners to examine demonstration reactor siting alternatives. The analytic aspects of this NRIC funded effort are led by Argonne National Laboratory (Argonne), in collaboration with Idaho National Laboratory (INL), Oak Ridge National Laboratory (ORNL), and representatives of the Fastest Path to Zero (FPTZ) Initiative from the University of Michigan (UMich). The first phase of the study, described in this report, is a quick-look assessment of a limited number of known siting alternatives. Phase II efforts will focus on development of an integrated tool that utilizes data and models from UMich, ORNL, and Argonne to provide a more comprehensive way to evaluate reactor siting.

Sustaining America's leadership in nuclear energy requires proactively aligning and integrating technology research and demonstration activities with efforts to address known regulatory, socioeconomic, and commercialization challenges. Among these are issues such as consent-based siting, grid integration, environmental impact, and deregulated market viability. To address this, the NRIC sponsored study includes consideration for demonstration across a broad geographic range of sites including both government-controlled and private sector locations in both regulated and deregulated markets. Beyond typical siting guidelines required by the Nuclear Regulatory Commission (NRC), consideration has also been given to a wide range of issues including availability of National Laboratory support; and the potential for siting at locations that may enable research into new use cases (e.g., process heat, H2 production). These use cases may affect design choices and impact the reactor technologies that ultimately prove successful in reaching commercialization. A critical near-term factor is speed of site access and regulatory support given the rapid development timeline proposed in the ARDP.

In this siting analysis, consideration has been given to a wide range of siting criteria including geographic diversity, social equity, and economic viability. A focus on a range of sites across the U.S. will help ensure success of the multi-dimensional DOE-NE development portfolio by helping spread management, research, and support for demonstration across the National Laboratory complex. This approach may also build program support across a broader base of legislative, industry, and public stakeholders.

Sites include options that address regulatory and public engagement challenges that siting in remote locations and regulated markets cannot, and sites that may enable near-term research into renewables and storage integration, as well as Hydrogen (H2) production or process heat service. The end goal is the development of siting options that will strengthen and accelerate deployment of U.S. nuclear technologies that incorporate scientific advancements, realize safety and economic objectives, and meet consent-based siting parameters.

Phase I Participants: The National Reactor Innovation Center at Idaho National Laboratory (Sponsor, Program Lead), Argonne National Laboratory (Analysis Lead), Oak Ridge National Laboratory (Oak Ridge Siting Analysis for power Generation Expansion (OR-SAGE) Modeling team), the University of Michigan (Fastest Path to Zero Initiative)

For Phase I of the siting assessment, the following sites (shown on Figure 1-1) were evaluated:

- Idaho National Laboratory (Areas surrounding the Advanced Test Reactor (ATR) Complex, the Critical Infrastructure Test Range Complex (CITRC), and the Materials and Fuels Complex (MFC))
- Eagle Rock Site, Idaho
- Clinch River (TVA) (Areas covered by Clinch River Early Site Permit (ESP) No. ESP-006)
- East Tennessee Technology Park (ETTP)
- Savannah River National Laboratory (H-2 Site)
- Energy Northwest (Hanford, WA)
- Nevada National Security Site
- Joint Base Elmendorf-Richardson, AK (Elmendorf)
- Portsmouth Site, Portsmouth, OH
- The University of Illinois, Urbana-Champaign (2 sites: Abbott Power Plant and an area south of campus)

Figure 1-1: Proposed Demonstration Reactor Sites

The remainder of this report is structured as follows:

Section 2: Approach and Methods

Section 3: Example Case: Idaho National Laboratory – Advanced Test Reactor Site

Section 4: Preliminary Results

Section 5: Discussion and Recommendations

Section 6: Site Summaries

2 Approach and Method

2.1 Summary of analytic approach

The general approach taken for Phase I of this assessment is shown in Figure 2-1 and an example case of the initial modeling approach is described in Section 3.

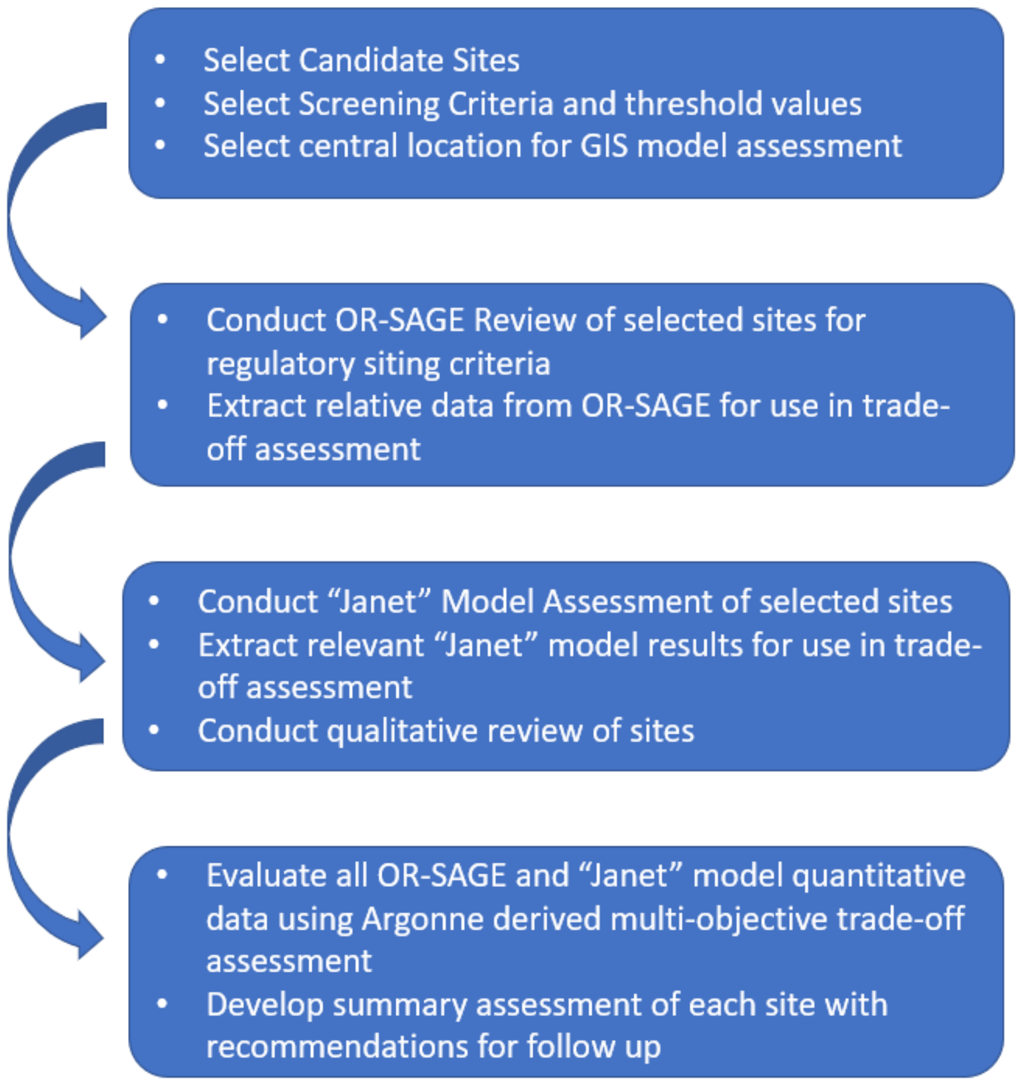


Figure 2-1: Overview of the siting review process

Initial candidate sites were provided to the assessment team by NRIC leadership. These sites included both locations that had previously hosted operating reactors or nuclear facilities and several new site options that may provide benefits for advanced reactors now under development. The assessment began with a general survey of the overall location to select a central site location to conduct the geographic information system (GIS) model assessments that are described in the following sections using the OR-SAGE [1] and UMich "Janet" models. The assessment team also determined which site evaluation attributes would be included in

Phase I of the analysis including determination of a representative threshold value. The attributes were drawn from NRC guidelines [2] and Electric Power Research Institute (EPRI) nuclear plant siting guidelines [3].

Using the criteria selected in step 1, the ORNL team conducted model simulations to evaluate each site across the technical attributes from the definitive NRC siting regulations and guidance. The OR-SAGE model and approach are described in the Section 2.2. Following the initial screening, a "pin drop" was made to identify a representative 50-acre site and specific proximity and safety attributes (e.g. distance to airport, distance to population center) were calculated for use within a multi-attribute trade-off assessment. The selection of the central point (pin drop) for the area of interest does not impact the evaluation results and the team considered the broader area of interest regarding any query threshold values. Evaluated areas include a visual representation of more than 2,000 acres.

The same sites were evaluated by the UMich team considering socioeconomic factors. The UMich "Janet" model, which is currently under development, is described in Section 2.3. In addition to quantitative attributes drawn from the "Janet" model, the UMich team also conducted an assessment of each location to consider data such as the demographic overview of the area near each site which can be utilized to identify marginalized populations. These summary assessments are provided in Sections 3 and 6.

As a final quantitative assessment of the sites, and to allow for a cross-site comparison, the team from Argonne developed a multi-attribute assessment model, incorporating the quantitative outputs from the OR-SAGE and "Janet" models. This model is described in Section 2.4. The goal of this model is not to rule out any individual site but rather to provide a mechanism for stakeholders to compare across site options based on their assessment of importance/utility for each of the attributes included.

As a final addition to the Phase I assessment of these sites, Argonne analysts also gathered information related to air quality and extreme weather. Due to time constraints for Phase I, these attributes were not incorporated into the preference model but are described below and full details are provided in the Appendices to provide additional factors for consideration. The assessment team considers these factors as potentially vital considerations for any demonstration plant should they plan to endure beyond demonstration and testing as an electric grid generating source.

2.2 OR-SAGE Tool Description

The OR-SAGE tool is designed to use industry-accepted practices in screening sites and then employ the proper array of data sources through the considerable computational capabilities of GIS technology available at ORNL. Detailed discussions of the OR-SAGE development and application are available in a number of reports [1, 4]. Initially, ORNL staff (1) adapted and extended the 2002 EPRI Siting Guide [3] methodology, developed to support early site permit applications, for the purpose of screening sites and (2) employed three of the four steps in the Bechtel site evaluation process [5] for nuclear plant siting. The screening process divides the contiguous United States into 100 by 100 m (1-hectare) squares (cells), applying successive suitability criterion to each cell. If a cell meets the requirements of each criterion, the cell is deemed a candidate area for siting a power plant of a particular size in terms of power (MWe). Some suitability parameters recommend against siting a plant because of an environmental, regulatory, or land-use constraint. Other parameters assist in identifying less favorable areas such as proximity to hazardous operations.

There is well defined regulatory guidance for siting a nuclear power plant in the United States, though some of the existing guidance, developed with large light water reactors in mind, may be less applicable to advanced reactor designs. Approximately 50 potential siting criteria were identified in various sources related to health and safety, environment, socioeconomic, and engineering factors. ORNL staff developed a subset of parameters for nuclear plant siting that were considered to have the most impact on the viability of any given site and were directly amenable to application of GIS techniques. The selected advanced reactor parameters are based on providing a high level of discrimination and readily available data. A summary of the parameters selected for advanced reactor site analysis is provided here and a more detailed discussion of each individual parameter layer, including data sources and time stamp, is provided in Appendix A.

1. Land with a population density greater than 500 people per square mile (including a 4-mile buffer) is excluded.
2. Wetlands and open water are excluded.
3. Protected lands (e.g., national parks, historic areas, wildlife refuges) are excluded.
4. Land with a moderate or high landslide hazard susceptibility is excluded.
5. Land that lies within a 100-year floodplain is excluded.
6. Land with a slope greater than 18% (~10°) is excluded.
7. Land areas that are more than 20 miles from cooling water makeup sources with at least 30,000 gallons per minute (gpm) are avoided for nominal advanced reactor plant applications. (This layer can be ignored for air-cooled applications.)
8. Land too close to identified fault lines is excluded (the length of the fault line determines the standoff distance based on Table 1 in 10 Code of Federal Regulations (CFR) 100 Appendix A).
9. Land located in proximity to hazardous facilities (airports and oil refineries) is avoided.
10. Land with safe shutdown earthquake (SSE) peak ground acceleration (2% chance in a 50-year return period) greater than 0.5 g is excluded.

Based on preliminary NRIC discussions and expert judgment, it is assumed that the advanced reactor technologies to be demonstrated can easily be accommodated on a 50-acre footprint. An overview of the OR-SAGE tool application is detailed in Figure 2-2.

The first step shown in Figure 2-2 is to select input datasets and then process and convert the input datasets. This involves vector to raster conversion and raster reclassification. The datasets are typically not to the same scale. The conversion process allows all the data sets to be represented to the same scale on a common map (100 by 100 meter (m) cells or approximately 2.5 acres per cell).

Appropriate layered selection queries are generated associated with each siting criterion, including the application of any buffer zones. The application of a buffer zone can be a complex process such as evaluating population density in the vicinity of each cell or it can be a simple stand-off distance such as is applied to fault lines. Then, the parameter layers are assembled into a single output. Essentially, the applicable layers are summed cell-by-cell. The result is a highlighted US contiguous map of all the areas that do not meet one or more of the threshold criteria for the static query under consideration, typically highlighted in red. During this step, individual layers can be moved in and out of the study to conduct sensitivity analyses. The limits associated with any given parameter layer can also be adjusted to conduct sensitivity analyses.

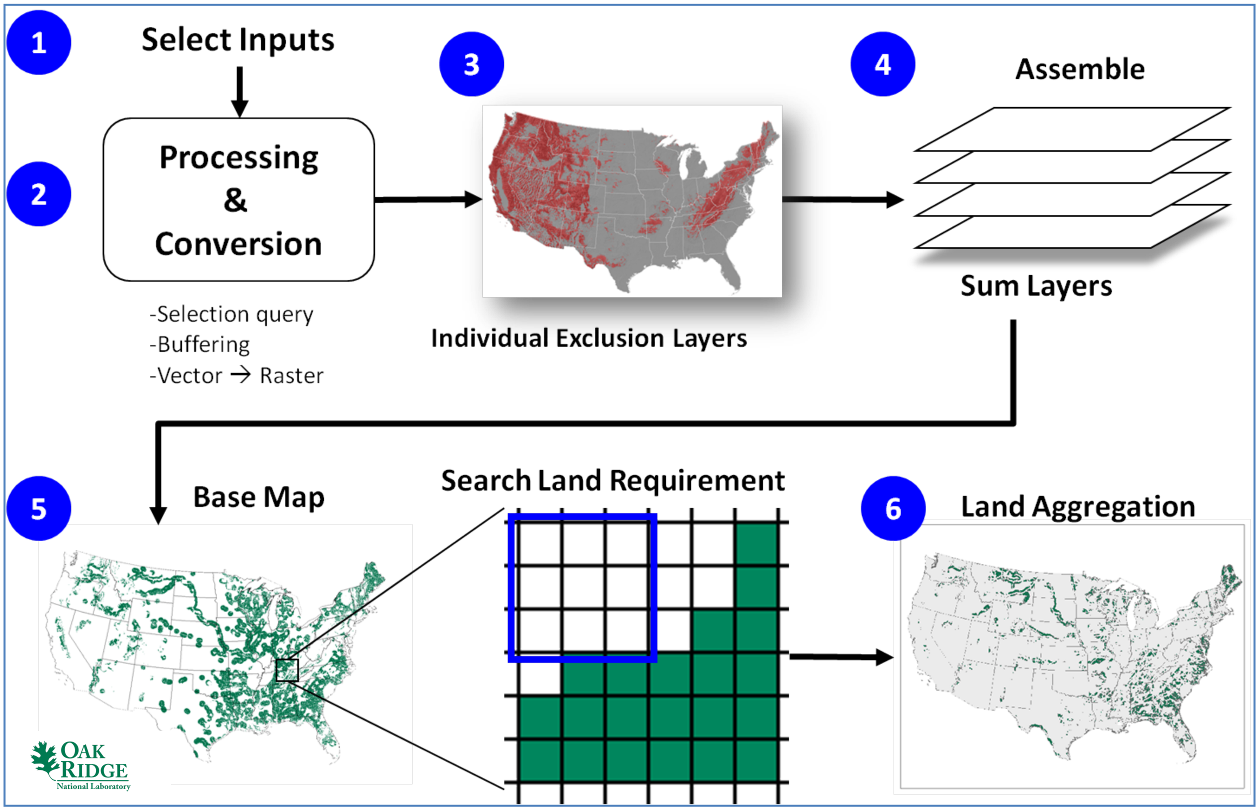


Figure 2-2: Overview of the OR-SAGE analysis processes

Since the desired result is to identify cells where a given power source is viable, the highlighted portions of the map are inverted to reveal all the areas that have no siting challenges based on the selected siting parameter values. Each individual 100 by 100 m cell that meets every site parameter threshold is typically highlighted in green on the base map. Given that a single cell represents approximately 2.5 acres of land, a land search must be conducted to identify realistically sized, connected plots of land that can support the typical size of a given power source. For this NRIC study, 50-acre plots were determined to be acceptable and the cells were evaluated in 5x5 arrays with a requirement that 90% of the cells in each array meet the threshold siting parameter values.

2.3 Summary of "Janet" Model and additional qualitative criteria

Decisions about energy technology adoption typically require the consideration of many different criteria and the cooperation and consent of many different stakeholders. The variety of size, scale, and applications of advanced reactors could open the door for many use-case scenarios. The complexity of these interactions is difficult to capture in model form; however, the UMich model has been developed to help identify, collect, and organize key geographic, political, economic, and social attributes to aid in the decision-making process. This database tool, called “Janet”, enables a systematic characterization of communities that have hosted nuclear facilities in the past as well as those that may want to host advanced nuclear technologies in the future.

“Janet” data are hosted through the UMich as a PostgreSQL relational database with PostGIS extensions; this allows analysts to perform spatial querying as well as the ability to update data automatically over time. The extensive database includes geographic, economic, organizational/structural, and behavioral data—all of which are necessary in order to fully understand and provide proposals for both site selection and community outreach (See Figure 2-3).

Geographic	Economic	Structural/Political	Behavioral/Social
• Political Boundaries • Protected Lands • Energy Potential by Source • Electricity Infrastructure • Pipelines • Water Resources • Electrical Grid • Transportation Networks • Mines and Mills • Electric Facilities • Power Stations • Location and Distribution of Non-Renewable Natural Resources • Climate Change Vulnerability	• Electrical Energy Prices • Electrical Energy Production • Electrical Energy Consumption • PPPs • Electrical Energy Provider Service Areas • Retail Electric Power Markets • Social Cost of Carbon • Wholesale Electricity Market Data • LACE and LCOE costs by Generator • Fuel Costs • Capacity Factors • Energy Imports and Exports	• Legislative Vote Counts • Incentives that Support Renewables and Energy Efficiency • Elected Officials at the National and State Level • Political Lean • Election results 2008-2018 • Renewable Energy Portfolio goals • Clean Energy Standards • Labor Union Organizations and Leadership • Restrictions on Nuclear Energy • Energy Related Bills	• Census Demographic Data • Pro and Anti-Nuclear Organizations • Climate Change Perceptions Survey Results • Social Vulnerability • Nuclear Sentiment/Mood Survey Data • Risk Perception Data

Note: LACE is the Levelized Avoided Cost of Electricity and LCOE is the Levelized Cost of Electricity.

Figure 2-3: Summary of the geographic, economic, political and social factors that are included in the University of Michigan “Janet” Model

UMich staff leveraged the expertise of the entire siting study team to identify data sets from “Janet”, both quantitative and qualitative to be included in the analysis. The selected data sets are described below and data sources are provided in Appendix B.

2.3.1 Quantitative Model Data Attributes:

1. Favorable State Energy Policy: Favorable State Energy policy is quantified on an ordinal 3 point scale; ‘Negative’, ‘Neutral’, and ‘Positive’. States with a ‘Negative’ value for Favorable State Energy Policy are those with state level restrictions on the siting of new nuclear reactors. State level restrictions on the siting of new nuclear

reactors are a substantial limiting factor for successful siting. Overcoming these policy hurdles would likely take substantial time and resources. The focus of this study is the siting of demonstration reactors and thus the sites may fall under different policy requirements than the siting of traditional reactors.

States with a 'Positive' value for Favorable State Energy Policy are those states which have state policy incentives such as; zero emission credits (ZEC), renewable portfolio standards and goals (RPS/RPG), or clean energy standards (CES) that can be used to support nuclear energy development. As the focus of this analysis is new nuclear development, only state policies that either explicitly includes, or does not explicitly exclude new nuclear development were included in the model. CES or RPS/RPG which were passed by executive order are not included.

States with a 'Neutral' value for Favorable State Energy Policy are those which have neither state level restrictions on the siting of new nuclear reactors nor state policy incentives.

2. Electric Energy Price: "Janet" uses the DOE Energy Information Administration (EIA) Application Programming Interface (API) to collect the state monthly average electricity price for ultimate customers across all sectors, updated monthly and used to calculate the twelve-month rolling average. This attribute provides the twelve-month rolling average for the time period May 2019 – April 2020. The unit of measure is cents per kWh.
3. Net Electricity Imports: The net electricity imports combine two EIA datasets from the DOE States Energy Data System (SEDS) database (2018) accessed through "Janet" by the EIA API. The values from these two datasets are added to together to indicate the total net energy flow both interstate and internationally for each state. A positive value indicates state is a net importer. States which are consuming more energy than they are producing are considered more likely to prioritize the development of new facilities.
4. Electric Energy Trend Slope: Electric trend slope also utilizes the DOE States Energy Data System (SEDS) database (2018) accessed through "Janet" by API. Yearly average data, from a five-year period (2014-2018) were used for each state to determine the trend of net imports over time. These data are plotted and a linear regression is run to determine the trend line. The slope of this trend line is used to measure the change over time. Positive values indicate a state is increasing imports. If a state is importing substantially more energy over time, due to decrease in production or increase in consumption that state is considered more likely to prioritize the development of new facilities.
5. Nuclear Sentiment % Favorable: The overall nuclear sentiment score was built on over 10 years of public polling data on nuclear sentiment collected by the University of Oklahoma (OU). The models were developed by estimating a multi-level regression model using an aggregate database of variables ranging from individual level factors (race, gender, ethnicity, age) to county level factors (partisanship, distance to existing nuclear facilities, social vulnerability scores). Parameters from the multi-level regression models were used to create a net favorability measure towards nuclear energy for each county in the contiguous United States (CONUS). US Census data were then

used to post-stratify (weight) the predictions to match the demographic characteristics of each county. This resulted in a demographically adjusted set of predictions for every county that were standardized by converting them into percentiles that indicate the rank of each county relative to other counties in the country on each metric.

One challenge of local-scale estimation of public attitudes is that rural counties in the least populous states have relatively few survey observations. These sparsely populated counties may be of particular interest as potential hosts for nuclear facilities. To address this, the models combine multi-level regression estimates and population post-stratification to utilize information about the effects of individual-level characteristics (from the larger body of survey data), coupled with the known distribution of these characteristics in rural counties (from Census data and elections data), to make strong inferences about the level of support for hosting nuclear facilities even when direct survey observations in the area are relatively sparse.

The overall nuclear sentiment score is not fully complete and still in the process of completing the validation step. These results are preliminary. For inclusion into the Multi-Objective Preference Model (MOPM), county level percentiles for the counties included in the study were weighted by population to create an overall percentile. At this time the model covers only the CONUS. Survey data for Alaska have been collected and are being analyzed. The attribute value for the preference model for the Elmendorf Air Force Base (AFB) site is estimated based on initial results.

6. Proximity to Nuclear R&D Support: The original dataset for this attribute was compiled from multiple sources by the UMich team. It contains all colleges and universities with nuclear engineering or nuclear technology programs as well as all national labs. This dataset was filtered to identify R&D support which meet at least one of the following requirements:

    a. A national lab with robust support for advanced reactors.

    b. A university or college with an active research reactor.

    The value used in the multi-attribute trade off assessment is the number of these support facilities that are located within a 100-mile radius of the site.

7. Centers for Disease Control (CDC) Social Vulnerability Index (SVI) [6]: This attribute measures county level resilience to natural disasters, human-caused disasters, and disease outbreaks. These vulnerability factors are critical in assessment of the implications for a potential accident scenario. The SVI data are provided at a county level and the results presented are population weighted for the counties that surround a given proposed site.

2.3.2 Qualitative "Janet" Model Attributes:

1. Pro-/Anti-Nuclear Organizations: This section provides information about pro- and anti-nuclear organizations that meet at least one of the following requirements:

    a. Within 100 miles of a proposed site

    b. Within the same state as a proposed site

2. Marginalized Populations: This section provides an overview of demographic data that can be utilized to identify marginalized groups. This includes data on race and ethnicity, education, poverty, and unemployment weighted by county population. The dataset used was the American Community Survey (ACS) 2014 -2018, 5-year estimates.

2.4 Summary of Multi-Objective Trade-off Assessment Process

The MOPM used in this siting study is a method, process, and model that provide a means to evaluate alternatives (advanced reactor demonstration site options, in this assessment), where there are multiple conflicting objectives to be achieved. The MOPM is a decision support framework that is based on rigorous decision analysis methods and techniques. These proven approaches provide structure to complex comparative evaluations and produce insight and understanding of tradeoffs across multiple objectives [7]. The use of multi-objective methods in energy infrastructure siting assessment is well established including an extended history of use in nuclear plant siting assessments [8, 9].

An important advantage of this approach is the explicit separation of the evaluation elements into five components (1) objectives, (2) performance measures, (3) decision-maker priorities and value hierarchies, (4) alternatives, and (5) outcomes of alternative solutions. With high transparency across the objectives, priorities, and outcomes from different perspectives on an issue, the method can extend to the development of improved solutions than may be originally proposed.

2.4.1 Value Theory – The Underlying Principle

Understanding the concept of value is central to understanding multi-objective evaluation. Value is the worth or usefulness of something to someone in satisfying their needs, wants, or objectives. In this method, value is assessed by the degree to which the performance of an alternative satisfies stated objectives. That is, high performance with respect to some objective provides more value than does low performance.

Computationally, the method is a mathematical model of values that affect preference between alternative outcomes, e.g. the preference for one demonstration site from among several alternatives based on desired objectives. This model is used to calculate component and aggregate measures of value based on performance across multiple objectives. It can be implemented for a single or multiple decision-makers or decision-makers faced with a complex decision or trade-off assessment. Decision-makers generally have a higher preference for alternatives that create more value for them. Therefore, the model helps provide insights into different alternatives based on the decision-maker's expressed preferences.

Figure 2-4 shows the relationship between five fundamental elements of the model and how they contribute to the mathematical model. The model can support an iterative process by which the up-facing arrow on the right side of the figure represents results from the model being used to help define or identify better alternatives that improve composite value.

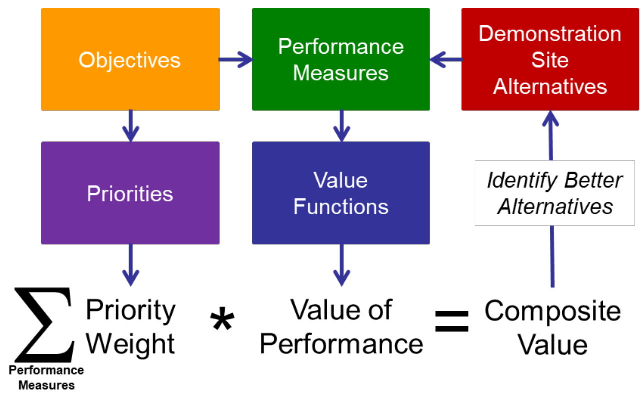


Figure 2-4: Elements of the Composite Preference Model

This model has been described in detail in earlier reports [10-13]. The reader is referred to these reports for a thorough discussion of the theory and techniques underlying the model. The sections that follow briefly highlight the purpose and role of each element in the framework and how they are related in contributing to composite value.

2.4.2 Objectives

Objectives are expressed in terms of system-level attributes that are believed to be most important for a desirable advanced reactor demonstration site.

Starting with well-stated objectives is important because the objectives define what a decision-maker wishes to achieve from the choice of an alternative. Objectives of structurally complex decisions are usually defined in hierarchical structures in which the most important or "fundamental" objectives are expressed in terms of a system-level criteria, or system-level attributes to be achieved. Fundamental objectives are those things that are at the core of the decision maker's satisfaction with the outcome of a decision or choice.

Objectives should be stated with an indication of either the directionality or the resulting condition (state) that is preferred to provide greatest satisfaction with the outcome of a decision. For example, objectives are usually stated in terms of maximizing, minimizing, or meeting some particular condition. Also, it is common that some objectives will conflict with other objectives. That is, options that perform well on one objective may perform poorly on another, such that no option would maximize the decision-maker's satisfaction across all objectives simultaneously. This preliminary assessment considered three fundamental objectives shown in Table 2-1.

Table 2-1: Fundamental Objectives of the NRIC Siting Study

1	Socioeconomic	Maximize favorable social, economic, and local energy policy factors that could potentially influence state and local acceptance of construction and operation of an advanced reactor demonstration.
2	Proximity	Satisfy all environmental and regulatory exclusion zone criteria and minimize the distance to infrastructure that could facilitate or support construction and operation of an advanced reactor demonstration.
3	Safety	Meet or exceed all regulatory guidelines for environmental and geologic safety factors or minimize safety risks to an acceptable level by mitigating such hazards.

2.4.3 Performance Measures

Each objective must be represented by at least one performance measure, or score, that quantifies performance with respect to that objective. Generally, as is the case in this assessment, several performance factors contribute to the satisfaction of an objective. For this study, Table 2-2 summarizes the performance measures selected to measure achievement of the above objectives. Also depicted in the table are the "Best" and "Worst" values taken by the performance measure across all the potential alternative demonstration sites considered.

Table 2-2: Performance Measures Supporting Each Fundamental Objective

Objective	Measure	Units	Best	Worst	Difference	% (B-W)/B
Socioeconimic	1.01 Electric Energy Price	cents / kWh (all Sectors)	20.46	7.84	12.62	62%
	1.02 Net Electricity Imports	million kWh / yr (neg. value = export)	36,651	-33,097	69,748	190%
	1.03 Electric Energy Flow Trend Slope	million kWh/yr / yr (neg. = growing exports)	3,810	-1,174	4,984	131%
	1.04 Energy Policy Supports Nuclear	Negative; Neutral; Positive	Positive	Negative	n/a	n/a
	1.05 Favorable Nuclear Sentiment	% of Favorability Toward Nuclear	84	17	67	80%
	1.06 CDC Social Vulnerability Index (SVI)	Social Vulnerability Index	33	78	45	58%
	1.07 Construction Labor Rate Index	Construction Labor Index (100 = nat. average)	80	145	65	45%
Proximity	2.01 Proximity to Nuclear R&D	Number within 100 miles	2	0	2	100%
	2.02 Distance to Airport	miles (threshold = 5 miles)	35	5	30	86%
	2.03 Distance to Population Center >25,000	miles (threshold = 4 miles)	65	2	64	98%
	2.04 Distance to a Refinery	miles (threshold - 1 mile)	62	380	318	84%
	2.05 Distance to Major Road	miles	0.1	13	13	99%
	2.06 Distance to Rail Transport	miles	0.1	94	94	100%
	2.07 Distance to Cooling Water >30,000 gpm	miles	0.5	121	120	100%
	2.08 Distance to Transmission System	miles	0.1	22	22	100%
	2.09 Distance to Navigable Waterway	miles	0.5	417	417	100%
Safety	3.01 Max Ground Acceleration > 0.5 g	No = not present; Yes = present	No	Yes	n/a	n/a
	3.02 Proximity to Fault Lines	No = not present; Yes = present	No	Yes	n/a	n/a
	3.03 Presents of 100-Year Floodplain	No = not present; Yes = present	No	Yes	n/a	n/a
	3.04 Presence of Landslide Hazard	No = not present; Yes = present	No	Yes	n/a	n/a
	3.05 Presence of Open Water or Wetlands	No = not present; Yes = present	No	No	n/a	n/a
	3.06 Presence of Protected Lands	No = not present; Yes = present	No	No	n/a	n/a
	3.07 Maximum Grade > 18%	No = not present; Yes = present	No	No	n/a	n/a

2.4.4 Value Functions

When there are multiple objectives, the performance of an alternative with respect to those objectives is usually measured in many different physical units – dollars, percent, miles, yes or no, and others. Mathematically, it is not possible to combine measures in a meaningful way by aggregating performance levels measured in different units. So, in the MOPM, value functions are used to convert performance level to the relative value that the performance creates for the decision-maker. The resulting value measures are the result of transforming a (raw) performance score (measure, level) to the level of satisfaction that the decision maker assigns to that level of performance. Value functions simply represent the translation of performance levels (in different units) to relative value created for the decision-maker on a consistent scale of 0 to 1.

For example, among the alternative demonstration sites considered in this report, distance to a transmission system varies from a low (best) level of 0.1 miles to a high (worst) level of 21.9 miles. For a value function on the range of [0,1], it is customary and convenient to assign a value of 0 to the worst level and a value of 1 to the best level. Generally, a linear value function like that shown in Figure 2-5 is adopted. A siting alternative with a distance to transmission of 0.1 miles, being the shortest distance among the alternatives considered, provides the best value of all alternatives. Because total system cost increases from 0.1 miles to 21.9 miles, the value function in Figure 2-5 assigns proportionally less value until the distance reaches 21.9 miles, which is the greatest distance and lowest level of value among the sites considered.

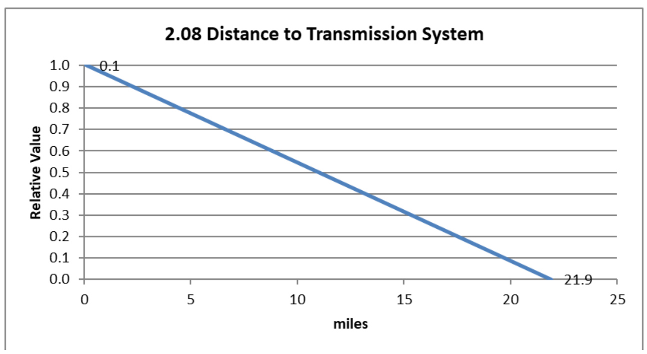


Figure 2-5: Distance to Transmission System Value Function

Value functions need not be straight lines; they can be any functional shape that represents the relative value derived from the measure as it progresses from the best condition to the worst. Value functions map performance scores to value measures that represents the decision maker’s relative value for a given level of performance on a criterion. Figure 2-6 illustrates several other generic forms of value functions.

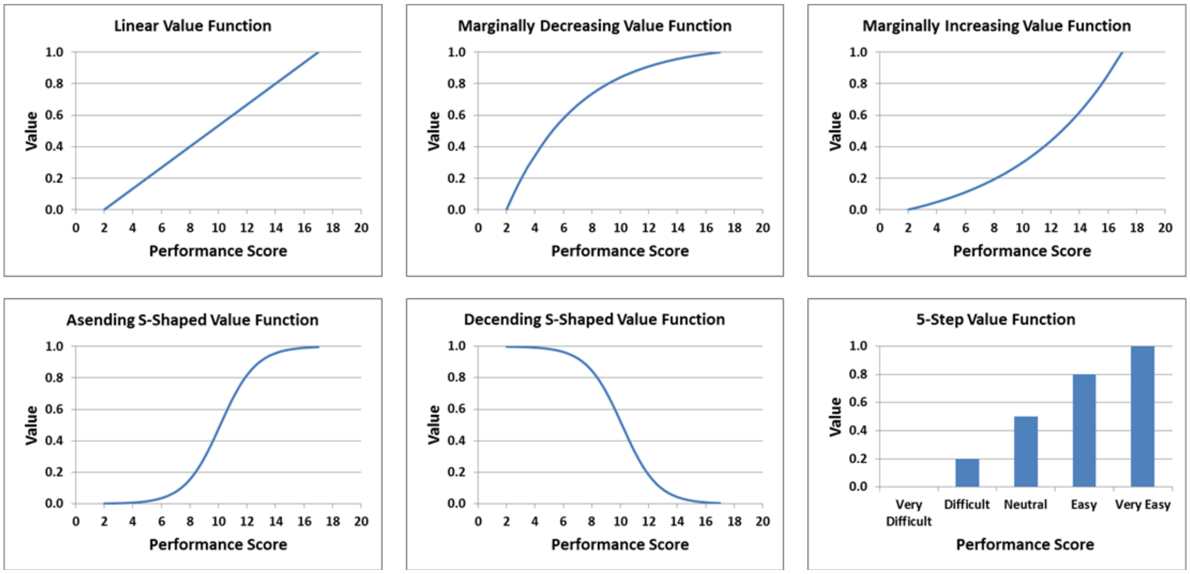


Figure 2-6: Examples of Value Functions

The MOPM prescribes that the decision maker explicitly specifies their value functions *a priori*, that is, before alternatives are compared on the basis of the performance measures. Thus, the value functions are the same regardless of the relevance of the performance measure to the decision-maker in assessing the alternatives. Relevance and scale variation are considered in assigning priority weights to the attributes.

Appendix C documents the value functions used in this assessment. Once converted, the individual value measures are weighted according to decision-maker priorities and then summed to a composite (total) value.

2.4.5 Priority Weights

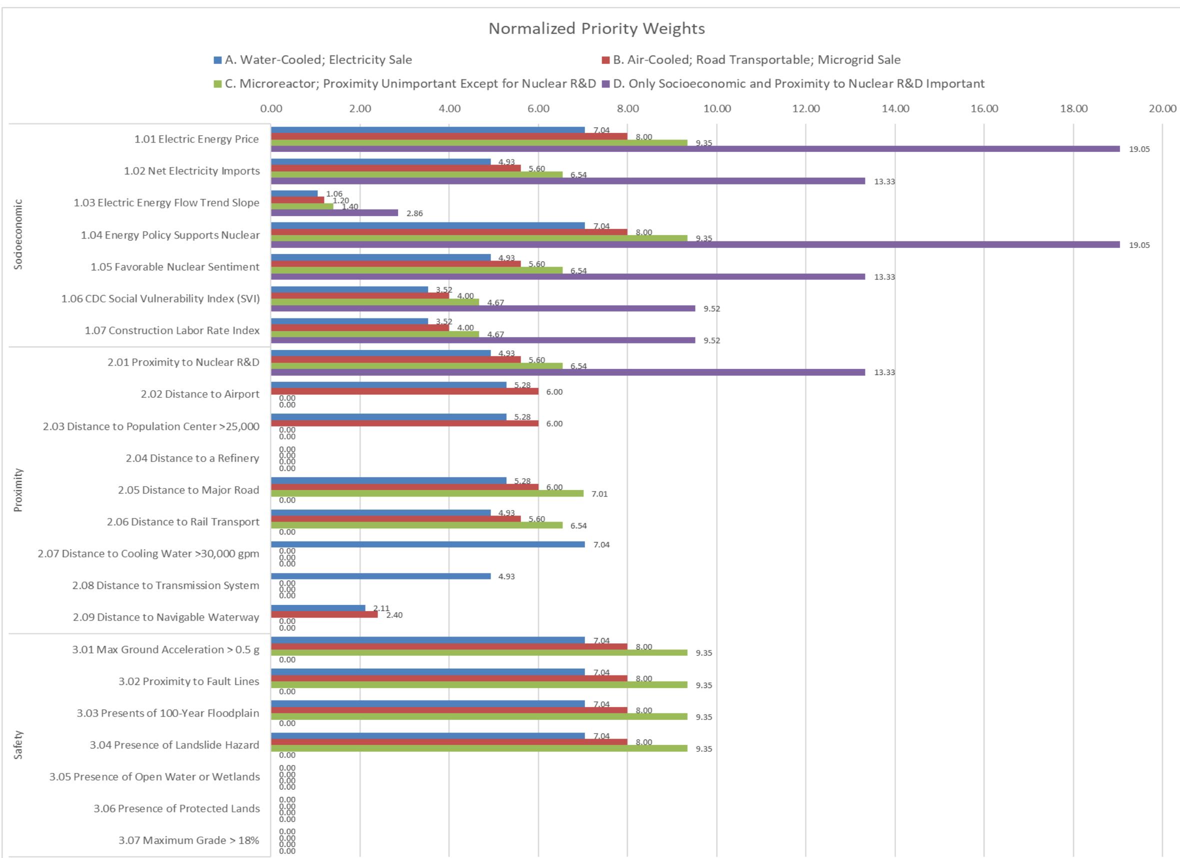
Value functions translate performance with respect to each measure into the relative value that a decision-maker receives. They do not account for variation in the relevance of the measures toward the creation of composite value, nor do they account for the significance of the scale range of the measures toward differentiating between alternatives. Priority weights, also known as swing weights, account for these factors.

In practice, some performance measures will be more influential in meeting stated objectives than will others. Furthermore, even if a performance measure is very relevant or important, it may be far less significant in differentiating between alternatives if it varies across the alternatives from only 1 to 2, for example, than if it varies across the alternatives from 1 to 50. Thus, the priority that a decision-maker assigns to performance measures depends on both the relevance of that measure in creating value and the significance of the performance range across the alternatives being considered. Priority weights account for these differences and have a sound mathematical foundation derived directly from the additive value model equation.[1] [14]

[1] Mathematically, when performance measures are converted to relative value scales on the interval [0, 1], the lowest performing alternative is assigned 0 and the highest performing 1. Thus, whether the performance range is small or large, the relative value will vary from 0 to 1. The weights assign importance and scale priority to these relative value ranges.

It holds from the above discussion, that for even a highly relevant measure, if performance does not vary at all among the alternative being considered, that measure should receive priority weight of zero because it contributes nothing to differentiating between the alternatives. Regardless of how important a measure is judged to be, if it offers no information by which to differentiate the alternatives, it is not relevant, and (for the purpose of differentiation) it logically must be assigned a priority weight of zero.

Synthetic priority weights were composed for four hypothetical advanced reactor developers for this study. It was assumed that developer A is interested in demonstrating an advanced reactor design that requires a natural cooling water source and would sell electricity generated to the grid. The developer B's design is air-cooled, transportable over road, and would sell electricity to a microgrid. Developer C is assumed to be an advanced micro-reactor developer who is unconcerned with the proximity of the demonstration site to population centers, airports, and other geographic features typically of concern to larger reactor complexes. Developer D provides an extreme example of someone who is concerned only with socioeconomic attributes that may affect or be affected by the demonstration and the demonstration site's proximity to a nuclear research and development institution. Figure 2-7 summarizes the priority weights, normalized to a sum of 100, for each of these hypothetical developers. Appendix C provides a fuller discussion of the method and procedure used to generate these weights.



2.04: Not relevant to any developer from a regulatory perspective or potential thermal sale customer because the nearest site-to-refinery distance is 63 miles.
2.08 & 2.09: Not relevant to developers B, C, or D because of air-cooling and no electricity sale.
3.05 – 3.07: Not relevant to any developer because these hazards are not present at any of the alternative sites.

Figure 2-7: Priority Weights for Hypothetical Advanced Reactor Developer Designs

2.4.6 Mathematical Formulation

One goal of a multi-objective evaluation may be to identify, or at least suggest, ways to create or find alternatives that provide the greatest value for decision-makers. The level of value provided by an alternative is measured by the performance of the alternative with respect to desired objectives. Performance measures are used to quantify the degree to which an alternative satisfies those objectives. For example, all other things being equal, an alternative that performs well with respect to a measure creates more value for decision-makers than does an alternative that performs poorly on the same measure.

In the Multi-Objective Preference Model, the value that each alternative, created by its performance level on individual measures, is aggregated in an additive model represented by the following equation, a mathematically formalized version of the more stylized version in Figure 2-4:

$$V(x) = \sum_{i=1}^{n} w_i v_i(x_i) \qquad \text{Eq 2-1}$$

where,

$V(x)$	is the total (aggregate) value of an alternative x;
n	is the number of performance measures;
x_i	is the level of performance of alternative x on the i^{th} performance measure;
$v_i(x_i)$	is the value of the level of performance of alternative x on the i^{th} performance measure; and
w_i	is the priority weight of the i^{th} performance measure (a.k.a. the swing weight).

As noted in the introduction to this section, a key advantage of this approach is the explicit separation of the evaluation elements into objectives, performance measures, decision-maker priorities and value hierarchies, alternatives, and outcomes of alternative solutions. With high transparency across the objectives, priorities, and outcomes from different perspectives on an issue, the method helps to segment and logically structure complex decision situations that can involve multiple and conflicting objectives.

2.5 Data and model parameters

The attributes considered in the OR-SAGE and "Janet" models are based on the best accessible data available at the time of the analysis. The data sources and time stamp for each model are summarized in Appendices A and B.

2.6 Air quality and climatological data

There are many attributes that may factor into a decision to site a demonstration reactor beyond those included in this analysis. For example, should a developer intend to build a demonstration plant that will eventually be licensed to operate for an extended period in an electricity or process heat market, understanding factors that could affect the market or that may impact operations may be important in making a final siting choice. Among these factors are demand for low carbon/low emission generation at a potential site and climatological factors that may affect operating efficiency.

There is long standing awareness of the health impacts that energy generation emissions can have on health and the U.S. Environmental Protection Agency (EPA) has even developed tools to quantify the benefits of more efficient and renewable generation [15]. As this relates to siting selection, poor air quality may be a leading indicator for increased low emission generation demand and therefore a potentially advantageous market future for a low carbon source like advanced nuclear. In order to include this in this assessment, analysts gathered Annual Outdoor Air Quality Index (AQI) data for 2019 recorded by the EPA. These data allow a comparative assessment of air quality at the sites under consideration. Areas with lower air quality may have higher future demand for clean energy. These data are included in Appendix D. It is noted that most sites under consideration in Phase I have reasonable air quality, making this attribute of lower importance for this first group of sites.

Climate change may also affect site selection decisions, with, for example, potential impacts on thermal plant efficiency or overall transmission line capacity as average temperatures rise in a given region [16, 17]. Climate impacts could also include increased incidence of severe weather which may also impact demand for stable generating sources like nuclear [18]. However, these same changes could also increase risk for outages in some siting locations if there is increased probability of flood or drought. To ensure there is some assessment of key climate factors, analysts also evaluated each region using the U.S. Climate Extreme Index (CEI) which was developed by the National Oceanic and Atmospheric Administration. While not incorporated for this phase into the preference assessment, details of the sites are provided in Appendix E and should be included in any final assessment of site readiness. Additional attributes were considered for inclusion in the Phase I analysis including solar and wind energy potential and presence or planning for energy development. These were not incorporated for Phase I but may be included in future assessments.

2.7 Labor Rates

Labor rate data [19] from the U.S. Department of Labor Bureau of Labor Statistics (BLS) were collected for the states where the potential sites are found. The data were from BLS releases in May 2019 and were for the labor categories – construction laborers, reinforcing iron and rebar workers, nuclear engineers, and security guards. The first two categories represent workers that would be involved in any construction activities to develop the systems and the last two categories would be required during operational activities. The intent of these data was to provide developers of a sense of the labor costs that could be representative of a given location.

Table 2-3 and Table 2-4 show the collected data for the initial construction and operational phase, respectively. The tables show the number of workers employed nationally and in the given state, the mean annual wage, the percent of a local wage relative to the national average, the number of workers per 1,000 total workers, and the location quotient for each state. The location quotient is the ratio of the area concentration of occupational employment to the national average concentration. A location quotient greater than one indicates the occupation has a higher share of employment than average, and a location quotient less than one indicates the occupation is less prevalent in the area than average. It is important to note that if there are no data for a given labor category, it does not imply that there are no employees of that category in the noted state, but only that the employers providing data to the BLS did not report any employees in that labor category.

Table 2-3: National and state labor rate data for construction laborers and reinforcing iron and rebar workers that could be representative during the initial phase of a technology demonstration effort.

	Initial Phase				
	47-2061 Construction Laborers				
Location	# Employed	Mean Annual Wage	Percent of Annual Wage	# per 1,000 Workers	Location Quotient
National Average	1,020,350	$41,730	-	6.947	-
Alaska	2,770	$52,290	125.3%	8.721	1.26
Idaho	7,510	$33,990	81.5%	10.334	1.49
Illinois	34,010	$60,500	145.0%	5.645	0.81
Nevada	11,220	$37,810	90.6%	8.057	1.16
Ohio	35,900	$46,190	110.7%	6.590	0.95
South Carolina	17,620	$33,650	80.6%	8.361	1.20
Tennessee	17,940	$33,550	80.4%	5.996	0.86
Washington	31,510	$49,880	119.5%	9.496	1.37
	47-2171 Reinforcing Iron and Rebar Workers				
Location	# Employed	Mean Annual Wage	Percent of Annual Wage	# per 1,000 Workers	Location Quotient
National Average	18,870	$54,650	-	0.128	-
Alaska	n/r	$74,570	136.5%	n/a	n/a
Idaho	n/r	$42,740	78.2%	n/r	n/r
Illinois	n/r	$94,440	172.8%	n/r	n/r
Nevada	380	$50,560	92.5%	0.276	2.15
Ohio	n/r	$65,510	119.9%	n/r	n/r
South Carolina	120	$46,740	85.5%	0.056	0.43
Tennessee	490	$46,990	86.0%	0.162	1.26
Washington	280	$73,230	134.0%	0.085	0.66

Table 2-4: National and state labor rate data for nuclear engineers and security guards that could be representative during the operational phase of a technology demonstration effort.

	Operational Phase				
	17-2161 Nuclear Engineers				
Location	# Employed	Mean Annual Wage	Percent of Annual Wage	# per 1,000 Workers	Location Quotient
National Average	15,850	$120,700	-	0.108	-
Alaska	n/a	n/a	n/a	n/a	n/a
Idaho	530	$131,900	109.3%	0.109	0.73
Illinois	660	$122,330	101.4%	1.010	1.01
Nevada	n/a	n/a	n/a	n/a	n/a
Ohio	n/a	n/a	n/a	n/a	n/a
South Carolina	1,580	$105,340	87.3%	0.747	6.92
Tennessee	460	$130,570	108.2%	0.152	1.40
Washington	n/a	n/a	n/a	n/a	n/a

	33-9032 Security Guards				
Location	# Employed	Mean Annual Wage	Percent of Annual Wage	# per 1,000 Workers	Location Quotient
National Average	1,126,370	$33,030	-	7.669	-
Alaska	1,770	$43,060	130.4%	5.580	0.73
Idaho	2,780	$30,840	93.4%	3.825	0.50
Illinois	46,120	$33,800	102.3%	7.654	1.00
Nevada	22,310	$33,050	100.1%	16.023	2.09
Ohio	30,360	$33,490	101.4%	5.574	0.73
South Carolina	15,430	$32,620	98.8%	7.323	0.95
Tennessee	23,990	$29,280	88.6%	7.978	1.04
Washington	18,720	$41,030	124.2%	5.641	0.74

3 Example Case: Idaho National Laboratory – Advanced Test Reactor (ATR) Complex

Following is an example of the process followed and data generated in conducting this site review using the INL-ATR site as an example. A similar review using the OR-SAGE and "Janet" models was completed for each of the other sites under consideration for this Phase. The quantitative factors for all sites were then incorporated into the multi-attribute assessment tool. One additional attribute was also included in the multi-attribute assessment that was not incorporated into either GIS Model – Construction Labor Rate. Details of this attribute are provided in Section 2.7. A summary assessment using the multi-attribute assessment method described above was then conducted. Preliminary results of this assessment are provided in the next section. Detailed model results for the other nine sites similar to those shown here for INL-ATR are provided in Section 6.

3.1 Site Description

INL is an 890-square-mile DOE National Laboratory site located in southeast Idaho. It was established in 1949 as the National Reactor Testing Station. As detailed in a 2015 report on INL site conditions, INL has hosted fifty-two reactors—most of them first-of-a-kind. The ATR complex, shown in Figure 3-1 and Figure 3-2 [20], is located in the southwestern region of the INL Site, 47 miles west of Idaho Falls, ID. Detailed geologic, climate, and seismic information about the site, including support services that may be available at the site are included in the cited 2015 report [20]. Appendix Section D.3 lists the counties that surround the site and their populations.

Figure 3-1: INL ATR Site. Central point for model analysis of siting attributes is shown at the pin drop.

Figure 3-2: INL operating facilities map showing the locations of the ATR and MFC sites

3.2 OR-SAGE Model Results – INL ATR Site

The baseline nuclear siting criteria used by the OR-SAGE siting tool for the proposed INL-ATR site are shown in Table 3-1. This represents a static query that can be rerun with alternate threshold values as desired.

Table 3-1. OR-SAGE Baseline Criteria Used for Phase I.

Screening Criterion	Baseline Query Value
Population density (people per square mile)	>500 within 4 miles (based on bounding the pending regulatory guidance for advanced reactors)
Safe shutdown earthquake (ground acceleration)	> 0.5
Proximity to fault lines – Buffer in miles (based on Table 1 in 10 CFR 100 Appendix A)	Standoff depends on fault length
Slope	>18% grade
Streamflow (makeup cooling water [k gpm] within 20 miles, assuming closed cycle cooling and limiting plant use to no more than 10% of the resource, and based on 10-year, 7-day low flow data)	30,000 [Alaska – 20,000]
Wetlands/Open water	- - [go-no go]
100-year floodplain	- - [go-no go]
Protected lands	- - [go-no go]
Landslide hazard (≥ moderate)	- - [go-no go] (not available for Alaska)
Proximity to hazards – buffer in miles	Commercial airports –5; DoD facilities* and oil refineries – 1
* Can be turned off for proposed base sites.	

Each of the 10 nuclear siting layers were applied to the ATR site shown in Figure 3-1, centered on the pinpoint to the west of the current structures. The results are shown with circles with half-mile and one-mile radii about the pinpoint for reference. A one-mile circle includes approximately 2000 acres to be evaluated by the OR-SAGE model, while the inner half-mile circle includes approximately 500 acres. The results for each individual layer are shown in Figure 3-1, Figure 3-3, and Figure 3-4. Cells that do not meet the query threshold criterion are depicted in magenta; otherwise, cells that meet the threshold criterion are clear.

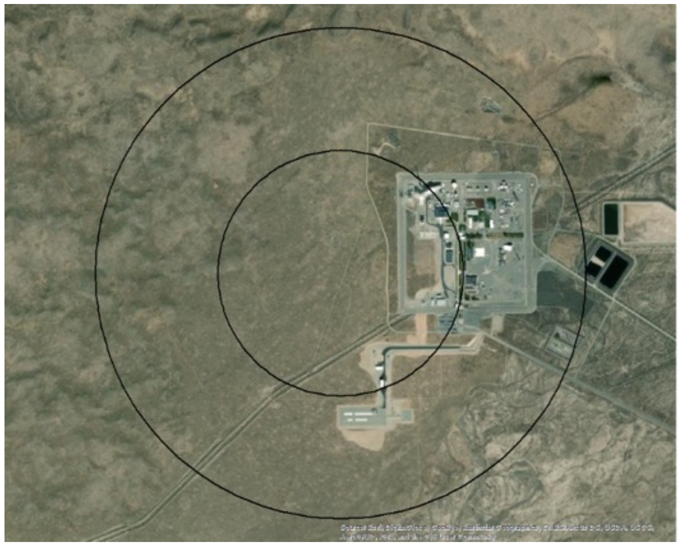


Figure 3-3: Layer results for population density, safe shutdown earthquake, faults, slope, 100-year floodplain, protected lands, landslide hazards, and proximity to hazards indicate no query threshold issues.

Eight of the OR-SAGE layers completely meet the threshold query value in the vicinity of the ATR site and are depicted clear as shown in Figure 3-3. The OR-SAGE layer for wetlands and open water identified some of the operating ponds and low areas east of the current structures as shown by the magenta markings in Figure 3-4. This does not represent an issue for the area of interest west of the current structures.

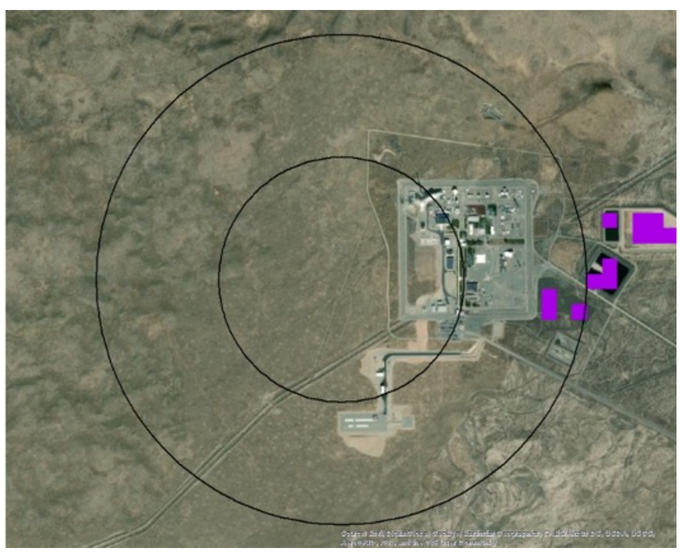


Figure 3-4: The layer result for wetlands and open water indicates the ponds associated with the facility.

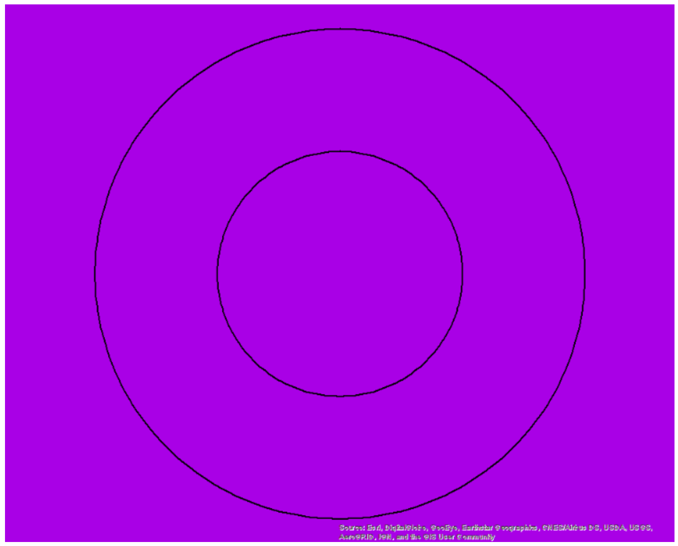


Figure 3-5: The layer associated with streamflow indicates that the threshold query value is not met for the facility.

The OR-SAGE layer for streamflow does not meet the threshold value anywhere in the immediate vicinity of the ATR site as shown by the magenta coloring of the entire map shown in Figure 3-5. This should not be evaluated as a disqualifying feature for the site. There may be alternative water sources available through an INL piping system. In addition, Birch Creek is available within 32 miles of the site, so a decision could be made to pipe fresh water from this source further than the 20 miles associated with the baseline OR-SAGE query. Finally, there may be advanced reactor technologies for demonstration that require little or no make-up cooling water rendering this discriminatory layer moot.

Since the OR-SAGE tool tracks the parameters for each 100- by 100-m cell, the ten OR-SAGE evaluation layers can be summed cell-by-cell to provide a visual summary of the layer results for the site. As a result, not only can the cells that meet all the baseline query threshold values be displayed visually, but also cells that are tripped by one, two, or three or more exclusions. This is known as the composite map. The composite map for the ATR site is shown in Figure 3-6. It is easy to see the impact of the streamflow layer and the wetlands and open water layer in the figure. However, without the water concern based on the OR-SAGE query, most of the composite map would be green.

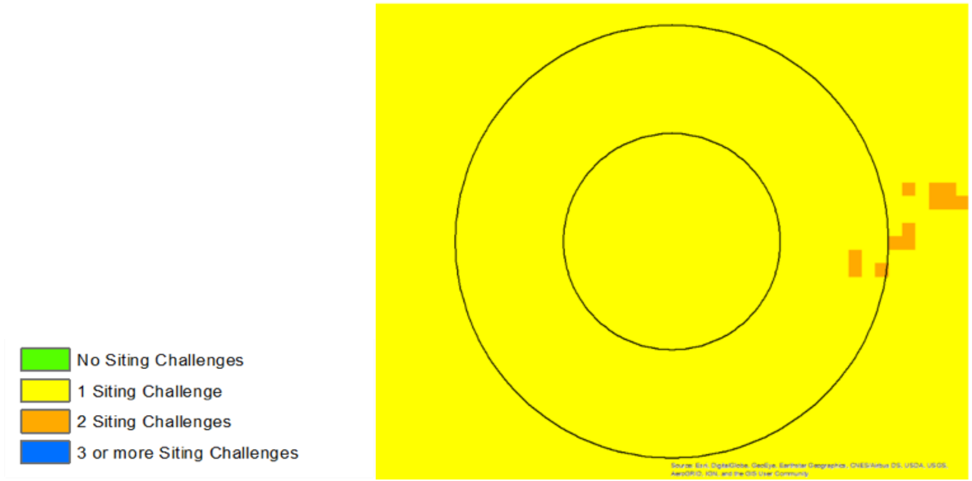


Figure 3-6: Composite OR-SAGE results for the INL-ATR site showing locations with siting challenges.

The map in Figure 3-6 shows a composite map identifying those locations with no, one, or more than one siting challenges. Each of these cells is about 2.5 acres and typically cannot individually support an advanced reactor installation, with the possible exception of a micro-reactor. Therefore, the results are aggregated in Figure 3-7 to show the effect of gathering the available land into 50-acre tracts at a 90% aggregation rate (90% of the individual cells in the group must pass all the query threshold value criteria). Aggregated cells that meet the threshold values are shown in green; otherwise the cells are shown as clear. No 50-acre aggregated sites in the vicinity of the ATR site met all the query threshold values because of the water issue discussed previously. If the water issue were discarded based on technology selection or otherwise resolved, the aggregate map would be green in the area of interest, because each colored area on the composite map would move up one color on the key and the aggregation would become a simple evaluation of a large block of individual cells that meet the query threshold values. Therefore, with the water issue resolved, any 50-acre tract in the target area of interest would be amenable to siting an advanced reactor demonstration based on the OR-SAGE evaluation.

Figure 3-7: Aggregate map for the INL-ATR site.

In addition to specific parameters selected for advanced reactor site analysis identified in Table 3-1, other GIS data representing parameters of interest can be evaluated relative to the site of interest. Table 3-2 provides a number of relative distance parameters that may weigh on the decision to site a demonstration reactor at any particular location of interest.

Table 3-2. Distance from the INL-ATR site to various parameters of interest.

Parameter	**Identification**	**Distance (miles)**
Population Center (≥ 25,000 residents)	Idaho Falls	65.4
Airport	Big Southern Butte	15.7
Major Road	US 20	4.2
Rail Transport	US Government	3.3
Navigable waterway	Snake River	390.1
Cooling water (≥ 30,000 gpm makeup)	Birch Creek	31.5
Grid Capacity	PacifiCorp	0.7
Oil Refineries	Woods Cross, UT	262.8

The first parameter of interest in Table 3-2 is the distance to the nearest population center with greater than 25,000 residents. This provides insight on power reactor siting regarding the NRC siting requirements for population found in 10 CFR 100 [21], whereas the OR-SAGE population density parameter listed in Table 3-1 is taken from siting guidance found in Regulatory Guide (RG) 4.7 [2] and SECY-20-0045 [22]. Non-power reactor siting is evaluated by the NRC using a performance-based evaluation using U.S. Nuclear Regulatory Commission Regulatory Report (NUREG)-1537 [23] and is not closely tied to a specific population value; furthermore, siting of non-power reactors on DOE land, such as the ATR site, would be authorized by DOE standards and guidance.

The next several parameters provide information on transportation options, which may weigh on the decision to site an advanced reactor at a particular location of interest. In addition, there is some risk associated with siting near commercial airports and the stand-off distance to the nearest airport can be weighed separately with regard to hazard risk.

The last several parameters may or may not apply to the decision to site an advanced reactor at a particular location of interest depending on the technology selected and the long-term goal of the demonstration.

3.3 "Janet" Model results

Table 3-3 provides "Janet" model outputs related to the INL ATR Site. Details of each attribute are provided in Section 2.3.

Table 3-3: "Janet" Model attribute outputs

"Janet" Model Attribute	Units	INL - ATR Value
Electric Energy Price	cents / kWh (all Sectors)	7.84
Total Net Imports	million kWh / yr	7,520
Electric Energy Flow Trend Slope	million kWh/yr / yr	-631
Favorable State Energy Policy	Negative, Neutral, or Positive	Neutral
Nuclear Sentiment % Favorable	% of Favorability Toward Nuclear	71.8
CDC Social Vulnerability Index	Social Vulnerability Index (x 100)	39
Proximity to Nuclear R&D	Number of Locations within 100 mi	2

Qualitative attributes were also considered by the UMich team. While there are four sites included for the study that are located in Idaho (three at INL and one near INL), these qualitative factors are typically evaluated at the county or regional level. As a result, the factors reflected in Table 3-3 cover all three INL sites. Table 3-4 provides demographic data for the INL-ATR site that can be utilized in an assessment to identify marginalized populations in the surrounding area. A list of known pro- and anti-nuclear groups relevant to the site is provided in Table B-6.

Table 3-4: Demographic overview of the area near the INL ATR Site

<table>
<tr><td rowspan="4">INL</td><th>Parameter</th><th>% White</th><th>% Black or African American</th><th>% Asian</th><th>% Native Hawaiian or Other Pacific Islander</th><th>% Some Other Race</th><th>% AIAN*</th></tr>
<tr><th>Value</th><td>89.1</td><td>.44</td><td>.99</td><td>.13</td><td>4.55</td><td>2.07</td></tr>
<tr><th>Parameter</th><th>% Two or More Races</th><th>% Minority</th><th>Per Capita Income ($)</th><th>% Unemployed</th><th>% No High School Diploma</th><th>% Below Poverty</th></tr>
<tr><th>Value</th><td>2.69</td><td>18.14</td><td>25409.87</td><td>4.44</td><td>9.63</td><td>13.25</td></tr>
</table>

*AIAN is an abbreviation for American Indian and Alaskan Native.

3.4 Site summary assessment

Proximity and Safety Assessment: The INL-ATR site is technically well qualified for siting of a demonstration reactor with the exception of possible cooling water limitations. As described earlier, the site did not meet the screening criteria used in the OR-SAGE Model for Phase I which required access within 20 miles of stream flow in excess of 30,000 gallons/minute. This requirement may be mitigated either through use of alternative water resources or demonstration of technologies with lower cooling demand or that use air cooling. There is strong support and security infrastructure given the long history of nuclear development at the site and demonstration efforts would be enhanced by proximity to one of the leading nuclear research laboratories in the world.

Socioeconomic Assessment: As reflected in Table 3-3, there is comparatively strong support for nuclear development at the INL site and a neutral state policy toward the technology, with recent support reflected in the Utah Associated Municipal Power Systems (UAMPS) decision to develop a new generation of light water reactors (built by NuScale) at the INL Site [24]. This new development may, however, create some market challenges for an advanced reactor developer who would like to follow their demonstration with a long-term license to generate and sell to the grid. It is unclear if electricity demand growth in the region will support additional generating capacity. The SVI was assessed as “Medium Vulnerability” to natural disasters and other disruptive events. The labor rates for the area are at the low end of the sites considered in this analysis.

Other Factors: There are no air quality issues at the site. Analysis of extreme weather conditions for the region show an increase in temperatures which could result in reductions in the efficiency of cooling water and an increase in the requirements for installation of heating, ventilation, and air-conditioning (HVAC) systems. Not evaluated are potential implications of multiple other high-profile nuclear developments that may also be occurring at the INL site to include the Versatile Test Reactor, support for Army Project Pele, and commercial demonstrations by the vendors NuScale and OKLO.

4 Preliminary Results – Preference Model

Once all site modeling was completed, detailed relative data were consolidated into the preference model, described in Section 2.4. Results from this assessment follow. These results are based on representative attribute weighting values postulated by the assessment team. Differing stakeholder value assessments and weightings would change relative preference results.

4.1 Performance Measure Assessment

Table 4-1 through Table 4-3 list the performance measures for the potential advanced reactor demonstration sites considered in this report drawn from the ORNL and UMich models. Table 4-1 to Table 4-3 presents the performance measures the for Socioeconomic, Proximity, and Safety considerations, respectively. For each primary objective there are 7 - 9 performance measures that contribute to the objective. These are listed horizontally as column headings along with the units of measure for each, as well as any threshold value set for the measure for this Phase I assessment. The body of the table contains the values of the performance measures for each site.

Note that Table 4-2 and Table 4-3 contain cells that are shaded. These cells represent values that did not meet the minimum or maximum threshold value set for the measure. Sites shaded in yellow did not meet cooling water criteria based on proximity to minimum assumed stream flow requirements. Availability of alternate water supplies or intent to use an air-cooled design may mitigate this challenge. Other factors that may pose a greater mitigation challenge are shaded in red. For example, the Distance to Airport and Distance to Population Center for the UIUC site reflects an inability to meet threshold values for these attributes as indicated in the column heading units cell (5 miles and 4 miles, respectively). The location assumed for the UIUC site is 4.9 miles and 3 miles, respectively, from these infrastructures. Other shaded cells refer to the presence of potential safety issues. For all shaded cells, additional analysis is needed to further quantify and clarify the extent to which the thresholds are satisfied or not, and the extent to which mitigation measures may be possible if a hazard exists. Some threshold proximity and safety values were chosen based on existing guidelines as discussed in Section 2.2. Follow on evaluations may consider alteration of these thresholds which may impact comparative site preference assessments.

Table 4-1: Socioeconomic Performance Measures for Potential Advanced Reactor Demonstration Sites

	Objective	Socioeconomic						
	Attribute	1.01 Electric Energy Price	1.02 Net Electricity Imports	1.03 Electric Energy Flow Trend Slope	1.04 Energy Policy Supports Nuclear	1.05 Favorable Nuclear Sentiment	1.06 CDC Social Vulnerability Index (SVI)	1.07 Construction Labor Rate Index
	Units	cents / kWh (all Sectors)	million kWh / yr	million kWh/yr / yr	No = not present; Yes = present	% of Favorability Toward Nuclear	Social Vulnerability Index	Construction Labor Index (100 = national average)
Site	Energy NW - Hanford	8.05	-20,625	-1,174	Positive	60	78	120
	TVA - Clinch River	9.70	29,717	-687	Neutral	84	43	80
	East TN Tech Park	9.70	29,717	-687	Neutral	84	43	80
	INL -ATR	7.84	7,520	-631	Neutral	75	39	81
	INL - CITRC	7.84	7,520	-631	Neutral	75	39	81
	INL - MFC	7.84	7,520	-631	Neutral	75	43	81
	SRNL	9.84	-10,788	-559	Neutral	71	61	81
	NNSS	8.57	459	-60	Positive	21	74	91
	DOD-ELM	20.46	1	0	Neutral	33	42	125
	Portsmouth	9.24	36,651	1,775	Positive	17	76	111
	UIUC Search Area	9.45	-33,097	3,810	Negative	48	42	145
	UIUC Abbott Plant	9.45	-33,097	3,810	Negative	48	42	145
	Eagle Rock	7.84	7,520	-631	Neutral	60	33	81

Note: Data for the 1.05 Favorable Nuclear Sentiment value at the DOD-ELM site was not available. This value is an estimate.

Table 4-2: Proximity Performance Measures for Potential Advanced Reactor Demonstration Sites

	Objective	Proximity								
	Attribute	2.01 Proximity to Nuclear R&D	2.02 Distance to Airport	2.03 Distance to Population Center >25,000	2.04 Distance to a Refinery	2.05 Distance to Major Road	2.06 Distance to Rail Transport	2.07 Distance to Cooling Water >30,000 gpm	2.08 Distance to Transmission System	2.09 Distance to Navigable Waterway
	Units	Number within 100 miles	miles (threshold = 5 miles)	miles (threshold = 4 miles)	miles (threshold - 1 mile)	miles	miles	miles	miles	miles
Site	Energy NW - Hanford	2	15.8	18	228	11	1	3	1	3
	TVA - Clinch River	1	27.5	13	103	1	3	1	1	1
	East TN Tech Park	1	30.4	12	99	6	0	1	1	1
	INL -ATR	2	15.7	65	263	4	3	32	1	390
	INL - CITRC	2	10.3	57	257	4	5	32	4	398
	INL - MFC	2	16.5	45	254	5	18	20	13	405
	SRNL	1	16.4	21	380	6	2	2	0	13
	NNSS	0	34.9	52	168	13	94	121	22	280
	DOD-ELM	0	24.4	14	142	12	6	44	0	13
	Portsmouth	1	15.2	65	62	2	2	3	1	23
	UIUC Search Area	1	4.9	3	103	1	1	55	1	108
	UIUC Abbott Plant	1	6.5	2	106	0	0	56	0	106
	Eagle Rock	2	25.3	29	246	2	18	18	4	417

Table 4-3: Safety Performance Measures for Potential Advanced Reactor Demonstration Sites

		Safety						
Objective								
Attribute		3.01 Max Ground Acceleration > 0.5 g	3.02 Proximity to Fault Lines	3.03 Presents of 100-Year Floodplain	3.04 Presence of Landslide Hazard	3.05 Presence of Open Water or Wetlands	3.06 Presence of Protected Lands	3.07 Maximum Grade > 18%
Units		No = not present; Yes = present	No = not present; Yes = present	No = not present; Yes = present	No = not present; Yes = present	No = not present; Yes = present	No = not present; Yes = present	No = not present; Yes = present
Site	Energy NW - Hanford	No	No	No	No	No	No	No
	TVA - Clinch River	No	No	No	No	No	No	No
	East TN Tech Park	No	No	No	No	No	No	No
	INL -ATR	No	No	No	No	No	No	No
	INL - CITRC	No	No	No	No	No	No	No
	INL - MFC	No	No	No	No	No	No	No
	SRNL	No	No	No	No	No	No	No
	NNSS	No	No	No	No	No	No	No
	DOD-ELM	Yes	Yes	No	No	No	No	No
	Portsmouth	No	No	No	Yes	No	No	No
	UIUC Search Area	No	No	No	No	No	No	No
	UIUC Abbott Plant	No	No	No	No	No	No	No
	Eagle Rock	No	No	No	No	No	No	No

4.2 Example Preference Model Results

Following the process described in Section 2.4, a comparative assessment was completed for the thirteen Phase I site options. The example of preference model results described below are based on the four hypothetical advanced reactor developers and their preference profiles described in Section 2.4.5. It was assumed that developer A is interested in demonstrating an advanced reactor design (Small Modular Reactor (SMR) scale) that requires a natural cooling water source and would ultimately be licensed to sell electricity generated to the grid (Case A). This is considered the "base case" or Case A since it incorporates all factors considered in the preference model. Developer B is assumed to have a demonstration reactor design that is air-cooled and transportable over roads (small-to-microreactor scale), and a business model that includes the intent to sell electricity to a microgrid (Case B). Developer C is assumed to be an advanced microreactor developer who is not concerned with the proximity of the demonstration site to population centers, airports, and other geographic features typically of concern to larger reactor developments (Case C). Developer D provides an example of someone who is concerned only with socioeconomic attributes that may affect or be affected by the demonstration and the demonstration site's proximity to a nuclear R&D institution (Case D).

Combining the performance measure values in Table 4-1 through Table 4-3 with the value functions (see Appendix C for detail) and priority weights (Figure 2-7) for each alternative demonstration site and developer perspective in accordance with Equation 2-1, results in the relative preference for each site illustrated in Figure 4-1. The figure shows the contribution to total composite value from the site performance measures associated with each primary objective. The total shown at the top of each stacked bar is the composite value for the indicated site and developer perspective. Note that the overall totals for Case D evaluations are noticeably lower than that of evaluations for the other cases. This is because Case D considers fewer attributes than the other cases.

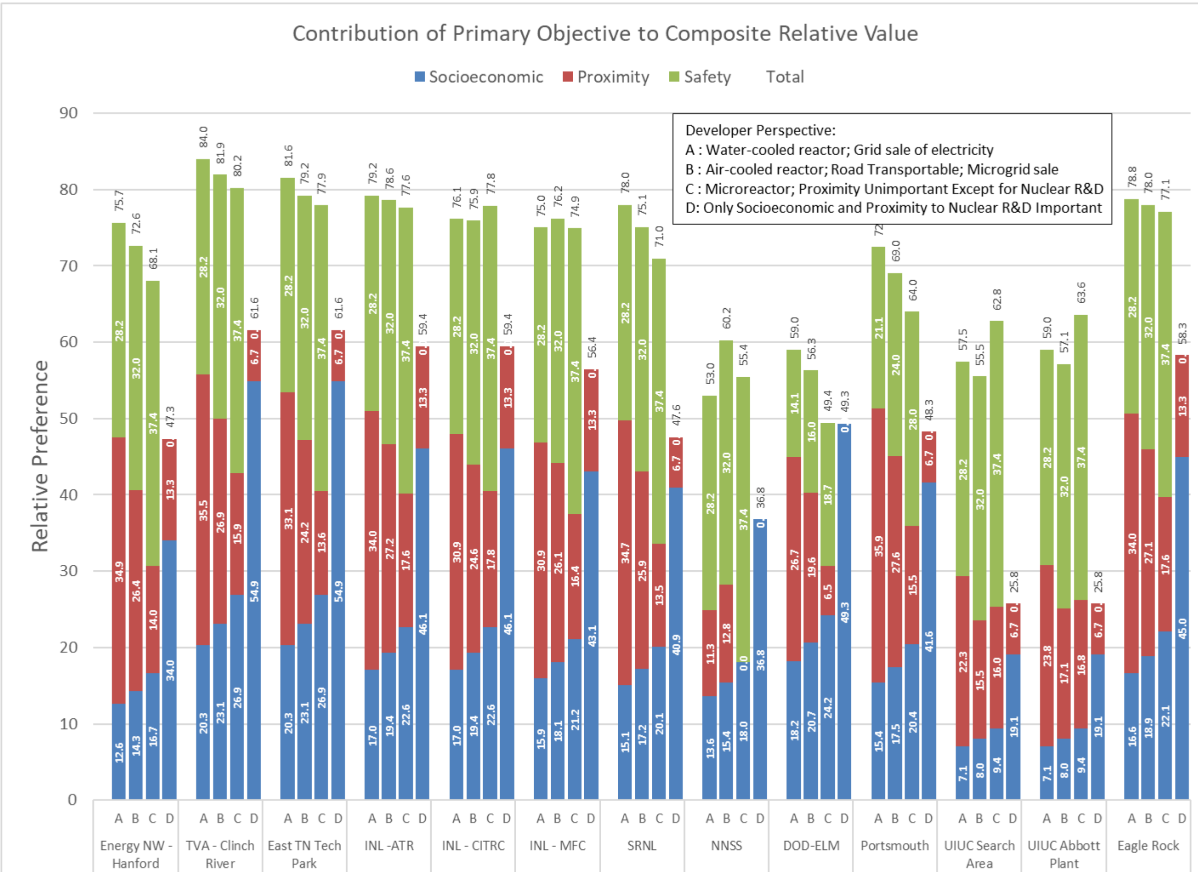


Figure 4-1: Example of Composite Relative Value for Potential Advanced Reactor Demonstration Sites and Four Technology Developer Perspectives

Appendix C provides a table that details each step of the method and calculations used to arrive at these relative preference values.

As discussed above, the results shown in Figure 4-1 are only notional and reflect the attribute weights assessment of the study team. Advanced reactor developers may have widely varying assessments of measure relevance or ranges significance which would impact relative preference rankings for the same scenarios. As an example, if the "measure relevance" rankings assumed in the base case scenario (Case A in Figure 4-1) are retained but weighting factors (see Table C-2) are allowed to vary randomly by $\pm$25%, the potential variation in final preference value for each site can be seen in the Figure 4-2 box plot.

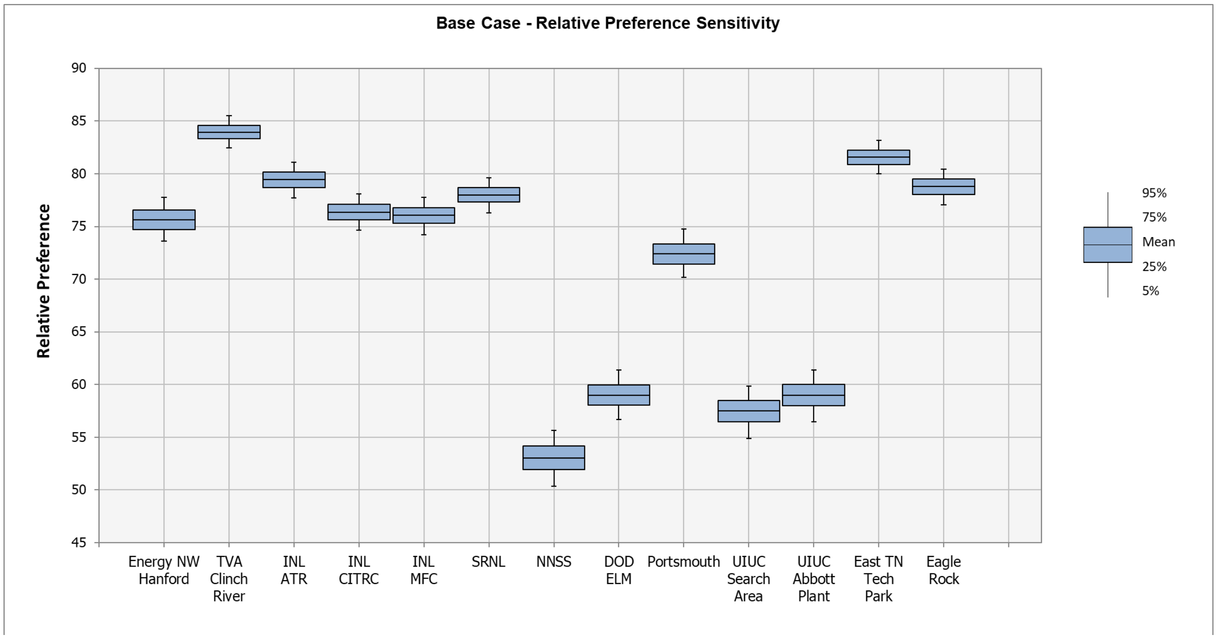


Figure 4-2: Representation of potential preference variation for site alternatives for the base case (Case A) when considering variations in attribute weight assignments

Figure 4-2 helps demonstrate a potential bounding of the alternatives considered in Phase I when considering weights used in the base case. The sites differentiate into two fairly definitive groups – those with relative preference rating above 70 and those below 60. The first group includes the Energy Northwest Hanford site, the Clinch River site which has already been evaluated to include an Early Site Permit, the three INL sites, the Savannah River National Laboratory H2 site, Portsmouth, The East Tennessee Technology Park, and the Eagle Rock site in Idaho.

The second group included four lower-preference sites based on the developer's objectives and preferences assumed for Case A. They are the NNSS site, Joint Base Elmendorf-Richardson, and the two sites near UIUC. This group may require additional screening and analysis if they were to be considered for the objectives assumed in Case A.

To further investigate the viability for microreactor development at all of the sites, an alternate Case D (Case D-alt) was constructed to explore the option of a microreactor design that intends to generate process heat for use instead of generating electricity. Case D-alt is identical to Case D except that three socioeconomic attributes related to electricity price and import/export are excluded from the assessment. The attributes excluded are:

- Electric Energy Price
- Net Electricity Imports, and
- Electric Energy Flow Trend Slope

Only the remaining socioeconomic attributes and proximity to nuclear R&D were considered:

- 1.04 Energy Policy Supports Nuclear
- 1.05 Favorable Nuclear Sentiment
- 1.06 CDC Social Vulnerability Index

- 1.07 Construction Labor Rate Index, and
- 2.10 Proximity to Nuclear R&D

Case D-alt was constructed by setting the raw weighting factors in Case D for the electricity-related attributes to zero and recalculating normalized priority weights for the remaining attributes in proportion to their (Case D) raw weight. The final normalized weights summed to 100.

Figure 4-3 compares Case D-alt to the original Case D. This chart plots an index which is the ratio of the preference value of a particular site to that of the highest preference site in each case. For example, in the original Case D, the TVA Clinch River and ETTP sites have the highest preference values, so here have a value of 1.00. The first site on the chart, the Energy Northwest Hanford site has a preference value in Case D that is 77% of the TVA Clinch River and ETTP values, so is shown as 0.77 on the chart. Likewise, for Case D-alt in which the INL-ATR, INL-CITRC, and Eagle Rock sites have the highest preference value and are shown with an index value of 1.00. The Case D-alt site preference values are shown indexed relative to these values.

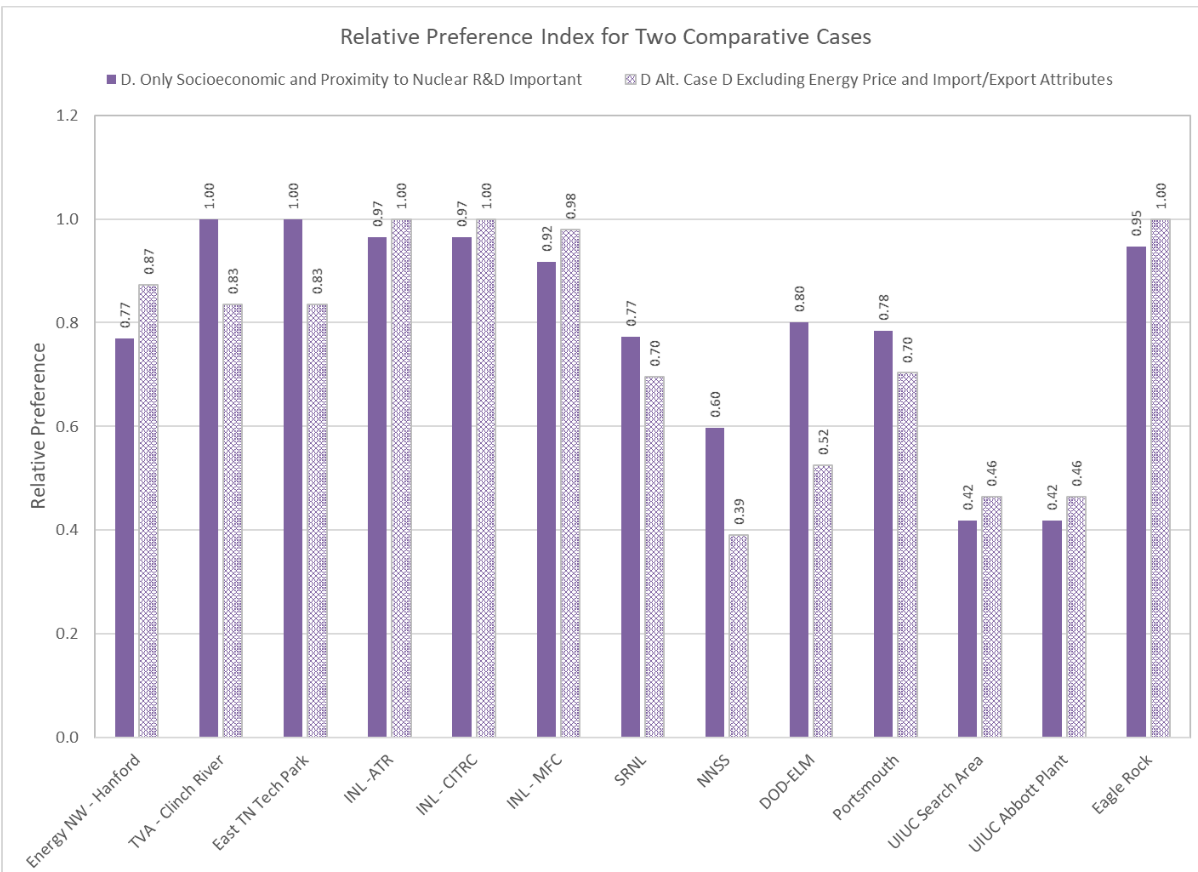


Figure 4-3: Relative preference index for Case D and Case D-alt

From the chart one can see the growth or slippage in relative preference value from one case to the other. This is measured by the difference in height of a site's bars from one case to the other. Noticeable drops in value include the NNSS and DOD-ELM sites.

Figure 4-3 also makes clear each site's relative position among the other sites in each case – the height of the bar relative to other sites in the same case. The elimination of electricity-related attributes has some marginal effect on relative preference value, both up and down, across the sites. But, in general, the rank of each site does not change much. Those that ranked high in Case D generally rank high in Case D-alt. Those that rank low in Case D also rank low in Case D-alt. Even the DOD-ELM, which has a large difference between the cases, still ranks 8th from the top in both cases. Those that rank near the bottom of the sites in one or both cases are characterized by having (1) low energy policy support or low nuclear sentiment favorability, or both; (2) a moderate to high construction labor rate index; and (3) a moderate to low proximity to nuclear R&D.

5 Discussion and Recommendations

5.1 Summary assessment of Phase I Sites

As indicated in Section 2 and Section 4, assessment of possible demonstration sites requires evaluation across a broad number of objectives and attributes. In this analysis, technical screening criteria required by the NRC and recommended by the EPRI have been incorporated. Also included are factors that may be important to a developer should their business case include the potential for long-term operation of the facility and sale of either electricity or process heat in a market environment. The four scenarios (referred to here as “A”, “B”, “C”, and “D”) included in the results section are meant to be examples only. They are meant to demonstrate a process and tools that may be used to help stakeholders evaluate options for demonstration reactor siting. Summary rankings for each site for each scenario are provided in Table 5-1 through Table 5-3 along with rankings for each site for each of the performance measure categories (socioeconomic, proximity, and safety). Table 5-1 also provides a listing of technical challenges identified for the sites.

Six sites meet all criteria used in the initial screening model runs for OR-SAGE. The other seven sites would require some additional review to determine if mitigation is possible (or necessary). For example, the site that ranked third overall for scenario A in relative preference – INL ATR – did not meet model screening criteria for cooling water. As noted in Section 4, this may not ultimately impact the readiness of that site if alternative cooling resources are available or an air-cooled design is postulated. Specific details of technical challenges for each site are noted in Section 3 and Section 6 including demographic information that can be utilized in assessments of marginalized populations and other factors such as anti-nuclear organizations that are operating in the area of these sites. In no case is any location “ruled out” for possible use as a demonstration site. The relative ranking could certainly change for these sites should a developer value attributes differently. Details of air quality and extreme weather for each region are provided in Appendices D and E, respectively.

Table 5-1: Summary assessment for potential demonstration reactor sites for Case A

Site	Summary Rank (Case A)	Socioeconomic Rank	Proximity Rank	Safety Rank	Technical Challenges
TVA – Clinch River	1	1	2	1	n/a
East TN Tech Park	2	1	7	1	n/a
INL – ATR	3	4	5	1	Cooling Water
Eagle Rock	4	6	5	1	n/a
SRNL	5	9	4	1	n/a
INL – CITRC	6	4	8	1	Cooling Water
Energy NW - Hanford	7	11	3	1	n/a
INL – MFC	8	7	8	1	n/a
Portsmouth	9	8	1	12	Landslide
DOD - ELM	10	3	10	13	Cooling Water, Ground Acceleration, Proximity to Faults
UIUC Abbott Plant	10	12	11	1	Cooling Water, Proximity to Airport & Population
UIUC Search Area	12	12	12	1	Cooling Water, Proximity to Airport & Population
NNSS	13	10	13	1	Cooling Water

Table 5-2: Summary assessment for potential demonstration reactor sites for Case B

Site	Summary Rank (Case B)	Socioeconomic Rank	Proximity Rank	Safety Rank
TVA – Clinch River	1	1	4	1
East TN Tech Park	2	1	9	1
INL – ATR	3	4	2	1
Eagle Rock	4	6	3	1
INL – MFC	5	7	6	1
INL – CITRC	6	4	8	1
SRNL	7	9	7	1
Energy NW - Hanford	8	11	5	1
Portsmouth	9	8	1	12
NNSS	10	10	13	1
UIUC Abbott Plant	11	12	11	1
DOD - ELM	12	3	10	13
UIUC Search Area	13	12	12	1

Table 5-3: Summary assessment for potential demonstration reactor sites for Case C

Site	Summary Rank (Case C)	Socioeconomic Rank	Proximity Rank	Safety Rank
TVA – Clinch River	1	1	7	1
East TN Tech Park	2	1	10	1
INL – CITRC	3	4	1	1
INL – ATR	4	4	2	1
Eagle Rock	5	6	2	1
INL – MFC	6	7	5	1
SRNL	7	9	11	1
Energy NW - Hanford	8	11	9	1
Portsmouth	9	8	8	12
UIUC Abbott Plant	10	12	4	1
UIUC Search Area	11	12	6	1
NNSS	12	10	13	1
DOD - ELM	13	3	12	13

Table 5-4: Summary assessment for potential demonstration reactor sites for Case D

Site	Summary Rank (Case D)	Socioeconomic Rank	Proximity Rank
TVA – Clinch River	1	1	6
East TN Tech Park	1	1	6
INL – ATR	3	4	1
INL – CITRC	3	4	1
Eagle Rock	5	6	1
INL – MFC	6	7	1
DOD - ELM	7	3	12
Portsmouth	8	8	6
SRNL	9	9	6
Energy NW - Hanford	10	11	1
NNSS	11	10	12
UIUC Abbott Plant	12	12	6
UIUC Search Area	12	12	6

5.2 Observations

Overall observations based on the preliminary assessment are as follows:

- For each scenario, multiple sites emerge as good candidates based on the parameters considered while others have challenges that would require further investigation.
- Sites such as TVA-Clinch River, ETTP, the three INL sites, Eagle Rock ID, SRNL, and Energy Northwest-Hanford scored well overall. Most of these sites have hosted nuclear

facilities in the past, are reasonably well characterized with few apparent technical challenges, and are located in close proximity to support infrastructure that may help ensure success in advanced reactor demonstration.

- Further assessment of cooling water availability should be completed for INL-ATR and INL-CITRC given that both sites did not meet the Phase I threshold criterion used in the OR-SAGE model for cooling water availability.
- An additional assessment of socioeconomic factors, specifically the high social vulnerability and labor costs would be advisable for siting considerations at the Energy Northwest – Hanford location.
- If Portsmouth, OH is considered for siting, additional review would be necessary to further characterize landslide risk noted in the OR-SAGE screening.
- The NNSS location is primarily impacted (from a technical perspective) by cooling water availability, which may not be a constraining factor. It may be a viable option for an air-cooled demonstration design where there is no intent to eventually license for sale of electricity. However, the location also has one of the lowest ratings for public acceptability and may pose challenges for development of a larger design with a long-term business model that envisions grid tie-in due to its remote location.
- The two UIUC sites have challenges related to proximity (distance to airport, population centers, and cooling water) which may be less of a concern for a microreactor design. However, the site also scored low due to the current moratorium for building new nuclear facilities in the state of Illinois and other factors related to the electricity market. If a demonstration reactor intended to generate heat for uses other than electricity generation, some of these challenges could be removed.
- If further consideration of siting at Joint Base Elmendorf-Richardson is deemed desirable, a re-assessment of the site central location to mitigate technical challenges noted in this analysis is recommended. Results show that the site has technical challenges that are safety related (ground acceleration and proximity to faults).

Future Analysis Recommendations:

- If future analyses are performed, NRIC and the evaluation team should evaluate the screening criteria used in Phase I to ensure it is reasonable for likely ARDP participants.
- Given that time limitations did not allow full consideration in Phase I, future analyses should include a determination of whether to include weather, climate, and air quality factors into the multi-attribute assessment tool.
- A screening survey for use by developers should be developed that will help select the attribute weights for use in future modeling.

6 Site Summaries

In addition to the ATR site summarized in Section 3 of the report, nine additional sites were evaluated in the Phase I site quick-look assessment of a limited number of known siting alternatives. The site summaries are presented below.

6.1 Joint Base Elmendorf-Richardson

6.1.1 Site Description

Joint Base Elmendorf-Richardson (hereafter referred to as Elmendorf), is a joint military installation located adjacent to the city of Anchorage, Alaska. At over 13K acres, it is the largest Air Force installation in Alaska and home of the Headquarters, Alaskan Command, Alaskan NORAD Region, Eleventh Air Force (11th AF) and the 3rd Wing. Base realignment in 2005 led to consolidation of Elmendorf AFB with U.S. Army Garrison Fort Richardson. The general site location for analysis is shown at Figure 6-1, and Figure 6-2 indicates the overall boundaries of the Joint Base [25]. Additional details related to the site and contact information may be found at https://www.jber.jb.mil/. Appendix Section D.1 lists the counties that surround the site and their populations.

Figure 6-1: Joint Base Elmendorf-Richardson site (Elmendorf). Central point for model analysis of siting attributes is shown at the pin drop in the upper left.

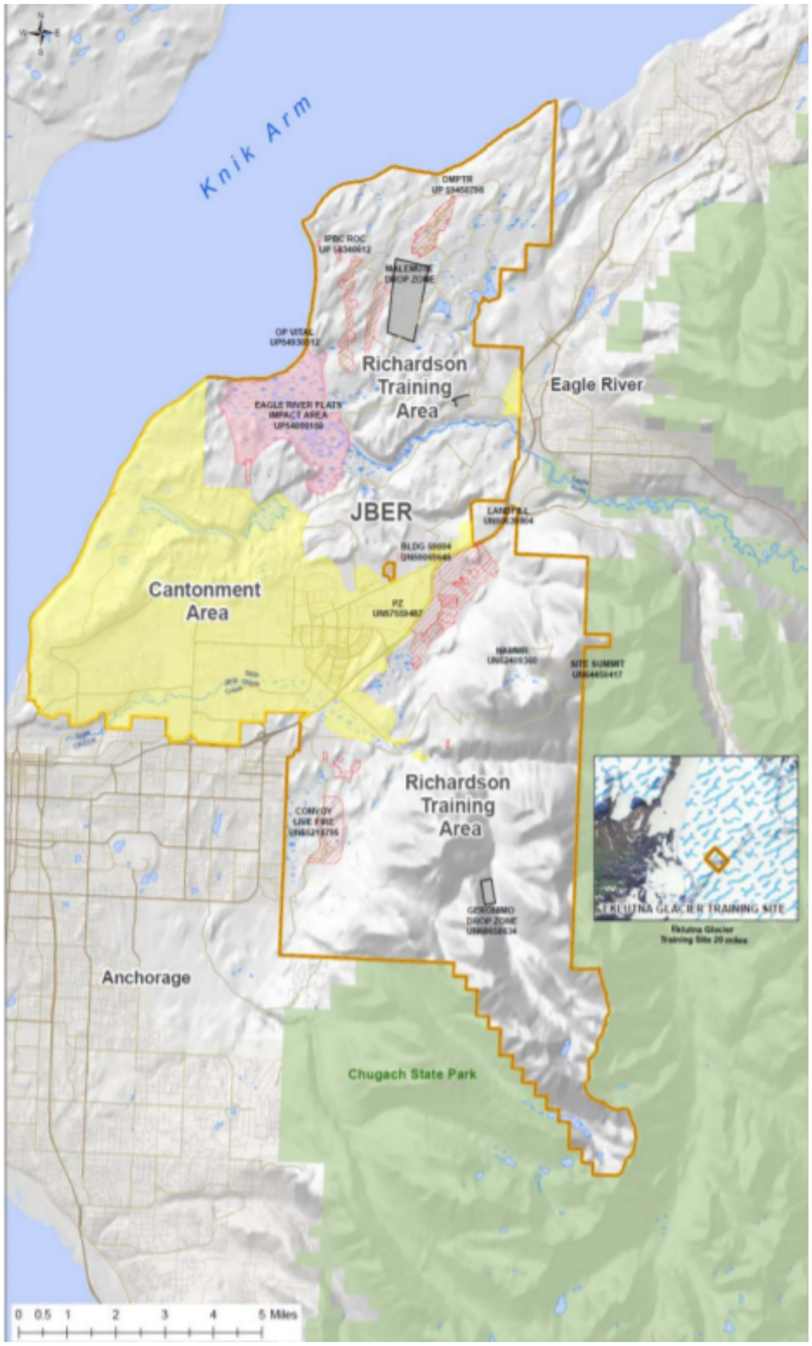


Figure 6-2: Boundary representation for Joint Base Elmendorf-Richardson

6.1.2 OR-SAGE Results and detailed data

The OR-SAGE model for Alaska is more limited than the OR-SAGE model for the contiguous US. As noted in Table 3-1, only nine of the OR-SAGE parameters are available for Alaska and the closest available pre-calculated streamflow makeup value is 20,000 gpm. In addition, the military base hazard layer is turned off for this site. Each of the 9 nuclear siting parameters were applied to a representative Elmendorf site situated approximately 4 miles north of the main base runways as shown in the Google Earth map in Figure 6-2. The hypothesized site was selected to minimize any population concerns. The results for each individual layer are shown in Figure 6-3, Figure 6-4, and Figure 6-5. Cells that do not meet the query threshold criterion are depicted in magenta; otherwise, cells that meet the threshold criterion are clear.

Figure 6-3: Elmendorf OR-SAGE results for population density, slope, 100-year floodplain, protected lands, and proximity to hazards indicate no query threshold issues.

Five of the OR-SAGE parameters completely meet the threshold query value in the vicinity of the Elmendorf site and are depicted clear as shown in Figure 6-3. The OR-SAGE layer for wetlands and open water identified some marshy areas around the central site location as shown by the magenta markings in Figure 6-4. This does not represent an issue for the central area of interest.

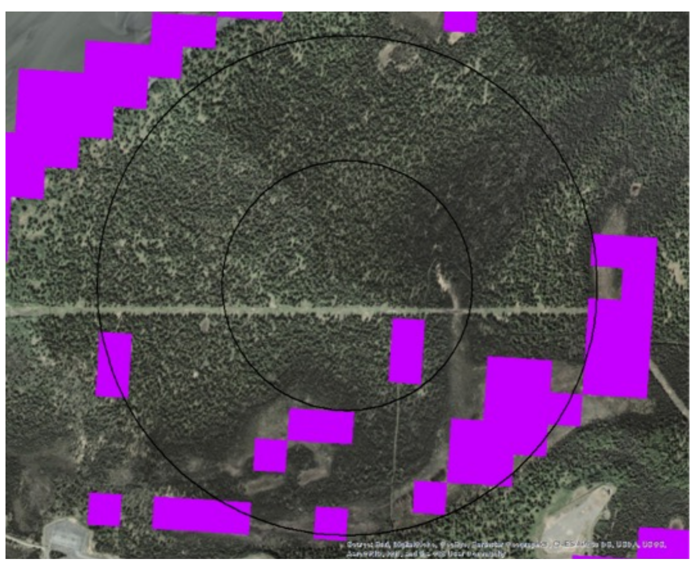


Figure 6-4: The Elmendorf OR-SAGE results for wetlands and open water issues indicates the shoreline and marshy areas around the selected site.

Figure 6-5: The Elmendorf OR-SAGE results associated with safe shutdown earthquake, faults, and streamflow indicates that the threshold query value is not met for the site.

The OR-SAGE layer for faults, safe shutdown earthquake, and streamflow does not meet the threshold value anywhere in the immediate vicinity of the Elmendorf site as shown by the magenta coloring over most of the map shown in Figure 6-5. This should not be evaluated as a disqualifying feature for the site. The lack of water is a map edge-effect combined with a preference for freshwater cooling. There is ample saltwater makeup just west of the site. Alaska as a whole, is not favorable with respect to proximity to fault lines and safe shutdown earthquake threshold values. However, these parameters would require additional site-specific evaluations and may become less important if compact advanced reactor designs with less piping and fewer safety systems are proposed at this location.

The composite map for the Elmendorf site is shown in Figure 6-6. It is easy to see the impact of the area geology and the streamflow layer in the figure. Without the water concern based on the OR-SAGE query, most of the composite map would be orange. Further seismic evaluations relative to the selected technology to be demonstrated could ultimately turn the composite map green.

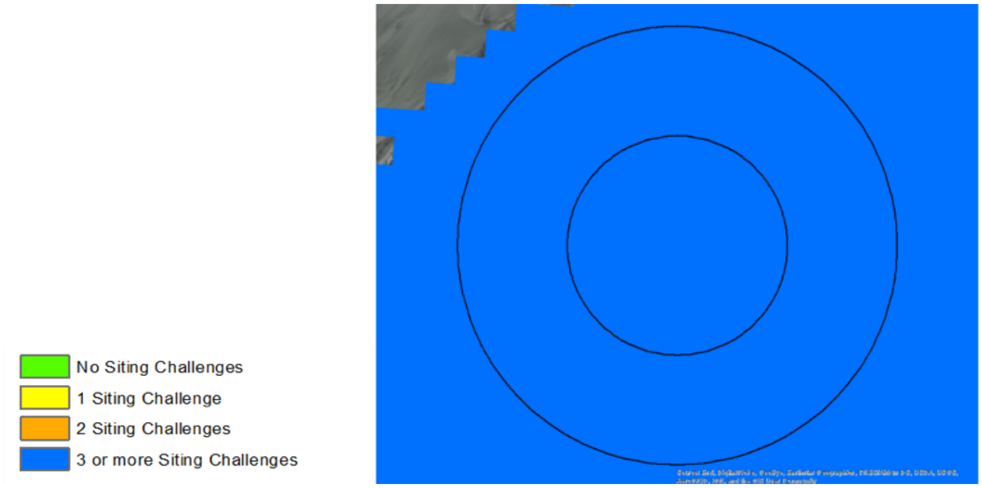


Figure 6-6: Composite OR-SAGE results for the Elmendorf site showing locations with siting challenges.

The map in Figure 6-7 shows the aggregate 50-acre tracts at a 90% aggregation rate (90% of the individual cells in the group must pass all the query threshold value criteria). Aggregated cells that meet the threshold values are shown in green; otherwise the cells are shown as clear. No 50-acre aggregated sites in the vicinity of the Elmendorf site met all the query threshold value because of the geological issues discussed previously. This result can be mitigated with the selection of technology and further localized geologic site evaluations.

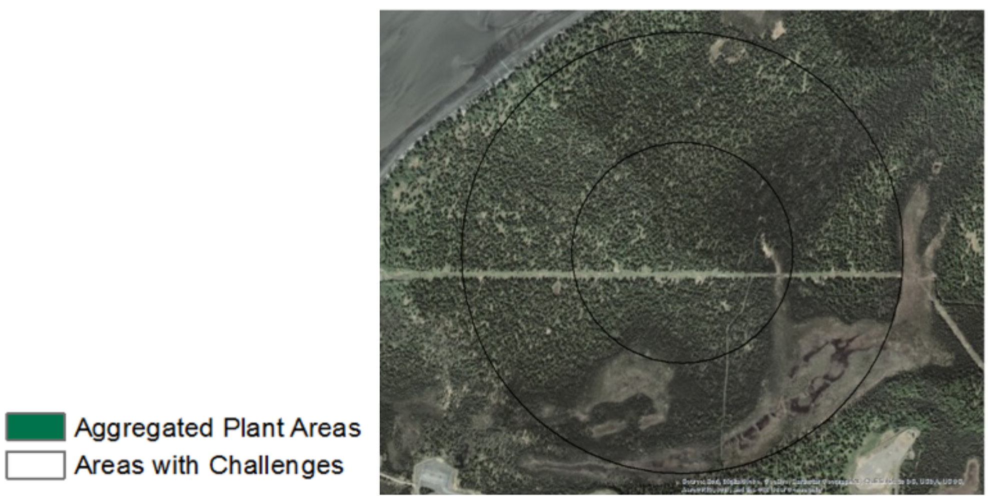


Figure 6-7: Aggregate map for the Elmendorf site.

Table 6-1 provides several relative distance parameters that may weigh on the decision to site a demonstration reactor at Elmendorf.

Table 6-1: Distance from the Elmendorf site to various parameters of interest.

Parameter	Identification	Distance (miles)
Population Center (≥ 25,000 residents)	Anchorage	14.4
Airport	Ted Stevens Anchorage *Elmendorf AFB*	24.4 *4*
Major Road	State Road 1	12.1
Rail Transport	Alaska Railroad	5.7
Navigable waterway	Cook Inlet	13.1
Cooling water (≥ 20,000 gpm makeup)	Matanuska River (freshwater)	43.7
Grid Capacity	Anchorage Municipal Light & Power	0.1
Oil Refineries	Tesoro Alaska	141.7

6.1.3 "Janet" results

Each of the quantitative and qualitative factors, as described in Section 2.3, were applied to the Elmendorf AFB site. As noted in Section 2, data for the Favorable Nuclear Sentiment value at the DOD-ELM site were not available. This value is an estimate. There are no pro or anti-nuclear organizations within 100 miles that are within the same state as the Elmendorf site.

Table 6-2 provides quantitative and qualitative parameter values that are included in the model for the Elmendorf site.

Table 6-2: "Janet" model attributes for the Elmendorf site.

"Janet" Model Attribute	Units	Elmendorf Value
Electric Energy Price	cents / kWh (all Sectors)	20.46
Total Net Imports	million kWh / yr	1
Electric Energy Flow Trend Slope	million kWh/yr / yr	0
Favorable State Energy Policy	Negative, Neutral, or Positive	Neutral
Nuclear Sentiment % Favorable*	% of Favorability Toward Nuclear	33.0
CDC Social Vulnerability Index	Social Vulnerability Index (x 100)	42
Proximity to Nuclear R&D	Number of Locations within 100 mi	0

*Data for the Favorable Nuclear Sentiment value at the Elmendorf site was not available. The value for this indicator is estimated from initial survey results.

Table 6-3 provides demographic data for the Elmendorf site that can be utilized in an assessment to identify marginalized populations in the surrounding area.

Table 6-3: Demographic overview of the area near the Elmendorf site.

Elmendorf	**Parameter**	**% White**	**% Black or African American**	**% Asian**	**% Native Hawaiian or Other Pacific Islander**	**% Some Other Race**	**% AIAN***
	Value	70.18	3.87	6.66	1.55	1.71	7.17
	Parameter	**% Two or More Races**	**% Minority**	**Per Capita Income ($)**	**% Unemployed**	**% No High School Diploma**	**% Below Poverty**
	Value	8.87	33.87	37091.75	6.76	6.59	9.77

*AIAN is an abbreviation for American Indian and Alaskan Native.
Source: American Community Survey (ACS) 2014-2018, 5-year estimates.

6.1.4 Assessment

Proximity and Safety Assessment: Only nine of the siting attributes could be evaluated for this site and four of them exceeded thresholds (wetlands and open water, safe shutdown, proximity to faults, and available streamflow) at some locations within the site boundaries. These factors do not eliminate the site from consideration but would require additional evaluation if the site was selected. The lack of available streamflow could be mitigated by using seawater as the source of cooling water. Finally, there are no major nuclear R&D facilities in close proximity to the site.

Socioeconomic Assessment: Alaska's energy policy towards nuclear energy is neutral and favorable sentiment for nuclear was assessed as 33 percent. The population-weighted social vulnerability index for the counties surrounding the proposed site was assessed as "Medium Vulnerability" to natural disasters and disruptive events. The labor rates were high in all of the labor categories, with Alaska being the second highest in the construction categories and highest for security guards. There were no data for Alaska regarding nuclear engineer salaries.

Other Factors: There are no air quality issues at the site. Analysis of extreme weather conditions for the region show an increase in temperatures which could result in reductions in the efficiency of cooling water and an increase in the requirements for installation HVAC systems.

6.2 Energy Northwest (Hanford Site)

6.2.1 Site Description

The Energy Northwest – Hanford site considered in the analysis is located near the Columbia Generating Station, a ~560 square mile reservation in Benton County, Washington, approximately 12 miles north of the City of Richland, WA. Per the original site permit application for the generating station, the site has served as a nuclear industrial center since 1943 when it was selected by the federal government as the location for construction of one of the world's first nuclear production reactors. Since 1943 nine plutonium production reactors and a number of test reactors have been constructed and operated at the Hanford Reservation. Full details of the site may be available through Energy Northwest [26]. Appendix Section D.2 lists the counties that surround the site and their populations.

Figure 6-8: Energy Northwest - Hanford site (Hanford). Central point for model analysis of siting attributes is shown at the pin drop near the center of the image.

6.2.2 OR-SAGE Results and detailed data

Each of the 10 nuclear siting parameters were applied to an Energy Northwest site southeast of the older Washington Nuclear Project structures as shown in the Google Earth map in Figure 6-8. The results for each individual layer are shown in Figure 6-9, Figure 6-10, and Figure 6-11. Cells that do not meet the query threshold criterion are depicted in magenta; otherwise, cells that meet the threshold criterion are clear.

Figure 6-9: Energy Northwest OR-SAGE results for population density, safe shutdown earthquake, slope, streamflow, 100-year floodplain, protected lands, and proximity to hazards and indicate no query threshold issues.

Seven of the OR-SAGE parameters completely meet the threshold query value in the vicinity of the Energy Northwest site and are depicted clear as shown in Figure 6-9. The OR-SAGE results for landslide hazard and wetlands and open water identified some limited impacts as shown by the magenta markings in Figure 6-10. These thresholds are well outside the central area of interest.

Figure 6-10: The Energy Northwest OR-SAGE results for landslides (left) and wetlands and open water (right) indicates limited site impact beyond the 1-mile site radius.

Figure 6-11: The Energy Northwest OR-SAGE results associated with faults indicates that the threshold query value is not met in the northwest area of the site.

The OR-SAGE parameter for faults exceeds the threshold value northwest of the site as shown in Figure 6-11. Further geologic evaluation would likely show this to not be an area issue because the Columbia Generating Station would have evaluated this as part of an environmental site permit.

The composite results for the Energy Northwest site is shown in Figure 6-12. Most of the area of interest meets all threshold values.

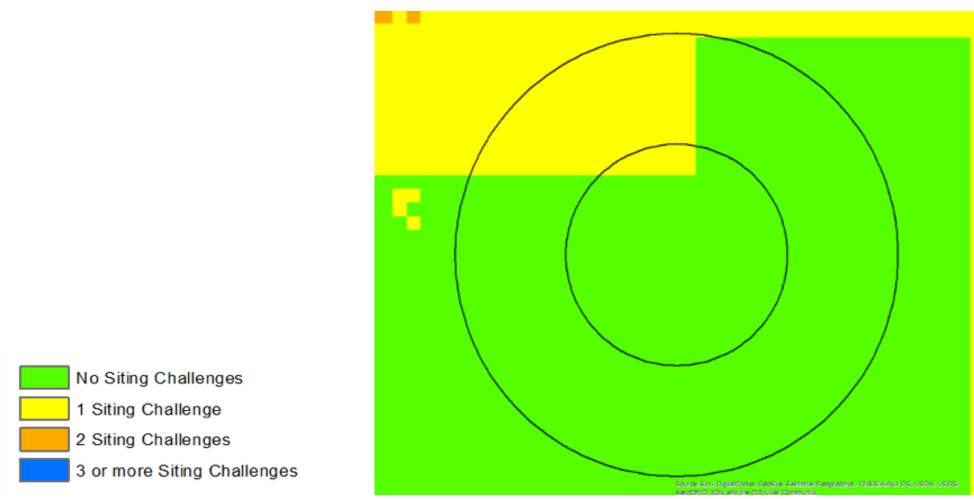


Figure 6-12: Composite OR-SAGE results for the Energy Northwest site showing locations with siting challenges.

The map in Figure 6-13 shows the aggregate 50-acre tracts at a 90% aggregation rate. Aggregated cells that meet the threshold values are shown in green; otherwise the cells are shown as clear. Most of the area around the Energy Northwest site meet all the query threshold value. With further evaluation of the geologic pedigree for the area, it is likely that all of the map could be aggregated in 50-acre parcels to meet the threshold values for the static OR-SAGE query.

Figure 6-13: Aggregate map for the Energy Northwest site.

Table 6-4 provides several relative distance parameters that may weigh on the decision to site a demonstration reactor at Energy Northwest.

Table 6-4: Distance from the Energy Northwest site to various parameters of interest.

Parameter	Identification	Distance (miles)
Population Center (≥ 25,000 residents)	Richland	18.1
Airport	Richland	15.8
Major Road	State Road 240	11.1
Rail Transport	Tri-City Railroad	0.6
Navigable waterway	Columbia River	3.3
Cooling water (≥ 30,000 gpm makeup)	Columbia River	3.3
Grid Capacity	Bonneville Power Administration	0.5
Oil Refineries	US Oil	228.0

6.2.3 "Janet" results

Each of the quantitative and qualitative factors, as described in Section 2.3, were applied to the Energy Northwest site. Table 6-5 provides parameter values that are included in the model for the Energy Northwest site.

Table 6-5: "Janet" model attributes for the Energy Northwest site.

"Janet" Model Attribute	Units	Energy Northwest Value
Electric Energy Price	cents / kWh (all Sectors)	8.05
Total Net Imports	million kWh / yr	-20625
Electric Energy Flow Trend Slope	million kWh/yr / yr	-1174
Favorable State Energy Policy	Negative, Neutral, or Positive	Positive
Nuclear Sentiment % Favorable	% of Favorability Toward Nuclear	60.4
CDC Social Vulnerability Index	Social Vulnerability Index (x 100)	78
Proximity to Nuclear R&D	Number of Locations within 100 mi	1

Table 6-6 provides demographic data for the Energy Northwest site that can be utilized in an assessment to identify marginalized populations in the surrounding area. A list of known pro- and anti-nuclear groups relevant to the site is provided in Table B-6.

Table 6-6: Demographic overview of the area near the Energy Northwest site.

Energy Northwest	**Parameter**	**% White**	**% Black or African American**	**% Asian**	**% Native Hawaiian or Other Pacific Islander**	**% Some Other Race**	**% AIAN***
	Value	78.86	1.32	1.54	12.14	1.71	2.2
	Parameter	**% Two or More Races**	**% Minority**	**Per Capita Income ($)**	**% Unemployed**	**% No High School Diploma**	**% Below Poverty**
	Value	3.84	43.2	25521.78	6.01	19.81	15.69

*AIAN is an abbreviation for American Indian and Alaskan Native.
Source: American Community Survey (ACS) 2014-2018, 5-year estimates.

6.2.4 Assessment

Proximity and Safety Assessment: The majority of the Energy Northwest region (2000 acres) considered had no siting issues, the exception being part of the upper left quadrant which exceeded the proximity to faults threshold in the OR-SAGE analyses. There were, however, multiple potential 50 acres parcels that posed no siting challenges. There is potential for strong support and security infrastructure given the long history of nuclear development at the site and demonstration efforts would be enhanced by proximity to one of the leading nuclear research laboratories in the world (Pacific Northwest National Laboratory).

Socioeconomic Assessment: The state of Washington has a favorable policy towards nuclear and public favorability sentiment towards nuclear was 60 percent. The population-weighted SVI for the surrounding counties was rated as "Highest Vulnerability" to natural disasters and other disruptive events. The labor rates for Washington State were among the highest of all of the states involved in all labor categories.

Other Factors: There are no air quality issues at the site. Analysis of extreme weather conditions for the region show an increase in temperatures which could result in reductions in

the efficiency of cooling water and an increase in the requirements for installation HVAC systems.

6.3 INL – CITRC Area

6.3.1 Site Description

The location of the Critical Infrastructure Test Range Complex (CITRC) on the INL complex is shown in Figure 3-2 and the specific site considered in this assessment is shown in Figure 6-14. INL-CITRC encompasses a collection of specialized test beds and ranges, including the full-scale Electric Power Reliability Test Bed and the Radiological Dispersion Devices Training Ranges and Biotechnology Center. There are also locations utilized for nuclear nonproliferation detection testing and aqueous reprocessing. As with the INL ATR site, there are significant security and support services available at the site. Appendix Section D.3 lists the counties that surround the site and their populations.

Figure 6-14: INL-CITRC Site. Central point for model analysis of siting attributes is shown at the pin drop near the center of the image.

6.3.2 OR-SAGE Results and detailed data

Each of the 10 nuclear siting parameters were applied to a site centered in the vicinity of the INL-CITRC as shown in the Google Earth in Figure 6-14. The results for each individual layer are shown in Figure 6-15 and Figure 6-16. Cells that do not meet the query threshold criterion are depicted in magenta; otherwise, cells that meet the threshold criterion are clear.

Figure 6-15: INL-CITRC OR-SAGE results for all parameters except streamflow that indicate no query threshold issues.

With the exception of the streamflow threshold all the OR-SAGE parameters completely meet the threshold query value in the vicinity of the INL-CITRC area and are depicted clear as shown in Figure 6-15. The OR-SAGE layer for streamflow does not meet the threshold value anywhere in the immediate vicinity of the CITRC site as shown by the magenta coloring of the entire map shown in Figure 6-16. Similar to the ATR area, this should not be evaluated as a disqualifying feature for the CITRC area. There may be alternative water sources available through an INL piping system. In addition, Birch Creek is available within 32 miles of the site, so a decision could be made to pipe fresh water from this source further than the 20 miles associated with the baseline OR-SAGE query. Finally, there may be advanced reactor technologies for demonstration that require little or no make-up cooling water rendering this discriminatory layer moot.

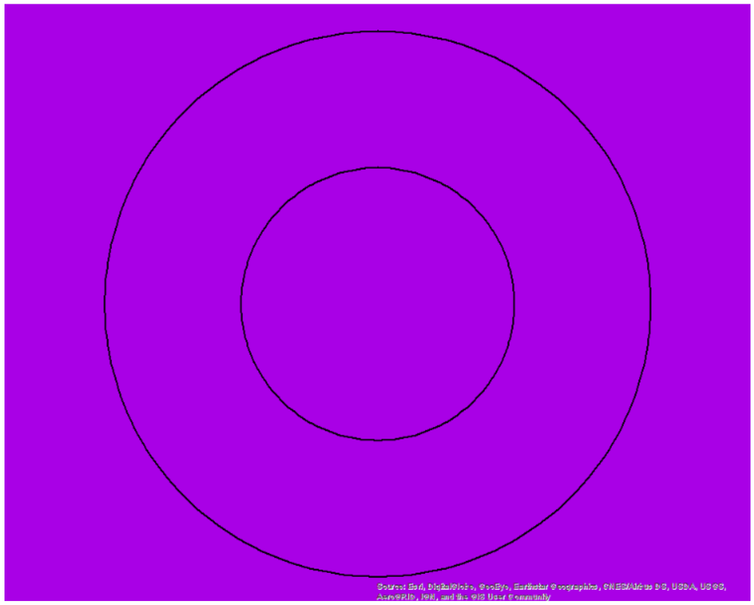


Figure 6-16: The INL-CITRC OR-SAGE results associated with streamflow indicates that the threshold query value is not met for this area.

The composite map for the CITRC site is shown in Figure 6-17. As discussed above, most of the area of interest meets all parameter threshold values. However, it is easy to see the impact of the streamflow layer in the figure. Without the water concern based on the OR-SAGE query, all of the composite map would be green.

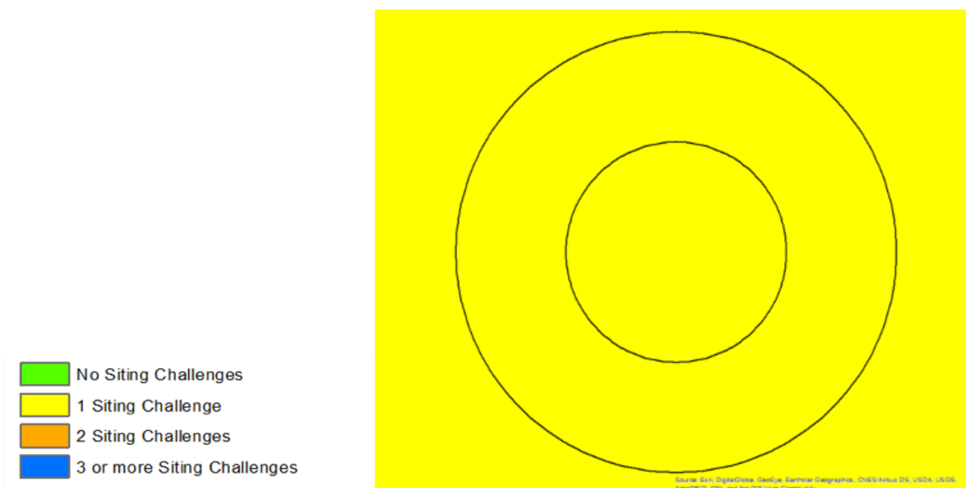


Figure 6-17: Composite OR-SAGE results for the INL-CITRC area showing locations with siting challenges.

Figure 6-18 shows the aggregate 50-acre tracts at a 90% aggregation rate. Aggregated cells that meet the threshold values are shown in green; otherwise the cells are shown as clear. No 50-acre aggregated sites in the vicinity of the CITRC site met all the query threshold value because of the water issue discussed previously. If the water issue were discarded based on technology selection or otherwise resolved, the aggregate map would be green over the entire area shown.

Therefore, with the water issue resolved, any 50-acre tract in the target area of interest would be amenable to siting an advanced reactor demonstration based on the OR-SAGE evaluation.

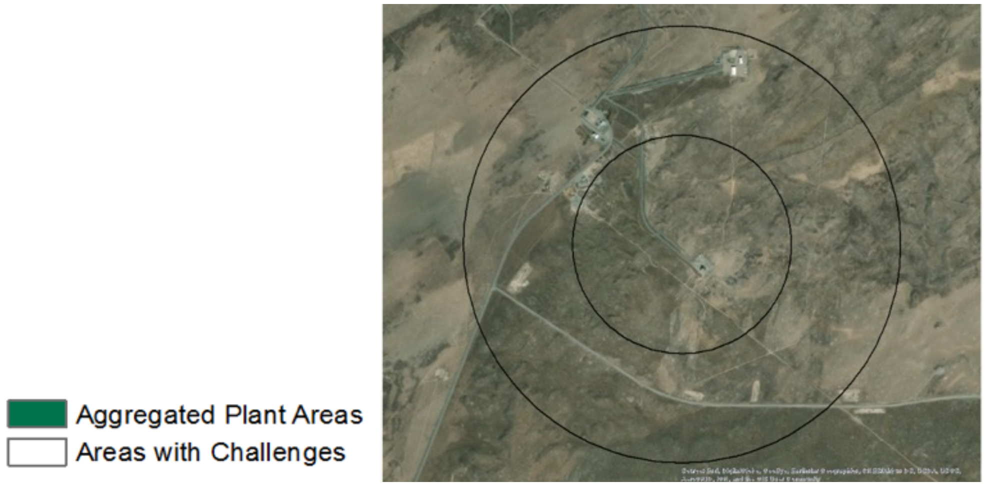


Figure 6-18: Aggregate map for the INL-CITRC area.

Table 6-7 provides several relative distance parameters that may weigh on the decision to site a demonstration reactor in the CITRC area.

Table 6-7: Distance from the INL-CITRC area to various parameters of interest.

Parameter	Identification	Distance (miles)
Population Center (≥ 25,000 residents)	Idaho Falls	57.4
Airport	Midway	10.3
Major Road	US 20	3.6
Rail Transport	US Government	4.7
Navigable waterway	Snake River	398.4
Cooling water (≥ 30,000 gpm makeup)	Birch Creek	31.9
Grid Capacity	PacificCorp	3.8
Oil Refineries	Silver Eagle Refining	256.7

6.3.3 “Janet” results

Each of the quantitative and qualitative factors, as described in Section 2.3, were applied to the INL-CITRC site. Table 6-8 provides parameter values that are included in the model for the INL-CITRC site.

Table 6-8: "Janet" model attributes for the INL-CITRC site.

"Janet" Model Attribute	Units	INL - CITRC Value
Electric Energy Price	cents / kWh (all Sectors)	7.84
Total Net Imports	million kWh / yr	7520
Electric Energy Flow Trend Slope	million kWh/yr / yr	-631
Favorable State Energy Policy	Negative, Neutral, or Positive	Neutral
Nuclear Sentiment % Favorable	% of Favorability Toward Nuclear	71.8
CDC Social Vulnerability Index	Social Vulnerability Index (x 100)	39
Proximity to Nuclear R&D	Number of Locations within 100 mi	2

Table 6-9 provides demographic data for the INL-CITRC site that can be utilized in an assessment to identify marginalized populations in the surrounding area. A list of known pro- and anti-nuclear groups relevant to the site is provided in Table B-6. While there are three sites included for the study that are located at INL, these qualitative factors are typically evaluated at the county or regional level. As a result, the factors reflected in Table 6-8 and Table B-6 cover all three INL sites.

Table 6-9: Demographic overview of the area near the INL sites.

INL	**Parameter**	**% White**	**% Black or African American**	**% Asian**	**% Native Hawaiian or Other Pacific Islander**	**% Some Other Race**	**% AIAN***
	Value	89.1	.44	.99	.13	4.55	2.07
	Parameter	**% Two or More Races**	**% Minority**	**Per Capita Income ($)**	**% Unemployed**	**% No High School Diploma**	**% Below Poverty**
	Value	2.69	18.14	25409.87	4.44	9.63	13.25

*AIAN is an abbreviation for American Indian and Alaskan Native.
Source: American Community Survey (ACS) 2014-2018, 5-year estimates.

6.3.4 Assessment

Proximity and Safety Assessment: The INL-CITRC site is technically well qualified for siting of a demonstration reactor with the exception of possible cooling water limitations. As described above, the site did not meet the screening criteria used in the OR-SAGE Model for Phase I which required access within 20 miles of stream flow in excess of 30,000 gallons/minute. This requirement may be mitigated either through use of alternative water resources or demonstration of technologies with lower cooling demand or that use air cooling. There is strong support and security infrastructure given the long history of nuclear development at the site and demonstration efforts would be enhanced by proximity to one of the leading nuclear research laboratories in the world.

Socioeconomic Assessment: As reflected in Table 6-8Table 3-3, there is comparatively strong support for nuclear development at the INL site and a neutral state policy toward the technology, with recent support reflected in the Utah Associated Municipal Power Systems (UAMPS) decision to develop a new generation of light water reactors (built by NuScale) at the INL Site [24]. This new development may, however, create some market challenges for an advanced reactor developer who would like to follow their demonstration with a long-term license to generate and sell to the grid. It is unclear if electricity demand growth in the region will support additional generating capacity. The population-weighted SVI for the counties surrounding the site was assessed as “Medium Vulnerability” to natural disasters and other disruptive events. The labor rates for the area are at the low end of the sites considered in this analysis.

Other Factors: There are no air quality issues at the site. Analysis of extreme weather conditions for the region show an increase in temperatures which could result in reductions in the efficiency of cooling water and an increase in the requirements for installation HVAC systems. Not evaluated are potential implications of multiple other high-profile nuclear developments that may also be occurring at the INL site to include the Versatile Test Reactor, support for Army Project Pele, and commercial demonstrations by the vendors NuScale and OKLO.

6.4 INL – MFC Area

6.4.1 Site Description

The Materials and Fuels Complex (MFC), located on the INL Site as shown in Figure 3-2, is one of the primary DOE testing centers for advanced technologies associated with nuclear power systems. The specific site considered in this assessment is shown in Figure 6-19. MFC is located 32 miles west of Idaho Falls. As with the ATR and CITRC facilities, INL offers a wide range of support services, with specific details provided in reference [20]. Appendix section D.3 lists the counties that surround the site and their populations.

Figure 6-19: INL-MFC Site. Central point for model analysis of siting attributes is shown at the pin drop near the lower center of the image.

6.4.2 OR-SAGE Results and detailed data

Each of the 10 nuclear siting parameters were applied to a site centered to the west of the INL-MFC area as shown in the Google Earth map in Figure 6-19. The results for each individual layer are shown in Figure 6-20. Cells that do not meet the query threshold criterion are depicted in magenta; otherwise, cells that meet the threshold criterion are clear.

Figure 6-20: INL-MFC OR-SAGE results for all parameters indicate no query threshold issues.

All of the OR-SAGE parameters completely meet the threshold query value in the vicinity of the INL-MFC area and are depicted clear as shown in Figure 6-20.

The composite results for the MFC site is shown in Figure 6-21. Because all the parameter threshold values are met in the baseline query, the map is completely green, indicating no OR-SAGE siting issues for the MFC area.

Likewise, Figure 6-22 shows aggregate 50-acre tracts at a 90% aggregation rate. Aggregated cells that meet the threshold values are shown in green; otherwise the cells are shown as clear. Essentially, there is no need to aggregate the individual cells in this case, because all the cells in the view meet the threshold values from the baseline OR-SAGE query.

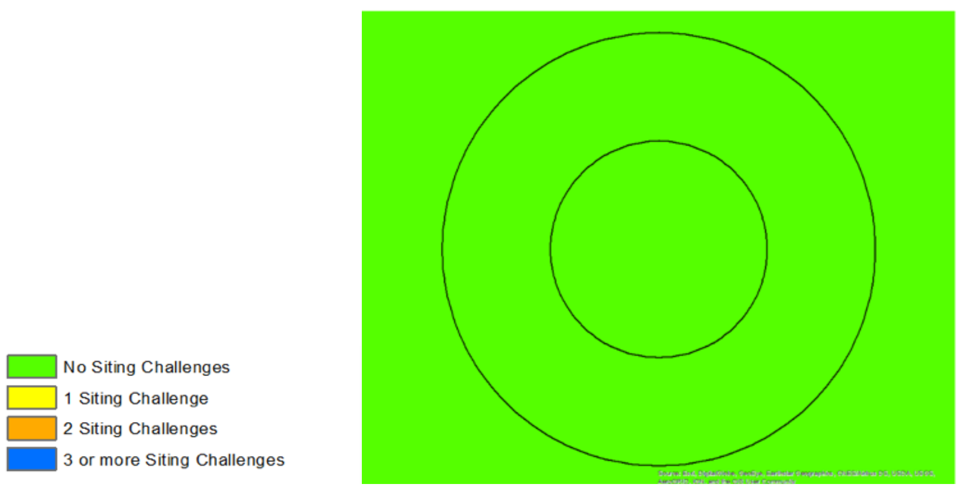


Figure 6-21: Composite OR-SAGE results for the INL-MFC area showing locations with siting challenges.

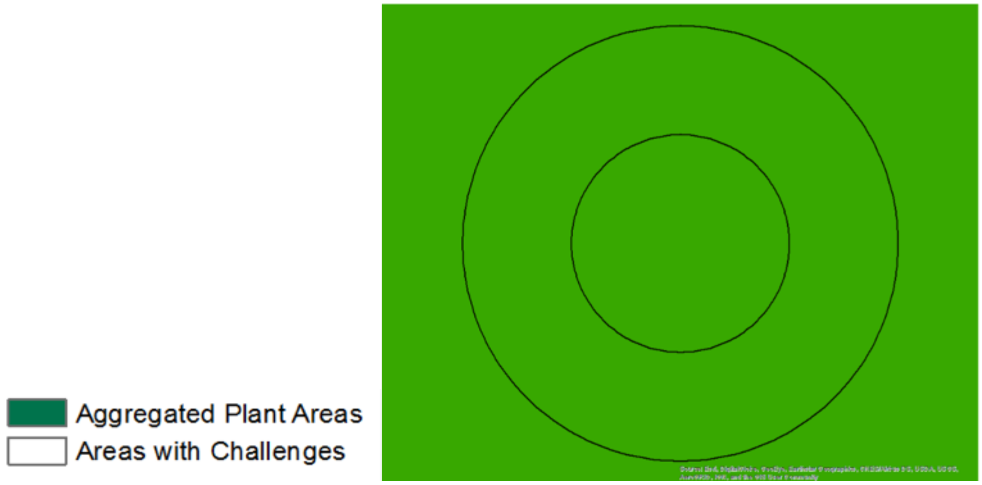


Figure 6-22: Aggregate OR-SAGE results for the INL-MFC area.

Table 6-10 provides several relative distance parameters that may weigh on the decision to site a demonstration reactor in the MFC area.

Table 6-10: Distance from the INL-MFC area to various parameters of interest.

Parameter	**Identification**	**Distance (miles)**
Population Center (≥ 25,000 residents)	Idaho Falls	44.6
Airport	Midway	16.5
Major Road	US 20	4.6
Rail Transport	US Government	17.9
Navigable waterway	Snake River	405.2
Cooling water (≥ 30,000 gpm makeup)	Birch Creek	19.6
Grid Capacity	PacificCorp	12.9
Oil Refineries	Silver Eagle Refining	253.5

6.4.3 "Janet" results

Each of the quantitative and qualitative factors, as described in Section 2.3, were applied to the INL-MFC site. Table 6-11 provides parameter values that are included in the model for the INL-MFC site.

Table 6-11: “Janet” model attributes for the INL-MFC site.

“Janet” Model Attribute	Units	INL - MFC Value
Electric Energy Price	cents / kWh (all Sectors)	7.84
Total Net Imports	million kWh / yr	7520
Electric Energy Flow Trend Slope	million kWh/yr / yr	-631
Favorable State Energy Policy	Negative, Neutral, or Positive	Neutral
Nuclear Sentiment % Favorable	% of Favorability Toward Nuclear	61.0
CDC Social Vulnerability Index	Social Vulnerability Index (x 100)	43
Proximity to Nuclear R&D	Number of Locations within 100 mi	2

Table 6-12 provides demographic data for the INL-MFC site that can be utilized in an assessment to identify marginalized populations in the surrounding area. A list of known pro- and anti-nuclear groups relevant to the site is provided in Table B-6. While there are three sites included for the study that are located at INL, these qualitative factors are typically evaluated at the county or regional level. As a result, the factors reflected in Table 6-12 and Table B-6 cover all three INL sites.

Table 6-12: Demographic overview of the area near the INL sites.

INL	**Parameter**	**% White**	**% Black or African American**	**% Asian**	**% Native Hawaiian or Other Pacific Islander**	**% Some Other Race**	**% AIAN***
	Value	89.1	.44	.99	.13	4.55	2.07
	Parameter	**% Two or More Races**	**% Minority**	**Per Capita Income ($)**	**% Unemployed**	**% No High School Diploma**	**% Below Poverty**
	Value	2.69	18.14	25409.87	4.44	9.63	13.25

*AIAN is an abbreviation for American Indian and Alaskan Native.
Source: American Community Survey (ACS) 2014-2018, 5-year estimates.

6.4.4 Assessment

Proximity and Safety Assessment: The INL-MFC site is technically well qualified for siting of a demonstration reactor and did not exceed any of the thresholds established in the OR-SAGE analysis. There is strong support and security infrastructure given the long history of nuclear development at the site and demonstration efforts would be enhanced by proximity to one of the leading nuclear research laboratories in the world.

Socioeconomic Assessment: As reflected in Table 6-11, there is comparatively strong support for nuclear development at the INL site and a neutral state policy toward the technology, with recent support reflected in the UAMPS decision to develop a new generation of light water reactors (built by NuScale) at the INL Site [24]. This new development may, however, create some market challenges for an advanced reactor developer who would like to follow their demonstration with a long-term license to generate and sell to the grid. It is unclear if electricity demand growth in the region will support additional generating capacity. The population-weighted SVI for the counties surrounding the proposed site was assessed as "Medium Vulnerability" to natural disasters and other disruptive events. The labor rates for the area are at the low end of the sites considered in this analysis.

Other Factors: There are no air quality issues at the site. Analysis of extreme weather conditions for the region show an increase in temperatures which could result in reductions in the efficiency of cooling water and an increase in the requirements for installation HVAC systems. Not evaluated are potential implications of multiple other high-profile nuclear developments that may also be occurring at the INL site to include the Versatile Test Reactor, support for Army Project Pele, and commercial demonstrations by the vendors NuScale and OKLO.

6.5 Eagle Rock, Idaho

6.5.1 Site Description

The Eagle Rock site is a 4,200-ac area located in Bonneville County, Idaho, approximately 20 miles west of Idaho Falls. The site was previously proposed to house the Eagle Rock Enrichment Facility, but all efforts associated with the site officially ended in August 2018 when the holding company of the NRC license to construct and operate the enrichment facility requested that the license be terminated. The specific area of the Eagle Rock site analyzed here is centered around the previously proposed location of the enrichment facility which is shown at the pin drop location in Figure 6-23. Appendix section D.6 lists the counties that surround the site and their populations.

Figure 6-23: Eagle Rock Site. Central point for model analysis of siting attributes is shown at the pin drop near the upper left center of the image.

6.5.2 OR-SAGE Results and detailed data

Each of the OR-SAGE siting parameters were applied to the Eagle Rock site as shown in the Google Earth map in Figure 6-23. The results for each individual layer are shown in Figure 6-24. Cells that do not meet the query threshold criterion are depicted in magenta; otherwise, cells that meet the threshold criterion are clear. In this case, there are no query threshold issues identified for the Eagle Rock site.

Figure 6-24: Eagle Rock OR-SAGE results for all parameters indicating no query threshold issues.

Based on the baseline static OR-SAGE database query, all of the OR-SAGE parameters completely meet the threshold query values in the vicinity of the Eagle Rock site and are depicted clear as shown in Figure 6-24.

The composite results for the Eagle Rock site are shown in Figure 6-25. As shown, the entire Eagle Rock area of interest meets all query threshold values by the depiction in green.

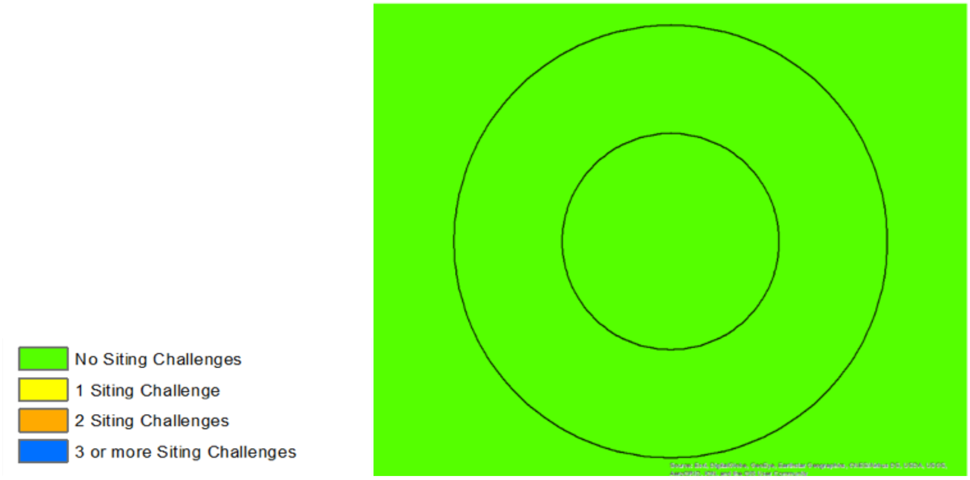


Figure 6-25: Composite OR-SAGE results for the Eagle Rock site showing locations with siting challenges.

Figure 6-26 shows the aggregate 50-acre tracts at a 90% aggregation rate for the area. Aggregated cells that meet the threshold values are shown in green; otherwise the cells would be shown as clear. All the land within a 1.0-mile radius of the Eagle Rock site center point can be aggregated into 50-acre parcels.

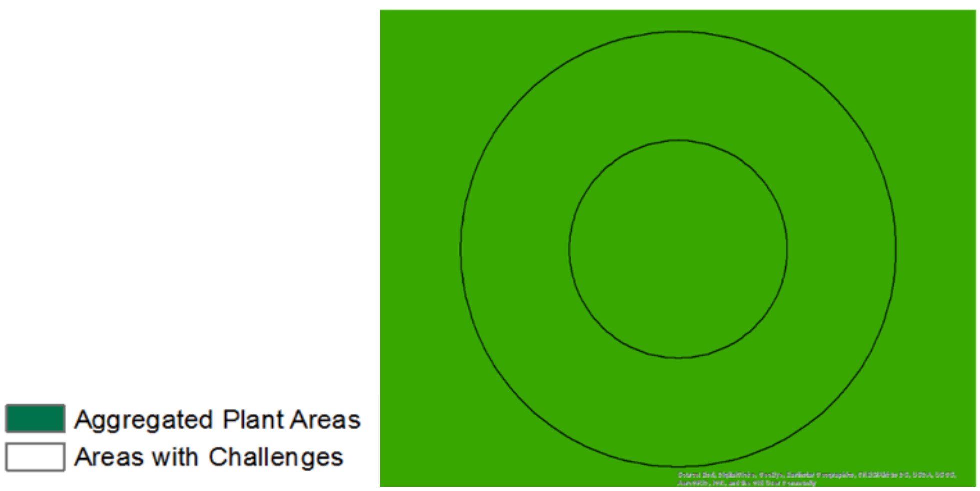


Figure 6-26: Aggregate OR-SAGE results for the Eagle Rock site.

Table 6-13 provides several relative distance parameters that may weigh on the decision to site a demonstration reactor at the Eagle Rock site.

Table 6-13: Distance from the Eagle Rock site to various parameters of interest.

Parameter	Identification	Distance (miles)
Population Center (≥ 25,000 residents)	Idaho Falls	29.4
Airport	Mud Lake/West Jefferson County	25.3
Major Road	US 20	2.3
Rail Transport	Union Pacific	17.7
Navigable waterway	Snake River	417.4
Cooling water (≥ 30,000 gpm makeup)	Snake River	17.8
Grid Capacity	PacificCorp	3.7
Oil Refineries	Silver Eagle Refining	245.9

6.5.3 "Janet" results

Each of the quantitative and qualitative factors, as described in Section 2.3, were applied to the Eagle Rock site. Table 6-14 provides parameter values that are included in the model for the Eagle Rock site.

Table 6-14: "Janet" model attributes for the Eagle Rock site.

"Janet" Model Attribute	Units	Eagle Rock Site Value
Electric Energy Price	cents / kWh (all Sectors)	7.84
Total Net Imports	million kWh / yr	7520
Electric Energy Flow Trend Slope	million kWh/yr / yr	-631
Favorable State Energy Policy	Negative, Neutral, or Positive	Neutral
Nuclear Sentiment % Favorable	% of Favorability Toward Nuclear	59.66
CDC Social Vulnerability Index	Social Vulnerability Index (x 100)	33
Proximity to Nuclear R&D	Number of Locations within 100 mi	2

Table 6-15 provides demographic data for the Eagle Rock site that can be utilized in an assessment to identify marginalized populations in the surrounding area. A list of known pro- and anti-nuclear groups relevant to the site is provided in Table B-6.

Table 6-15: Demographic overview of the area near the Eagle Rock site.

Eagle Rock	**Parameter**	**% White**	**% Black or African American**	**% Asian**	**% Native Hawaiian or Other Pacific Islander**	**% Some Other Race**	**% AIAN***
	Value	89.58	.41	.82	.01	5.28	1.37
	Parameter	**% Two or More Races**	**% Minority**	**Per Capita Income ($)**	**% Unemployed**	**% No High School Diploma**	**% Below Poverty**
	Value	2.45	16.62	26759.44	4.23	8.24	13.31

*AIAN is an abbreviation for American Indian and Alaskan Native.
Source: American Community Survey (ACS) 2014-2018, 5-year estimates.

6.5.4 Assessment

Proximity and Safety Assessment: The Eagle Rock site is technically well qualified for siting of a demonstration reactor and did not exceed any of the thresholds established in the OR-SAGE analysis. Demonstration efforts would be enhanced by proximity to one of the leading nuclear research laboratories in the world.

Socioeconomic Assessment: As reflected in Table 6-14, there is comparatively strong support for nuclear development at the Eagle Rock site and a neutral state policy toward the technology, with recent support reflected in the UAMPS decision to develop a new generation of light water reactors (built by NuScale) at the nearby INL Site [24]. This new development may, however, create some market challenges for an advanced reactor developer who would like to follow their demonstration with a long-term license to generate and sell to the grid. It is unclear if electricity demand growth in the region will support additional generating capacity. The population-weighted SVI for the counties surrounding the proposed site was assessed as "Medium Vulnerability" to natural disasters and other disruptive events. The labor rates for the area are at the low end of the sites considered in this analysis.

Other Factors: There are no air quality issues at the site. Analysis of extreme weather conditions for the region show an increase in temperatures which could result in reductions in the efficiency of cooling water and an increase in the requirements for installation HVAC systems.

6.6 Nevada National Security Site

6.6.1 Site Description

The Nevada National Security Site (NNSS) is a 1360 square mile facility located in a remote region of Nevada, approximately 65 miles northwest of Las Vegas, NV [27]. The site has a long history of support to development of the U.S. national nuclear stockpile and was previously known as the Nevada Test Site. This name was changed in 2010 to the Nevada National Security Site, reflecting an evolution of its mission. The site is managed by Mission Support and Test Services, LLC. The site is home to significant test and analysis facilities, but these are focused on the stockpile stewardship mission. Full environmental details for the site are available at the NNSS website [28]. Site boundaries are shown at Figure 6-27 and the specific location shown for this analysis is shown in Figure 6-28. Appendix section D.4 lists the counties that surround the site and their populations.

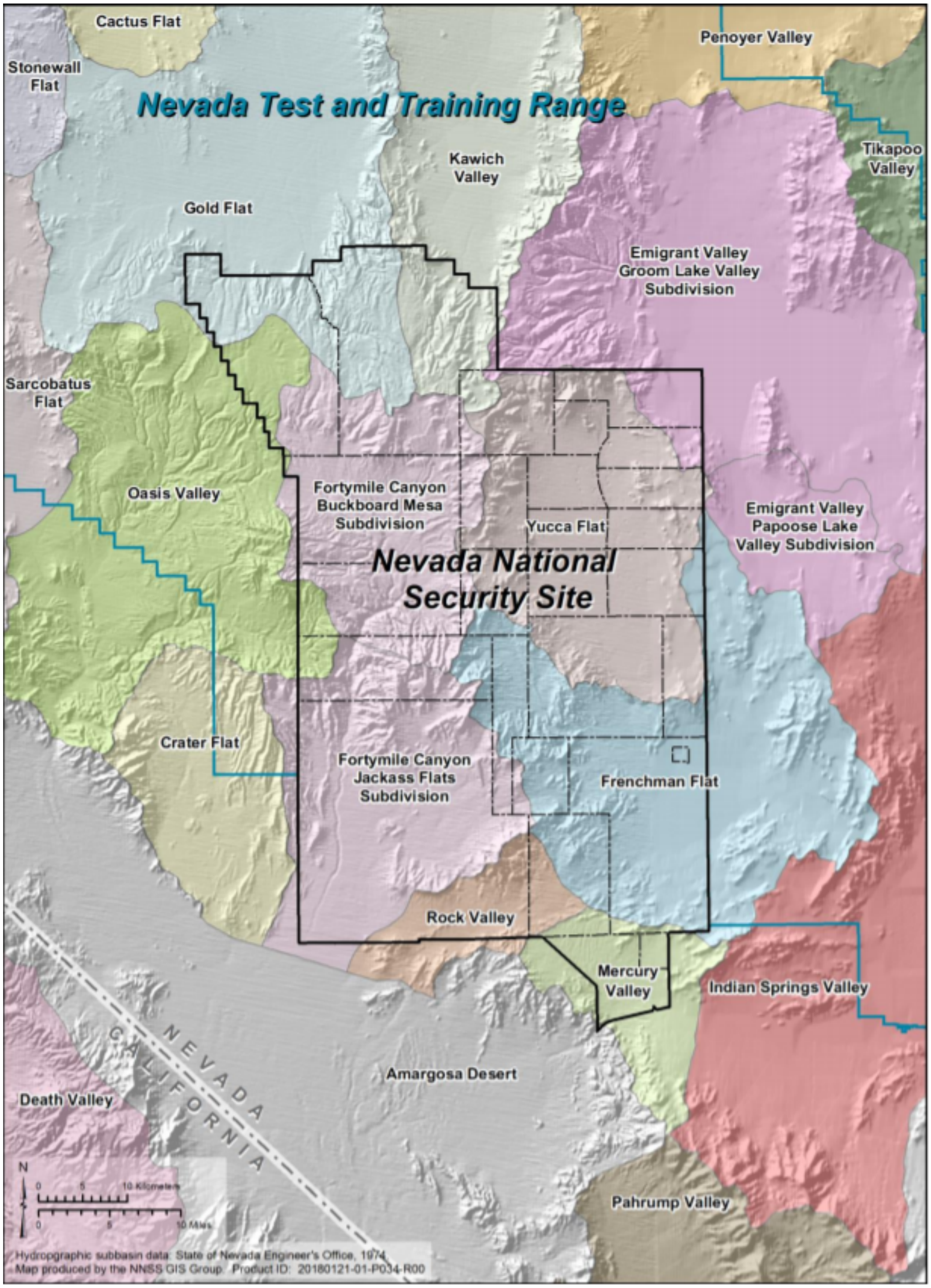


Figure 6-27: Map of Nevada National Security Site

Figure 6-28: NNSS Representative Site. Central point for model analysis of siting attributes is shown at the pin drop near the lower center area of the image.

6.6.2 OR-SAGE Results and detailed data

Each of the 10 nuclear siting parameters were applied to a representative NNSS area as shown in the Google Earth map in Figure 6-28. The results for each individual layer are shown in Figure 6-29 and Figure 6-30. Cells that do not meet the query threshold criterion are depicted in magenta; otherwise, cells that meet the threshold criterion are clear.

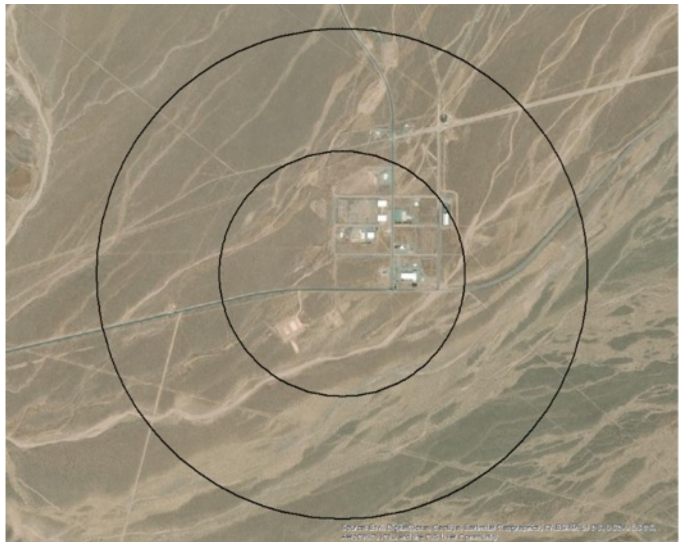


Figure 6-29: NNSS OR-SAGE results for all parameters except streamflow that indicate no query threshold issues.

With the exception of the streamflow threshold all the OR-SAGE parameters completely meet the threshold query value in the vicinity of the representative NNSS site and are depicted clear as shown in Figure 6-29. The OR-SAGE layer for streamflow does not meet the threshold value anywhere in the immediate vicinity of the NNSS site as shown by the magenta coloring of the entire map shown in Figure 6-30. As with other DOE facilities, this should not be evaluated as a disqualifying feature. There may be alternative water sources available through an NNSS piping system. Furthermore, there may be advanced reactor technologies for demonstration that require little or no make-up cooling water making this discriminatory layer unnecessary.

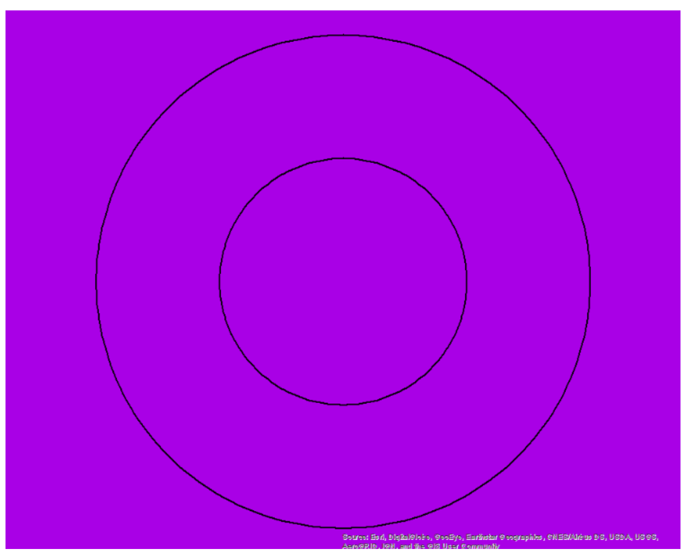


Figure 6-30: The NNSS OR-SAGE results associated with streamflow indicates that the threshold query value is not met for this area.

The composite map for the NNSS site is shown in Figure 6-31. As discussed above, most of the area of interest meets all parameter threshold values. However, it is easy to see the impact of the streamflow layer in the figure. Without the water concern based on the OR-SAGE query, all of the composite map would be green.

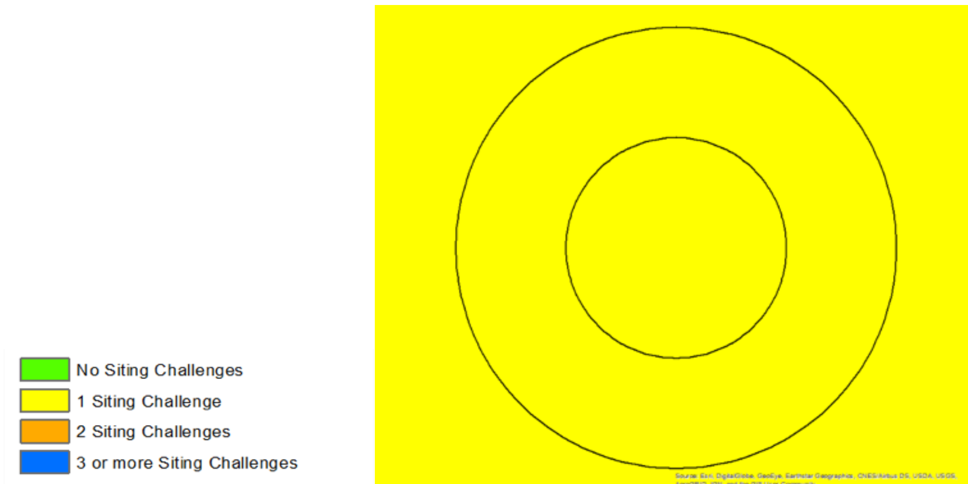


Figure 6-31: Composite OR-SAGE results for the representative NNSS site showing locations with siting challenges.

Figure 6-32 shows the aggregate 50-acre tracts at a 90% aggregation rate for the area. Aggregated cells that meet the threshold values are shown in green; otherwise the cells are shown as clear. No 50-acre aggregated sites in the vicinity of the NNSS site met all the query threshold value because of the water issue discussed previously. If the water issue were discarded based on technology selection or otherwise resolved, the aggregate map would be green over the entire area shown. Therefore, with the water issue resolved, any 50-acre tract in the target area of interest would be amenable to siting an advanced reactor demonstration based on the OR-SAGE evaluation.

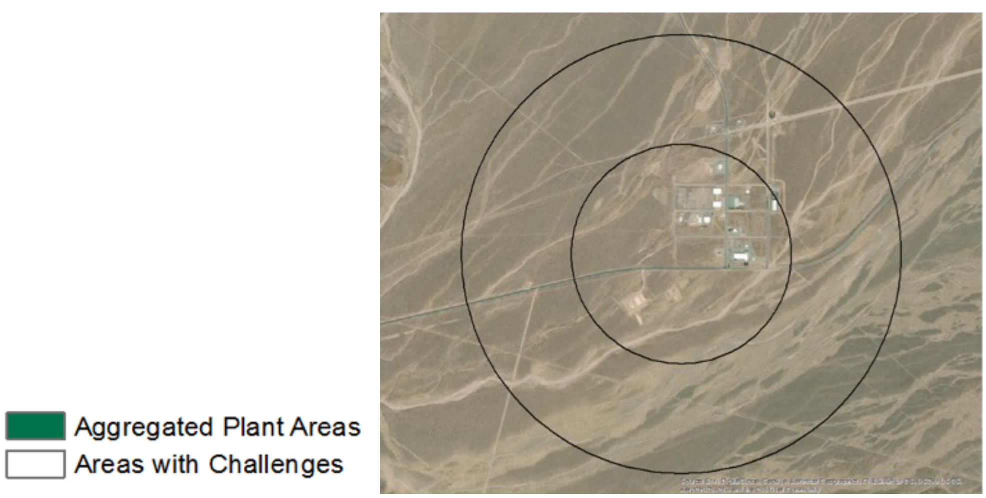


Figure 6-32: Aggregate map for the representative NNSS site.

Table 6-16 provides several relative distance parameters that may weigh on the decision to site a demonstration reactor at the NNSS site.

Table 6-16: Distance from the NNSS representative site to various parameters of interest.

Parameter	Identification	Distance (miles)
Population Center (≥ 25,000 residents)	Pahrump	52.4
Airport	Beatty	34.9
Major Road	US 95	12.8
Rail Transport	Union Pacific	94.0
Navigable waterway	Santa Monica Harbor	279.7
Cooling water (≥ 30,000 gpm makeup)	Colorado River	120.8
Grid Capacity	Nevada Power Company	21.9
Oil Refineries	Foreland Refining-Ely	167.8

6.6.3 "Janet" results

Each of the quantitative and qualitative factors, as described in Section 2.3, were applied to the NNSS site. Table 6-17 provides parameter values that are included in the model for the NNSS site.

Table 6-17: "Janet" model attributes for the NNSS site.

"Janet" Model Attribute	Units	NNSS Value
Electric Energy Price	cents / kWh (all Sectors)	8.57
Total Net Imports	million kWh / yr	459
Electric Energy Flow Trend Slope	million kWh/yr / yr	-60
Favorable State Energy Policy	Negative, Neutral, or Positive	Positive
Nuclear Sentiment % Favorable	% of Favorability Toward Nuclear	21.0
CDC Social Vulnerability Index	Social Vulnerability Index (x 100)	74
Proximity to Nuclear R&D	Number of Locations within 100 mi	0

Table 6-18 provides demographic data for the NNSS site that can be utilized in an assessment to identify marginalized populations in the surrounding area. A list of known pro- and anti-nuclear groups relevant to the site is provided in Table B-6.

Table 6-18: Demographic overview of the area near the NNSS site.

NNSS	**Parameter**	**% White**	**% Black or African American**	**% Asian**	**% Native Hawaiian or Other Pacific Islander**	**% Some Other Race**	**% AIAN***
	Value	61.6	11.13	9.27	.68	11.23	.98
	Parameter	**% Two or More Races**	**% Minority**	**Per Capita Income ($)**	**% Unemployed**	**% No High School Diploma**	**% Below Poverty**
	Value	5.1	55.32	29171.57	7.23	14.26	14.09

*AIAN is an abbreviation for American Indian and Alaskan Native.
Source: American Community Survey (ACS) 2014-2018, 5-year estimates.

6.6.4 Assessment

Proximity and Safety Assessment: The streamflow siting threshold in OR-SAGE was the only siting attribute that was not satisfied for this location. However, this does not eliminate the site from consideration as the choice of technology to develop a reactor will determine the type of cooling required. In addition, alternate sources of water could be established if required. Security support at the site would be considerable given the weapons stockpile support mission of NNSS. Less clear is the availability of other support services. The site suffers in comparison with other sites evaluated due to greater distance from transmission and transportation infrastructure. This may not be a limiting factor for some developers.

Socioeconomic Assessment: The state of Nevada has a favorable policy towards nuclear although the public favorability is low at 21 percent. The population-weighted SVI for the counties surrounding the proposed site was assessed as “Medium Vulnerability” to natural disasters and other disruptive events, but it is noted that one of the categories that contributes to the overall index, Minority Status and Language, had a very high value, indicating very high vulnerability in the category. The labor rates were below the national average and put Nevada in one of the four states with the lowest labor rates.

Other Factors: There are no air quality issues at the site. Analysis of extreme weather conditions for the region show an increase in temperatures which could result in reductions in the efficiency of cooling water and an increase in the requirements for installation HVAC systems.

6.7 Portsmouth Site

6.7.1 Site Description

The Portsmouth site considered in this analysis is located near the Portsmouth Gaseous Diffusion Plant in south-central Ohio. It is situated south of Piketon, OH on ~3700 acres. The gas diffusion plant was first used to produce enriched uranium for national defense programs beginning in 1952. The plant continued to produce enriched uranium to fuel commercial nuclear power plants until 2001. After 2001, the site was returned to the DOE and an environmental cleanup was begun. The DOE’s Office of Environmental Management and the Ohio EPA oversee cleanup activities at the site. The specific location chosen for evaluation is shown in Figure 6-33. As decontamination and decommissioning efforts continue at the site, surrounding communities have begun to review opportunities to reindustrialize portions of the Portsmouth

Site property. These efforts could impact availability of land for demonstration plant development [29]. A DOE environmental assessment completed at the time of plant decommissioning (2001) contains additional site environmental details [30]. Appendix section D.8 lists the counties that surround the site and their populations.

Figure 6-33: Portsmouth, OH Site. Central point for model analysis of siting attributes is shown at the pin drop near the center of the image.

6.7.2 OR-SAGE Results and detailed data

Each of the 10 nuclear siting parameters were applied to a Portsmouth site southeast of the main complex structures as shown in the Google Earth map in Figure 6-33. The results for each individual layer are shown in Figure 6-34, Figure 6-35, and Figure 6-36. Cells that do not meet the query threshold criterion are depicted in magenta; otherwise, cells that meet the threshold criterion are clear.

Figure 6-34: Portsmouth OR-SAGE results for population density, faults, safe shutdown earthquake, slope, streamflow, 100-year floodplain, protected lands, and proximity to hazards indicate no query threshold issues.

Eight of the OR-SAGE layers completely meet the threshold query value in the vicinity of the Portsmouth site and are depicted clear as shown in Figure 6-34. The OR-SAGE layer for wetlands and open water identified a small area outside the central area of interest as shown by the magenta markings in Figure 6-35.

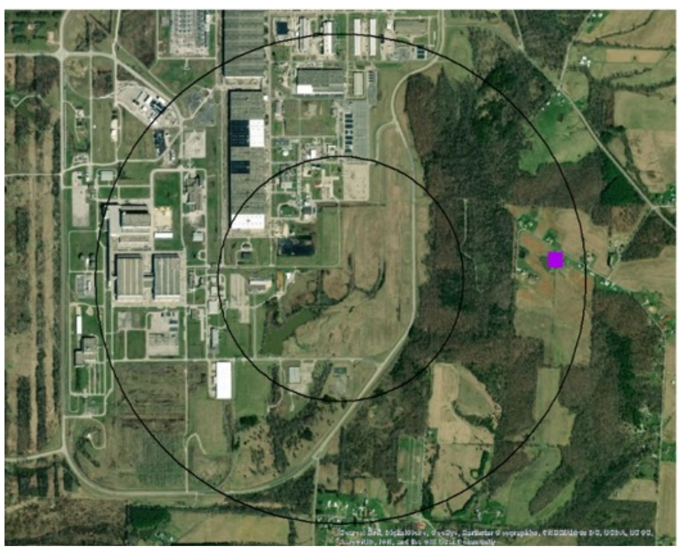


Figure 6-35: The Portsmouth OR-SAGE results for wetlands and open water indicates limited site impact outside the immediate area of interest.

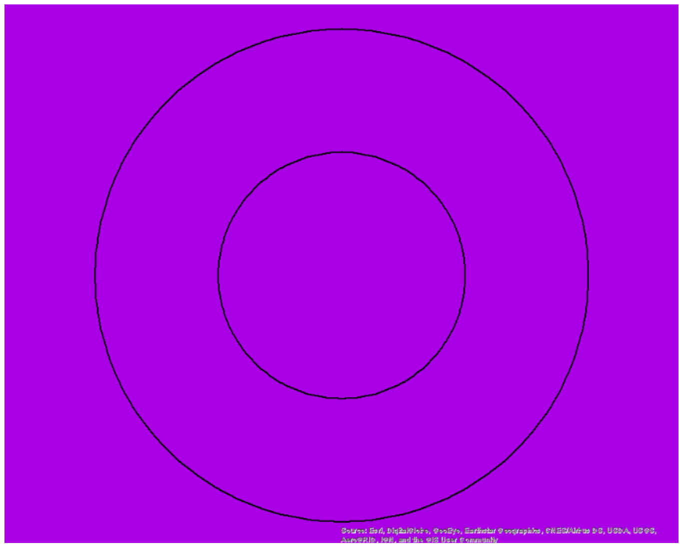


Figure 6-36: The Portsmouth OR-SAGE results associated with landslide risk indicates that the threshold query value is not met in the area.

The OR-SAGE layer for landslide risk exceeds the threshold value over the entire area as shown in Figure 6-36. The OR-SAGE data are based on a US geological survey (USGS) landslide risk evaluation, including disambiguation (sink holes) of broad areas of land based on the general geological attributes of the area. The OR-SAGE GIS tool merely acts to flag such areas and a localized geological assessment would be necessary to further evaluate the specific geologic conditions for the site. In this case, the Portsmouth plant likely has an environmental pedigree that includes a geologic evaluation indicating minimal landslide risk.

The composite map for the Portsmouth site is shown in Figure 6-37. Most of the area of interest meets all threshold values. However, it is easy to see the impact of the landslide risk layer in the figure. If the landslide risk could be mitigated based on direct site knowledge, all the composite map colors would move up one level and most of the figure would be green.

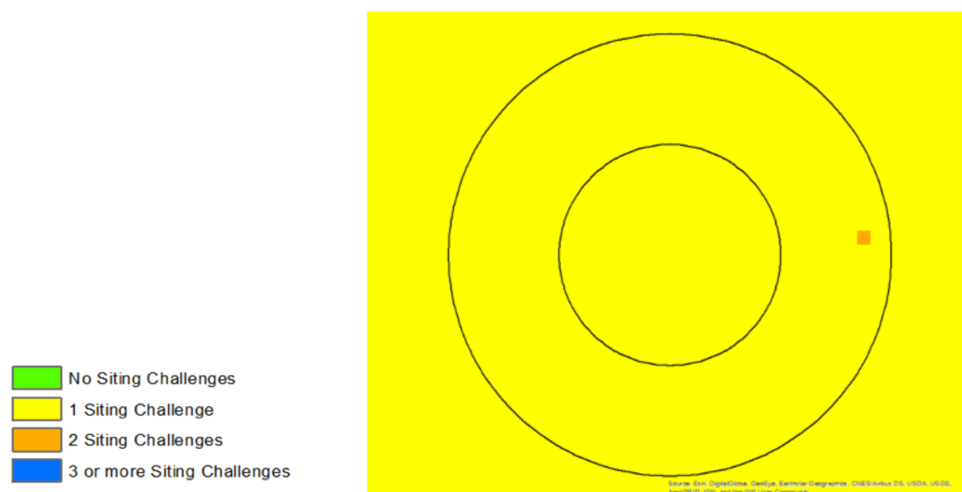


Figure 6-37: Composite OR-SAGE results for the Portsmouth site showing locations with siting challenges.

Figure 6-38 shows the aggregate 50-acre tracts at a 90% aggregation rate for the area. Aggregated cells that meet the threshold values are shown in green; otherwise the cells are shown as clear. Most of the area around the Portsmouth site meet all the query threshold values. With further evaluation of the geologic pedigree for the area, it is likely that all of the map could be aggregated in 50-acre parcels to meet the threshold values for the static OR-SAGE query.

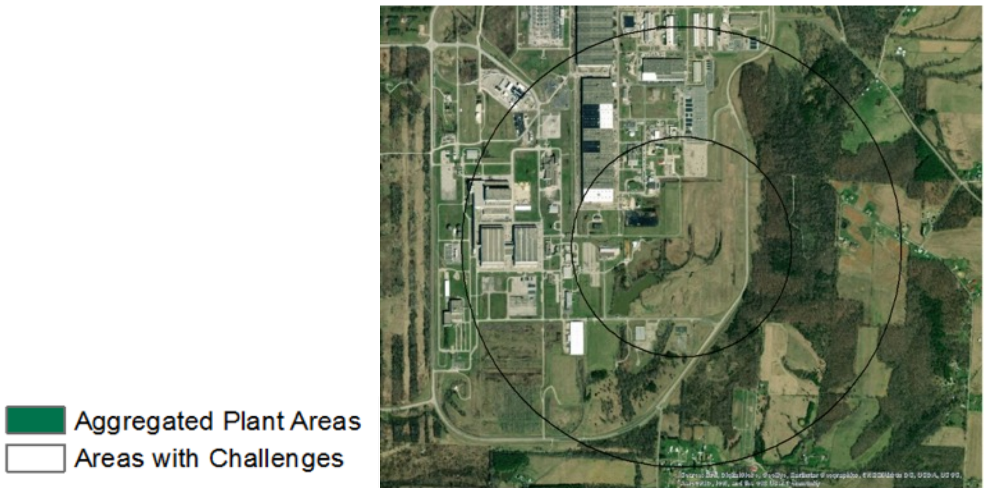


Figure 6-38: Aggregate map for the Portsmouth site.

Table 6-19 provides several relative distance parameters that may weigh on the decision to site a demonstration reactor at the Portsmouth site.

Table 6-19: Distance from the Portsmouth site to various parameters of interest.

Parameter	Identification	Distance (miles)
Population Center (≥ 25,000 residents)	Huntington	65.3
Airport	Pike County	15.2
Major Road	US 23	2.2
Rail Transport	Norfolk Southern	1.9
Navigable waterway	Ohio River	23.1
Cooling water (≥ 30,000 gpm makeup)	Scioto River	2.5
Grid Capacity	Ohio Power Company	0.9
Oil Refineries	Marathon-Catlettsburg	62.1

6.7.3 *"Janet" results*

Each of the quantitative and qualitative factors, as described in Section 2.3, were applied to the Portsmouth site. Table 6-20 provides parameter values that are included in the model for the Portsmouth site.

Table 6-20: "Janet" model attributes for the Portsmouth site.

"Janet" Model Attribute	Units	Portsmouth Value
Electric Energy Price	cents / kWh (all Sectors)	9.24
Total Net Imports	million kWh / yr	36651
Electric Energy Flow Trend Slope	million kWh/yr / yr	1775
Favorable State Energy Policy	Negative, Neutral, or Positive	Positive
Nuclear Sentiment % Favorable	% of Favorability Toward Nuclear	17.0
CDC Social Vulnerability Index	Social Vulnerability Index (x 100)	76
Proximity to Nuclear R&D	Number of Locations within 100 mi	1

Table 6-21 provides demographic data for the Portsmouth site that can be utilized in an assessment to identify marginalized populations in the surrounding area. A list of known pro- and anti-nuclear groups relevant to the site is provided in Table B-6.

Table 6-21: Demographic overview of the area near the Portsmouth site.

	Parameter	% White	% Black or African American	% Asian	% Native Hawaiian or Other Pacific Islander	% Some Other Race	% AIAN*
Portsmouth	Value	94.3	2.58	.33	.01	.32	.19
	Parameter	**% Two or More Races**	**% Minority**	**Per Capita Income ($)**	**% Unemployed**	**% No High School Diploma**	**% Below Poverty**
	Value	2.24	6.42	22757.47	7.96	15.93	20.69

*AIAN is an abbreviation for American Indian and Alaskan Native.
Source: American Community Survey (ACS) 2014-2018, 5-year estimates.

6.7.4 Assessment

Proximity and Safety Assessment: The entire Portsmouth, Ohio site exceeded the siting threshold for landslide risk and had a small number of additional areas with presence of wetlands and open water. Exceeding the landslide risk could be the result of underlying geological conditions which, with further study, may not pose a siting limitation.

Socioeconomic Assessment: The state of Ohio has a positive policy towards nuclear energy although the public sentiment towards nuclear is low, 17 percent. The population-weighted SVI for the surrounding counties was assessed as "Highest Vulnerability" to natural disasters and other disruptive events. The labor rates are above the national average in all categories resulting in the state being in the top four states.

Other Factors: Other Factors: There are no air quality issues at the site. Analysis of extreme weather conditions for the region show an increase in temperatures which could result in reductions in the efficiency of cooling water and an increase in the requirements for installation HVAC systems.

6.8 Savannah River National Laboratory (H-2 Site)

6.8.1 Site Description

The Savannah River Site was established in the early 1950s to produce specialty nuclear materials for national defense missions. The site occupies > 300 square miles near Aiken, SC and is home to five retired nuclear reactors that were used for DOE defense materials production, two nuclear materials separation and stabilization buildings, fuel and target fabrication facilities, as well as high-level waste management and state-of-the-art vitrification capabilities. The site selected for assessment in this analysis is the H-2 site shown in Figure 6-39 with central location indicated by the pin drop shown in Figure 6-40. The site has been well characterized [31] and multiple demonstration sites may be available at this location. Appendix section D.5 lists the counties that surround the site and their populations.

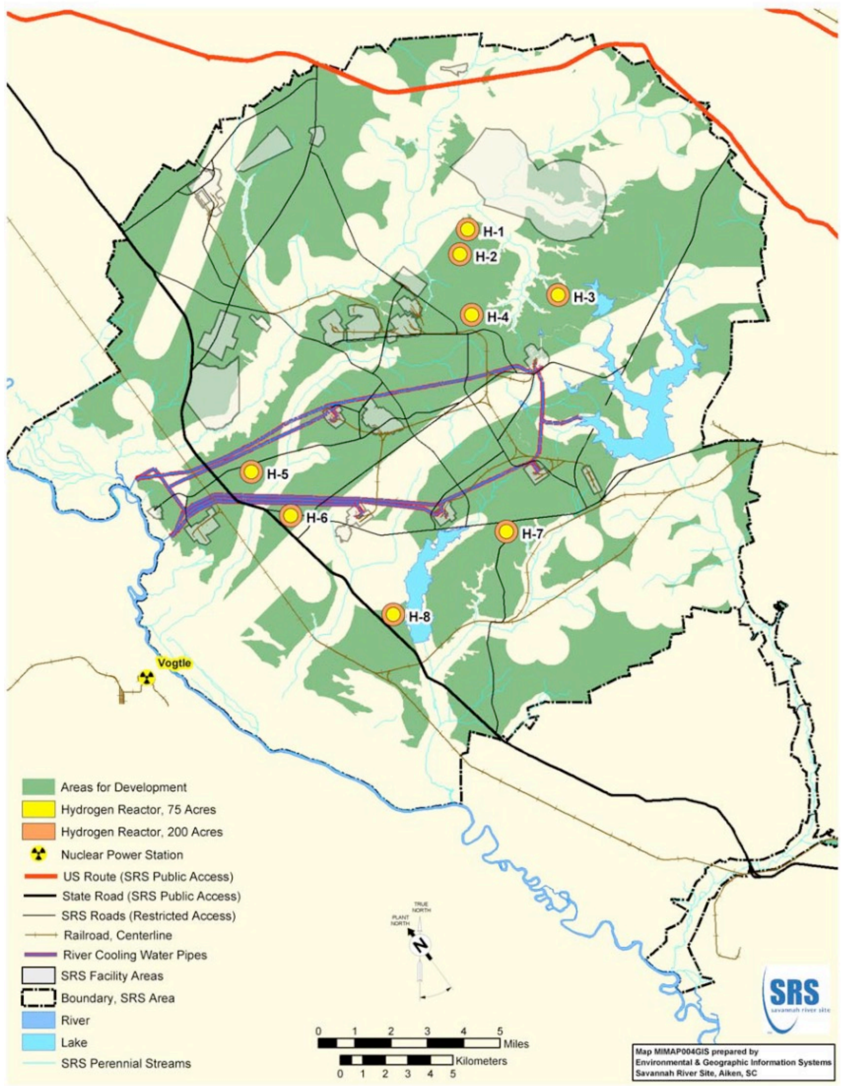


Figure 6-39: Map of the Savannah River Site with eight potential reactor sites reflected.

Figure 6-40: SRNL H-2 Site. Central point for model analysis of siting attributes is shown at the pin drop in the center of the image.

6.8.2 OR-SAGE Results and detailed data

Each of the 10 nuclear siting parameters were applied to the Savannah River National Laboratory (SRNL) site identified as H-2 as shown in the Google Earth map in Figure 6-40. The results for each individual layer are shown in Figure 6-41 and Figure 6-42. Cells that do not meet the query threshold criterion are depicted in magenta; otherwise, cells that meet the threshold criterion are clear.

Figure 6-41: SRNL H2 OR-SAGE results for all parameters except wetlands and open water that indicate no query threshold issues.

With the exception of the wetlands and open waters threshold, all of the OR-SAGE parameters completely meet the threshold query value in the vicinity of the SRNL H-2 site and are depicted clear as shown in Figure 6-41. The OR-SAGE layer for wetlands and open water identified some limited area impacts as shown by the magenta markings in Figure 6-42. These thresholds are well outside the central area of interest (the inner circle includes approximately 500 acres).

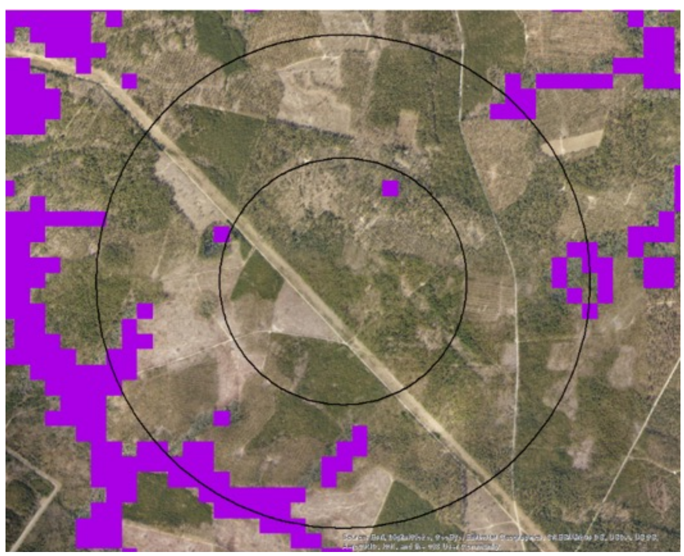


Figure 6-42: The SRNL H-2 OR-SAGE results associated with wetlands and open waters indicates that the threshold query value is not met primarily in areas away from the site of interest.

The composite map for the H-2 site is shown in Figure 6-43. Most of the area of interest meets all threshold values as depicted by the green color.

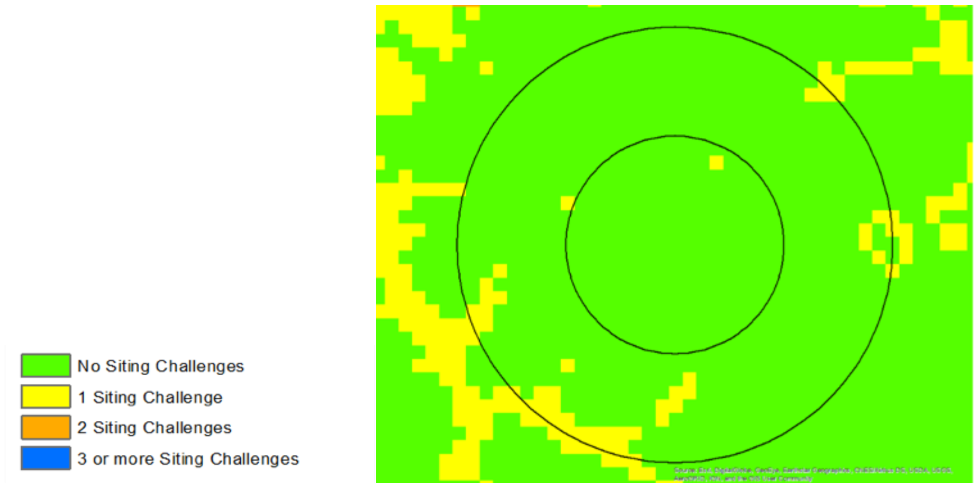


Figure 6-43: Composite OR-SAGE results for the SRNL H-2 site showing locations with siting challenges.

Figure 6-44 shows the aggregate 50-acre tracts at a 90% aggregation rate for the area. Aggregated cells that meet the threshold values are shown in green; otherwise the cells are shown as clear. The entire area around the H-2 site can be aggregated into 50-acre parcels (at a 90% aggregation rate).

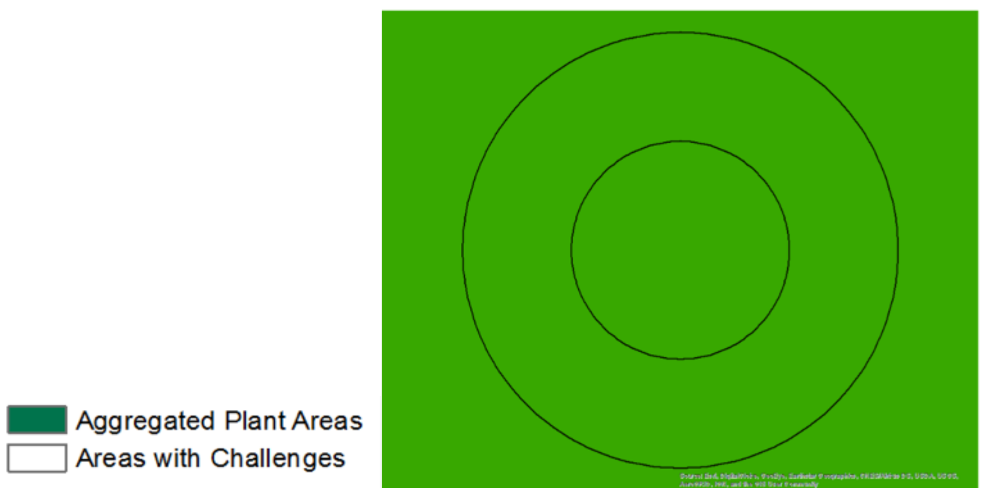


Figure 6-44: Aggregate OR-SAGE results for the SRNL H-2 site.

Table 6-22 provides several relative distance parameters that may weigh on the decision to site a demonstration reactor at the SRNL H-2 site.

Table 6-22: Distance from the SRNL H-2 site to various parameters of interest.

Parameter	Identification	Distance (miles)
Population Center (≥ 25,000 residents)	Aiken	21.2
Airport	Barnwell	16.4
Major Road	US 278	5.8
Rail Transport	US Government	2.4
Navigable waterway	Savannah River	13.2
Cooling water (≥ 30,000 gpm makeup)	Upper Three Runs	1.9
Grid Capacity	South Carolina Energy & Gas	0.1
Oil Refineries	Continental – Somerset	379.7

6.8.3 "Janet" results

Each of the quantitative and qualitative factors, as described in Section 2.3, were applied to the SRNL H-2 site. Table 6-23 provides parameter values that are included in the model for the SRNL H-2 site.

Table 6-23: "Janet" model attributes for the SRNL-H2 site.

"Janet" Model Attribute	Units	SRNL H-2 Value
Electric Energy Price	cents / kWh (all Sectors)	9.84
Total Net Imports	million kWh / yr	-10788
Electric Energy Flow Trend Slope	million kWh/yr / yr	-559
Favorable State Energy Policy	Negative, Neutral, or Positive	Neutral
Nuclear Sentiment % Favorable	% of Favorability Toward Nuclear	71.3
CDC Social Vulnerability Index	Social Vulnerability Index (x 100)	61
Proximity to Nuclear R&D	Number of Locations within 100 mi	1

Table 6-24 provides demographic data for the SRNL H-2 site that can be utilized in an assessment to identify marginalized populations in the surrounding area. A list of known pro- and anti-nuclear groups relevant to the site is provided in Table B-6.

Table 6-24: Demographic overview of the area near the SRNL H-2 site.

	Parameter	% White	% Black or African American	% Asian	% Native Hawaiian or Other Pacific Islander	% Some Other Race	% AIAN*
SRNL H-2	Value	62.35	31.75	1.8	.08	1.35	.31
	Parameter	**% Two or More Races**	**% Minority**	**Per Capita Income ($)**	**% Unemployed**	**% No High School Diploma**	**% Below Poverty**
	Value	2.39	41.22	26799.33	7.32	14.26	12.81

*AIAN is an abbreviation for American Indian and Alaskan Native.
Source: American Community Survey (ACS) 2014-2018, 5-year estimates.

6.8.4 Assessment

Proximity and Safety Assessment: There were areas of the broader area considered that exceeded the wetlands and open water siting attribute, but the large majority of the area had no siting issues. There is strong support and security infrastructure given the long history of nuclear development at the site. This site is very well characterized as noted in the site summary above.

Socioeconomic Assessment: The state of South Carolina has a neutral energy policy towards nuclear although the public sentiment towards nuclear is high, 71 percent. The population-weighted SVI for the counties surrounding the proposed site was evaluated as “High Vulnerability” to natural disasters and other disruptive events, but it is noted that it is in the low end of that range. The labor rates for the state were the lowest of all of the states in each of the labor categories.

Other Factors: There are no air quality issues at the site. Analysis of extreme weather conditions for the region show an increase in temperatures which could result in reductions in the efficiency of cooling water and an increase in the requirements for installation HVAC systems.

6.9 TVA Clinch River Site

6.9.1 Site Description

The TVA-Clinch River Site is located on the approximately 34,000-ac Oak Ridge Reservation (ORR) in eastern Tennessee near the city of Oak Ridge. The site has been well characterized and full details are available for the site in the documentation for an early site permit (ESP-006), issued in 2019 by the NRC. This includes a full siting study and environmental study completed in 2016 by the TVA [32]. The specific site chosen for this analysis is shown in Figure 6-45. Appendix section D.6 lists the counties that surround the site and their populations.

Figure 6-45: TVA-Clinch River Site. Central point for model analysis of siting attributes is shown at the pin drop in the center left of the image.

6.9.2 OR-SAGE Results and detailed data

Each of the 10 nuclear siting parameters were applied to the TVA Clinch River site as shown in the Google Earth map in Figure 6-45. The results for each individual layer are shown in Figure 6-46, Figure 6-47, and Figure 6-48. Cells that do not meet the query threshold criterion are depicted in magenta; otherwise, cells that meet the threshold criterion are clear.

Figure 6-46: TVA Clinch River OR-SAGE results for population density, safe shutdown earthquake, faults, streamflow, landslide risk, and proximity to hazards indicate no query threshold issues.

Six of the OR-SAGE parameters completely meet the threshold query value in the vicinity of the Clinch River site and are depicted clear as shown in Figure 6-46. The OR-SAGE layers for the 100-year floodplain and protected lands identified some limited impacts as shown by the magenta markings in Figure 6-47. The 100-year floodplain primarily affects land on the opposite bank of the Clinch River away from the site of interest. Likewise, the protected land area is on the opposite side of the river from the site. Therefore, these query threshold results do not impact the availability of the site.

Figure 6-47: The TVA Clinch River OR-SAGE results for floodplains (left) and protected lands (right) indicates limited site impact beyond the central site area.

Figure 6-48: The TVA Clinch River OR-SAGE results for wetlands and open water (left) and slope (right) indicates limited site beyond the central site area.

The Clinch River wraps around the site which shows up as a magenta ribbon in the left image in Figure 6-48 where the wetlands and open water threshold is exceeded. On the far side of the river, the land slopes down to the river in numerous places in excess of the slope threshold value for the baseline OR-SAGE query as shown in the right image in Figure 6-48. Again, based on their location across the Clinch River from the site of interest, these query threshold results do not impact the availability of the site.

The composite map for the Clinch River site is shown in Figure 6-49. As shown, the central site area of interest meets all query threshold values.

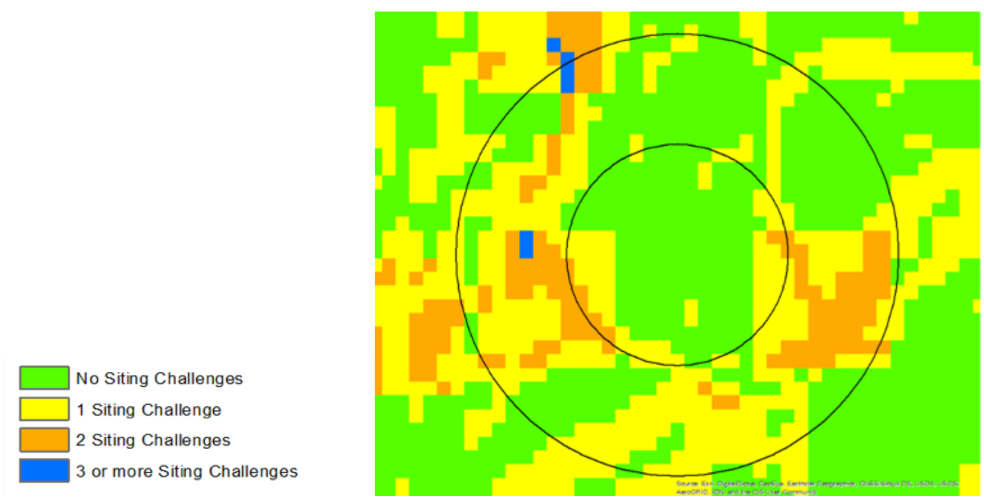


Figure 6-49: Composite OR-SAGE results for the TVA Clinch River site showing locations with siting challenges.

Figure 6-50 shows the aggregate 50-acre tracts at a 90% aggregation rate for the area. Aggregated cells that meet the threshold values are shown in green; otherwise the cells are shown as clear. The majority of the land within a 0.5-mile radius of the site center point can be aggregated into 50-acre parcels, which reflects the TVA early site permit locale.

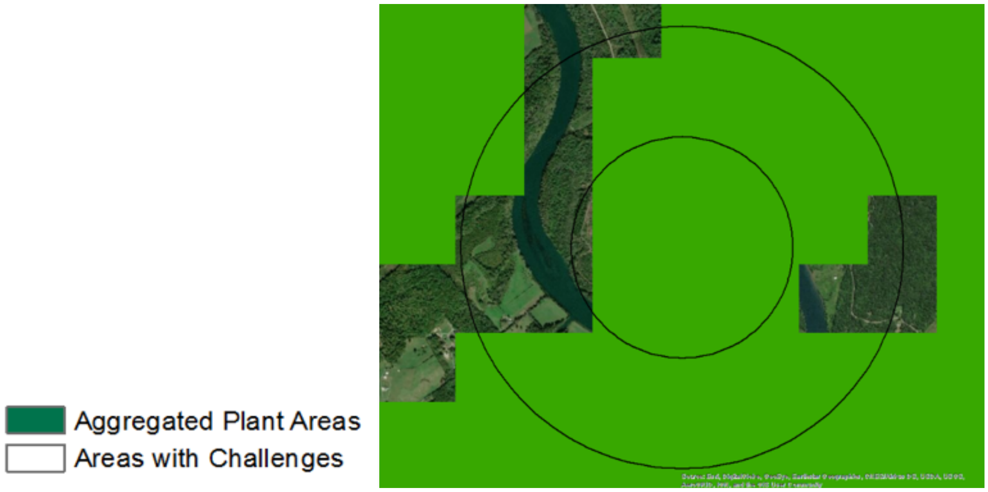


Figure 6-50: Aggregate OR-SAGE results for the TVA Clinch River site.

Table 6-25 provides several relative distance parameters that may weigh on the decision to site a demonstration reactor at the Clinch River site.

Table 6-25: Distance from the TVA Clinch River site to various parameters of interest.

Parameter	Identification	Distance (miles)
Population Center (≥ 25,000 residents)	Oak Ridge	12.9
Airport	Mc Ghee Tyson	27.5
Major Road	I-40	1.4
Rail Transport	Knoxville & Holston River Railroad	2.7
Navigable waterway	Clinch River	0.5
Cooling water (≥ 30,000 gpm makeup)	Clinch River	0.5
Grid Capacity	TVA	0.7
Oil Refineries	Continental – Somerset	102.8

6.9.3 "Janet" results

Each of the quantitative and qualitative factors, as described in Section 2.3, were applied to the TVA Clinch River site. Table 6-26 provides parameter values that are included in the model for the TVA Clinch River site.

Table 6-26: "Janet" model attributes for the TVA Clinch River site.

"Janet" Model Attribute	Units	TVA Clinch River Value
Electric Energy Price	cents / kWh (all Sectors)	9.7
Total Net Imports	million kWh / yr	29717
Electric Energy Flow Trend Slope	million kWh/yr / yr	-687
Favorable State Energy Policy	Negative, Neutral, or Positive	Neutral
Nuclear Sentiment % Favorable	% of Favorability Toward Nuclear	84.2
CDC Social Vulnerability Index	Social Vulnerability Index (x 100)	43
Proximity to Nuclear R&D	Number of Locations within 100 mi	1

Table 6-27 provides demographic data for the TVA Clinch River site that can be utilized in an assessment to identify marginalized populations in the surrounding area. A list of known pro- and anti-nuclear groups relevant to the site is provided in Table B-6.

Table 6-27: Demographic overview of the area near the TVA Clinch River site.

<table>
<tr><td rowspan="4">TVA Clinch River</td><th>Parameter</th><th>% White</th><th>% Black or African American</th><th>% Asian</th><th>% Native Hawaiian or Other Pacific Islander</th><th>% Some Other Race</th><th>% AIAN*</th></tr>
<tr><th>Value</th><td>89.45</td><td>5.79</td><td>1.48</td><td>0</td><td>.93</td><td>.35</td></tr>
<tr><th>Parameter</th><th>% Two or More Races</th><th>% Minority</th><th>Per Capita Income ($)</th><th>% Unemployed</th><th>% No High School Diploma</th><th>% Below Poverty</th></tr>
<tr><th>Value</th><td>2</td><td>13.44</td><td>28787.89</td><td>5.85</td><td>12.04</td><td>16.02</td></tr>
</table>

*AIAN is an abbreviation for American Indian and Alaskan Native.
Source: American Community Survey (ACS) 2014-2018, 5-year estimates.

6.9.4 Assessment

Proximity and Safety Assessment: The broad TVA-Clinch River site evaluated contained a number of areas in which one or more of the OR-SAGE thresholds were exceeded. The attributes involved were presence of flood plains, protected areas, wetlands, or open water. However, there were still a number of 50-acre parcels in which there were no siting challenges. There is strong support and security infrastructure given the long history of nuclear development at the site and demonstration efforts would be enhanced by proximity to one of the leading nuclear research laboratories in the world.

Socioeconomic Assessment: The state of Tennessee has a neutral energy policy towards nuclear although the public sentiment is highly favorable at 84 percent. The population-weighted SVI for the surrounding counties is "Medium Vulnerability" to natural disasters and other disruptive events. In addition, the labor rates for the state are at the low end of the states evaluated.

Other Factors: There are no air quality issues at the site. Analysis of extreme weather conditions for the region show an increase in temperatures which could result in reductions in

the efficiency of cooling water and an increase in the requirements for installation HVAC systems.

6.10 East Tennessee Technology Park

6.10.1 Site Description

The East Tennessee Technology Park (ETTP) is a 2,200-ac area located in the Roane County portion of Oak Ridge, Tennessee, approximately 13 miles west of downtown Oak Ridge. The site previously housed a complex of facilities that enriched uranium for use in atomic weapons and also the commercial nuclear industry. Enrichment operations at the site operated from 1945 to 1985 and the site was permanently shut down in 1987. Current work at the site now focuses on restoration of the environment, decontamination and demolition of the site's facilities, and management of the legacy wastes. The specific area of ETTP analyzed here is shown in Figure 6-51. It is centered at the location of building K-33, which was demolished and the last waste disposed of in 2011. Appendix section D.6 lists the counties that surround the site and their populations.

Figure 6-51: ETTP Site. Central point for model analysis of siting attributes is shown at the pin drop in the upper center of the image.

6.10.2 OR-SAGE Results and detailed data

Each of the 10 nuclear siting parameters were applied to the ETTP site as shown in the Google Earth map in Figure 6-51. The results for each individual layer are shown in Figure 6-52, Figure 6-53, and Figure 6-54. Cells that do not meet the query threshold criterion are depicted in magenta; otherwise, cells that meet the threshold criterion are clear.

Figure 6-52: The ETTP OR-SAGE results for population density, safe shutdown earthquake, faults, streamflow, protected lands, and proximity to hazards indicate no query threshold issues.

Six of the OR-SAGE parameters completely meet the threshold query value in the vicinity of the ETTP site and are depicted clear as shown in Figure 6-52. The OR-SAGE layers for the 100-year floodplain and wetlands and open water identified some very limited impacts outside the central area of interest as shown by the magenta markings in Figure 6-53. The 100-year floodplain affects land beyond the 2,000 acres that makeup the site of interest. Likewise, the wetlands and open water, from the Clinch River and a small tributary at the ETTP the site, do not affect the central area of interest.

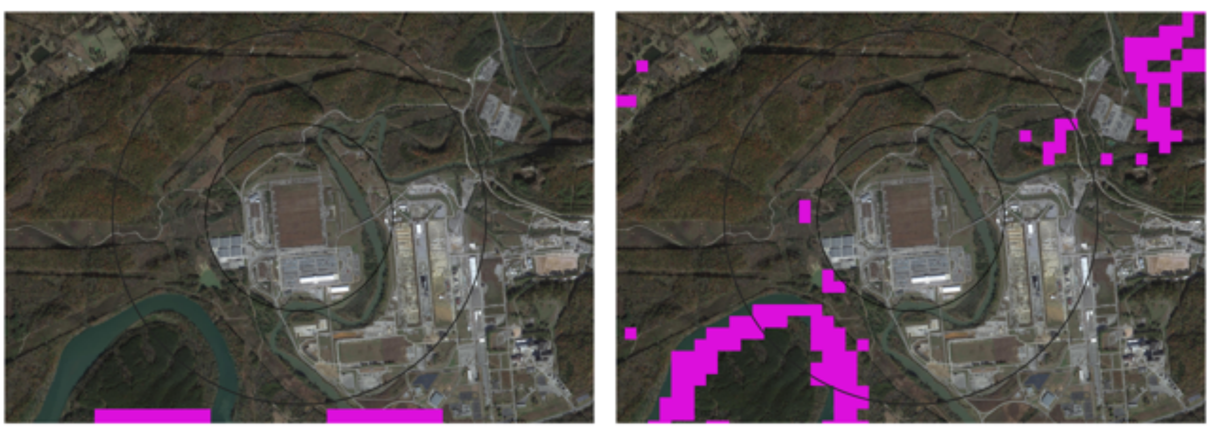


Figure 6-53: The ETTP OR-SAGE results for floodplains (left) and wetlands and open water (right) indicates limited site impact beyond the central site area.

Figure 6-54: The ETTP OR-SAGE results for landslide risk (left) and slope (right) indicates limitations may exist northwest of the central site area.

There is an identified moderate to high landslide risk to the northwest of the site central area shown in the left image in Figure 6-54. This only impacts a portion of the central area of interest and simply indicates a need for further investigation for siting in this direction. This corresponds with land identified with a higher slope in the same direction as shown in the right image in Figure 6-54. Neither of these query thresholds appears to be limiting.

The composite map for the ETTP site is shown in Figure 6-55. As shown, most of the central ETTP site area of interest meets all query threshold values by the depiction in green.

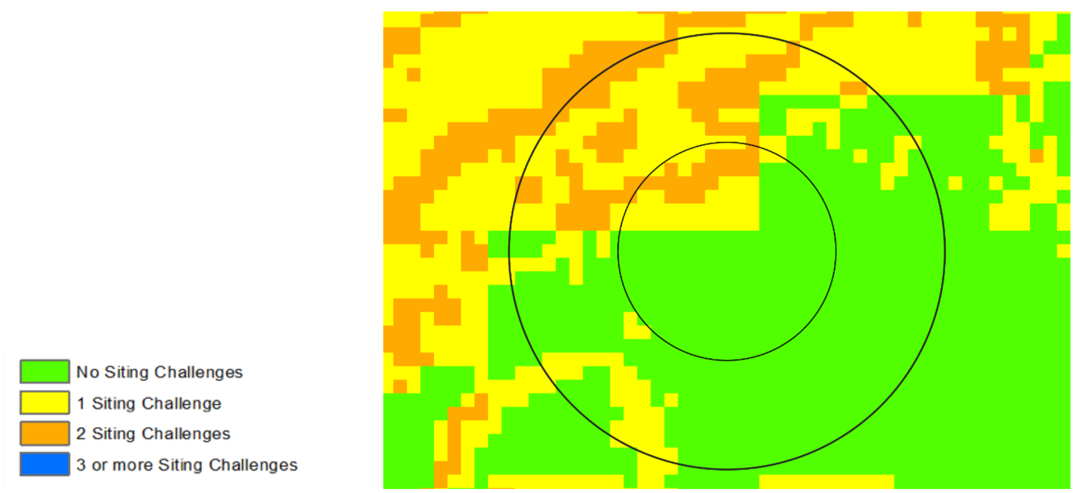


Figure 6-55: Composite OR-SAGE results for the ETTP site showing locations with siting challenges.

Figure 6-56 shows the aggregate 50-acre tracts at a 90% aggregation rate for the area. Aggregated cells that meet the threshold values are shown in green; otherwise the cells are shown as clear. Most of the land within a 0.5-mile radius of the ETTP site center can be aggregated into 50-acre parcels.

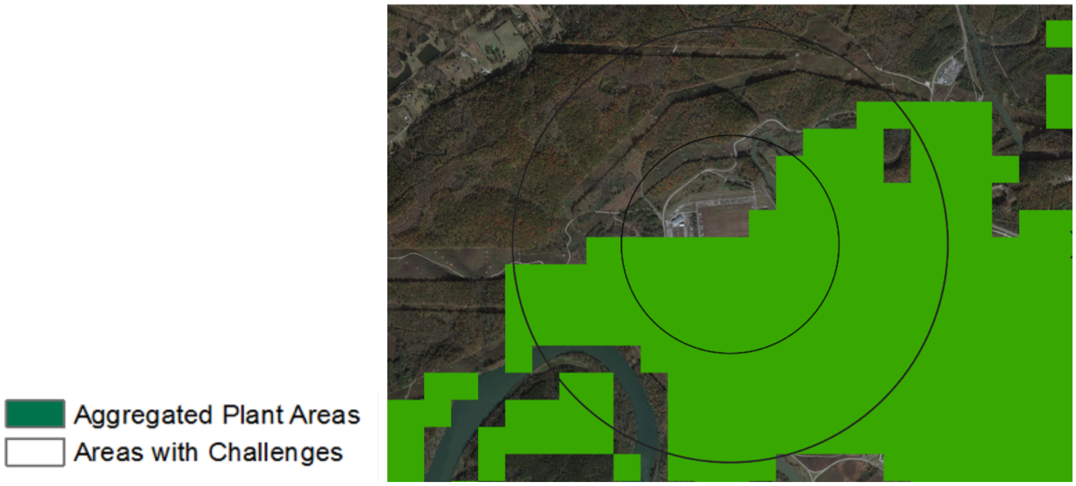


Figure 6-56: Aggregate OR-SAGE results for the ETTP site.

Table 6-28 provides several relative distance parameters that may weigh on the decision to site a demonstration reactor at the ETTP site.

Table 6-28: Distance from the ETTP site to various parameters of interest.

Parameter	Identification	Distance (miles)
Population Center (≥ 25,000 residents)	Oak Ridge	11.6
Airport	Mc Ghee Tyson	30.4
Major Road	I-40	5.9
Rail Transport	Knoxville & Holston River Railroad	0.2
Navigable waterway	Clinch River	0.7
Cooling water (≥ 30,000 gpm makeup)	Clinch River	0.7
Grid Capacity	TVA	0.7
Oil Refineries	Continental – Somerset	98.5

6.10.3 "Janet" results

Each of the quantitative and qualitative factors, as described in Section 2.3, were applied to the ETTP site. Table 6-29 provides parameter values that are included in the model for the ETTP site.

Table 6-29: "Janet" model attributes for the ETTP site.

"Janet" Model Attribute	Units	ETTP Value
Electric Energy Price	cents / kWh (all Sectors)	9.7
Total Net Imports	million kWh / yr	29717
Electric Energy Flow Trend Slope	million kWh/yr / yr	-687
Favorable State Energy Policy	Negative, Neutral, or Positive	Neutral
Nuclear Sentiment % Favorable	% of Favorability Toward Nuclear	84.2
CDC Social Vulnerability Index	Social Vulnerability Index (x 100)	43
Proximity to Nuclear R&D	Number of Locations within 100 mi	1

Table 6-30 provides demographic data for the ETTP site that can be utilized in an assessment to identify marginalized populations in the surrounding area. A list of known pro- and anti-nuclear groups relevant to the site is provided in Table B-6.

Table 6-30: Demographic overview of the area near the ETTP site.

ETTP	**Parameter**	**% White**	**% Black or African American**	**% Asian**	**% Native Hawaiian or Other Pacific Islander**	**% Some Other Race**	**% AIAN***
	Value	89.45	5.79	1.48	0	.93	.35
	Parameter	**% Two or More Races**	**% Minority**	**Per Capita Income ($)**	**% Unemployed**	**% No High School Diploma**	**% Below Poverty**
	Value	2	13.44	28787.89	5.85	12.04	16.02

*AIAN is an abbreviation for American Indian and Alaskan Native.
Source: American Community Survey (ACS) 2014-2018, 5-year estimates.

6.10.4 Assessment

Proximity and Safety Assessment: The broad ETTP site evaluated contained a number of areas in which one or more of the OR-SAGE thresholds were exceeded. The attributes involved were presence of flood plains, protected areas, wetlands, or open water as well as landside and slope challenges in the northwest of the site. However, there were still a number of 50-acre parcels in which there were no siting challenges. There is strong support and security infrastructure given the long history of nuclear development at the site and demonstration efforts would be enhanced by proximity to one of the leading nuclear research laboratories in the world.

Socioeconomic Assessment: The state of Tennessee has a neutral energy policy towards nuclear although the public sentiment is highly favorable at 84 percent. The population-weighted SVI for the surrounding counties is "Medium Vulnerability" to natural disasters and other disruptive events. In addition, the labor rates for the state are at the low end of the states evaluated.

Other Factors: There are no air quality issues at the site. Analysis of extreme weather conditions for the region show an increase in temperatures which could result in reductions in

the efficiency of cooling water and an increase in the requirements for installation HVAC systems.

6.11 The University of Illinois, Urbana-Champaign (UIUC) – Two Sites

6.11.1 Site Description

The UIUC locations selected for assessment are shown in Figure 6-57 and Figure 6-58. The locations analyzed assumes development of a smaller scale demonstration reactor that may allow siting closer to or on the University campus. The first potential site is located at the current location of the Abbott Power Plant. The second potential site is nominally 3 miles from Urbana, Illinois, a city with a population of approximately 42,000. Other alternative sites near Urbana-Champaign may be possible that would mitigate issues related to proximity to population centers. UIUC is home to one of the leading nuclear engineering programs in the nation and additional research and development support may be available from the Argonne National Laboratory which is located approximately 140 miles to the north of this site. Illinois is also home to the largest number of operating nuclear power plants for any state in the US. Appendix section D.7 lists the counties that surround the site and their populations.

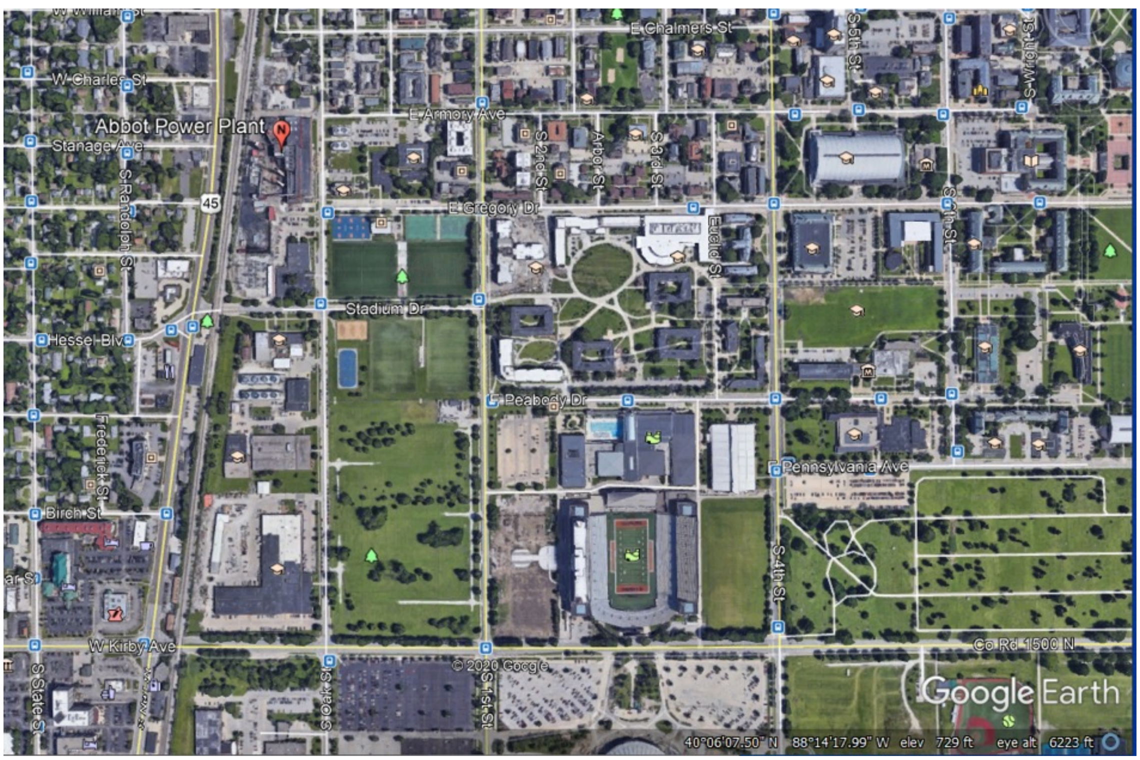


Figure 6-57: UIUC Abbott Power Plant Site. Central point for model analysis of siting attributes is shown at the pin drop in the upper left of the image.

Figure 6-58: UIUC Search Area. Central point for model analysis of siting attributes is shown at the pin drop in the center of the image.

6.11.2 OR-SAGE Results and detailed data – Abbott Power Plant Site

Each of the 10 nuclear siting parameters were applied to the Abbott Power Plant site on the main campus at UIUC along South Neil Street as shown in the Google Earth map in Figure 6-57. The results for each individual layer are shown in Figure 6-59, Figure 6-60, and Figure 6-61. Cells that do not meet the query threshold criterion are depicted in magenta; otherwise, cells that meet the threshold criterion are clear.

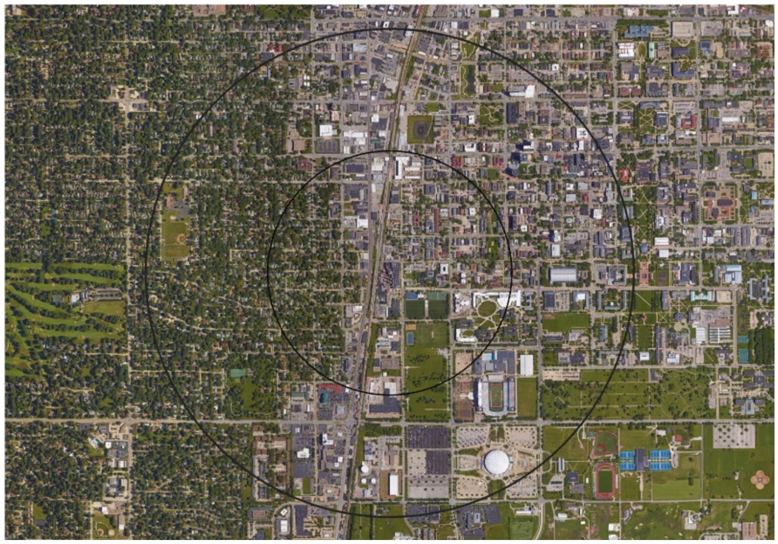


Figure 6-59: The Abbott Power Plant OR-SAGE results for faults, safe shutdown earthquake, slope, 100-year floodplain, wetlands and open water, and landslide risk indicate no query threshold issues.

Six of the OR-SAGE parameters completely meet the threshold query value in the vicinity of the UIUC site and are depicted clear as shown in Figure 6-59. The OR-SAGE parameters for protected lands and proximity to hazards (local airport) identified some limited impacts as shown by the magenta markings in Figure 6-60. These parameter thresholds do not encompass the entire central area of interest and warrant further investigation prior to eliminating the Abbott Power Plant site from consideration.

Figure 6-60: The Abbott Power Plant OR-SAGE results for protected lands (left) and proximity to hazards (right) indicates limited site impact beyond the central site area.

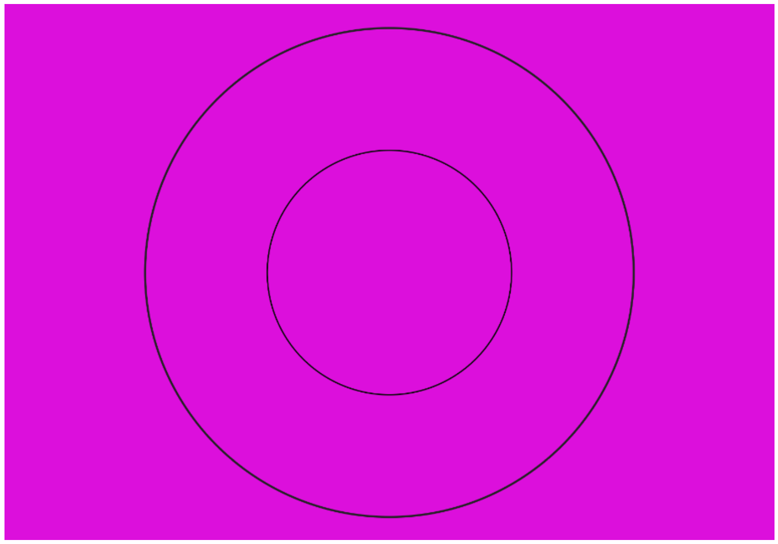


Figure 6-61: The Abbott Power Plant OR-SAGE results associated with population and streamflow indicates that the threshold query value is not met in area around the site.

The OR-SAGE parameters for population density and streamflow exceed the baseline query threshold values over the entire site as shown in Figure 6-61. The population density calculation can be adjusted smaller to evaluate the potential for siting a micro-reactor demonstration like the evaluation for a research reactor. If it can be shown that there are is no dose risk to the population beyond the site boundary, then it may be possible to eliminate the population parameter layer from consideration. However, it should be noted that for power reactors, 10 CFR 100 precludes siting within a population center of 25,000 residents or more. The streamflow issue can be eliminated with the selection of an advanced reactor technology that does not require significant cooling water makeup.

The composite map for the UIUC site is shown in Figure 6-62. Based on the discussion above, most of the map indicates three or more issues to be investigated further. If the population and streamflow constraints are removed, then the orange area would become green (no query threshold issues) and the blue area would become yellow (one query threshold issue). In this case, the Abbott Power Plant site would be more amenable for siting a reactor.

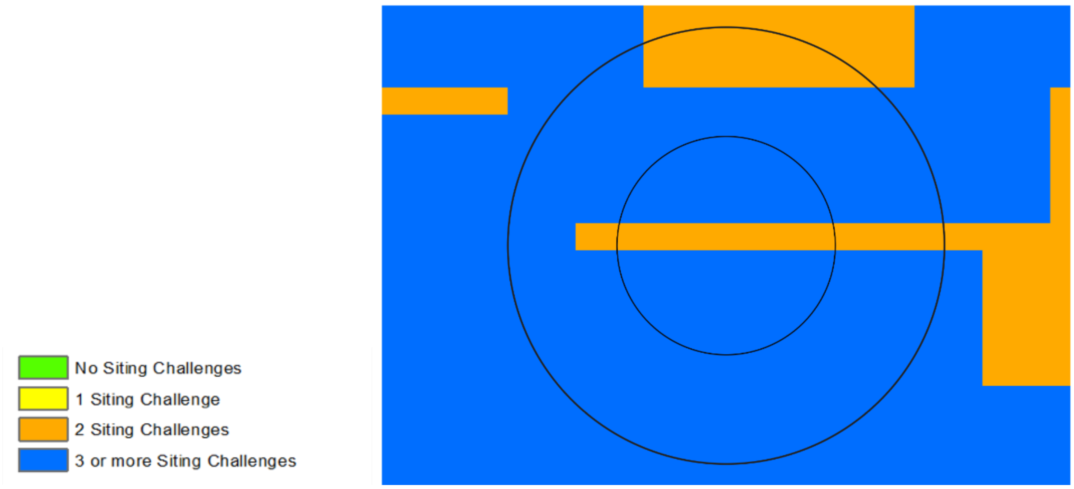


Figure 6-62: Composite OR-SAGE results for the Abbott Power Plant site showing locations with siting challenges.

Figure 6-63 shows the aggregate 50-acre tracts at a 90% aggregation rate. Aggregated cells that meet the threshold values are shown in green; otherwise the cells are shown as clear. None of the area around the Abbott Power Plant site meets all the query threshold values as discussed above. Therefore, the current OR-SAGE query results do not provide any 50-acre aggregated sites. As discussed above, further analysis and technology considerations could mitigate these results.

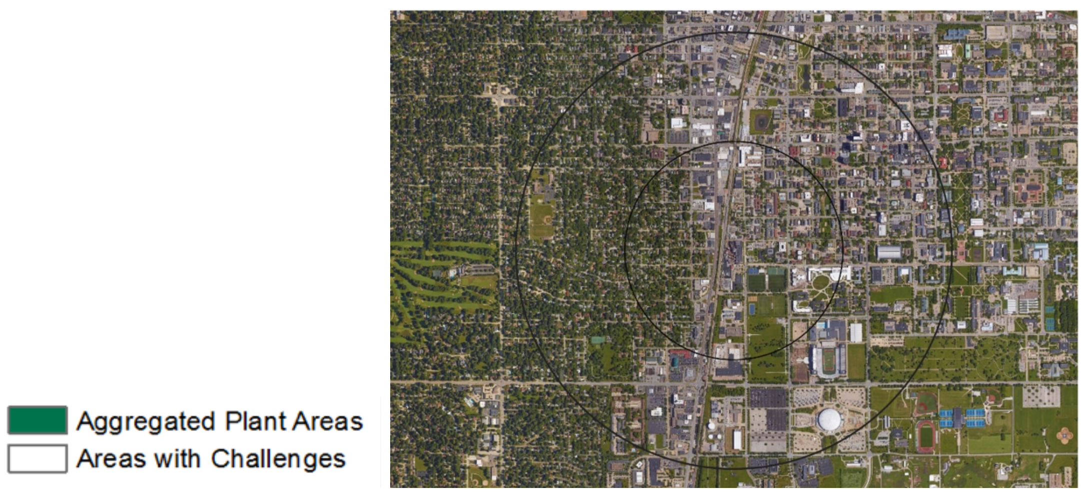


Figure 6-63: Aggregate map for the Abbott Power Plant site.

Table 6-31 provides several relative distance parameters that may weigh on the decision to site a demonstration reactor at the Abbott Power Plant site.

Table 6-31: Distance from the Abbott Power Plant site to various parameters of interest.

Parameter	Identification	Distance (miles)
Population Center (≥ 25,000 residents)	Champaign, IL	1.5
Airport	Willard	6.5
Major Road	US-45	0.08
Rail Transport	Canadian National Railway	0.05
Navigable waterway	Illinois River	106.0
Cooling water (≥ 30,000 gpm makeup)	Wabash River	55.9
Grid Capacity	Bonneville Power Administration	0.11
Oil Refineries	Marathon – Robinson	105.7

6.11.3 OR-SAGE Results and detailed data – UIUC Search Area

Each of the 10 nuclear siting parameters were applied to a representative UIUC site south of the main campus as shown in the Google Earth map in Figure 6-58. The results for each individual layer are shown in Figure 6-64, Figure 6-65, and Figure 6-66. Cells that do not meet the query threshold criterion are depicted in magenta; otherwise, cells that meet the threshold criterion are clear.

Figure 6-64: UIUC Search Area OR-SAGE results for faults, safe shutdown earthquake, slope, 100-year floodplain, protected lands, and landslide risk indicate no query threshold issues.

Six of the OR-SAGE parameters completely meet the threshold query value in the vicinity of the UIUC site and are depicted clear as shown in Figure 6-64. The OR-SAGE parameter for wetlands and open water identified some limited impacts as shown by the magenta markings in Figure 6-65. These parameter thresholds are outside the central area of interest.

Figure 6-65: The UIUC Search Area OR-SAGE results for wetlands and open water indicates limited site impact beyond the central site area.

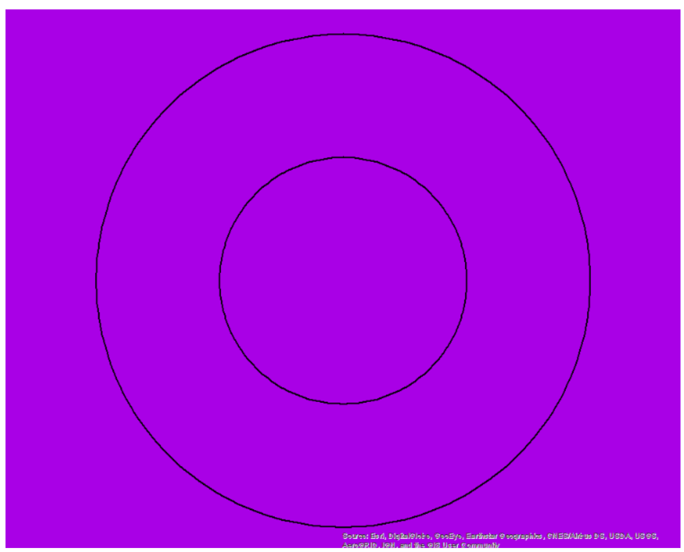


Figure 6-66: The UIUC Search Area OR-SAGE results associated with population, streamflow, and proximity to hazards indicates that the threshold query value is not met in area around the site.

The OR-SAGE parameters for population density, streamflow, and proximity to hazards (local airport) exceed the baseline query threshold values over the entire site as shown in Figure 6-66. The population density calculation can be adjusted smaller to evaluate the potential for siting a micro-reactor demonstration like the evaluation for a research reactor. The streamflow issue could be eliminated with the selection of an advanced reactor technology that does not require significant cooling water makeup. Finally, the proximity to the airport can be subjected to further risk evaluations that consider factors such as runway alignment, traffic, and site footprint.

The composite map for the UIUC site is shown in Figure 6-67. Based on the discussion above, the entire map indicates three or more issues to be investigated further.

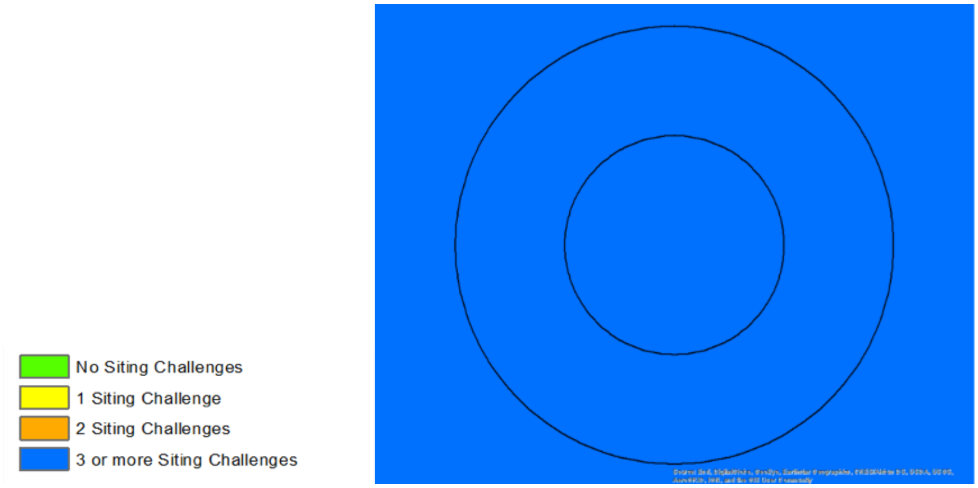


Figure 6-67: Composite OR-SAGE results for the UIUC Search Area showing the locations with siting challenges.

Figure 6-68 shows the aggregate 50-acre tracts at a 90% aggregation rate. Aggregated cells that meet the threshold values are shown in green; otherwise the cells are shown as clear. None of the area around the UIUC site meets all the query threshold values as discussed above. Therefore, the current OR-SAGE query results do not provide any 50-acre aggregated sites. Further analysis and technology considerations could mitigate these results.

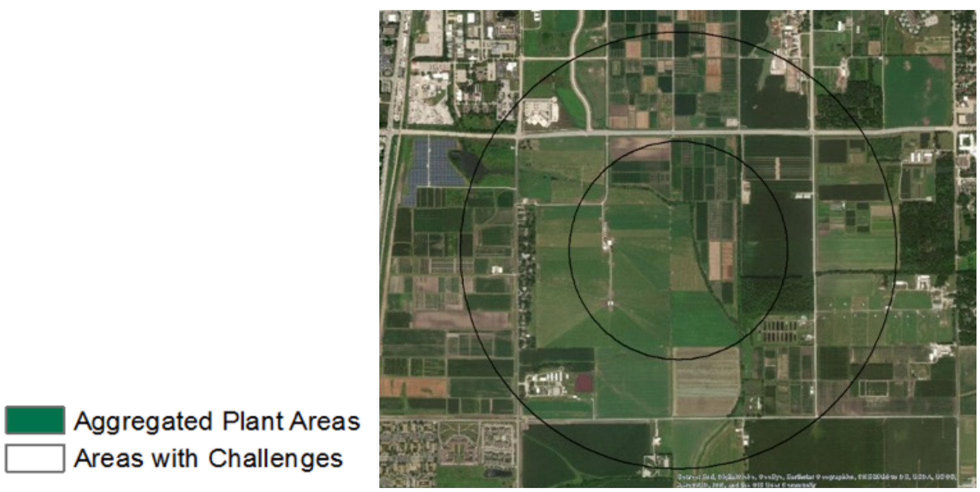


Figure 6-68: Aggregate OR-SAGE results for the UIUC Search Area.

Table 6-32 provides several relative distance parameters that may weigh on the decision to site a demonstration reactor at UIUC.

Table 6-32: Distance from the UIUC Search Area to various parameters of interest.

Parameter	Identification	Distance (miles)
Population Center (≥ 25,000 residents)	Urbana	3.3
Airport	Willard	4.9
Major Road	US-45	1.4
Rail Transport	Canadian National Railway	1.3
Navigable waterway	Illinois River	108.1
Cooling water (≥ 30,000 gpm makeup)	Wabash River	55.0
Grid Capacity	Bonneville Power Administration	0.5
Oil Refineries	Marathon – Robinson	103.2

6.11.4 "Janet" results

Each of the quantitative and qualitative factors, as described in Section 2.3, were applied to the UIUC sites. The close proximity of the Abbott Power Plant site to the Search Area results in identical results from "Janet." Table 6-33 provides parameter values that are included in the model for the UIUC sites.

Table 6-33: "Janet" model attributes for the UIUC sites.

"Janet" Model Attribute	Units	UIUC Value
Electric Energy Price	cents / kWh (all Sectors)	9.45
Total Net Imports	million kWh / yr	-33097
Electric Energy Flow Trend Slope	million kWh/yr / yr	3810
Favorable State Energy Policy	Negative, Neutral, or Positive	Negative
Nuclear Sentiment % Favorable	% of Favorability Toward Nuclear	48.1
CDC Social Vulnerability Index	Social Vulnerability Index (x 100)	42
Proximity to Nuclear R&D	Number of Locations within 100 mi	1

Table 6-34 provides demographic data for the UIUC sites that can be utilized in an assessment to identify marginalized populations in the surrounding area. A list of known pro- and anti-nuclear groups relevant to the site is provided in Table B-6.

Table 6-34: Demographic overview of the area near the UIUC sites.

	Parameter	% White	% Black or African American	% Asian	% Native Hawaiian or Other Pacific Islander	% Some Other Race	% AIAN*
UIUC	Value	80.39	10.18	6.14	.04	.9	.19
	Parameter	**% Two or More Races**	**% Minority**	**Per Capita Income ($)**	**% Unemployed**	**% No High School Diploma**	**% Below Poverty**
	Value	2.16	23.45	30142.84	4.79	6.53	17.4

*AIAN is an abbreviation for American Indian and Alaskan Native.
Source: American Community Survey (ACS) 2014-2018, 5-year estimates.

6.11.5 Assessment

Proximity and Safety Assessment: The entire UIUC Abbott site exceeded the OR-SAGE siting thresholds for population density and streamflow. Additionally, areas around the site exceeded the OR-SAGE siting thresholds for protected lands and proximity to hazards (the local airport), however, some 50-acre parcels were identified which were below the thresholds. Depending on the type of reactor proposed for the site, some of these challenges could be removed while others would need further investigation.

The entire UIUC Search Area site exceeded OR-SAGE siting thresholds for population density, stream flow, and proximity to hazards. OR-SAGE could not identify any 50-acre locations without a siting challenge based on the chosen site centroid. Mitigation may be possible if alternate locations further from the Urbana-Champaign population center and airport were considered. This could be assessed in future siting analyses.

Demonstration efforts at both UIUC sites would be enhanced by proximity to one of the leading University nuclear engineering programs in the US and availability of support from Argonne National Laboratory, one of the premier nuclear research laboratories in the world.

Socioeconomic Assessment: The state of Illinois has a negative energy policy for nuclear due to the current state moratorium for new reactor builds and the public favorability sentiment is neutral, at 48 percent. The population-weighted SVI for the surrounding counties was assessed as “Medium Vulnerability” to natural disasters and other disruptive events. The labor rates for Illinois were the highest of all of the states involved for the two construction related categories and were third in the two operational phase categories.

Other Factors: Other Factors: There are no air quality issues at the site. Analysis of extreme weather conditions for the region show an increase in temperatures which could result in reductions in the efficiency of cooling water and an increase in the requirements for installation HVAC systems.

APPENDICES

Appendix A: OR-SAGE Model Details

Numerous studies have been conducted that spotlight the country's future energy needs. One such energy assurance study conducted by ORNL in 2009 examined the key issues associated with the country's future energy needs, focusing on generation sources, base load options, transmission and distribution, reduction of greenhouse gases, and overall energy security issues. One principal finding was that significant new nuclear electrical generating capacity would be needed by 2050. With that need identified, an initial, obvious question was the availability of installation sites for additional nuclear capacity in the United States. To address that question and others, ORNL initiated an internally-funded multiphase national electric generation siting study addressing several key questions related to the U.S. national electrical energy supply. That effort led to the development of the OR-SAGE tool to support power generation siting evaluations.

The objective in developing OR-SAGE was to use industry-accepted approaches and/or develop appropriate criteria for screening sites and employ an array of GIS data sources at ORNL to identify candidate areas for a variety of power generation technology applications. The available guiding concepts were used to develop exclusionary, avoidance, and suitability criteria for screening sites for a variety of power generation types, including nuclear power plants. For a given technology application, it is necessary to develop evaluation parameters that encompass several key screening criteria that essentially provide for a basic site characterization for that application. Parameters evaluated include population density, slope, seismic activity, proximity to cooling water sources, proximity to hazard facilities, avoidance of protected lands and floodplains, susceptibility to landslide hazards, and others. OR-SAGE is a visual, relational database. The evaluation parameters are the fields of the database, and the GIS data for a given variable represent the values against which searches, or queries can be performed. Figure A-1 demonstrates the visual database concept. Over time, the OR-SAGE tool has been used extensively to inform nuclear power plant siting. The database partitions the contiguous U.S., a total of 7.2E8 hectares (~1.8 billion acres), into 100- by 100-m (1 hectare or ~2.5 acre) cells. Therefore, the database is tracking just under 700 million individual land cells.

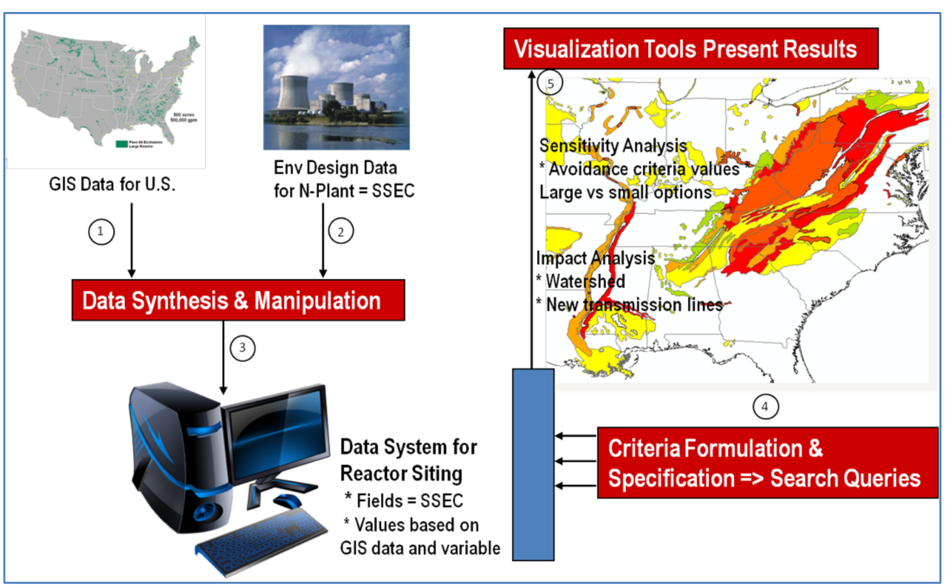


Figure A-1: OR-SAGE functions as a visual database.

The OR-SAGE process is very versatile and ORNL staff have used the OR-SAGE tool to evaluate site screening criteria for large and small nuclear power plants, advanced coal plants with carbon sequestration, wet and dry solar power technologies (excluding photovoltaic cells), compressed air energy storage, nuclear fuel cycle component siting, spent nuclear fuel storage siting, and borehole waste storage siting. The principal differences between large and small nuclear power plants in the EPRI study [3] were cooling water demand and plant footprint.

A.1 Approach and Methodology

The screening process divides the contiguous U.S. into 100- by 100-m (1 hectare) squares (cells), applying successive site suitability parameters from more than 40 different datasets to each cell. Some site suitability parameters preclude siting a plant because of an environmental, regulatory, or land-use constraint. Other parameters assist in identifying less-favorable areas such as proximity to hazardous operations. All the selected site suitability parameters tend to recommend against sites; that is, they tend to identify areas in which there are challenges to using the site for the purpose of interest. At this point, the suitability criteria are employed to assist in evaluating the acceptability of candidate areas and sites.

In general, the OR-SAGE site evaluation process stops short of identifying specific power plant sites. The OR-SAGE approach was initially designed to quickly screen for and characterize candidate areas. However, over time, the OR-SAGE process has been used to evaluate siting parameters for pre-designated sites. It must be noted that any OR-SAGE results are simply used to flag potential siting issues and all parameters must be followed up with a more thorough investigation for any site of interest.

A discussion of the OR-SAGE process steps is available from the EPRI GIS report [3]. Datasets that provide national or greater coverage with attributes matching the desired site evaluation parameters are selected. The specific parameters identified for each power source are detailed as part of the results discussion for each power source. Greater than national coverage is preferred to prevent map "edge-effects." Appropriate scaling and resolution of each dataset must be considered before using a dataset in the study. There are 22 datasets supporting the nuclear plant siting evaluations. The dataset sources include:

- U.S. Geological Survey (USGS), U.S. National Park Service,
- U.S. Forest Service,
- U.S. Fish and Wildlife Service,
- U.S. Department of Transportation,
- Federal Emergency Management Agency,
- Federal Aviation Administration,
- U.S. Census Bureau,
- ORNL LandScanTM data (a high-resolution population distribution database developed by ORNL),
- ORNL 7-Day, 10-Year Low Flow Calculated Data, and
- other commercial sources.

Some data layers involve generating an appropriate selection query and applying a buffer zone to the parameter of interest. The application of the buffer zone can be a complex process. For example, one of the nuclear power plant siting parameters is population density of less than 500 people per square mile out to a specified distance from the site. NRC Regulatory Guide 4.7 [2] indicates 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.*

To meet the guidance, each cell in the database is queried for the nearby population, taking into consideration the weighted transient population. If a cell population is greater than 500 people per square mile, it is immediately excluded. If a cell population is less than 500 people per square mile, the surrounding area is evaluated by calculating the population density in an expanding set of 1-mile rings out to a maximum of 20 miles (in simple terms, a buffer zone). If any ring is determined to have a population density above 500 people per square mile, then the center cell is excluded. If no ring around the central cell exceeds a population density of 500 people per square mile, then the cell remains viable with regard to population. Figure A-2 shows a representative result of a population dataset query with a buffer distance considered. The maximum search radii can be set at a value less than 20 miles to create alternate buffer distances. Smaller reactor technologies can evaluate the impact on siting with smaller population density caps to reflect to reflect the industry contention of smaller source terms and other favorable design attributes. This is discussed further in Section A.2.1.

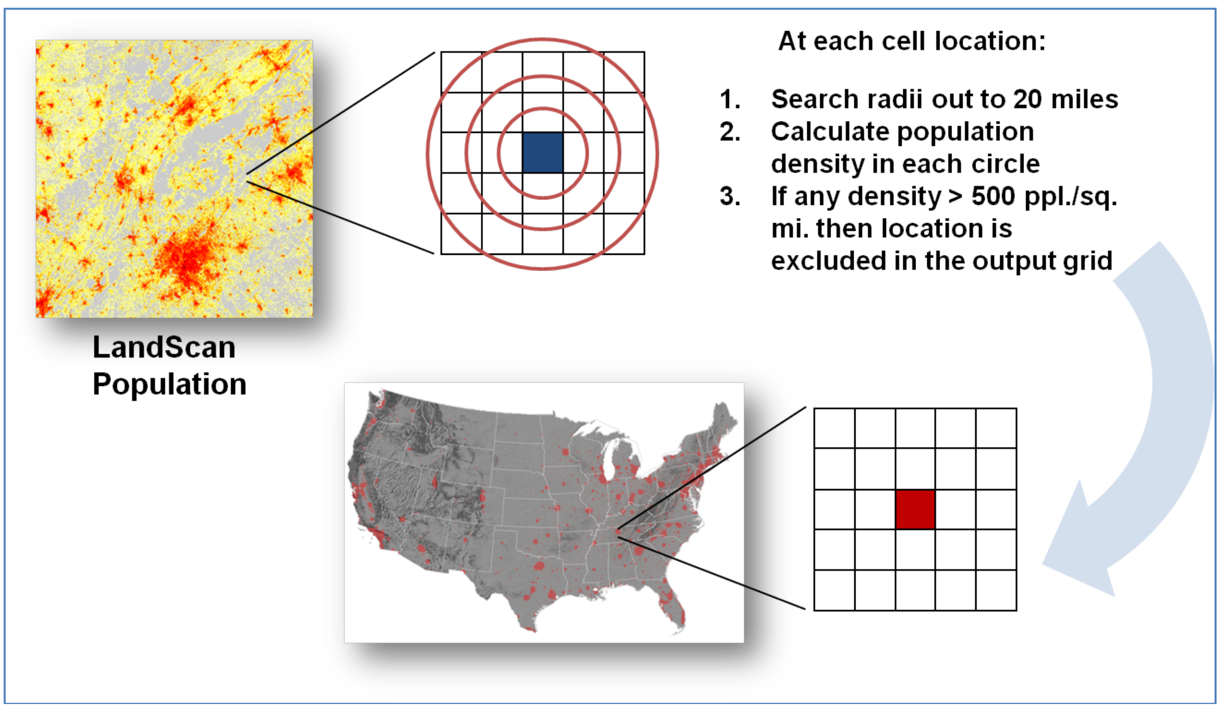


Figure A-2: Sample population calculation for each grid cell.

Buffering can also be a much simpler process, such as applying an area of land around a known geological feature. For example, Figure A-3 shows a stream segment and a 20-mile buffer zone to allow for pumping cooling water to a thermal power plant.

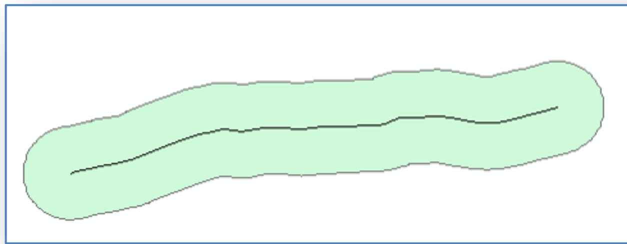


Figure A-3: Sample river segment with a 20-mile piping distance buffering.

A threshold value is selected for each parameter layer. A baseline set of threshold siting values is provided. Individual parameter layers from the query results are then assembled into a single output. Essentially, the applicable layers are summed cell-by-cell. The result is a highlighted map of all the areas that pose a challenge to the envelope criteria for the power source under consideration. Individual layers can be moved in and out of the study to conduct sensitivity analyses. Additional data layers can also be added as deemed appropriate for the analysis. Since the desired result is to identify candidate areas where a given power plant technology is viable, the highlighted portions of the challenge map are inverted to reveal an alternately highlighted map of all areas that have no siting challenges based on the chosen site selection and evaluation criterion. This result is the siting base map for the baseline OR-SAGE query. In effect, it is one static look in time at a set of threshold criteria that are thought to bound the placement of a power plant technology. Each 100- by 100-m cell that meets the selected threshold for each query parameter is typically highlighted in green on the base map. The overall concept, as shown in Figure A-4, depicts the general application of OR-SAGE methodology by applying the individual bounding parameters as GIS dataset layers to identify and highlight challenge areas (red map) leading to the identification of candidate areas (inverse green map). This is not intended to provide go-no go insight on siting. Other considerations are available for map areas that have one or more identified siting challenges.

Given that a single cell represents approximately 2.5 acres of land, a technology footprint must be identified along with connected plots of land (cells) that can support the technology. A typical size for a given power source can be highly subjective, but the essential footprint of most small nuclear technologies under consideration is typically 50 acres or less. The land aggregation process is the initial sensitivity study for any given power source. Cells that cannot be combined into a larger (50-acre) plot of land to support a given technology are turned off in the output display. The result is a pared-down base map or aggregate map identifying candidate areas where the power source of interest could realistically be sited. Aggregation of the cells into larger footprint parcels requires only 90% or more of the individual cells to pass the collective threshold parameter values. This allows for small imperfections in a given parcel size without requiring that the parcel be discarded from further consideration. This land aggregation process is discussed in more detail in the EPRI GIS report [3].

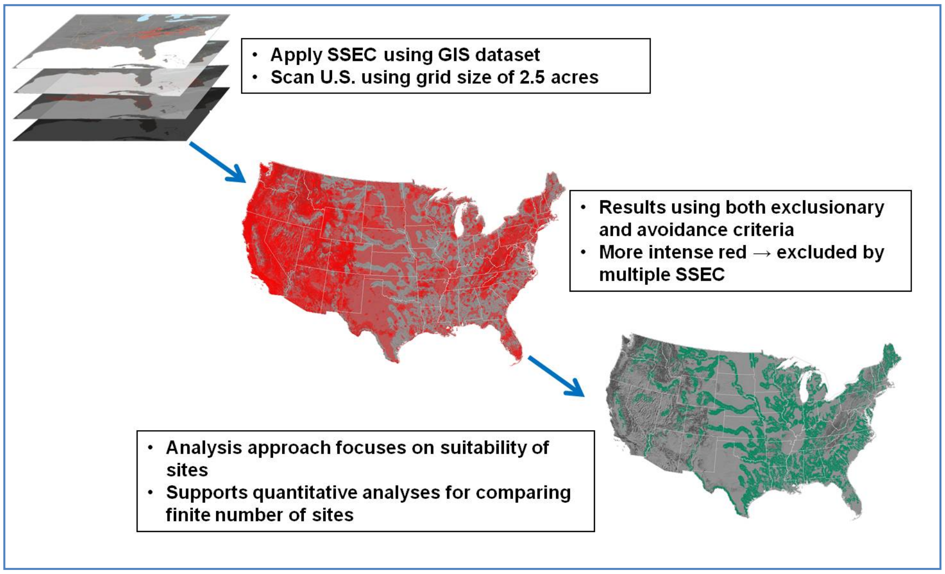


Figure A-4: Generating a base map with no siting challenges.

A.2 Nominal Site Selection and Evaluation Criteria

The NRC provides regulations for nuclear plant siting in 10 CFR 100 [21] and provides well defined regulatory guidance for siting a nuclear power plant in Regulatory Guide (RG) 4.7 [2]. DOE does not need to conform to NRC requirements and guidance for non-power reactors; however, recent projects have used the non-power siting guidance provided in NUREG-1537 [23]. The selected nuclear power plant siting parameters in OR-SAGE are based on providing a high level of discrimination and readily available data while providing a reasonable set of bounding criteria. A discussion of each nuclear parameter from Table 3-1 is provided below.

A.2.1 Population Density

The regulatory requirements in 10 CFR 100 for population have to do with potential radiation dose at the site boundary and in the low population zone (LPZ) surrounding the site, as well as the distance to a population center of 25,000 residents or more. In addition, 10 CFR 100 states that reactor sites should be located away from very densely populated centers. Areas of low population density are, generally, preferred.

Population densities of greater than 500 people per square mile begin to transition into an urban setting. One of the advantages of small modular reactors and advanced reactor technologies is the ability to replace smaller, aging electric plants located closer to population centers. Arguments for allowing SMRs to be closer to population centers typically include a reduced core damage frequency, elimination of large-break loss-of-coolant accident sequences, smaller source term, reduced early release fraction, reactor vessels and containment vessels that are located entirely underwater or below grade, and reactor buildings that are located partially or totally below grade.

The NRC has provided siting guidance to help applicants meet the requirements in 10 CFR 100. Since radiation dose is technology specific and closely held data, the NRC has established siting guidance in Regulatory Guide (RG) 4.7 that focuses more on remote siting with a limited population density near the proposed plant site. OR-SAGE uses technology site footprint surrogates and the NRC siting guidance found in RG 4.7 which recommends an evaluation of population density of 500 people per square mile (ppsm) out to 20 miles from the site and to consider population density for 5 years following commissioning. OR-SAGE has an algorithm to calculate the population density in and around each cell in successive 1-mile ring calculations. If any calculation fails, then the cell is flagged. This methodology can be plotted to show that a current large Light Water Reactor (LWR) must be at least 4 miles from a population center of 25,000 people (10 CFR 100 siting reference population), implying an associated LPZ of 3 miles (regulatory dose limits). This can further be interpreted to show that the population within 10 miles of a proposed site must be less than 157,000 people and the population within 20 miles must be less than 628,000 people.

One way that the OR-SAGE evaluation has been adjusted to address smaller reactor technologies is to reduce the population cap calculation from 20 miles to a smaller value. Past OR-SAGE studies have used a population cap calculation value of 10 miles for small modular reactor evaluations assuming that they could be sited closer to population centers, although this adjustment had no regulatory or guidance basis. However, the NRC has recently begun taking a closer look at advanced reactor siting.

The NRC staff has prepared SECY 20-0045 [22] for consideration by the Commission with some alternative siting guidance options for advanced reactors based on the Nuclear Energy and Innovation Modernization Act (NEIMA) definition. The NRC is not proposing any change in the 10 CFR 100 regulations for siting. Instead, they are looking at providing alternative siting guidance. The siting guidance option recommended by the staff in SECY 20-0045 aligns the advanced reactor (NEIMA definition) siting guidance with proposed revisions to the emergency planning requirements and the radiological consequences calculated for design-specific events. The staff has recognized that the LPZ for a given reactor technology and the reactor exclusion area boundary (EAB) may be the same based on dose requirements as associated source terms diminish with size. Therefore, the staff has recommended that if the LPZ remains larger than the EAB based on calculated dose from a design basis event or if a design basis event results in an offsite dose exceeding 1 Rem over the following 30 days then siting guidance will exclude areas with greater than 500 ppsm out to a distance equal to twice the distance at which the 1 rem dose over 30 days is calculated. This will likely be a short distance. The TVA Clinch River ESP had emergency planning calculations for 2 miles and for the site boundary. Under the same staff option, if there is no licensing basis event dose exceeding 1 Rem beyond the EAB, then the reactor can be sited right up to the edge of a population center of 25,000 people or more and within population centers smaller than 25,000 people. Therefore, for Phase I of this project, the OR-SAGE population density calculation was capped at 4 miles to reflect the opportunity to site advanced demonstration power reactors much closer to population centers. The population density calculation for very small demonstration power reactors could potentially be capped at even smaller values, such as 2 miles in accordance with the SECY 20-0045 recommendations.

A.2.2 Geologic Considerations

There are a number of geologic considerations that must be considered for nuclear power plant siting. Parameters that are easily evaluated on a national basis include seismic restrictions, proximity to fault lines, steep slopes, and landslide risk. These parameters are incorporated into the OR-SAGE tool.

The safe shutdown earthquake peak ground acceleration (2% chance in a 50-year return period) greater than a selected threshold parameter value is flagged by OR-SAGE. The 2002 EPRI siting guidance recommended limiting large reactor technologies to less than 0.3 g safe shutdown earthquake peak ground acceleration. As small modular reactors and advanced reactor technologies allow for more seismic mitigation through design, the OR-SAGE threshold parameter for seismic activity has been set slightly higher at 0.5 g safe shutdown earthquake peak ground acceleration. Mitigating design features may include smaller footprints, smaller piping systems, passive safety systems, underground installation, and improved seismic isolation. As noted, this value is variable within the database and can be adjusted based on technology.

Land too close to identified fault lines is flagged by the OR-SAGE tool. Table 1 in Appendix A to 10 CFR 100 provides a relationship between fault length and a standoff distance from the reactor site. This table is embedded in the OR-SAGE evaluation of faults. If a cell is too close to a fault of a given length per the table, then the cell is flagged. The fault evaluation in OR-SAGE is fixed and cannot be adjusted.

Steeper slopes are avoided based on the economic cost of preparing the site for construction. The 2002 EPRI siting guidance recommended limiting the slope to 12% for large reactor sites. Since small modular reactors and advanced reactor technologies tend to have smaller footprints compared to current large reactors, this value is relaxed to 18% as the baseline threshold value in OR-SAGE for these technologies recognizing that more extensive site work to prepare a relatively small site may be justifiable. This threshold value is variable within the database and can be adjusted based on technology and site economics.

The USGS provides broad landslide and sink hole risk based on generic geological data for land regions. OR-SAGE flags cells falling within areas of moderate or high risk. This does not imply that a site is unusable; it is merely a flag to indicate the need for further localized geologic evaluation for landslide and sink hole risk.

A.2.3 Water Considerations

Current large LWRs rely on cooling water for heat rejection. Therefore, plants that rely on makeup cooling water will need to be located in proximity to a water source. Conflicting water considerations for siting include wetlands and open water as well as areas that lie within a designated 100-year flood plain. These parameters are easily evaluated on a national basis and are incorporated into the OR-SAGE tool.

The OR-SAGE tool assumes a closed-cycle cooling system with freshwater makeup water requirements. Cooling water makeup requirements are based on rules of thumb for cooling water makeup required per megawatt of generation. These rules of thumb are consistent with environmental analyses supporting site evaluations submitted to the NRC. A subset of reactor technologies can be bounded by a threshold makeup need and a siting assessment for makeup cooling water need can be evaluated. In this case, the threshold parameter value is selected based on the largest MWe rating of the nominal reactor technology configuration (single plant, multi-module, etc.). Additionally, based on the EPRI siting guidance it was assumed that cooling water makeup should be limited to taking no more than 10% of the available stream flow. This limits the siting of reactor plants to the vicinity of streams with sufficient flow volumes. Twenty miles was considered to be within reasonable proximity to a cooling water source, allowing for piping and pumps. The OR-SAGE tool has a number of preset makeup water values for selection as the threshold value of interest. Other methods for providing cooling include saltwater, aquifers, grey (sanitized) water, and air-cooling. Alternate cooling water sources are not directly modeled. For air-cooled technologies, the cooling water layer can be pulled from the analysis.

Cells in the OR-SAGE model that are evaluated to fall within wetlands and open water are flagged and excluded. In general, the tool will identify all areas containing surface water, including engineered cooling ponds near a site of interest. Follow-up consideration of a site can determine any limitations associated with such features. Likewise, cells that are evaluated to fall within an identified 100-year floodplain are flagged and excluded.

A.2.4 Other Considerations

Proximity of a cell to other land uses or risks are also evaluated by the OR-SAGE tool. Areas considered include a large class of land that is considered protected for other public uses and cells that may be excluded based on their proximity to facilities that could provide a hazard to nearby reactor operation.

Protected lands include national parks, national monuments, national forests, wilderness areas, wildlife refuges, wild and scenic rivers, state parks, county parks, American Indian lands, Bureau of Land Management, hospitals, colleges, schools, and correctional facilities. These lands are excluded based on their public nature. Exclusions based on the individual datasets are fixed; however, any given protected land dataset can be turned off for special consideration. For example, the American Indian lands layer could be turned off if there were interest in siting a facility on American Indian land.

Land in the vicinity of facilities that could pose a hazard to the safe operation of a reactor include commercial airports, oil refineries, and military bases. The vapor plume from any associated reactor cooling water tower could also pose a risk to a nearby commercial airport. Commercial airports are identified with a 10-mile buffer in the OR-SAGE database. Refineries are pinpointed with a 1-mile buffer and military facilities are outlined with a 1-mile buffer. Cells that fall inside the buffer zone for one of these facilities are flagged for further analysis. In the case of airports, this could be a risk assessment to further evaluate the runway orientation and the operations tempo. Military bases may be considering siting a reactor on the facility. In this case, the exclusion layer for military bases can be removed.

A.3 Data Summary

The OR-SAGE data sources and time stamp are shown in Table A-1.

Table A-1: OR-SAGE Data Summary

Data Category	Data Set Details and Use	Source Date
Population	Excludes all areas with population density greater than 500 people per square mile. [30 arcsecond (~ 1 km) resolution, ambient population distribution]	2019
Data Source: http://www.ornl.gov/sci/landscan.		

Data Category	Data Set Details and Use	Source Date
Safe Shutdown Earthquake	Excludes areas having a 2% chance in 50-year return period of peak ground acceleration greater than specified value	CONUS – 2019 Alaska - 2007
Data Source: https://www.sciencebase.gov/catalog/item/5d5597d0e4b01d82ce8e3ff1		
Tectonic Sources and Faults	Used to exclude areas using a variable buffer distance based on the length of the fault line	2018
Data Source: https://www.usgs.gov/natural-hazards/earthquake-hazards/faults?qt-science_support_page_related_con=4#qt-science_support_page_related_con		
Wetlands	Used to exclude areas defined as open water or wetlands through satellite remote sensing of land cover	2016
Data Source: https://www.mrlc.gov/data/nlcd-2016-land-cover-conus		
Protected Lands (Sub-categories noted below)	Used to exclude managed lands and built environment.	
National parks, monuments, forests, and wilderness areas	National Atlas– Federal Lands	2016
Data Source: https://prd-tnm.s3.amazonaws.com/StagedProducts/Small-scale/data/Boundaries/fedlanp010g.shp_nt00966.tar.gz		
National, state, and local parks and forests	Contains national, state, county, local parks and forests	2019
Data Source: https://www.arcgis.com/home/item.html?id=578968f975774d3fab79fe56c8c90941		
Wild and scenic rivers	2-mile buffer added	2016
Data Source: https://enterprisecontentnew-usfs.hub.arcgis.com/datasets/national-wild-and-scenic-river-lines-feature-layer/data		
Wildlife refuges	Merged from regional data	2019
Data Source: https://www.fws.gov/gis/data/CadastralDB/links_cadastral.html		
American Indian reservations		2017
Data Source: https://www2.census.gov/geo/tiger/TIGER2017/AIANNH/		
Hospitals	0.25-mile buffer around points	2020
Data Source: https://hifld-geoplatform.opendata.arcgis.com/datasets/hospitals		
Correctional facilities	0.25-mile buffer around points	2018
Data Source: https://hifld-geoplatform.opendata.arcgis.com/datasets/prison-boundaries/data		
Schools/colleges	0.25-mile buffer around points	2019
Data Source: https://hifld-geoplatform.opendata.arcgis.com/datasets/colleges-and-universities		

Data Category	Data Set Details and Use	Source Date
Inventoried roadless areas		2014
Data Source: https://www.fs.usda.gov/detail/roadless/2001roadlessrule/maps/?cid=stelprdb5382437		
Areas of critical environmental concern	Merged from state data	2012-2019
Data Source: https://navigator.blm.gov/data?keyword=critical		
Slope	Used to exclude areas with slopes greater than desired.	2013
Source: http://nationalatlas.gov/atlasftp-1m.html		
Landslides	Used to exclude all areas with moderate of high incidence or susceptab9ility to landslides.	2020
Data Source: https://maps1.arcgisonline.com/arcgis/rest/services/USGS_Landslides/MapServer/0		
100-year Floodplain	Used to exclude all areas with the 100-year flood plan. Data quality and availability vary by county.	2018
Data Source: ftp://newftp.epa.gov/epadatacommons/ORD/EnviroAtlas/Estimated_floodplain_CONUS.zip		
Hazardous Facilities	EPRI siting guidelines consider these existing facilities as avoidance criteria. Major airports have a 10-mile buffer zone; Refineries have a 5-mile buffer. (Some SMR studies use 5-mile and 1-mile buffers)	2019
Data Sources: https://data-usdot.opendata.arcgis.com/datasets/airports https://www.eia.gov/maps/layer_info-m.php		
Streamflow Cooling Water Makeup	Used to exclude areas further than 20 miles from streams with varying flow, depending on the makeup requirements of the energy source.	2012
ORNL calculated data using USGS gage data		

Appendix B: "Janet" Model Details

Identifying the best suited end users for early adoption can have an outsized influence on the ultimate success of any new technology – and this is perhaps especially true for advanced nuclear energy. The FPTZ Initiative at the UMich has incorporated a broad range of geographic, social, political, and economic data into a geo-spatial database to support research and decision-making objectives related to the early demonstration and deployment of advanced nuclear technologies. The Initiative is first and foremost comprised of practitioners who are applying insights drawn from social science concepts to the effort of building tools to help improve the real-world process of technology deployment.

Decisions about energy technology adoption typically require the consideration of many different criteria and the cooperation and consent of many different stakeholders. The variety of size, scale, and applications of advanced reactors could open the door for many use-case scenarios. The complexity of these interactions is difficult to capture in model form; however, efforts to identify, collect, and organize key geographic, political, economic, and social attributes to aid in the decision-making process are being made. This unique database tool, called "Janet", has allowed for the initiation of systematic characterization of communities that have hosted nuclear facilities in the past as well as those that may want to host advanced nuclear technologies in the future. The approach is not a fixed model, but rather a flexible, user-driven process of weighing and prioritizing criteria in a tailored fashion. This approach should not be thought of as a replacement for community engagement, grant-making, or feasibility studies aimed at assessing community consent for hosting advanced reactors, but rather as an integral aid in those efforts.

B.1 Technical Summary of Database

To collect and cross-reference key information that can help identify potential early adopters of advanced nuclear technologies, a comprehensive database, "Janet," has been developed covering the whole of the U.S. The data are hosted through the UMich, using the Google Cloud Platform. "Janet" is a PostgreSQL relational database with PostGIS extension. This allows users to perform spatial querying. The database is designed to leverage data relationships in two primary ways, the first is through the relationship between two geographies or a set of geographic coordinates. The second is through codes or keys which uniquely identify geographic areas. An example of this would be Federal Information Processing System codes. The extensive database includes geographic, economic, political, and social—all of which are necessary in order to fully understand and provide accurate proposals for both site selection and community outreach. An overview of some of the key data sources can be seen in Table B-1 through Table B-4. Table B-5 identifies the specific data and data sources utilized in this current effort.

Table B-1: "Janet" Selected Economic Data

Basic Description	Date	Data Source	Janet Architecture Element
SEDS Database	2018 Updated \yearly with a one year delay. API and bulk download	EIA	Economic-Energy Costs
EIA Datasets	Updated on the schedule provided by API (yearly, monthly, daily)	EIA	Economic-Energy Costs
Monthly Electric Generator Inventory	2020 Updated monthly	EIA	Economic-Energy Costs
Social Cost of CO2	2018	EPA	Economic-Energy Costs
DSIRE Database	2020 Updated inconsistently, bulk download	North Carolina Clean Energy Technology Center	Economic-Energy Incentives and Financing
Energy Mix	2019	EIA	Economic-Energy Mix

Table B-2: "Janet" Selected Geographic Data

Basic Description	Date	Data Source	Janet Architecture Element
Census Geographies	2018	Census/Tiger Lines	Geographic-Buildable Areas
Tribal Lands 2017	2017	Tiger Line	Geographic-Buildable Areas
Protected Lands: Designation, Easement,Fee,Proclamation,Marine	2015	USGS Protected Areas Database-US	Geographic-Buildable Areas
Border Crossing Elect	2019	US Dept. Energy	Geographic-Locational Data
Border Crossing Liquids	2019	US Dept. Energy	Geographic-Locational Data
Border Crossing Natural Gas	2019	U.S. Department of Energy, Federal Energy Regulatory Commission	Geographic-Locational Data
Coal Mines	2019	U.S. Department of Labor, Mine Safety and Health Administration Form 7000-2	Geographic-Locational Data
Crude Oil Pipelines	2020	Created by EIA using publicly available data	Geographic-Locational Data
Crude Oil Rail Terminals	2019	Created by EIA using publicly available data	Geographic-Locational Data
Electric Retail Service Territories	2019	Homeland Infrastructure Foundation	Geographic-Locational Data
Electric Substations	2019	Homeland Infrastructure Foundation	Geographic-Locational Data
Electric Transmission Lines	2019	Homeland Infrastructure Foundation	Geographic-Locational Data
Thermal Potential	2012	National Renewable Energy Laboratory	Geographic-Locational Data
Hydrocarbon Gas Liquids Pipelines	2020	EIA	Geographic-Locational Data
Liquid Natural Gas Terminals	2020	EIA	Geographic-Locational Data
Natural Gas Pipelines	2020	EIA	Geographic-Locational Data
Natural Gas Processing Plants	2020	EIA	Geographic-Locational Data
Natural Gas Storage Regions	2020	EIA	Geographic-Locational Data
Natural Gas Underground Storage	2019	EIA	Geographic-Locational Data

Nuclear Energy Regulatory Council Regions	2020	EIA	Geographic-Locational Data
Petroleum Product Pipeline	2020	EIA	Geographic-Locational Data
Petroleum Product Terminals	2020	EIA	Geographic-Locational Data
Petroleum Refineries	2019	EIA	Geographic-Locational Data
Railroads	2015	US Census	Geographic-Locational Data
Sedimentary Basins	2018	U.S. Geological Survey, Drilling Info Inc., and state agencies.	Geographic-Locational Data
Solar Resource Potential	1998-2018	National Renewable Energy Laboratory	Geographic-Locational Data
Strategic Petroleum Reserve	2016	U.S. Department of Energy, Office of Fossil Energy	Geographic-Locational Data
Oil Shale Gas Plays	2019	EIA	Geographic-Locational Data
Uranium Identified Resource Areas	2019	Compiled by USGS from published sources	Geographic-Locational Data
Uranium National Uranium Resource Evaluation Favorable Areas	2019	Compiled by USGS from published sources	Geographic-Locational Data
Wind Potential 80M Current Tech	2017	National Renewable Energy Laboratory (NREL)	Geographic-Locational Data
Wind Potential 80M Future Tech	2017	NREL	Geographic-Locational Data
College And University Campuses	2019	Homeland Infrastructure Foundation	Geographic-Locational Data
Public Primary And Secondary Schools	2019	Homeland Infrastructure Foundation	Geographic-Locational Data
Electric Energy Provider Service Areas	2019	EIA	Geographic-Locational Data
Electric Energy Providers By County	2019	Compiled from several EIA datasets	Geographic-Locational Data
Formerly Utilized Sites Remedial Action Program Sites	1974 -	Data compiled from Army Corp of Engineers. Cleaned and geo-located by FPTZ	Geographic-Locational Data
Universities With Nuclear Programs	2019	FPTZ	Geographic-Locational Data
Uranium Mines And Mills	2020	USGS, EIA, FPTZ	Geographic-Locational Data
Uranium Processing Facilities	2019	USNRC	Geographic-Locational Data
Uranium Storage Facilities	2019	USNRC	Geographic-Locational Data

Table B-3: "Janet" Selected Political Data

Basic Description	Date	Data Source	Janet Architecture Element
Election Results County	2012- 2018	Massachusetts Institute of Technology (MIT) Election Data and Science Lab	Political-Political/ Election Results
Election Results Congressional Districts	2012 - 2018	MIT Election Data and Science Lab	Political-Political/ Election Results
Nuclear Restrictions State	2020	FPTZ	Political-Public Policy
Nuclear Legislation	2019	Open State and FPTZ	Political-Public Policy
Open State	2020 Updated monthly through bulk download or API	Open States	Political-Stakeholder Database
Labor Unions	2018	Department of Labor multiple forms compiled by FPTZ	Political-Stakeholder Database
Labor Union Elected Officials	2018	Department of Labor multiple forms compiled by FPTZ	Political-Stakeholder Database

Table B-4: "Janet" Selected Social Data

Basic Description	Date	Data Source	Janet Architecture Element
Anti-Nuclear Organization	2019	FPTZ	Social-Advocacy
Pro-Nuclear Organizations	2019	FPTZ	Social-Advocacy
Demographic data : all geographic scales	1950 - 2017	Census	Social-Demographics
Nuclear Sentiment	2020	University of Oklahoma/FPTZ	Social-Public Polling
Social Vulnerability	2016 and 2018	CDC	Social-Demographics
School District Free and Reduced Lunch	2019	State Departments of Education compiled by FPTZ	Social-Demographics
Climate Change Surveys :County, Tract, Block	2018 and 2019	Yale Climate Change Survey	Social-Public Polling

Table B-5: Siting attributes, the data currency, and data sources used by the UMich analysis tool.

Siting Attribute	Data Currency	Source
Electric Energy Price	2020	U.S. Energy Information Administration, Form EIA-861M (formerly EIA-826), Monthly Electric Power Industry Report 2020.
Electric Energy Net Flow	2018	https://www.eia.gov/state/seds/
Electric Energy Flow Trend	2018	https://www.eia.gov/state/seds/
Renewable Portfolio Standard (RPS) / Renewable Portfolio Goal (RPG)	2019 - 2020	Anne Kolesnikoff, Megan Cleveland, "State Renewable Portfolio Standards and Goals". National Conference of State Legislators (NCSL), 17 Apr. 2020. www.ncsl.org/research/energy/renewable-portfolio-standards.aspx. "Database of State Incentives for Renewables & Efficiency (DSIRE)", 2019. Web. Accessed 7 January 2020. http://www.dsireusa.org/
RPS/RPG Aggressiveness		
RPS/RPG Nuclear Inclusivity		
RPS/RPG Cost Cap		
RPS/RPG Zero Emissions Credit (ZEC)		
Clean Energy Standard (CES)		
Pro Nuclear Organizations	June 2020	See Table B-6
Anti-Nuclear Organizations		
Marginalized Populations	2019	United States Census Bureau, "Summary File 2014 – 2018 American Community Survey". U.S. Census Bureau's American Community Survey Office, Accessed March 1, 2020. http://ftp2.census.gov/.
Social Vulnerability Index	2018	Centers for Disease Control and Prevention/ Agency for Toxic Substances and Disease Registry/ Geospatial Research, Analysis, and Services Program. Social Vulnerability Index, Accessed June 5, 2020. https://svi.cdc.gov/.

Table B-6: Pro- and anti-nuclear organizations operating near proposed sites.

Organization	Link	Purpose/Mission
Snake River Alliance (Idaho)	www.snakeriveralliance.org	"Snake River Alliance is an Idaho-based grassroots organization which focuses its work on nuclear issues, most especially monitoring activities at the Idaho National Engineering and Environmental Laboratory."
Nevada Desert Experience (Nevada)	Nevadadesertexperience.org	n/a
Citizens for Nuclear Technology Awareness (CNTA) (South Carolina)	cntaware.org	"CNTA serves to educate the public by providing objective information on the value of nuclear technology with respect to our health, economy, environment, and national security."
Savanna River Site Watch (South Carolina)	www.srswatch.org	"Savannah River Site Watch is a watchdog organization at the Savannah River Site in South Carolina."
Southern Alliance for Clean Energy (SACE) (South Carolina)	cleanenergy.org	"The Southern Alliance for Clean Energy (SACE) is a nonprofit organization that promotes responsible energy choices to ensure clean, safe, and healthy communities throughout the Southeast."
The Committee For Nuclear Responsibility (South Carolina)	ratical.org/radiation/CNR/	"The Committee for Nuclear Responsibility was formed as a "political and educational organization to disseminate anti-nuclear views and information to the public". The goals of the organization were a moratorium on nuclear power and the commercialization of alternative energy sources."
Oak Ridge Environmental Peace Alliance (Tennessee)	orepa.org	"We are a multi-disciplinary advocacy and activist organization which monitors and addresses social and environmental issues in the Upper Tennessee Valley and the Southern Appalachian Mountains"
Fernald Residents for Environmental Safety and Health (FRESH) (Ohio)	www.nuclearactive.org/docs/ANAlinks.html	"Formed to educate ourselves and the community about problems at the Fernald site. We watchdog the activities of the Fernald site and work for meaningful public participation throughout the remediation process."
Miamisburg Environmental Safety and Health (MESH) (Ohio)	www.nuclearactive.org/docs/ANAlinks.html	"A watchdog for environment and health concerns for the public and residents around the Mound Nuclear Weapons Facility."
Portsmouth/Piketon Residents for Environmental Safety and Security (PRESS) (Ohio)	www.nuclearactive.org/docs/ANAlinks.html	"PRESS works to educate, organize and empower residents and workers affected by the Piketon uranium enrichment site, and to represent their interest in economic vitality, environmental quality, health, justice and expanded job opportunities."
Thorium Energy Alliance (Illinois)	Thoriumenergyalliance.com	"We are a nonprofit group composed of engineers, scientists, and concerned citizens interested in reducing the cost of energy, increasing the availability of critical materials and protecting the health of the planet and the future of the human race."
Nuclear Energy Information Service (NEIS) (Illinois)	neis.org	"We are working to create a nuclear-free world. To accomplish this NEIS: Educates, activates and organizes the public on energy issues."

Table B-6: Pro- and anti-nuclear organizations operating near proposed sites. (Cont.)

Organization	Link	Purpose/Mission
Hanford Challenge (Washington)	www.hanfordchallenge.org	"Hanford Challenge is working to make Hanford a model of safe and effective cleanup by advocating on behalf of, empowering, and representing whistleblowers; working for transparency and accountability; educating the public and influencing decision-makers at the regional, state, and national levels; and empowering the next generation of leaders to be involved in Hanford cleanup. Hanford Challenge's mission is to help create a future for Hanford that secures human health and safety, advances accountability, and promotes a sustainable environmental legacy."
Heart of America Northwest (Washington)	www.hanfordcleanup.org	"Heart of America North West is a citizens' membership organization dedicated to the cleanup of the Hanford Nuclear Reservation."

"Janet" is not a static database and is thus constantly growing and changing. New data sources are being added and existing sources are always being updated. With the most up-to-date information always available, research/analysis can be conducted quickly and accurately. Many of the data sources are updated automatically as new data become available through the data pipeline, a collection of scheduled extract, transform, and load (ETL) processes scripted in python. Data are acquired through API calls or web scrapping techniques. The database pipeline backend core technologies utilizes primarily open-source software. (See Figure B-1)

Technology	Licensing	Purpose
GitLab	U-M	File hosting and project management
Jupyter Notebooks	Opensource	Shareable documents for writing code, creating data visualizations and providing formatted narrative
Docker	Opensource	Resource containerization (lightweight virtual machines)
Terraform	Opensource	Container deployment
Linux	Opensource	Operating system
PostgreSQL	Opensource	Database server
Google Cloud Platform	U-M	Cloud computing resources

Figure B-1: "Janet" Database Pipeline Core Technologies

B.2 Database Usage

Energy technology decisions are complex and involve many stakeholders, each with their own perspective. In order to account for this "Janet" is very flexible. However, there are two common approaches for utilizing the database capabilities; site analyses based on user-provided locations and identifying possible sites for technology adoption based on user-defined parameters.

Site analyses for user-provided locations can be conducted at the county level, census tract level, or using geographic coordinates. Users provide a search distance from their location to create an area of interest. "Janet" can then be leveraged to cross reference this area of interest or location, with all data sets the stakeholder feels are relevant, to provide a site report. (See Figure B-2)

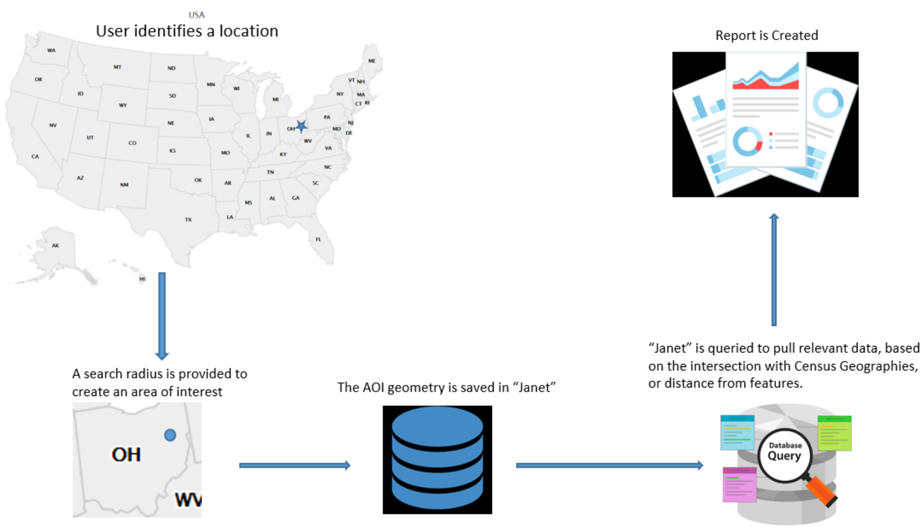


Figure B-2: Analysis process for a location provided by user

The process for identifying possible sites for technology adoption based on user-defined parameters is similar to the process above with a few distinctions. This process involves the stakeholders identifying what parameters they deem most important from the selection of parameters and ranking their relative importance. Then users are able to utilize "Janet" to identify and create a ranked list of locations that best meet these priorities. This can be done at the state, county, or census tract level. A report can then be created for each of these proposed sites.

Appendix C: Argonne Multi-Objective Preference Model Details

This section describes the Argonne Multi-Objective Preference Model (MOPM) developed and utilized in the Phase I analyses.

C.1 Multi-Objective Preference Model Value Functions

When there are multiple objectives, the performance of an alternative with respect to those objectives is usually measured in many different physical units – dollars, percent, miles, yes or no, and others. Value functions are used to convert performance level to the relative value that the performance creates for the decision-maker. The resulting value measures are the result of transforming a raw performance measure to the level of satisfaction that the decision maker assigns to that level of performance. Value functions simply represent the translation of performance levels (in different units) to relative value created for the decision-maker on a consistent scale of 0 to 1. Figure C-1 through Figure C-4 show the value functions used in the MOPM for this study.

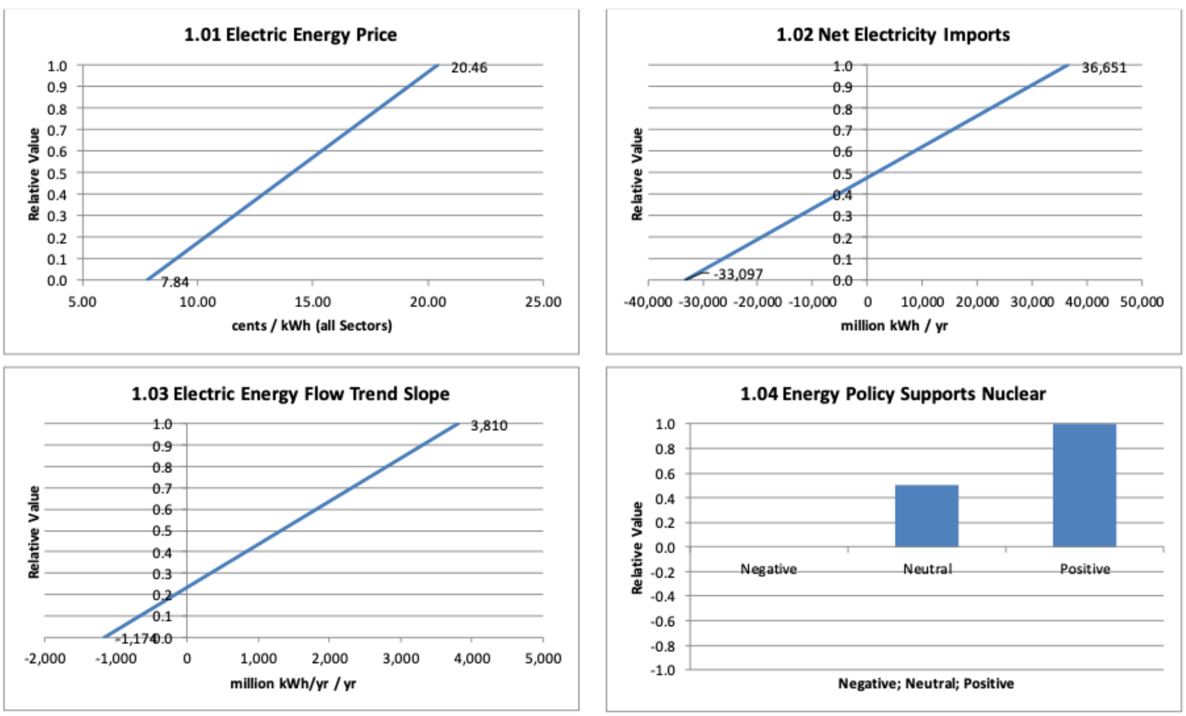


Figure C-1: MOPM Value Functions

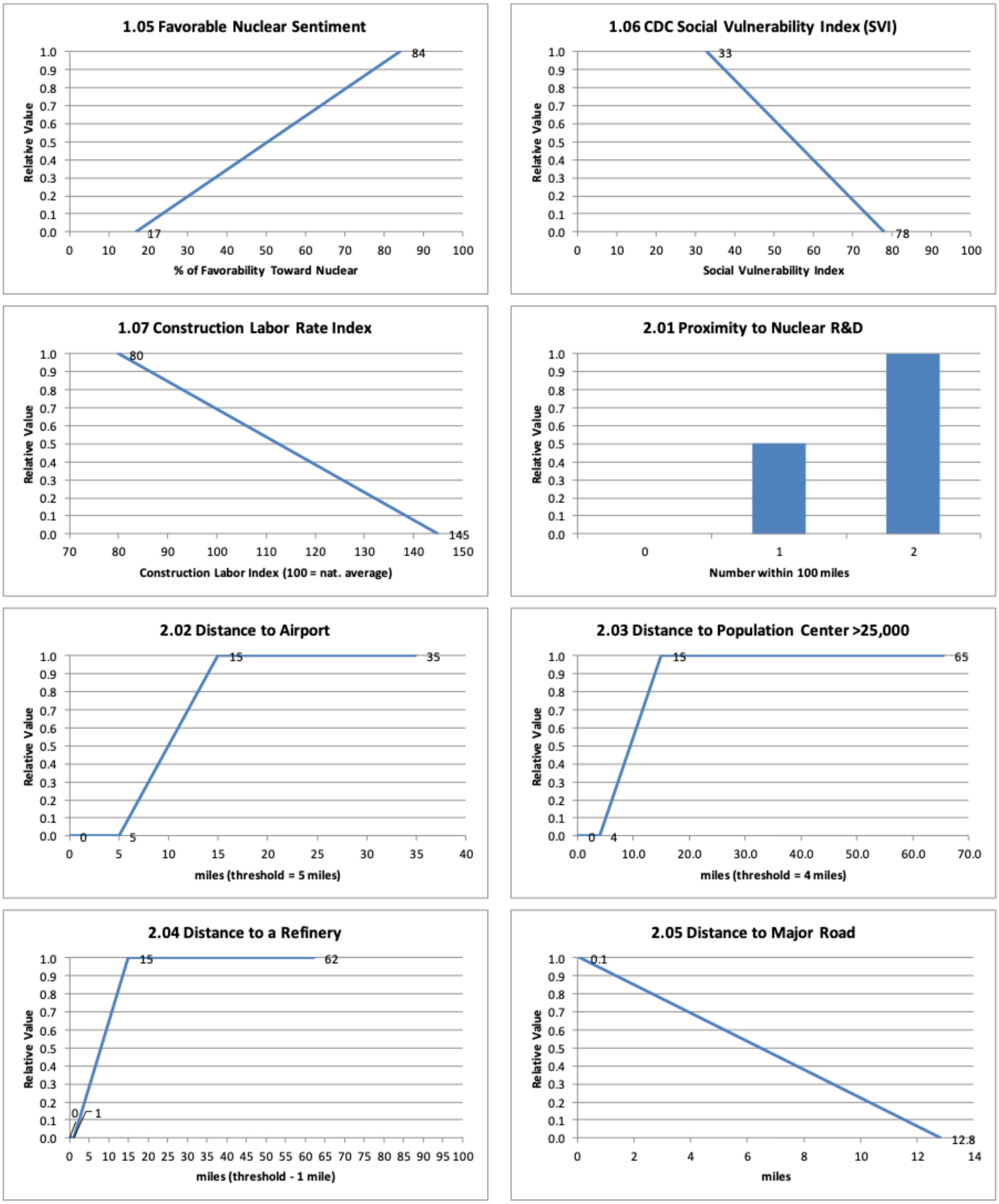


Figure C-2: MOPM Value Functions (cont.)

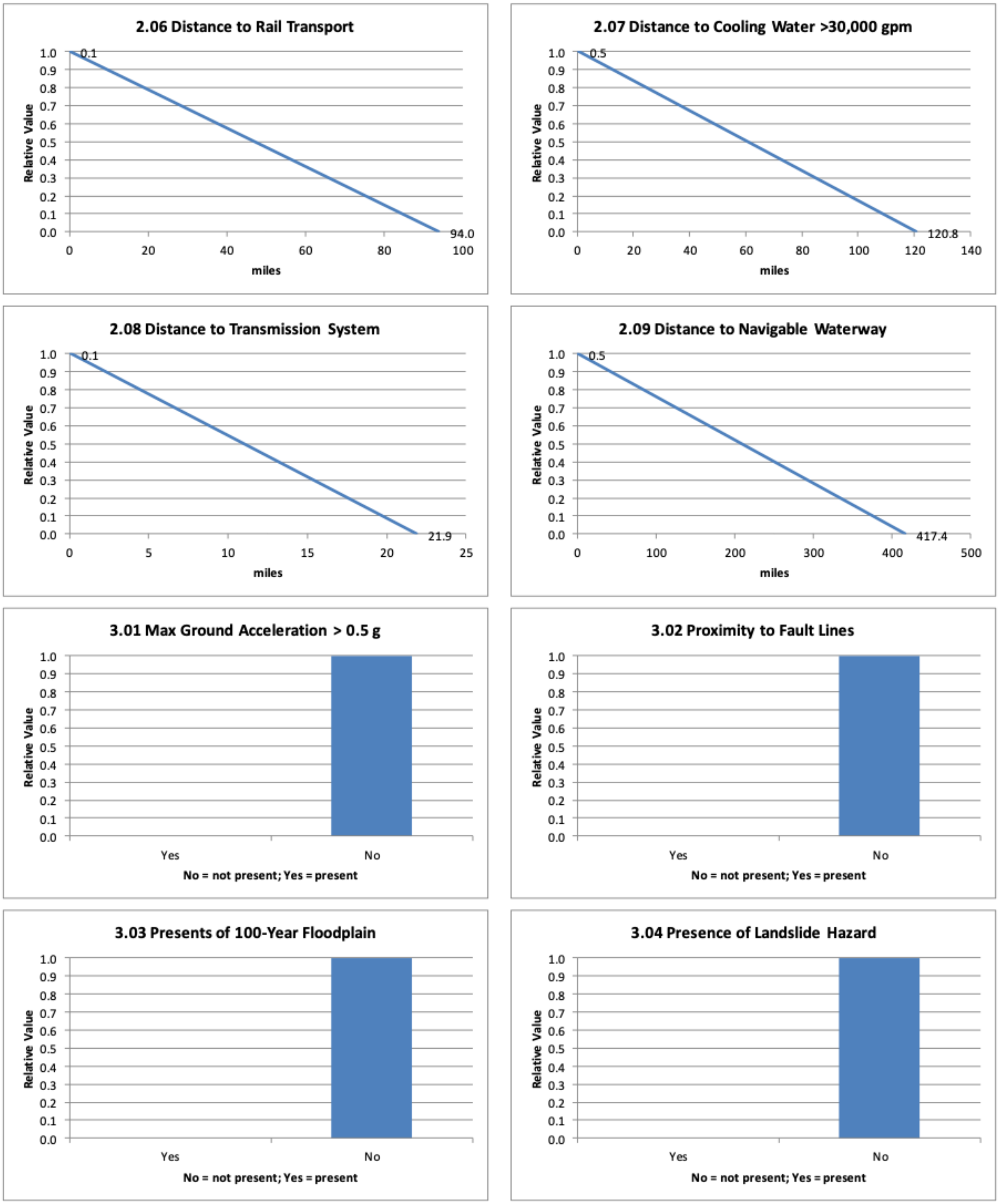
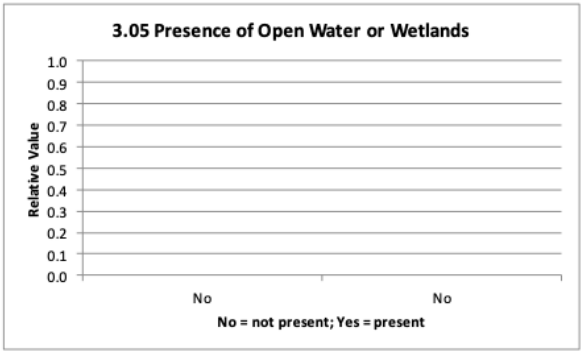
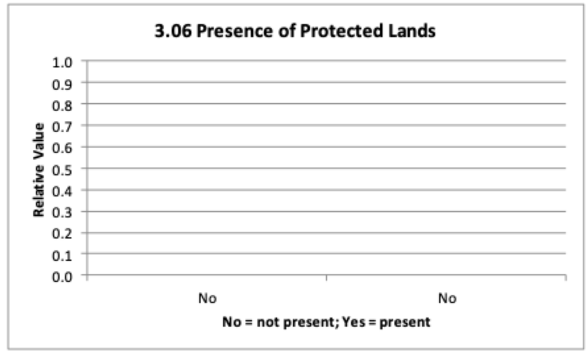


Figure C-3: MOPM Value Functions (cont.)





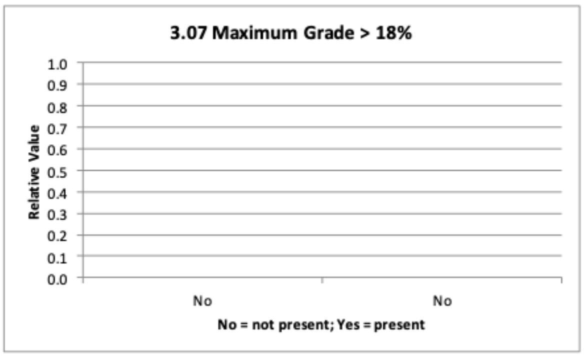


Figure C-4: MOPM Value Functions (cont.)

C.2 Procedure for Eliciting Decision-Maker Priority Weights

Step 1 – Measure Relevance and Range Significance

The decision-maker is presented with a table like that illustrated in Table C-1.

The first three columns in the table list the objectives, measures, and their units. The next two columns indicate the best value and the worst value for each measure from among the alternative sites. Where appropriate, the next two columns show the absolute and percentage difference between the best and the worst values.

The decision-maker is asked is to complete the last two columns.

> **Measure Relevance** is the relative degree of relevance that the measure has in the selection of a preferred demonstration site. Measure relevance is completely independent of the value that the measure takes for any site. It only has to do with how important the decision maker believes the attribute is in choosing a site, regardless of value. Measures that the decision-maker wishes to not consider or that are totally unimportant from a decision-maker's perspective should be indicated as NR for Not Relevant.
>
> **Range Significance** considers the range of values between the best and worst site for each measure, regardless of how relevant or irrelevant it is. For example, a construction labor index that varies from 0.10 to 0.90 across the alternative sites might be considered highly significant in terms of influence over site preference. Whereas, a construction labor index that varies from 0.88 to 0.90 across the alternative sites might be considered of low significance.

The choices are:

H for Highly Relevant / Significant

M for Medium Relevance / Significance;

L for Low Relevance / Significance, and

NR for Not Relevant and/or Insignificant

Table C-1: Measure Relevance and Range Significance Table

	Measure	Units	Best	Worst	Difference	% (B-W)/B	MEASURE RELEVANCE	RANGE SIGNIFICANCE
Socioeconimic	1.01 Electric Energy Price	cents / kWh (all Sectors)	20.46	7.84	12.62	62%	H	H
	1.02 Net Electricity Imports	million kWh / yr (neg. value = export)	36,651	-33,097	69,748	190%	M	H
	1.03 Electric Energy Flow Trend Slope	million kWh/yr / yr (neg. = growing exports)	3,810	-1,174	4,984	131%	L	M
	1.04 Energy Policy Supports Nuclear	Negative; Neutral; Positive	Positive	Negative	n/a	n/a	H	H
	1.05 Favorable Nuclear Sentiment	% of Favorability Toward Nuclear	84	17	67	80%	M	H
	1.06 CDC Social Vulnerability Index (SVI)	Social Vulnerability Index	33	78	45	58%	M	M
	1.07 Construction Labor Rate Index	Construction Labor Index (100 = nat. average)	80	145	65	45%	M	M
Proximity	2.01 Proximity to Nuclear R&D	Number within 100 miles	2	0	2	100%	M	H
	2.02 Distance to Airport	miles (threshold = 5 miles)	35	5	30	86%	H	M
	2.03 Distance to Population Center >25,000	miles (threshold = 4 miles)	65	2	64	98%	H	M
	2.04 Distance to a Refinery	miles (threshold - 1 mile)	62	380	318	84%	H	NR
	2.05 Distance to Major Road	miles	0.1	13	13	99%	H	M
	2.06 Distance to Rail Transport	miles	0.1	94	94	100%	M	H
	2.07 Distance to Cooling Water >30,000 gpm	miles	0.5	121	120	100%	H	H
	2.08 Distance to Transmission System	miles	0.1	22	22	100%	M	H
	2.09 Distance to Navigable Waterway	miles	0.5	417	417	100%	L	H
Safety	3.01 Max Ground Acceleration > 0.5 g	No = not present; Yes = present	No	Yes	n/a	n/a	H	H
	3.02 Proximity to Fault Lines	No = not present; Yes = present	No	Yes	n/a	n/a	H	H
	3.03 Presents of 100-Year Floodplain	No = not present; Yes = present	No	Yes	n/a	n/a	H	H
	3.04 Presence of Landslide Hazard	No = not present; Yes = present	No	Yes	n/a	n/a	H	H
	3.05 Presence of Open Water or Wetlands	No = not present; Yes = present	No	No	n/a	n/a	NR	NR
	3.06 Presence of Protected Lands	No = not present; Yes = present	No	No	n/a	n/a	NR	NR
	3.07 Maximum Grade > 18%	No = not present; Yes = present	No	No	n/a	n/a	NR	NR

Measures for which the best value equals the worst value are, by definition, Not Relevant (NR) because without a difference among the sites, there can be no preference for one site over another with respect to that measure. The last three measures are marked NR because none of the indicated measures are present at any of the sites.

Step 2 – Raw Priority Weights

Measure titles are then copied to a matrix similar to the one shown in Table C-2 and placed in the cell corresponding with the decision-maker's measure relevance and range significance ratings. Any measure rated as not relevant in either measure, range, or both may be copied to any of the three cells in the bottom row, as all cells in this row are Not Relevant and will receive a priority weight of zero.

Table C-2: Raw Weights Matrix

RAW WEIGHTS		MEASURE RELEVANCE					
		High		Medium		Low	
PERFORMANCE RANGE	High	Appropriate Weight Range	76 - 100	Appropriate Weight Range	51 - 75	Appropriate Weight Range	26 - 50
		1.01 Electric Energy Price	100	1.02 Net Electricity Imports	70	2.09 Distance to Navigable Waterway	30
		1.04 Energy Policy Supports Nuclear	100	1.05 Favorable Nuclear Sentiment	70		
		2.07 Distance to Cooling Water >30,000 g	100	2.01 Proximity to Nuclear R&D	70		
		3.01 Max Ground Acceleration > 0.5 g	100	2.06 Distance to Rail Transport	70		
		3.02 Proximity to Fault Lines	100	2.08 Distance to Transmission System	70		
		3.03 Presents of 100-Year Floodplain	100				
		3.04 Presence of Landslide Hazard	100				
	Medium	Appropriate Weight Range	51 - 75	Appropriate Weight Range	26 - 50	Appropriate Weight Range	11 - 25
		2.02 Distance to Airport	75	1.06 CDC Social Vulnerability Index (SVI)	50	1.03 Electric Energy Flow Trend Slope	15
		2.03 Distance to Population Center >25,0	75	1.07 Construction Labor Rate Index	50		
		2.05 Distance to Major Road	75				
	Low	Appropriate Weight Range	26 - 50	Appropriate Weight Range	11 - 25	Appropriate Weight Range	1 - 10
	Not Relevant	Maximum Weight	0	Maximum Weight	0	Maximum Weight	0
		2.04 Distance to a Refinery	0				
		3.05 Presence of Open Water or Wetland	0				
		3.06 Presence of Protected Lands	0				
		3.07 Maximum Grade > 18%	0				

Note that as the cells progress from the High-High cell to the Low-Low cell, the appropriate weight range in the lower-right of each cell decreases. Measures that are highly relevant and that have a high range significance should receive a higher weight than measures that are medium relevance / high range significance or high relevance / medium range significance, and so on. The appropriate raw weight range associated with each cell ensures that these relationships are maintained and allows for refinement of the weights among measures in the same cell. The decision-maker is given the opportunity to adjust the raw weights within each cell. The decision-maker may also move a measure from one cell to another if he or she wishes to reconsider relevance and range significance.

Step 3 – Normalized Priority Weights

Raw weights from the matrix are then compiled to a table similar to the one shown in Table C-3. Depending on the raw weights assigned by the decision-maker, the raw weights can sum to many different values. In order to compare one perspective to another, the weights from each must be normalized to constant value, in in this case, 100.

Table C-3: Normalized Priority Weights

NORMALIZED WEIGHTS	RAW	PRIORITY
Measure	WEIGHT	WEIGHT
1.01 Electric Energy Price	100	7.04
1.02 Net Electricity Imports	70	4.93
1.03 Electric Energy Flow Trend Slope	15	1.06
1.04 Energy Policy Supports Nuclear	100	7.04
1.05 Favorable Nuclear Sentiment	70	4.93
1.06 CDC Social Vulnerability Index (SVI)	50	3.52
1.07 Construction Labor Rate Index	50	3.52
2.01 Proximity to Nuclear R&D	70	4.93
2.02 Distance to Airport	75	5.28
2.03 Distance to Population Center >25,000	75	5.28
2.04 Distance to a Refinery	0	0.00
2.05 Distance to Major Road	75	5.28
2.06 Distance to Rail Transport	70	4.93
2.07 Distance to Cooling Water >30,000 gpm	100	7.04
2.08 Distance to Transmission System	70	4.93
2.09 Distance to Navigable Waterway	30	2.11
3.01 Max Ground Acceleration > 0.5 g	100	7.04
3.02 Proximity to Fault Lines	100	7.04
3.03 Presents of 100-Year Floodplain	100	7.04
3.04 Presence of Landslide Hazard	100	7.04
3.05 Presence of Open Water or Wetlands	0	0.00
3.06 Presence of Protected Lands	0	0.00
3.07 Maximum Grade > 18%	0	0.00
	1,420	100

C.3 Priority Weights for Four Hypothetical Advanced Reactor Demonstration Perspectives

To illustrate the Preference Model in this study, priority weights were synthesized for two hypothetical advanced reactor demonstration perspectives. The individual decision-makers in these two perspectives are identical in all respects except for the technology design each wishes to demonstrate.

Decision-Maker A is interested in demonstrating a water-cooled advanced reactor design and wishes to sell electricity generated by the demonstration reactor to the grid. This decision-maker prefers to be close to a natural cooling water source and to transmission infrastructure.

Decision-Maker B is interested in demonstrating an air-cooled advanced reactor design that is small enough to be transported over road and does not intend to sell electricity to the grid. Relative to Decision-Maker 1, this decision-maker does not care about distance to cooling water or transmission infrastructure but is concerned about being close to a major road.

Developer C is assumed to be an advanced micro-reactor developer who is unconcerned with the proximity of the demonstration site to population centers, airports, and other geographic features typically of concern to larger reactor complexes.

Developer D provides an extreme example of someone who is concerned only with socioeconomic attributes that may affect or be affected by the demonstration and the demonstration site's proximity to a nuclear R&D institution.

Table C-4 through Table C-8 show the measure relevance and range significance ratings along with the resulting normalized priority weights from these four hypothetical decision-maker perspectives. (Note that the perspective of Decision-Maker A was used as the basis in the foregoing example).

Table C-4: Measure Relevance, Range Significance, Raw and Normalized Priority Weights for Hypothetical Decision-Maker A - Water-Cooled Design; Electricity Sale to Grid

	Measure	Units	Best	Worst	Difference	% (B-W)/B	MEASURE RELEVANCE	RANGE SIGNIFICANCE	RAW WEIGHT	PRIORITY WEIGHT
Socioeconimic	1.01 Electric Energy Price	cents / kWh (all Sectors)	20.46	7.84	12.62	62%	H	H	100	7.04
	1.02 Net Electricity Imports	million kWh / yr (neg. value = export)	36,651	-33,097	69,748	190%	M	H	70	4.93
	1.03 Electric Energy Flow Trend Slope	million kWh/yr / yr (neg. = growing exports)	3,810	-1,174	4,984	131%	L	M	15	1.06
	1.04 Energy Policy Supports Nuclear	Negative; Neutral; Positive	Positive	Negative	n/a	n/a	H	H	100	7.04
	1.05 Favorable Nuclear Sentiment	% of Favorability Toward Nuclear	84	17	67	80%	M	H	70	4.93
	1.06 CDC Social Vulnerability Index (SVI)	Social Vulnerability Index	33	78	45	58%	M	M	50	3.52
	1.07 Construction Labor Rate Index	Construction Labor Index (100 = nat. average)	80	145	65	45%	M	M	50	3.52
Proximity	2.01 Proximity to Nuclear R&D	Number within 100 miles	2	0	2	100%	M	H	70	4.93
	2.02 Distance to Airport	miles (threshold = 5 miles)	35	5	30	86%	H	M	75	5.28
	2.03 Distance to Population Center >25,000	miles (threshold = 4 miles)	65	2	64	98%	H	M	75	5.28
	2.04 Distance to a Refinery	miles (threshold - 1 mile)	62	380	318	84%	H	NR	0	0.00
	2.05 Distance to Major Road	miles	0.1	13	13	99%	H	M	75	5.28
	2.06 Distance to Rail Transport	miles	0.1	94	94	100%	M	H	70	4.93
	2.07 Distance to Cooling Water >30,000 gpm	miles	0.5	121	120	100%	H	H	100	7.04
	2.08 Distance to Transmission System	miles	0.1	22	22	100%	M	H	70	4.93
	2.09 Distance to Navigable Waterway	miles	0.5	417	417	100%	L	H	30	2.11
Safety	3.01 Max Ground Acceleration > 0.5 g	No = not present; Yes = present	No	Yes	n/a	n/a	H	H	100	7.04
	3.02 Proximity to Fault Lines	No = not present; Yes = present	No	Yes	n/a	n/a	H	H	100	7.04
	3.03 Presents of 100-Year Floodplain	No = not present; Yes = present	No	Yes	n/a	n/a	H	H	100	7.04
	3.04 Presence of Landslide Hazard	No = not present; Yes = present	No	Yes	n/a	n/a	H	H	100	7.04
	3.05 Presence of Open Water or Wetlands	No = not present; Yes = present	No	No	n/a	n/a	NR	NR	0	0.00
	3.06 Presence of Protected Lands	No = not present; Yes = present	No	No	n/a	n/a	NR	NR	0	0.00
	3.07 Maximum Grade > 18%	No = not present; Yes = present	No	No	n/a	n/a	NR	NR	0	0.00
									1,420	100

Table C-5: Measure Relevance, Range Significance, Raw and Normalized Priority Weights for Hypothetical Decision-Maker B - Air-Cooled; Road Transportable; Micro-grid Sale

	Measure	Units	Best	Worst	Difference	% (B-W)/B	MEASURE RELEVANCE	RANGE SIGNIFICANCE	RAW WEIGHT	PRIORITY WEIGHT
Socioeconimic	1.01 Electric Energy Price	cents / kWh (all Sectors)	20.46	7.84	12.62	62%	H	H	100	8.00
	1.02 Net Electricity Imports	million kWh / yr (neg. value = export)	36,651	-33,097	69,748	190%	M	H	70	5.60
	1.03 Electric Energy Flow Trend Slope	million kWh/yr / yr (neg. = growing exports)	3,810	-1,174	4,984	131%	L	M	15	1.20
	1.04 Energy Policy Supports Nuclear	Negative; Neutral; Positive	Positive	Negative	n/a	n/a	H	H	100	8.00
	1.05 Favorable Nuclear Sentiment	% of Favorability Toward Nuclear	84	17	67	80%	M	H	70	5.60
	1.06 CDC Social Vulnerability Index (SVI)	Social Vulnerability Index	33	78	45	58%	M	M	50	4.00
	1.07 Construction Labor Rate Index	Construction Labor Index (100 = nat. average)	80	145	65	45%	M	M	50	4.00
Proximity	2.01 Proximity to Nuclear R&D	Number within 100 miles	2	0	2	100%	M	H	70	5.60
	2.02 Distance to Airport	miles (threshold = 5 miles)	35	5	30	86%	H	M	75	6.00
	2.03 Distance to Population Center >25,000	miles (threshold = 4 miles)	65	2	64	98%	H	M	75	6.00
	2.04 Distance to a Refinery	miles (threshold - 1 mile)	62	380	318	84%	H	NR	0	0.00
	2.05 Distance to Major Road	miles	0.1	13	13	99%	H	M	75	6.00
	2.06 Distance to Rail Transport	miles	0.1	94	94	100%	M	H	70	5.60
	2.07 Distance to Cooling Water >30,000 gpm	miles	0.5	121	120	100%	NR	NR	0	0.00
	2.08 Distance to Transmission System	miles	0.1	22	22	100%	NR	NR	0	0.00
	2.09 Distance to Navigable Waterway	miles	0.5	417	417	100%	L	H	30	2.40
Safety	3.01 Max Ground Acceleration > 0.5 g	No = not present; Yes = present	No	Yes	n/a	n/a	H	H	100	8.00
	3.02 Proximity to Fault Lines	No = not present; Yes = present	No	Yes	n/a	n/a	H	H	100	8.00
	3.03 Presents of 100-Year Floodplain	No = not present; Yes = present	No	Yes	n/a	n/a	H	H	100	8.00
	3.04 Presence of Landslide Hazard	No = not present; Yes = present	No	Yes	n/a	n/a	H	H	100	8.00
	3.05 Presence of Open Water or Wetlands	No = not present; Yes = present	No	No	n/a	n/a	NR	NR	0	0.00
	3.06 Presence of Protected Lands	No = not present; Yes = present	No	No	n/a	n/a	NR	NR	0	0.00
	3.07 Maximum Grade > 18%	No = not present; Yes = present	No	No	n/a	n/a	NR	NR	0	0.00
									1,250	100

Table C-6: Measure Relevance, Range Significance, Raw and Normalized Priority Weights for Hypothetical Decision-Maker C - Advanced Microreactor Developer Unconcerned with all Proximity Attributes, Except Nuclear R&D

	Measure	Units	Best	Worst	Difference	% (B-W)/B	MEASURE RELEVANCE	RANGE SIGNIFICANCE	RAW WEIGHT	PRIORITY WEIGHT
Socioeconimic	1.01 Electric Energy Price	cents / kWh (all Sectors)	20.46	7.84	12.62	62%	H	H	100	9.35
	1.02 Net Electricity Imports	million kWh / yr (neg. value = export)	36,651	-33,097	69,748	190%	M	H	70	6.54
	1.03 Electric Energy Flow Trend Slope	million kWh/yr / yr (neg. = growing exports)	3,810	-1,174	4,984	131%	L	M	15	1.40
	1.04 Energy Policy Supports Nuclear	Negative; Neutral; Positive	Positive	Negative	n/a	n/a	H	H	100	9.35
	1.05 Favorable Nuclear Sentiment	% of Favorability Toward Nuclear	84	17	67	80%	M	H	70	6.54
	1.06 CDC Social Vulnerability Index (SVI)	Social Vulnerability Index	33	78	45	58%	M	M	50	4.67
	1.07 Construction Labor Rate Index	Construction Labor Index (100 = nat. average)	80	145	65	45%	M	M	50	4.67
Proximity	2.01 Proximity to Nuclear R&D	Number within 100 miles	2	0	2	100%	M	H	70	6.54
	2.02 Distance to Airport	miles (threshold = 5 miles)	35	5	30	86%	NR	NR	0	0.00
	2.03 Distance to Population Center >25,000	miles (threshold = 4 miles)	65	2	64	98%	NR	NR	0	0.00
	2.04 Distance to a Refinery	miles (threshold - 1 mile)	62	380	318	84%	H	NR	0	0.00
	2.05 Distance to Major Road	miles	0.1	13	13	99%	H	M	75	7.01
	2.06 Distance to Rail Transport	miles	0.1	94	94	100%	M	H	70	6.54
	2.07 Distance to Cooling Water >30,000 gpm	miles	0.5	121	120	100%	NR	NR	0	0.00
	2.08 Distance to Transmission System	miles	0.1	22	22	100%	NR	NR	0	0.00
	2.09 Distance to Navigable Waterway	miles	0.5	417	417	100%	NR	NR	0	0.00
Safety	3.01 Max Ground Acceleration > 0.5 g	No = not present; Yes = present	No	Yes	n/a	n/a	H	H	100	9.35
	3.02 Proximity to Fault Lines	No = not present; Yes = present	No	Yes	n/a	n/a	H	H	100	9.35
	3.03 Presents of 100-Year Floodplain	No = not present; Yes = present	No	Yes	n/a	n/a	H	H	100	9.35
	3.04 Presence of Landslide Hazard	No = not present; Yes = present	No	Yes	n/a	n/a	H	H	100	9.35
	3.05 Presence of Open Water or Wetlands	No = not present; Yes = present	No	No	n/a	n/a	NR	NR	0	0.00
	3.06 Presence of Protected Lands	No = not present; Yes = present	No	No	n/a	n/a	NR	NR	0	0.00
	3.07 Maximum Grade > 18%	No = not present; Yes = present	No	No	n/a	n/a	NR	NR	0	0.00
									1,070	100

Table C- 7:Measure Relevance, Range Significance, Raw and Normalized Priority Weights for Hypothetical Decision-Maker D - Only Socioeconomic Attributes and Proximity to Nuclear R&D are Relevant

	Measure	Units	Best	Worst	Difference	% (B-W)/B	MEASURE RELEVANCE	RANGE SIGNIFICANCE	RAW WEIGHT	PRIORITY WEIGHT
Socioeconimic	1.01 Electric Energy Price	cents / kWh (all Sectors)	20.46	7.84	12.62	62%	H	H	100	19.05
	1.02 Net Electricity Imports	million kWh / yr (neg. value = export)	36,651	-33,097	69,748	190%	M	H	70	13.33
	1.03 Electric Energy Flow Trend Slope	million kWh/yr / yr (neg. = growing exports)	3,810	-1,174	4,984	131%	L	M	15	2.86
	1.04 Energy Policy Supports Nuclear	Negative; Neutral; Positive	Positive	Negative	n/a	n/a	H	H	100	19.05
	1.05 Favorable Nuclear Sentiment	% of Favorability Toward Nuclear	84	17	67	80%	M	H	70	13.33
	1.06 CDC Social Vulnerability Index (SVI)	Social Vulnerability Index	33	78	45	58%	M	M	50	9.52
	1.07 Construction Labor Rate Index	Construction Labor Index (100 = nat. average)	80	145	65	45%	M	M	50	9.52
Proximity	2.01 Proximity to Nuclear R&D	Number within 100 miles	2	0	2	100%	M	H	70	13.33
	2.02 Distance to Airport	miles (threshold = 5 miles)	35	5	30	86%	NR	NR	0	0.00
	2.03 Distance to Population Center >25,000	miles (threshold = 4 miles)	65	2	64	98%	NR	NR	0	0.00
	2.04 Distance to a Refinery	miles (threshold - 1 mile)	62	380	318	84%	NR	NR	0	0.00
	2.05 Distance to Major Road	miles	0.1	13	13	99%	NR	NR	0	0.00
	2.06 Distance to Rail Transport	miles	0.1	94	94	100%	NR	NR	0	0.00
	2.07 Distance to Cooling Water >30,000 gpm	miles	0.5	121	120	100%	NR	NR	0	0.00
	2.08 Distance to Transmission System	miles	0.1	22	22	100%	NR	NR	0	0.00
	2.09 Distance to Navigable Waterway	miles	0.5	417	417	100%	NR	NR	0	0.00
Safety	3.01 Max Ground Acceleration > 0.5 g	No = not present; Yes = present	No	Yes	n/a	n/a	NR	NR	0	0.00
	3.02 Proximity to Fault Lines	No = not present; Yes = present	No	Yes	n/a	n/a	NR	NR	0	0.00
	3.03 Presents of 100-Year Floodplain	No = not present; Yes = present	No	Yes	n/a	n/a	NR	NR	0	0.00
	3.04 Presence of Landslide Hazard	No = not present; Yes = present	No	Yes	n/a	n/a	NR	NR	0	0.00
	3.05 Presence of Open Water or Wetlands	No = not present; Yes = present	No	No	n/a	n/a	NR	NR	0	0.00
	3.06 Presence of Protected Lands	No = not present; Yes = present	No	No	n/a	n/a	NR	NR	0	0.00
	3.07 Maximum Grade > 18%	No = not present; Yes = present	No	No	n/a	n/a	NR	NR	0	0.00
									525	100

Table C-8: Detailed Step-by-Step Method and Calculation of Example Relative Preference for Advanced Reactor Demonstration Sites.

ATTRIBUTE MEASURES

OBJECTIVE	Socioeconomic							Proximity									Safety						
Attribute	1.01 Electric Energy Price	1.02 Net Electricity Imports	1.03 Electric Energy Flow Trend Slope	1.04 Energy Policy Supports Nuclear	1.05 Favorable Nuclear Sentiment	1.06 CDC Social Vulnerability Index (SVI)	1.07 Construction Labor Rate Index	2.01 Proximity to Nuclear R&D	2.02 Distance to Airport	2.03 Distance to Population Center >25,000	2.04 Distance to a Refinery	2.05 Distance to Major Road	2.06 Distance to Rail Transport	2.07 Distance to Cooling Water >30,000 gpm	2.08 Distance to Transmission System	2.09 Distance to Navigable Waterway	3.01 Max Ground Acceleration > 0.5 g	3.02 Proximity to Fault Lines	3.03 Presents of 100-Year Floodplain	3.04 Presence of Landslide Hazard	3.05 Presence of Open Water or Wetlands	3.06 Presence of Protected Lands	3.07 Maximum Grade > 18%
Units	cents / kWh (all Sectors)	million kWh / yr	million kWh/yr / yr	Negative; Neutral; Positive	% of Favorability Toward Nuclear	Social Vulnerability Index	Construction Labor Index (100 = nat. average)	Number within 100 miles	miles (threshold = 5 miles)	miles (threshold = 4 miles)	miles (threshold - 1 mile)	miles	miles	miles	miles	miles	No = not present; Yes = present	No = not present; Yes = present	No = not present; Yes = present	No = not present; Yes = present	No = not present; Yes = present	No = not present; Yes = present	No = not present; Yes = present
Site																							
Energy NW - Hanford	8.05	-20,625	-1,174	Positive	60	78	120	2	15.8	18	228	11	1	3	1	3	No	No	No	No	No	No	No
TVA - Clinch River	9.70	29,717	-687	Neutral	84	43	80	1	27.5	13	103	1	3	1	1	1	No	No	No	No	No	No	No
East TN Tech Park	9.70	29,717	-687	Neutral	84	43	80	1	30.4	12	99	6	0	1	1	1	No	No	No	No	No	No	No
INL -ATR	7.84	7,520	-631	Neutral	72	39	81	2	15.7	65	263	4	3	32	1	390	No	No	No	No	No	No	No
INL - CITRC	7.84	7,520	-631	Neutral	72	39	81	2	10.3	57	257	4	5	32	4	398	No	No	No	No	No	No	No
INL - MFC	7.84	7,520	-631	Neutral	61	43	81	2	16.5	45	254	5	18	20	13	405	No	No	No	No	No	No	No
SRNL	9.84	-10,788	-559	Neutral	71	61	81	1	16.4	21	380	6	2	2	0	13	No	No	No	No	No	No	No
NNSS	8.57	459	-60	Positive	21	74	91	0	34.9	52	168	13	94	121	22	280	No	No	No	No	No	No	No
DOD-ELM	20.46	1	0	Neutral	33	42	125	0	24.4	14	142	12	6	44	0	13	Yes	Yes	No	No	No	No	No
Portsmouth	9.24	36,651	1,775	Positive	17	76	111	1	15.2	65	62	2	2	3	1	23	No	No	No	Yes	No	No	No
UIUC Search Area	9.45	-33,097	3,810	Negative	48	42	145	1	4.9	3	103	1	1	55	1	108	No	No	No	No	No	No	No
UIUC Abbott Plant	9.45	-33,097	3,810	Negative	48	42	145	1	6.5	2	106	0	0	56	0	106	No	No	No	No	No	No	No
Eagle Rock	7.84	7,520	-631	Neutral	60	33	81	2	25.3	29	246	2	18	18	4	417	No	No	No	No	No	No	No

MEASURE-TO-VALUE TRANSLATION

Energy NW - Hanford	0.016	0.179	0.000	1.000	0.645	0.000	0.385	1.000	1.000	1.000	0.000	0.134	0.994	0.976	0.982	0.993	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TVA - Clinch River	0.148	0.901	0.098	0.500	1.000	0.778	1.000	0.500	1.000	0.809	0.000	0.896	0.972	1.000	0.972	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
East TN Tech Park	0.148	0.901	0.098	0.500	1.000	0.778	1.000	0.500	1.000	0.691	0.000	0.541	0.998	0.998	0.974	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
INL -ATR	0.000	0.582	0.109	0.500	0.815	0.867	0.985	1.000	1.000	1.000	0.000	0.676	0.965	0.742	0.972	0.065	1.000	1.000	1.000	1.000	1.000	1.000	1.000
INL - CITRC	0.000	0.582	0.109	0.500	0.815	0.867	0.985	1.000	0.530	1.000	0.000	0.723	0.951	0.739	0.830	0.046	1.000	1.000	1.000	1.000	1.000	1.000	1.000
INL - MFC	0.000	0.582	0.109	0.500	0.654	0.778	0.985	1.000	1.000	1.000	0.000	0.645	0.810	0.841	0.413	0.029	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SRNL	0.158	0.320	0.123	0.500	0.807	0.378	0.985	0.500	1.000	1.000	0.000	0.550	0.975	0.988	1.000	0.970	1.000	1.000	1.000	1.000	1.000	1.000	1.000
NNSS	0.058	0.481	0.224	1.000	0.060	0.089	0.831	0.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000	0.330	1.000	1.000	1.000	1.000	1.000	1.000	1.000
DOD-ELM	1.000	0.475	0.236	0.500	0.238	0.800	0.308	0.000	1.000	0.945	0.000	0.055	0.940	0.641	1.000	0.970	0.000	0.000	1.000	1.000	1.000	1.000	1.000
Portsmouth	0.111	1.000	0.592	1.000	0.000	0.044	0.523	0.500	1.000	1.000	0.000	0.833	0.980	0.983	0.963	0.946	1.000	1.000	1.000	0.000	1.000	1.000	1.000
UIUC Search Area	0.128	0.000	1.000	0.000	0.463	0.800	0.000	0.500	0.000	0.000	0.000	0.896	0.987	0.547	0.968	0.742	1.000	1.000	1.000	1.000	1.000	1.000	1.000
UIUC Abbott Plant	0.128	0.000	1.000	0.000	0.463	0.800	0.000	0.500	0.150	0.000	0.000	1.000	1.000	0.540	1.000	0.747	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Eagle Rock	0.000	0.582	0.109	0.500	0.635	1.000	0.985	1.000	1.000	1.000	0.000	0.822	0.812	0.857	0.833	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

PRIORITY WEIGHTS A	7.04	4.93	1.06	7.04	4.93	3.52	3.52	4.93	5.28	5.28	0.00	5.28	4.93	7.04	4.93	2.11	7.04	7.04	7.04	7.04	0.00	0.00	0.00
PRIORITY WEIGHTS B	8.00	5.60	1.20	8.00	5.60	4.00	4.00	5.60	6.00	6.00	0.00	6.00	5.60	0.00	0.00	2.40	8.00	8.00	8.00	8.00	0.00	0.00	0.00
PRIORITY WEIGHTS C	9.35	6.54	1.40	9.35	6.54	4.67	4.67	6.54	0.00	0.00	0.00	7.01	6.54	0.00	0.00	0.00	9.35	9.35	9.35	9.35	0.00	0.00	0.00
PRIORITY WEIGHTS D	19.05	13.33	2.86	19.05	13.33	9.52	9.52	13.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PERSPECTIVE A. Water-Cooled; Electricity Sale

PRIORITY WEIGHTS A	7.04	4.93	1.06	7.04	4.93	3.52	3.52	4.93	5.28	5.28	0.00	5.28	4.93	7.04	4.93	2.11	7.04	7.04	7.04	7.04	0.00	0.00	0.00	TOTAL
Energy NW - Hanford	0.12	0.88	0.00	7.04	3.18	0.00	1.35	4.93	5.28	5.28	0.00	0.71	4.90	6.87	4.84	2.10	7.04	7.04	7.04	7.04	0.00	0.00	0.00	75.65
TVA - Clinch River	1.04	4.44	0.10	3.52	4.93	2.74	3.52	2.46	5.28	4.27	0.00	4.73	4.79	7.04	4.79	2.11	7.04	7.04	7.04	7.04	0.00	0.00	0.00	83.95
East TN Tech Park	1.04	4.44	0.10	3.52	4.93	2.74	3.52	2.46	5.28	3.65	0.00	2.86	4.92	7.03	4.80	2.11	7.04	7.04	7.04	7.04	0.00	0.00	0.00	81.57
INL -ATR	0.00	2.87	0.12	3.52	4.02	3.05	3.47	4.93	5.28	5.28	0.00	3.57	4.76	5.23	4.79	0.14	7.04	7.04	7.04	7.04	0.00	0.00	0.00	79.19
INL - CITRC	0.00	2.87	0.12	3.52	4.02	3.05	3.47	4.93	2.80	5.28	0.00	3.82	4.69	5.20	4.09	0.10	7.04	7.04	7.04	7.04	0.00	0.00	0.00	76.12
INL - MFC	0.00	2.87	0.12	3.52	3.23	2.74	3.47	4.93	5.28	5.28	0.00	3.40	3.99	5.92	2.04	0.06	7.04	7.04	7.04	7.04	0.00	0.00	0.00	75.02
SRNL	1.11	1.58	0.13	3.52	3.98	1.33	3.47	2.46	5.28	5.28	0.00	2.91	4.81	6.96	4.93	2.05	7.04	7.04	7.04	7.04	0.00	0.00	0.00	77.97
NNSS	0.41	2.37	0.24	7.04	0.30	0.31	2.93	0.00	5.28	5.28	0.00	0.00	0.00	0.00	0.00	0.70	7.04	7.04	7.04	7.04	0.00	0.00	0.00	53.02
DOD-ELM	7.04	2.34	0.25	3.52	1.17	2.82	1.08	0.00	5.28	4.99	0.00	0.29	4.63	4.51	4.93	2.05	0.00	0.00	7.04	7.04	0.00	0.00	0.00	59.00
Portsmouth	0.78	4.93	0.63	7.04	0.00	0.16	1.84	2.46	5.28	5.28	0.00	4.40	4.83	6.93	4.75	2.00	7.04	7.04	7.04	0.00	0.00	0.00	0.00	72.44
UIUC Search Area	0.90	0.00	1.06	0.00	2.28	2.82	0.00	2.46	0.00	0.00	0.00	4.73	4.86	3.85	4.77	1.57	7.04	7.04	7.04	7.04	0.00	0.00	0.00	57.48
UIUC Abbott Plant	0.90	0.00	1.06	0.00	2.28	2.82	0.00	2.46	0.79	0.00	0.00	5.28	4.93	3.80	4.93	1.58	7.04	7.04	7.04	7.04	0.00	0.00	0.00	59.00
Eagle Rock	0.00	2.87	0.12	3.52	3.13	3.52	3.47	4.93	5.28	5.28	0.00	4.34	4.00	6.03	4.11	0.00	7.04	7.04	7.04	7.04	0.00	0.00	0.00	78.77

PERSPECTIVE B: Air-Cooled; Road Transportable; Microgrid Sale

PRIORITY WEIGHTS B	8.00	5.60	1.20	8.00	5.60	4.00	4.00	5.60	6.00	6.00	0.00	6.00	5.60	0.00	0.00	2.40	8.00	8.00	8.00	8.00	0.00	0.00	0.00	
																								TOTAL
Energy NW - Hanford	0.13	1.00	0.00	8.00	3.61	0.00	1.54	5.60	6.00	6.00	0.00	0.80	5.57	0.00	0.00	2.38	8.00	8.00	8.00	8.00	0.00	0.00	0.00	72.64
TVA - Clinch River	1.18	5.04	0.12	4.00	5.60	3.11	4.00	2.80	6.00	4.85	0.00	5.38	5.44	0.00	0.00	2.40	8.00	8.00	8.00	8.00	0.00	0.00	0.00	81.93
East TN Tech Park	1.18	5.04	0.12	4.00	5.60	3.11	4.00	2.80	6.00	4.15	0.00	3.25	5.59	0.00	0.00	2.40	8.00	8.00	8.00	8.00	0.00	0.00	0.00	79.23
INL -ATR	0.00	3.26	0.13	4.00	4.56	3.47	3.94	5.60	6.00	6.00	0.00	4.06	5.41	0.00	0.00	0.16	8.00	8.00	8.00	8.00	0.00	0.00	0.00	78.58
INL - CITRC	0.00	3.26	0.13	4.00	4.56	3.47	3.94	5.60	3.18	6.00	0.00	4.34	5.32	0.00	0.00	0.11	8.00	8.00	8.00	8.00	0.00	0.00	0.00	75.91
INL - MFC	0.00	3.26	0.13	4.00	3.66	3.11	3.94	5.60	6.00	6.00	0.00	3.87	4.54	0.00	0.00	0.07	8.00	8.00	8.00	8.00	0.00	0.00	0.00	76.18
SRNL	1.27	1.79	0.15	4.00	4.52	1.51	3.94	2.80	6.00	6.00	0.00	3.30	5.46	0.00	0.00	2.33	8.00	8.00	8.00	8.00	0.00	0.00	0.00	75.06
NNSS	0.46	2.69	0.27	8.00	0.34	0.36	3.32	0.00	6.00	6.00	0.00	0.00	0.00	0.00	0.00	0.79	8.00	8.00	8.00	8.00	0.00	0.00	0.00	60.23
DOD-ELM	8.00	2.66	0.28	4.00	1.33	3.20	1.23	0.00	6.00	5.67	0.00	0.33	5.26	0.00	0.00	2.33	0.00	0.00	8.00	8.00	0.00	0.00	0.00	56.30
Portsmouth	0.89	5.60	0.71	8.00	0.00	0.18	2.09	2.80	6.00	6.00	0.00	5.00	5.49	0.00	0.00	2.27	8.00	8.00	8.00	0.00	0.00	0.00	0.00	69.03
UIUC Search Area	1.02	0.00	1.20	0.00	2.60	3.20	0.00	2.80	0.00	0.00	0.00	5.38	5.53	0.00	0.00	1.78	8.00	8.00	8.00	8.00	0.00	0.00	0.00	55.50
UIUC Abbott Plant	1.02	0.00	1.20	0.00	2.60	3.20	0.00	2.80	0.90	0.00	0.00	6.00	5.60	0.00	0.00	1.79	8.00	8.00	8.00	8.00	0.00	0.00	0.00	57.11
Eagle Rock	0.00	3.26	0.13	4.00	3.55	4.00	3.94	5.60	6.00	6.00	0.00	4.93	4.55	0.00	0.00	0.00	8.00	8.00	8.00	8.00	0.00	0.00	0.00	77.97

PERSPECTIVE C: Microreactor; Proximity Unimportant Except for Nuclear R&D

PRIORITY WEIGHTS C	9.35	6.54	1.40	9.35	6.54	4.67	4.67	6.54	0.00	0.00	0.00	7.01	6.54	0.00	0.00	0.00	9.35	9.35	9.35	9.35	0.00	0.00	0.00	
																								TOTAL
Energy NW - Hanford	0.15	1.17	0.00	9.35	4.22	0.00	1.80	6.54	0.00	0.00	0.00	0.94	6.50	0.00	0.00	0.00	9.35	9.35	9.35	9.35	0.00	0.00	0.00	68.05
TVA - Clinch River	1.38	5.89	0.14	4.67	6.54	3.63	4.67	3.27	0.00	0.00	0.00	6.28	6.36	0.00	0.00	0.00	9.35	9.35	9.35	9.35	0.00	0.00	0.00	80.22
East TN Tech Park	1.38	5.89	0.14	4.67	6.54	3.63	4.67	3.27	0.00	0.00	0.00	3.79	6.53	0.00	0.00	0.00	9.35	9.35	9.35	9.35	0.00	0.00	0.00	77.90
INL -ATR	0.00	3.81	0.15	4.67	5.33	4.05	4.60	6.54	0.00	0.00	0.00	4.74	6.32	0.00	0.00	0.00	9.35	9.35	9.35	9.35	0.00	0.00	0.00	77.60
INL - CITRC	0.00	3.81	0.15	4.67	5.33	4.05	4.60	6.54	0.00	0.00	0.00	5.07	6.22	0.00	0.00	0.00	9.35	9.35	9.35	9.35	0.00	0.00	0.00	77.83
INL - MFC	0.00	3.81	0.15	4.67	4.28	3.63	4.60	6.54	0.00	0.00	0.00	4.52	5.30	0.00	0.00	0.00	9.35	9.35	9.35	9.35	0.00	0.00	0.00	74.90
SRNL	1.48	2.09	0.17	4.67	5.28	1.77	4.60	3.27	0.00	0.00	0.00	3.86	6.38	0.00	0.00	0.00	9.35	9.35	9.35	9.35	0.00	0.00	0.00	70.95
NNSS	0.54	3.15	0.31	9.35	0.39	0.42	3.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.35	9.35	9.35	9.35	0.00	0.00	0.00	55.42
DOD-ELM	9.35	3.10	0.33	4.67	1.56	3.74	1.44	0.00	0.00	0.00	0.00	0.39	6.15	0.00	0.00	0.00	0.00	0.00	9.35	9.35	0.00	0.00	0.00	49.41
Portsmouth	1.04	6.54	0.83	9.35	0.00	0.21	2.44	3.27	0.00	0.00	0.00	5.84	6.41	0.00	0.00	0.00	9.35	9.35	9.35	0.00	0.00	0.00	0.00	63.97
UIUC Search Area	1.19	0.00	1.40	0.00	3.03	3.74	0.00	3.27	0.00	0.00	0.00	6.28	6.46	0.00	0.00	0.00	9.35	9.35	9.35	9.35	0.00	0.00	0.00	62.76
UIUC Abbott Plant	1.19	0.00	1.40	0.00	3.03	3.74	0.00	3.27	0.00	0.00	0.00	7.01	6.54	0.00	0.00	0.00	9.35	9.35	9.35	9.35	0.00	0.00	0.00	63.57
Eagle Rock	0.00	3.81	0.15	4.67	4.15	4.67	4.60	6.54	0.00	0.00	0.00	5.76	5.31	0.00	0.00	0.00	9.35	9.35	9.35	9.35	0.00	0.00	0.00	77.06

PERSPECTIVE D: Only Socioeconomic and Proximity to Nuclear R&D Important

PRIORITY WEIGHTS D	19.05	13.33	2.86	19.05	13.33	9.52	9.52	13.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
																								TOTAL
Energy NW - Hanford	0.31	2.38	0.00	19.05	8.60	0.00	3.66	13.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.34
TVA - Clinch River	2.81	12.01	0.28	9.52	13.33	7.41	9.52	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	61.55
East TN Tech Park	2.81	12.01	0.28	9.52	13.33	7.41	9.52	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	61.55
INL -ATR	0.00	7.76	0.31	9.52	10.86	8.25	9.38	13.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.43
INL - CITRC	0.00	7.76	0.31	9.52	10.86	8.25	9.38	13.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.43
INL - MFC	0.00	7.76	0.31	9.52	8.73	7.41	9.38	13.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.44
SRNL	3.01	4.26	0.35	9.52	10.76	3.60	9.38	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.56
NNSS	1.10	6.41	0.64	19.05	0.81	0.85	7.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.77
DOD-ELM	19.05	6.33	0.67	9.52	3.18	7.62	2.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	49.30
Portsmouth	2.11	13.33	1.69	19.05	0.00	0.42	4.98	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.26
UIUC Search Area	2.43	0.00	2.86	0.00	6.18	7.62	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.75
UIUC Abbott Plant	2.43	0.00	2.86	0.00	6.18	7.62	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.75
Eagle Rock	0.00	7.76	0.31	9.52	8.46	9.52	9.38	13.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.30

Note 1: Twelve shaded cells in the table body represent values that did not meet the minimum or maximum threshold value set for the measure. For example, the Distance to Airport and Distance to Population Center for the UIUC Search Area site are shaded. The threshold values for these attributes are indicated in the column heading units cell as 5 miles and 4 miles, respectively. However, the location assumed for the UIUC site is 4.9 miles and 3 miles, respectively, from these infrastructures. Other shaded cell refer to the presence of potential safety issues. However, these sites are an Air Force base and an existing nuclear production site. Additional analysis is needed to further quantify and clarify the extent to which the thresholds are satisfied or not, and the extent to which mitigation measures may be possible if a hazard exists.

Note 2: Data for the 1.05 Favorable Nuclear Sentiment value at the DOD-ELM site was not available. This value is an estimate.

Appendix D: Air Quality Considerations

Annual Outdoor Air Quality Index (AQI) data for 2019 recorded by the U.S. EPA [33] were assessed for the counties surrounding each of the proposed sites. The data detail the number of days the measurement were in the five categories used to report AQI conditions.

For each of the counties assessed, the air quality index was generally rated as "good" and there were few days per year in which the air quality was considered unhealthy. The data support the argument that air quality issues would not be a factor in the selection of a site.

D.1 Joint Base Elmendorf-Richardson, AK

Figure D-1 shows the counties that surround the Elmendorf AFB site and Table D-1 shows the 2019 AQI summary data for the counties. Figure D-2 shows the annual AQI summaries for the years 2009 - 2019, expressed as the percent of time the AQI were in a given category for the Anchorage Municipality where the proposed site is located.

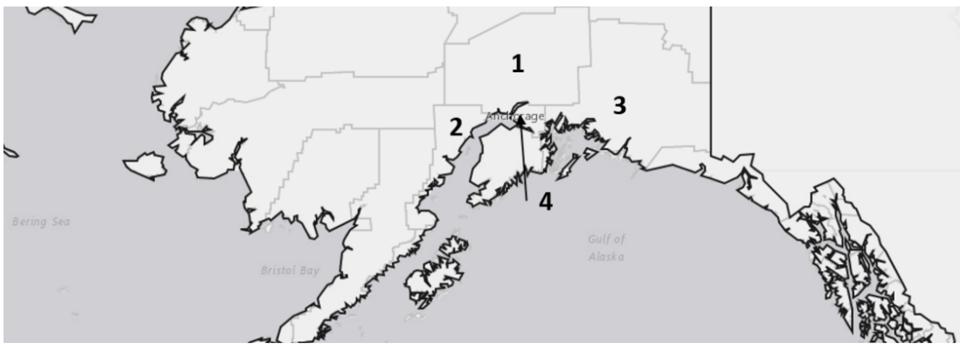


Figure D-1: Counties surrounding the proposed Joint Base Elmendorf-Richardson site.

Table D-1: Summary Air Quality Index data for the counties surrounding Joint Base Elmendorf-Richardson.

		Air Quality Index Data for 2019[1]						
Surrounding County	Population	Days Measured	Good (# of days)	Moderate (# of Days)	Unhealthy for Sensitive Groups (# of Days)	Unhealthy (# of Days)	Very Unhealthy (# of Days)
1. Matanuska-Susitna Borough, AK	103,464	360	294	63	3	0	0
2. Kenai Peninsula Borough, AK	58,220	90	87	2	1	0	0
3. Valdez-Cordova Census Area, AK	9,301	n/a	n/a	n/a	n/a	n/a	n/a
4. Anchorage Municipality, AK	296,112	365	289	67	5	4	0

1. Data source: https://www.epa.gov/outdoor-air-quality-data/air-quality-index-report

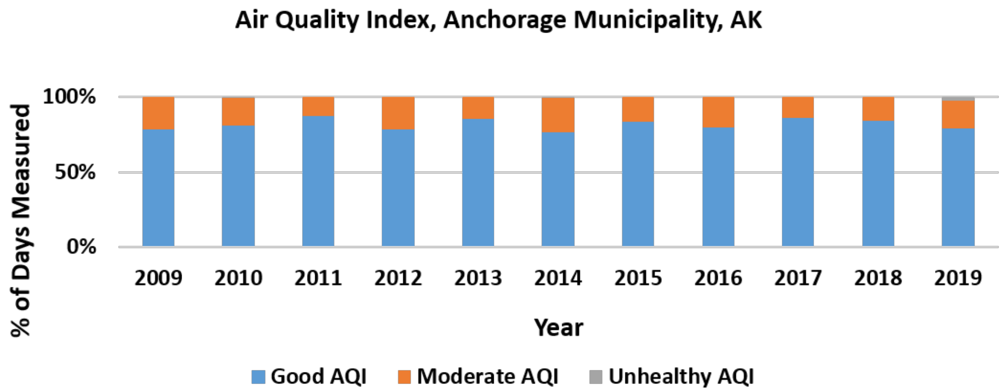


Figure D-2: Summary of the annual AQI data for the years 2009 to 2019 for Anchorage Municipality.

D.2 Energy Northwest

Figure D-3 shows the counties that surround the Energy Northwest site near the Pacific Northwest National Laboratory. Table D-2 shows the 2019 AQI summary data for the counties and Figure D-4 displays the annual AQI summaries for the years 2009 - 2019, expressed as the percent of time the AQI were in a given category for Benton County where the proposed site is located.

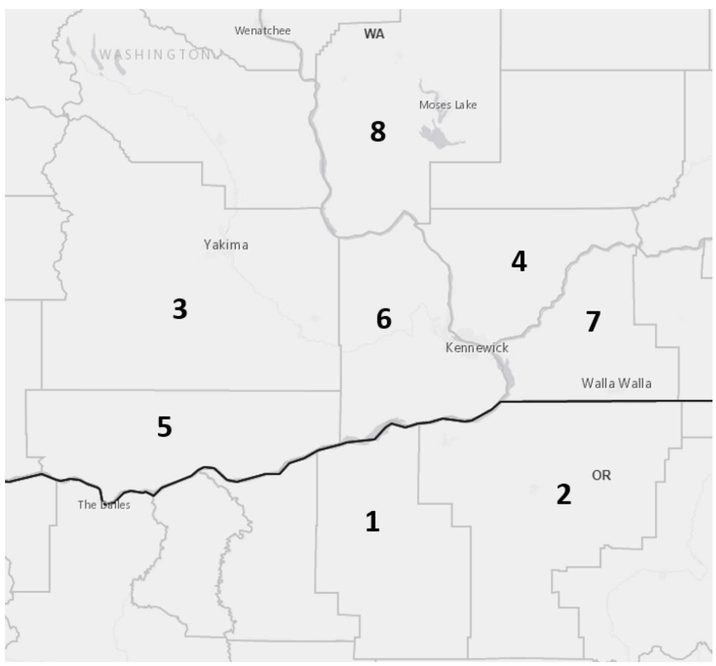


Figure D-3: Counties surrounding the proposed Energy Northwest site.

Table D-2: Summary Air Quality Index data for the counties surrounding the Energy Northwest site.

Surrounding County	Population[1] (July 2019 Estimate)	Days Measured	Good (# of days)	Moderate (# of Days)	Unhealthy for Sensitive Groups (# of Days)	Unhealthy (# of Days)	Very Unhealthy (# of Days)
		Air Quality Index Data for 2019[2]					
1. Morrow, OR	11,603	n/a	n/a	n/a	n/a	n/a	n/a
2. Umatilla, OR	77,950	365	296	68	1	0	0
3. Yakima, WA	250,873	365	227	128	10	0	0
4. Franklin, WA	95,222	333	314	19	0	0	0
5. Klickitat, WA	22,425	365	339	26	0	0	0
6. Benton, WA	204,390	364	303	61	0	0	0
7. Walla Walla, WA	60,760	365	328	37	0	0	0
8. Grant, WA	97,733	365	339	26	0	0	0

1. Census Bureau, https://www.census.gov/data/datasets/time-series/demo/popest/2010s-counties-total.html#par_textimage_739801612
2. Data source: https://www.epa.gov/outdoor-air-quality-data/air-quality-index-report

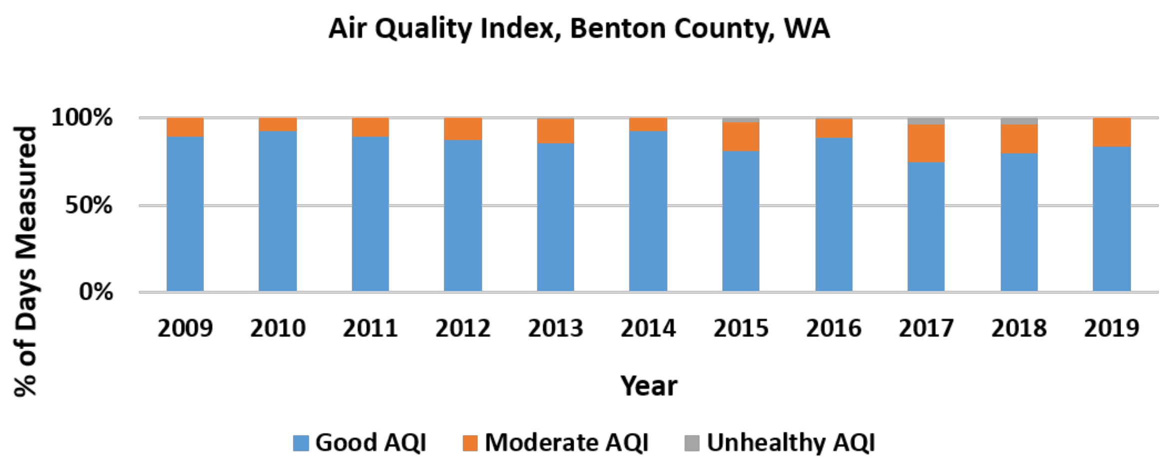


Figure D-4: Summary of the annual AQI data for the years 2009 to 2019 for Benton County, WA.

D.3 Idaho

Figure D-5 shows the counties that surround the four Idaho sites, three of which are at INL. Table D-3 maps the counties to the four Idaho sites. Table D-4 shows the 2019 AQI summary data for the counties surrounding the sites. Figure D-6 shows the annual AQI summaries for the years 2009 - 2019, expressed as the percent of time the AQI were in a given category for Butte County where the proposed sites are located.

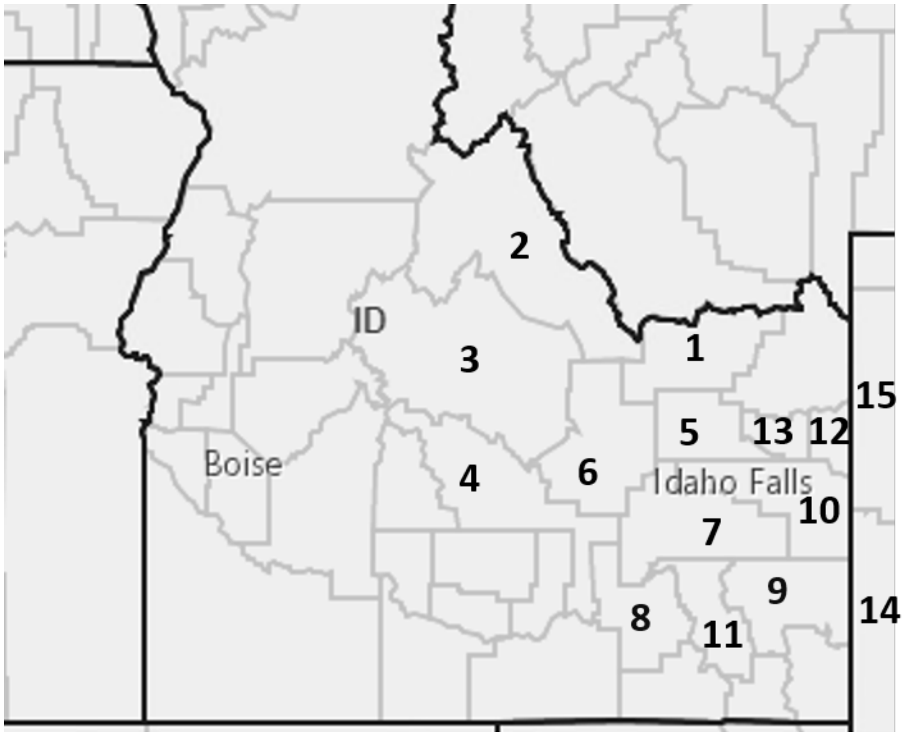


Figure D-5: Counties surrounding the proposed Idaho sites.

Table D-3: Mapping of the Idaho sites to the surrounding counties.

Site Name	Surrounding County
INL - ATR & CITRC	1. Clark, ID
INL - ATR & CITRC	2. Lemhi, ID
INL - ATR & CITRC	3. Custer, ID
INL - ATR & CITRC	4. Blaine, ID
INL - ATR, CITRC, MFC & Eagle Rock	5. Jefferson, ID
INL - ATR, CITRC, & MFC	6. Butte, ID
INL - ATR, CITRC, MFC & Eagle Rock	7. Bingham, ID
INL - MFC	8. Power, ID
INL - MFC & Eagle Rock	9. Caribou, ID
INL - MFC	10. Bonneville, ID
INL - MFC	11. Bannock, ID
Eagle Rock	12. Teton, ID
Eagle Rock	13. Madison, ID
Ragle Rock	14. Lincoln, WY
Eagle Rock	15. Teton, WY

Table D-4: Summary Air Quality Index data for the counties surrounding the INL-ATR, INL-CITRC, INL-MFC, and Eagle Rock sites in Idaho.

		Air Quality Index Data for 2019[1]					
Surrounding County	Population	Days Measured	Good (# of days)	Moderate (# of Days)	Unhealthy for Sensitive Groups (# of Days)	Unhealthy (# of Days)	Very Unhealthy (# of Days)
1. Clark, ID	1,077	n/a	n/a	n/a	n/a	n/a	n/a
2. Lemhi, ID	7,798	360	269	87	4	0	0
3. Custer, ID	4,141	68	68	0	0	0	0
4. Blaine, ID	21,994	314	313	1	0	0	0
5. Jefferson, ID	27,969	n/a	n/a	n/a	n/a	n/a	n/a
6. Butte, ID	2,602	361	348	13	0	0	0
7. Bingham, ID	45,551	n/a	n/a	n/a	n/a	n/a	n/a
8. Power, ID	7,713	n/a	n/a	n/a	n/a	n/a	n/a
9. Caribou, ID	6,918	330	326	2	2	0	0
10. Bonneville, ID	112,397	357	342	15	0	0	0
11. Bannock, ID	85,065	365	344	21	0	0	0
12. Teton, ID	11,080	n/a	n/a	n/a	n/a	n/a	n/a
13. Madison, ID	38,705	n/a	n/a	n/a	n/a	n/a	n/a
14. Lincoln, WY	19,011	n/a	n/a	n/a	n/a	n/a	n/a
15. Teton, WY	23,059	365	326	39	0	0	0

1. Data source: https://www.epa.gov/outdoor-air-quality-data/air-quality-index-report

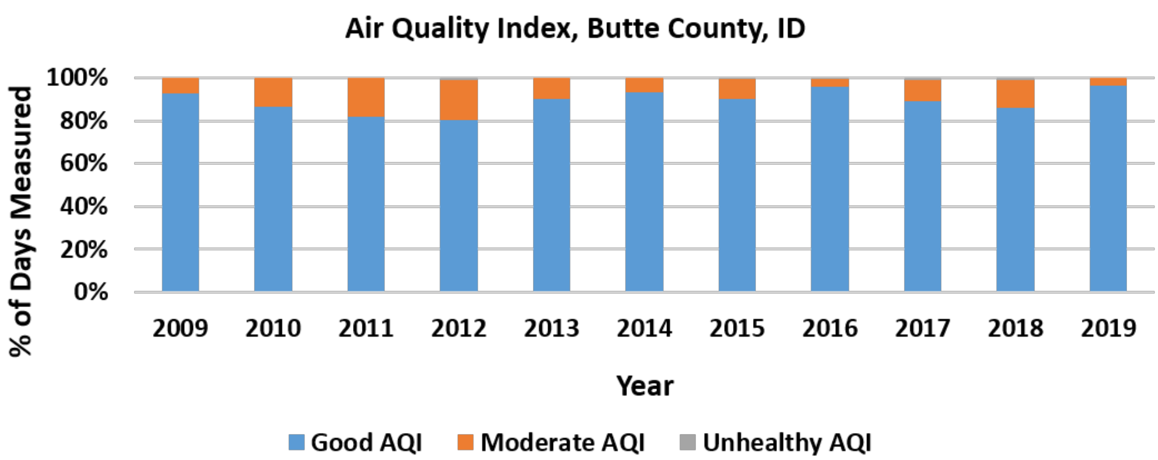


Figure D-6: Summary of the annual AQI data for the years 2009 to 2019 for Butte County, ID.

D.4 NNSS

Figure D-7 shows the counties that surround the NNSS site and Table D-5 shows the 2019 AQI summary data for the counties surrounding the site. Figure D-8 shows the annual AQI summaries for the years 2009 - 2019, expressed as the percent of time the AQI were in a given category for Nye County where the proposed site is located.

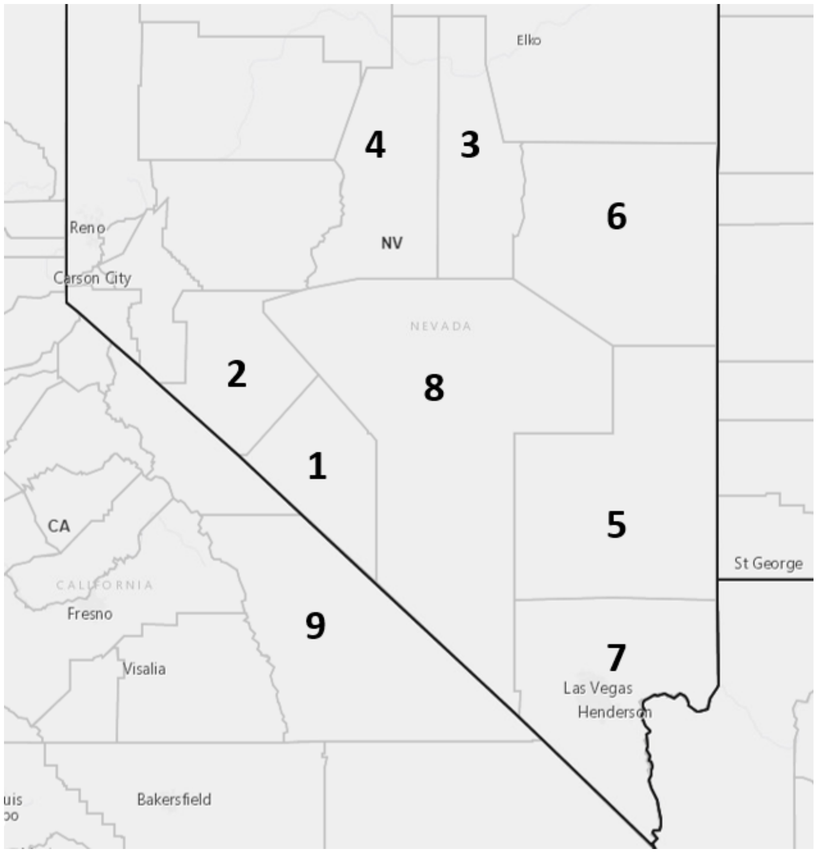


Figure D-7: Counties surrounding the proposed NNSS site.

Table D-5: Summary Air Quality Index data for the counties surrounding the proposed NNSS site.

		Air Quality Index Data for 2019[1]						
Surrounding County	Population	Days Measured	Good (# of days)	Moderate (# of Days)	Unhealthy for Sensitive Groups (# of Days)	Unhealthy (# of Days)	Very Unhealthy (# of Days)
1. Esmeralda, NV	981	n/a	n/a	n/a	n/a	n/a	n/a
2. Mineral, NV	4,448	n/a	n/a	n/a	n/a	n/a	n/a
3. Eureka, NV	1,830	n/a	n/a	n/a	n/a	n/a	n/a
4. Lander, NV	5,746	n/a	n/a	n/a	n/a	n/a	n/a
5. Lincoln, NV	5,174	n/a	n/a	n/a	n/a	n/a	n/a
6. White Pine, NV	9,737	n/a	n/a	n/a	n/a	n/a	n/a
7. Clark, NV	2,141,574	365	154	206	5	0	0
8. Nye, NV	43,705	365	352	12	1	0	0
9. Inyo, CA	18,085	365	232	121	6	2	4

1. Data source: https://www.epa.gov/outdoor-air-quality-data/air-quality-index-report

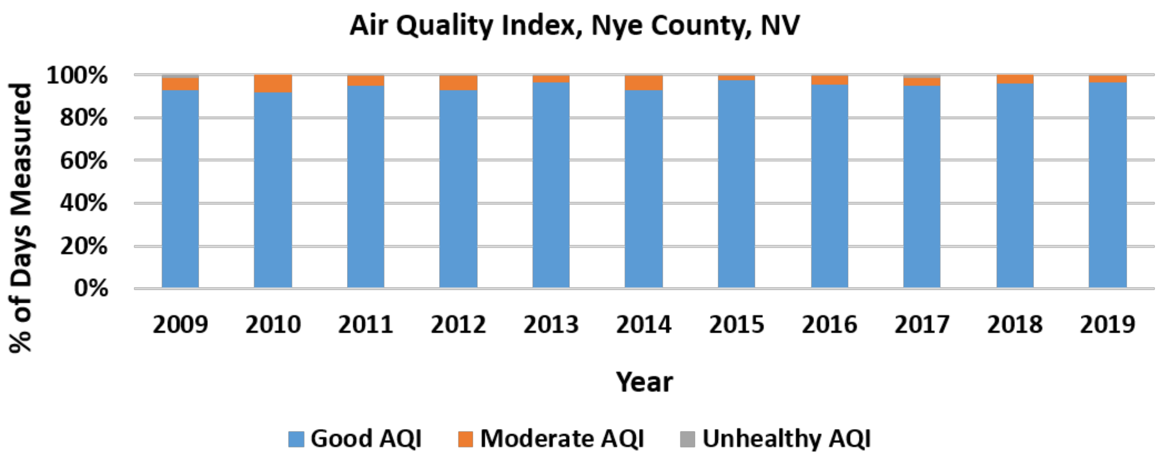


Figure D-8: Summary of the annual AQI data for the years 2009 to 2019 for Nye County, NV.

D.5 Savannah River National Laboratory

Figure D-9 shows the counties that surround the SRNL site and Table D-6 shows the 2019 AQI summary data for the counties surrounding the site. Figure D-10 shows the annual AQI summaries for the years 2009 - 2019 expressed as the percent of time the AQI were in a given category for Aiken County where the proposed site is located.

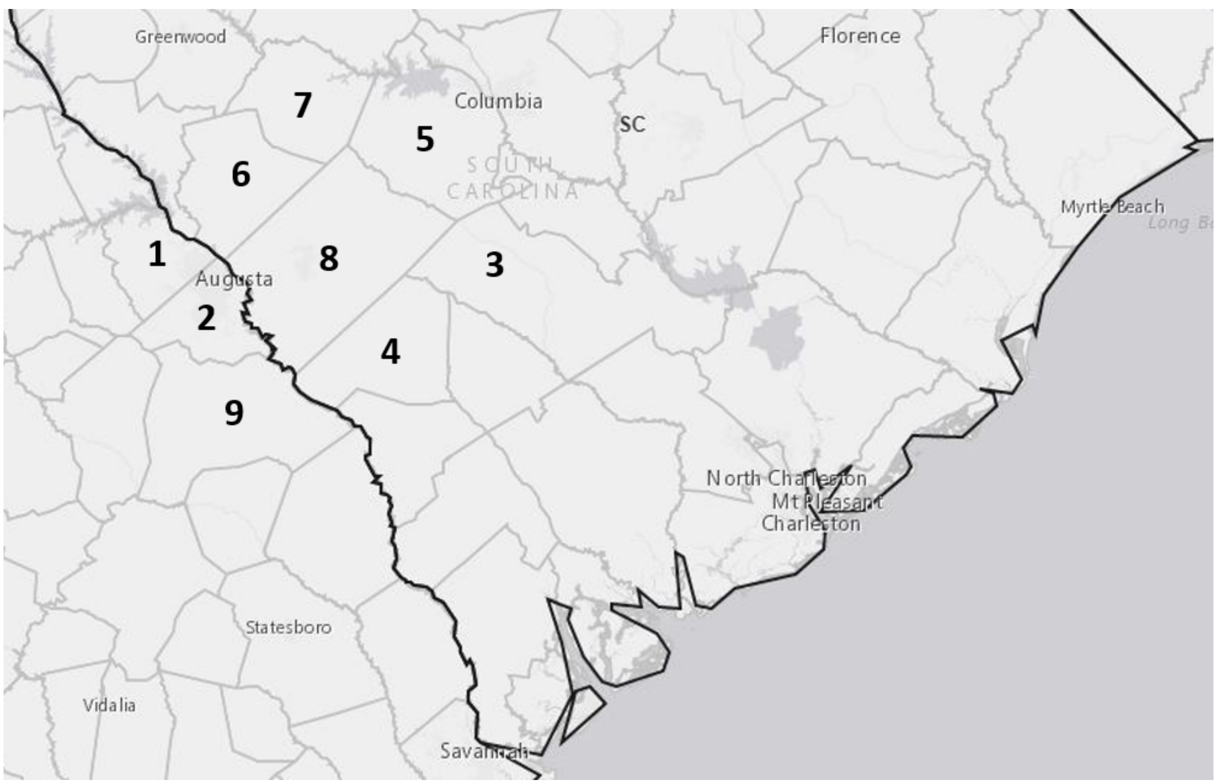


Figure D-9: Counties surrounding the proposed SRNL site.

Table D-6: Summary Air Quality Index data for the counties surrounding the proposed SRNL site.

		Air Quality Index Data for 2019[1]					
Surrounding County	Population	Days Measured	Good (# of days)	Moderate (# of Days)	Unhealthy for Sensitive Groups (# of Days)	Unhealthy (# of Days)	Very Unhealthy (# of Days)
1. Columbia, GA	147,295	245	229	16	0	0	0
2. Richmond, GA	201,463	364	231	131	2	0	0
3. Orangeburg, SC	88,454	n/a	n/a	n/a	n/a	n/a	n/a
4. Barnwell, SC	21,577	n/a	n/a	n/a	n/a	n/a	n/a
5. Lexington, SC	286,316	365	309	56	0	0	0
6. Edgefield, SC	26,769	365	299	66	0	0	0
7. Saluda, SC	20,299	n/a	n/a	n/a	n/a	n/a	n/a
8. Aiken, SC	166,926	265	230	35	0	0	0
9. Burke , GA	22,550	n/a	n/a	n/a	n/a	n/a	n/a

1. Data source: https://www.epa.gov/outdoor-air-quality-data/air-quality-index-report

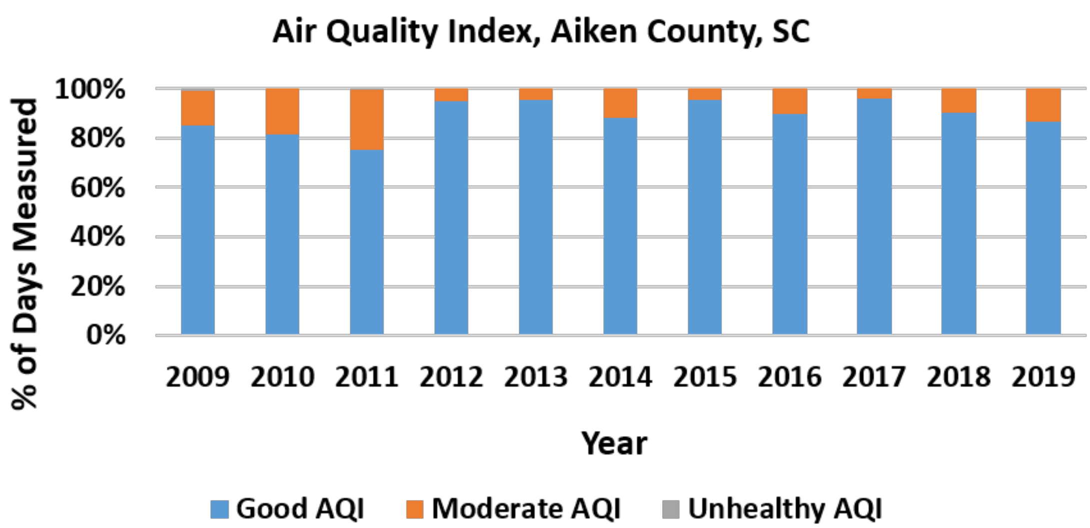


Figure D-10: Summary of the annual AQI data for the years 2009 to 2019 for Aiken County, SC.

D.6 Clinch River

Figure D-11 shows the counties that surround the TVA-Clinch River site and Table D-7 shows the 2019 AQI summary data for the counties surrounding the site. Figure D-12 shows the annual AQI summaries for the years 2009 - 2019, expressed as the percent of time the AQI were in a given category for Loudon County where the proposed site is located.

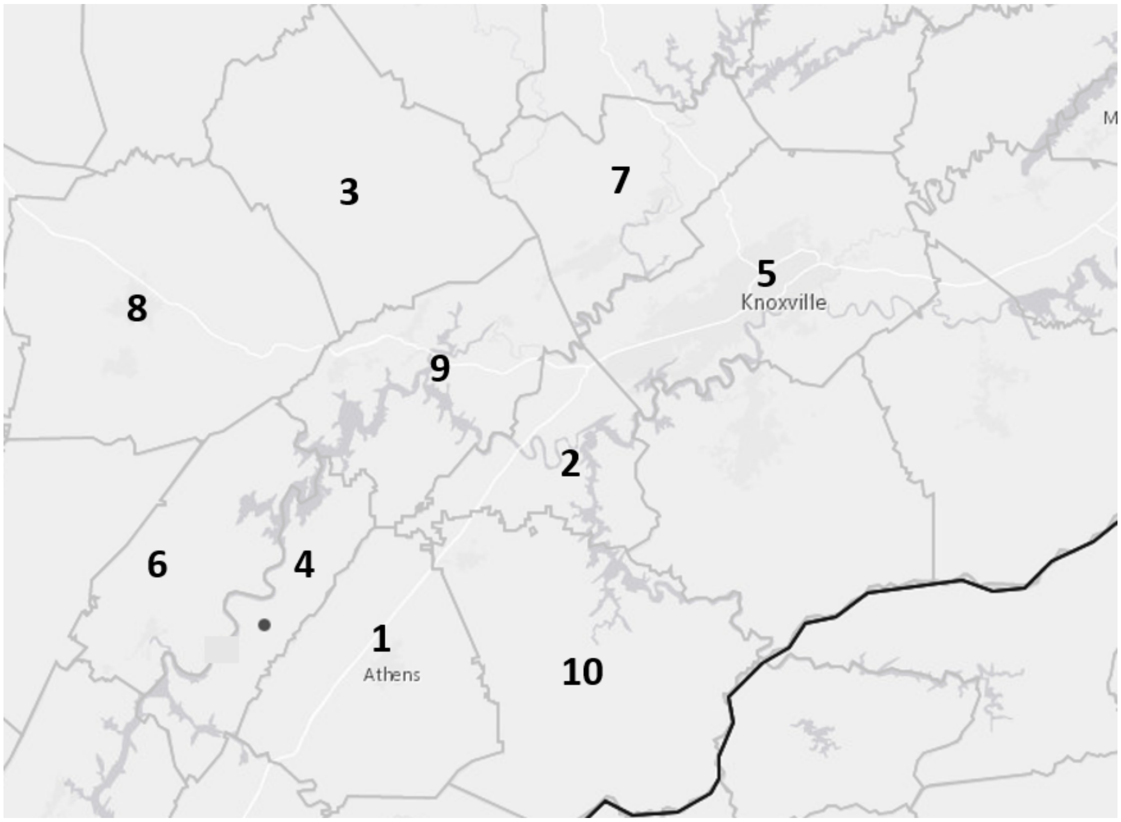


Figure D-11: Counties surrounding the proposed TVA – Clinch River site.

Table D-7: Summary Air Quality Index data for the counties surrounding the proposed Clinch River site.

		Air Quality Index Data for 2019[1]					
Surrounding County	Population	Days Measured	Good (# of days)	Moderate (# of Days)	Unhealthy for Sensitive Groups (# of Days)	Unhealthy (# of Days)	Very Unhealthy (# of Days)
1. McMinn , TN	52,773	357	316	41	0	0	0
2. Loudon, TN	51,610	365	313	52	0	0	0
3. Morgan, TN	21,596	n/a	n/a	n/a	n/a	n/a	n/a
4. Meigs, TN	11,962	n/a	n/a	n/a	n/a	n/a	n/a
5. Knox, TN	456,185	364	269	95	0	0	0
6. Rhea, TN	32,628	n/a	n/a	n/a	n/a	n/a	n/a
7. Anderson,TN	75,775	365	308	55	2	0	0
8. Cumberland, TN	58,634	n/a	n/a	n/a	n/a	n/a	n/a
9. Roane, TN	52,897	357	339	18	0	0	0
10. Monroe, TN	45,876	n/a	n/a	n/a	n/a	n/a	n/a

1. Data source: https://www.epa.gov/outdoor-air-quality-data/air-quality-index-report

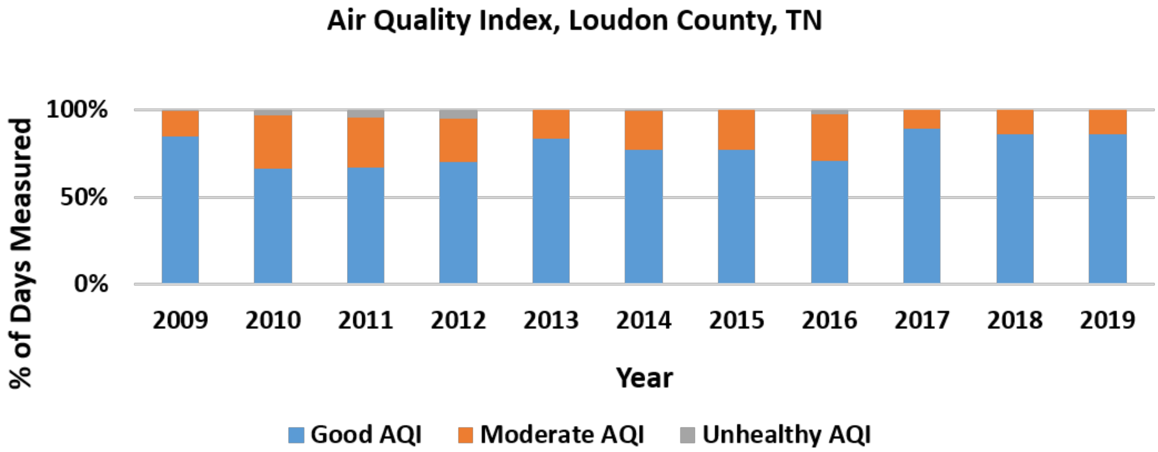


Figure D-12: Summary of the annual AQI data for the years 2009 to 2019 for Loudon County, TN.

D.7 University of Illinois-Urban Champaign

Figure D-13 shows the counties that surround the UIUC site and Table D-8 shows the 2019 AQI summary data for the counties surrounding the site. Figure D-14 shows the annual AQI summaries for the years 2009 - 2019, expressed as the percent of time the AQI were in a given category for Loudon County where the proposed site is located.

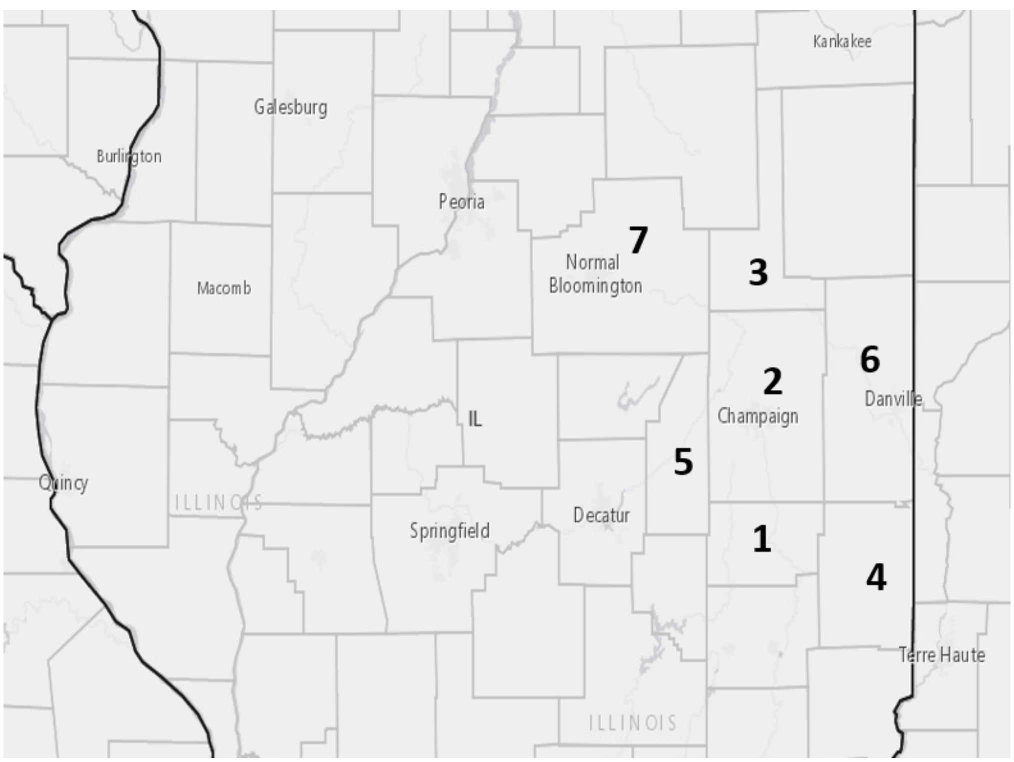


Figure D-13: Counties surrounding the proposed UIUC site.

Table D-8: Summary Air Quality Index data for the counties surrounding the proposed UIUC site.

Surrounding County	Population	Air Quality Index Data for 2019[1] Days Measured	Good (# of days)	Moderate (# of Days)	Unhealthy for Sensitive Groups (# of Days)	Unhealthy (# of Days)	Very Unhealthy (# of Days)
1. Douglas, IL	17,714	n/a	n/a	n/a	n/a	n/a	n/a
2. Champaign, IL	209,448	365	281	84	0	0	0
3. Ford , IL	13,398	n/a	n/a	n/a	n/a	n/a	n/a
4. Edgar, IL	17,539	n/a	n/a	n/a	n/a	n/a	n/a
5. Piatt, IL	16,427	n/a	n/a	n/a	n/a	n/a	n/a
6. Vermilion, IL	78,407	n/a	n/a	n/a	n/a	n/a	n/a
7. McLean, IL	173,219	364	256	108	0	0	0

1. Data source: https://www.epa.gov/outdoor-air-quality-data/air-quality-index-report

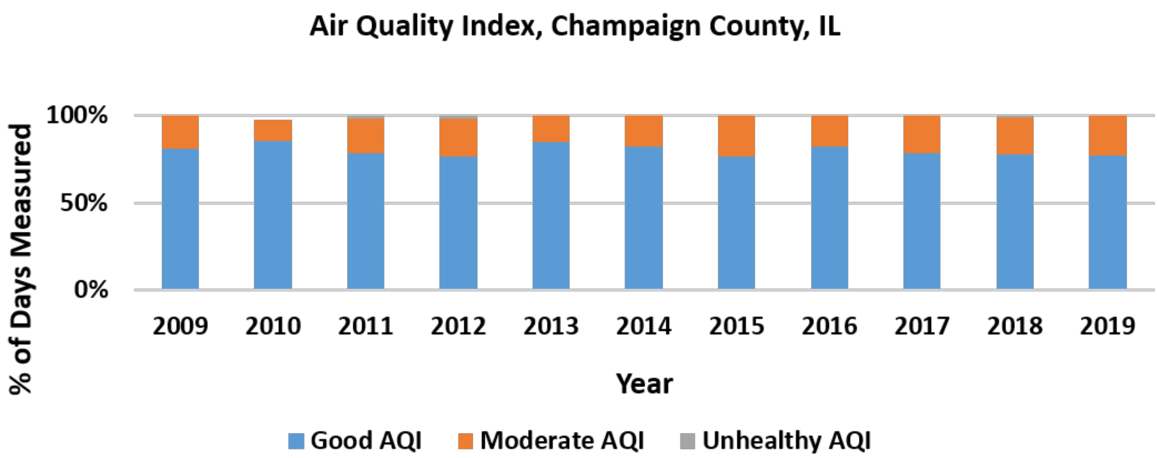


Figure D-14: Summary of the annual AQI data for the years 2009 to 2019 for Champaign County, IL.

D.8 TVA – Portsmouth, OH

Figure D-15 shows the counties that surround the Portsmouth site and Table D-9 shows the 2019 AQI summary data for the counties surrounding the site. Figure D-16 shows the annual AQI summary, expressed as the percent of time the AQI were in a given category for Adams County where the proposed site is located.

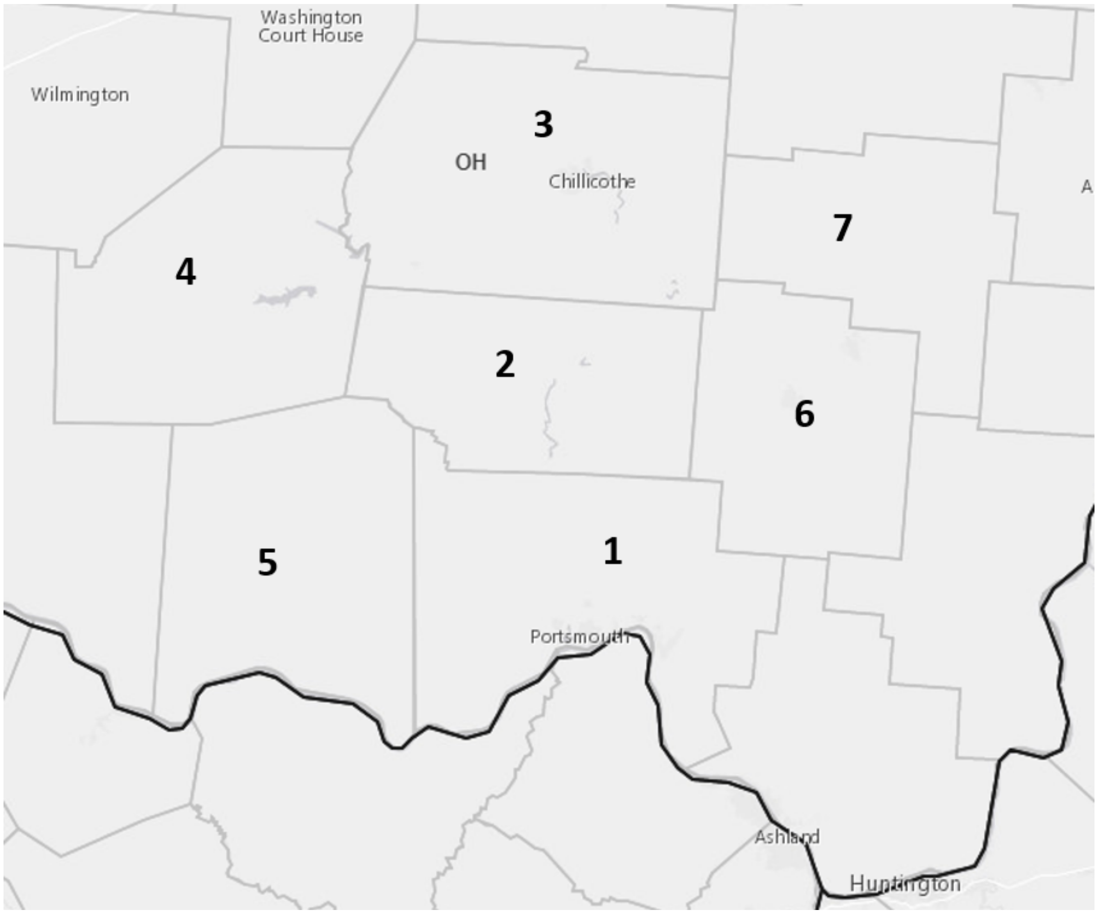


Figure D-15: Counties surrounding the proposed Portsmouth site.

Table D-9: Summary Air Quality Index data for the counties surrounding the proposed Portsmouth site.

		Air Quality Index Data for 2019[1]					
Surrounding County	Population	Days Measured	Good (# of days)	Moderate (# of Days)	Unhealthy for Sensitive Groups (# of Days)	Unhealthy (# of Days)	Very Unhealthy (# of Days)
1. Scioto , OH	76,377	365	356	9	0	0	0
2. Pike, OH	28,214	n/a	n/a	n/a	n/a	n/a	n/a
3. Ross, OH	77,051	n/a	n/a	n/a	n/a	n/a	n/a
4. Highland, OH	43,007	n/a	n/a	n/a	n/a	n/a	n/a
5. Adams, OH	27,878	365	361	4	0	0	0
6. Jackson , OH	32,524	n/a	n/a	n/a	n/a	n/a	n/a
7. Vinton, OH	13,111	n/a	n/a	n/a	n/a	n/a	n/a

1. Data source: https://www.epa.gov/outdoor-air-quality-data/air-quality-index-report

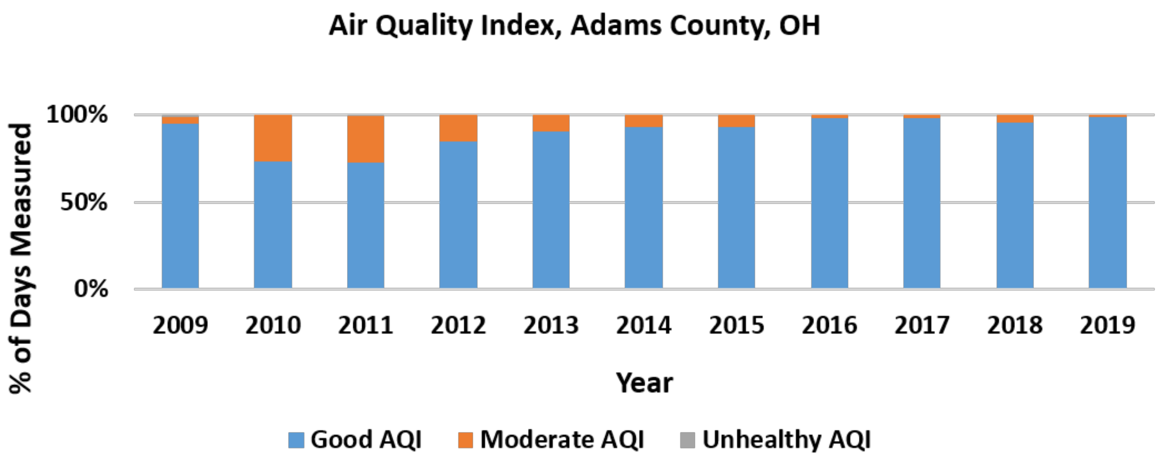


Figure D-16: Summary of the annual AQI data for the years 2009 to 2019 for Adams County, OH.

Appendix E: Extreme Weather Considerations

The sites have been evaluated using the U.S. Climate Extreme Index (CEI) which was developed by the National Oceanic and Atmospheric Administration [34] to quantify observed changes within the contiguous U.S. The CEI divides the U.S. into nine regions. The three INL sites and the Energy Northwest site are located in the Northwest region. The NNSA site is in the West region. The UIUC, Portsmouth, and Clinch River sites are in the Ohio Valley region and the Savannah River site is in the Southeast region. The CEI data that were examined provide a regional overview and should not be interpreted as being representative of conditions at a given site. In order to assess site specific conditions, meteorological data from reporting stations near the sites should be evaluated.

The data evaluated are the percentage of days in a year in which conditions were much above (the upper tenth percentile) or much below normal (lower tenth percentile) of the period of record. Figure E-1, Figure E-2, and Figure E-3 display the extremes in maximum temperatures, minimum temperatures, one-day precipitation for the Northwest region. Figure E-4, Figure E-5, and Figure E-6 show the corresponding data for the West region, Figure E-7, Figure E-8, and Figure E-9 show the results for the Ohio Valley region, and Figure E-10, Figure E-11, and Figure E-12 show the data for the Southeast region.

In each of the regions where the potential sites are located, the extremes in the maximum and minimum demonstrate an increasing trend since 1990's. This is consistent with temperature measurements across the U.S. in which there has been an observed increase in the average and extreme temperatures [35]. The increases in air temperature can have an impact on the cooling efficiency of available sources of water and on the efficiency of transmission lines [17]. The increases in temperature can also have an impact on the requirements for the HVAC systems in any facility that would support a reactors system.

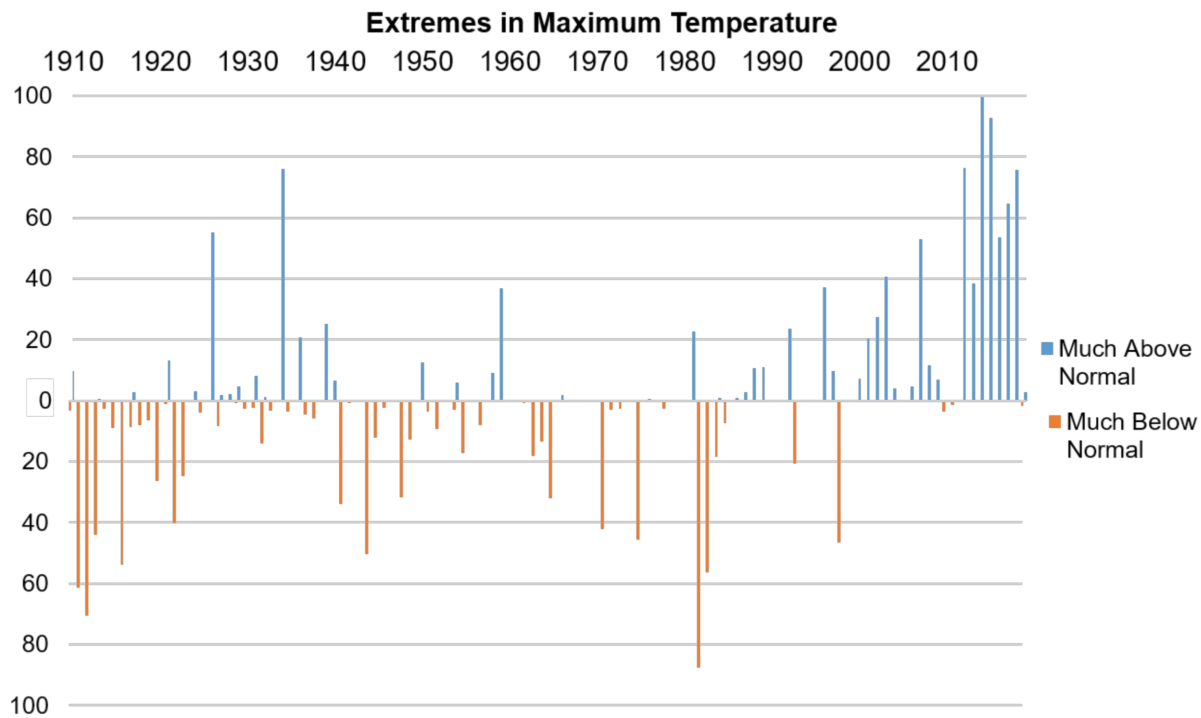


Figure E-1: Percent of days in a given year in which the daily maximum temperature was above or below normal between 1910 to 2019 for the North Region.

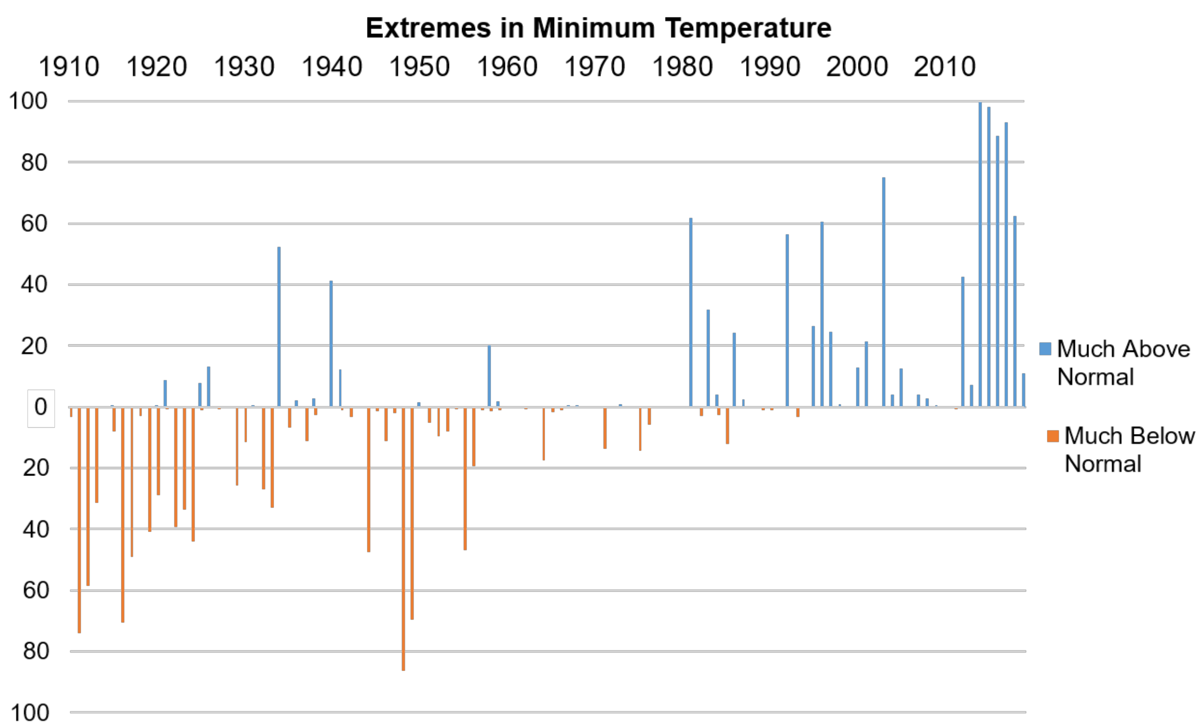


Figure E-2: Percent of days in a given year in which the daily minimum temperature was above or below normal between 1910 to 2019 for the North Region.

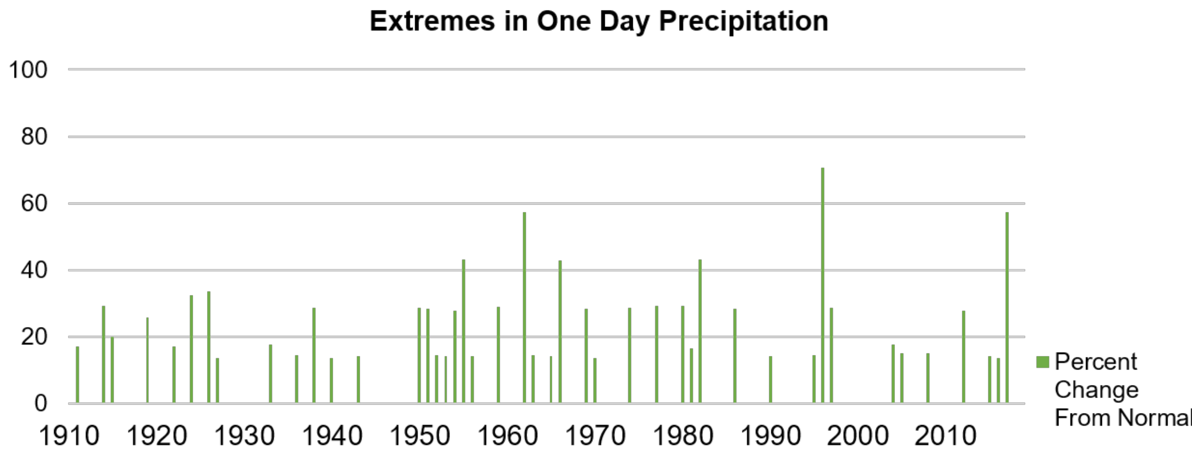


Figure E-3: Percent change from normal for the one-day precipitation rates between 1910 to 2019 for the North Region.

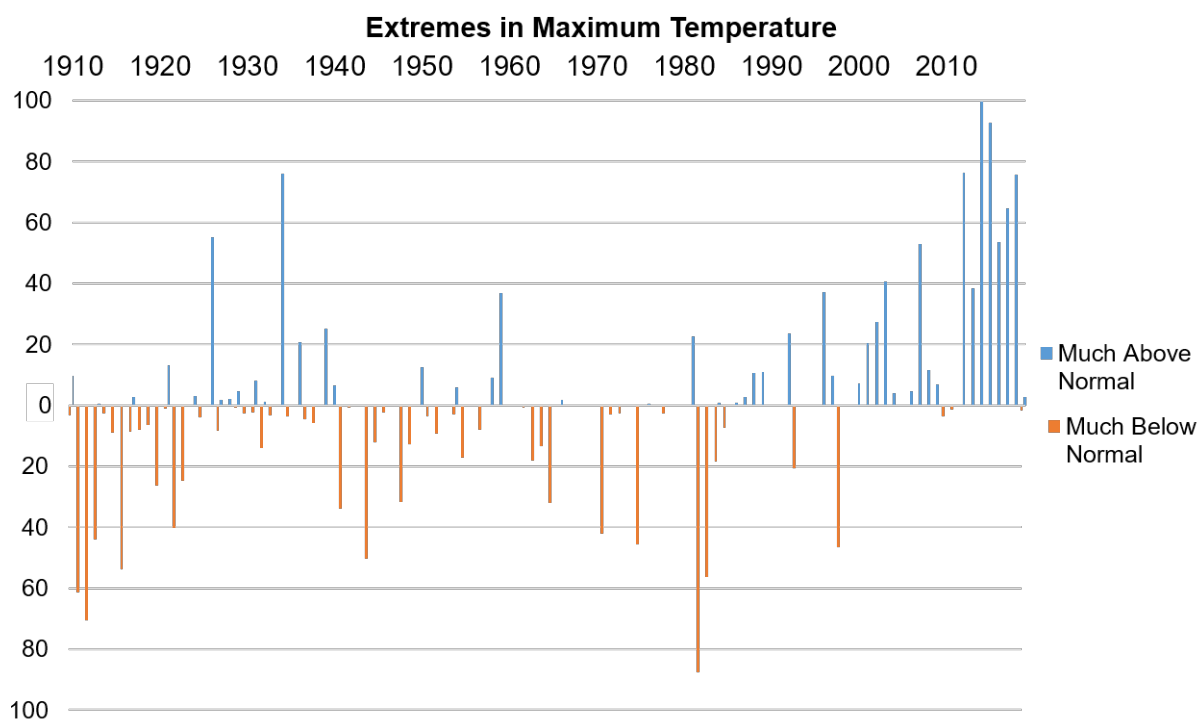


Figure E-4: Percent of days in a given year in which the daily maximum temperature was above or below normal between 1910 to 2019 for the West Region.

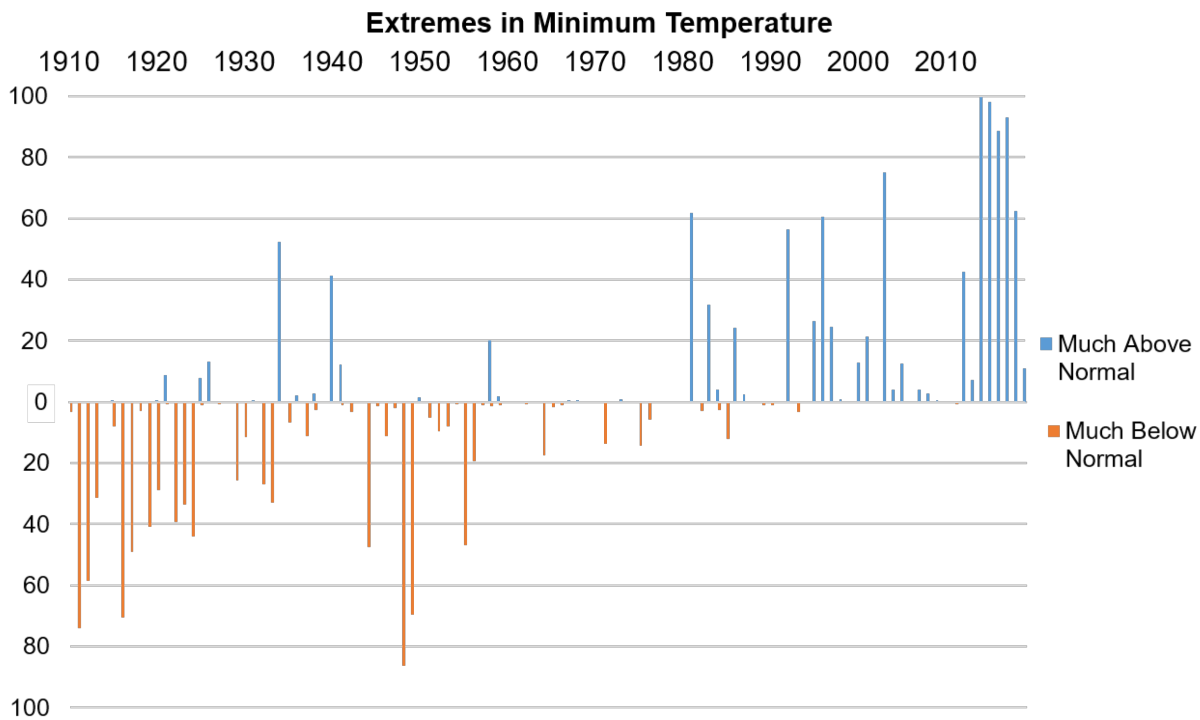


Figure E-5: Percent of days in a given year in which the daily minimum temperature was above or below normal between 1910 to 2019 for the West Region.

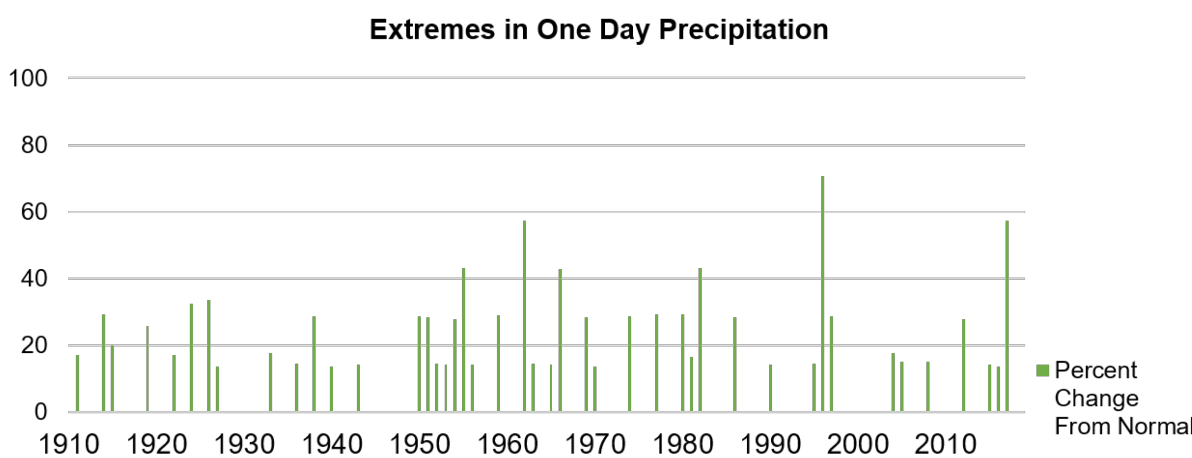


Figure E-6: Percent change from normal for the one-day precipitation rates between 1910 to 2019 for the West Region.

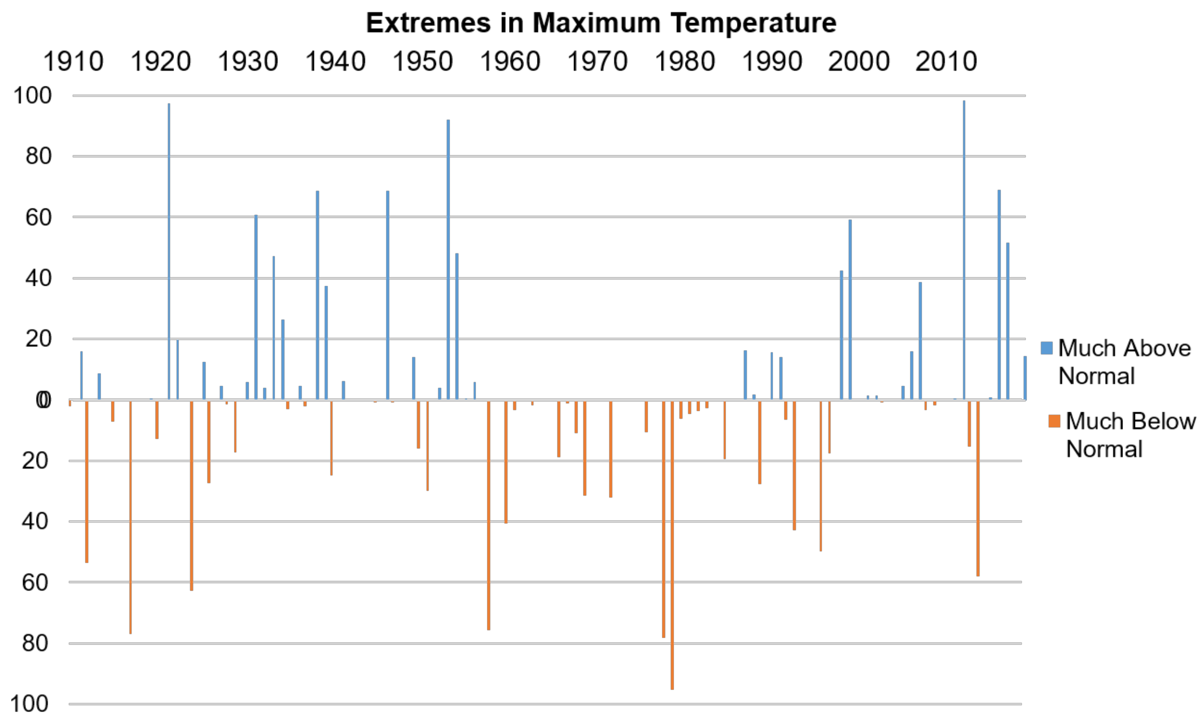


Figure E-7: Percent of days in a given year in which the daily maximum temperature was above or below normal between 1910 to 2019 for the Ohio Valley Region.

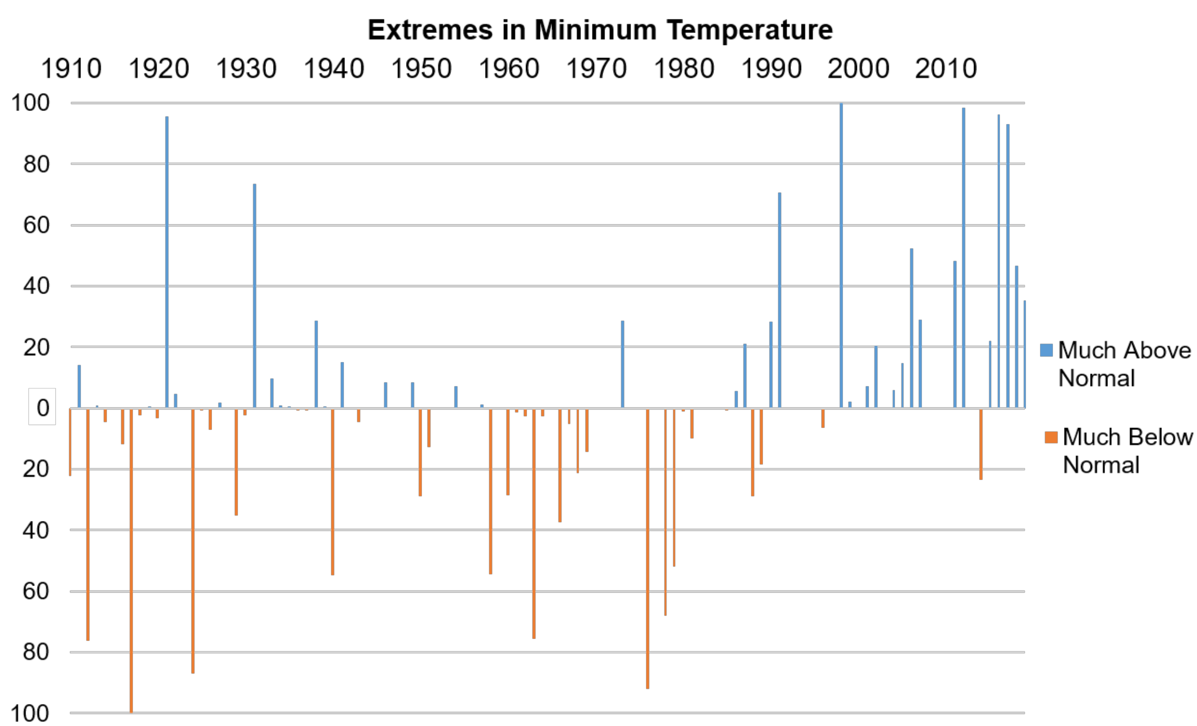


Figure E-8: Percent of days in a given year in which the daily minimum temperature was above or below normal between 1910 to 2019 for the Ohio Valley Region.

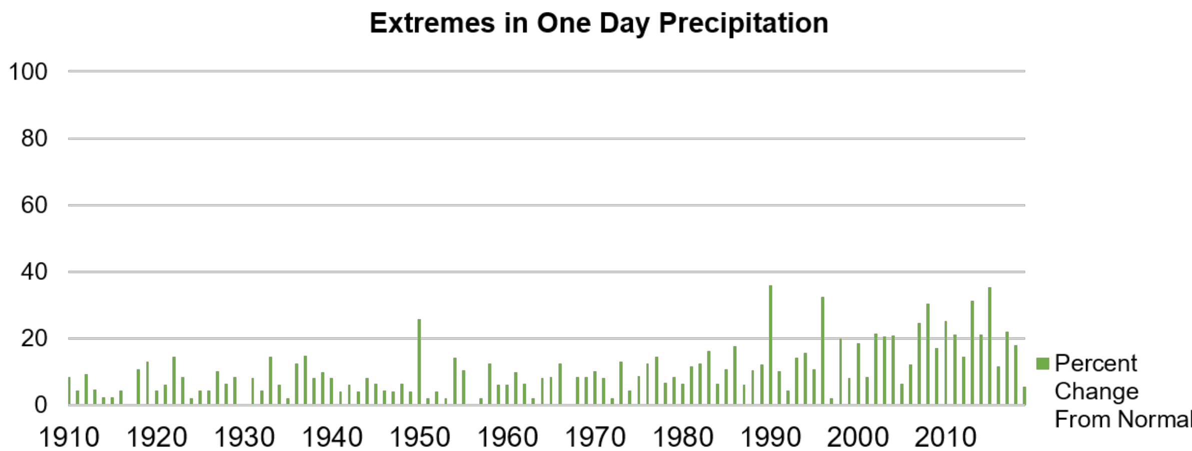


Figure E-9: Percent change from normal for the one-day precipitation rates between 1910 to 2019 for the Ohio Valley Region.

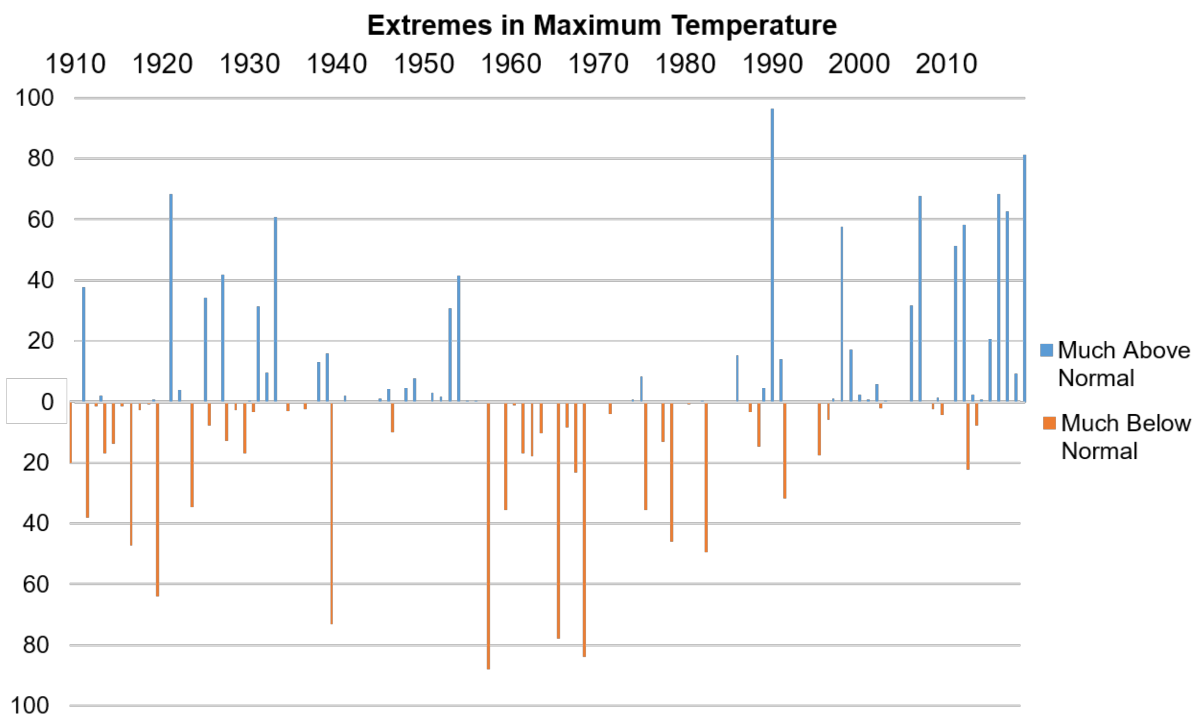


Figure E-10: Percent of days in a given year in which the daily maximum temperature was above or below normal between 1910 to 2019 for the Southeast Region.

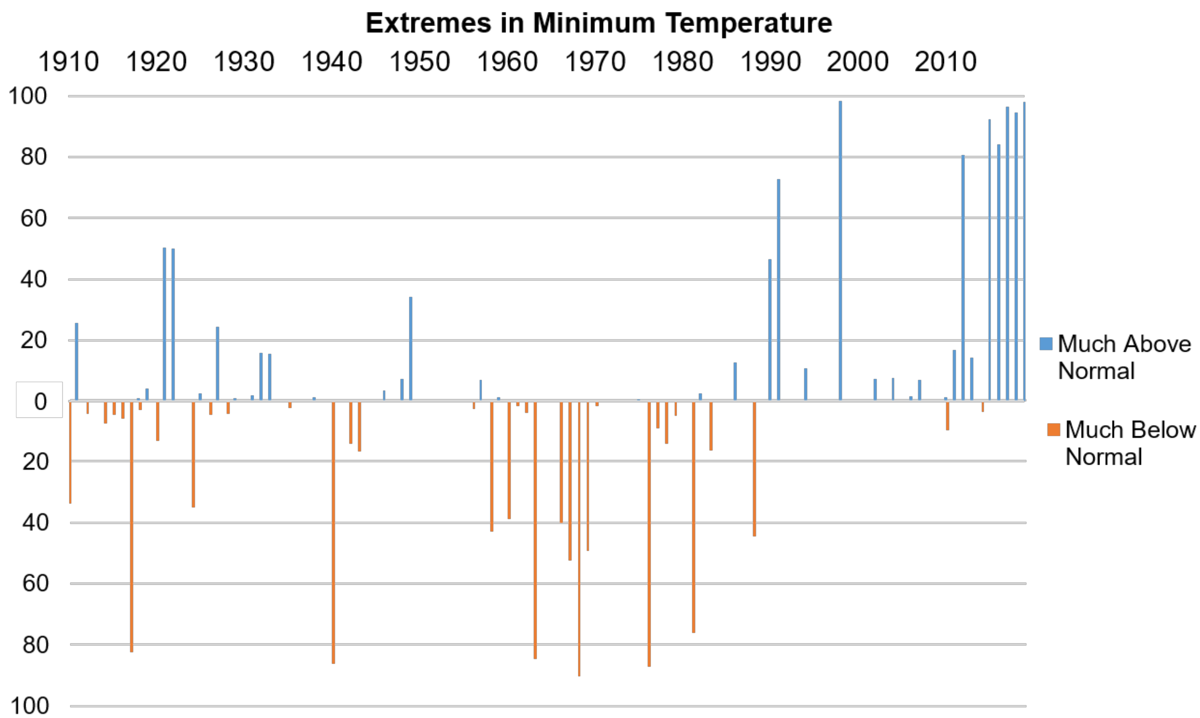


Figure E-11: Percent of days in a given year in which the daily minimum temperature was above or below normal between 1910 to 2019 for the Southeast Region.

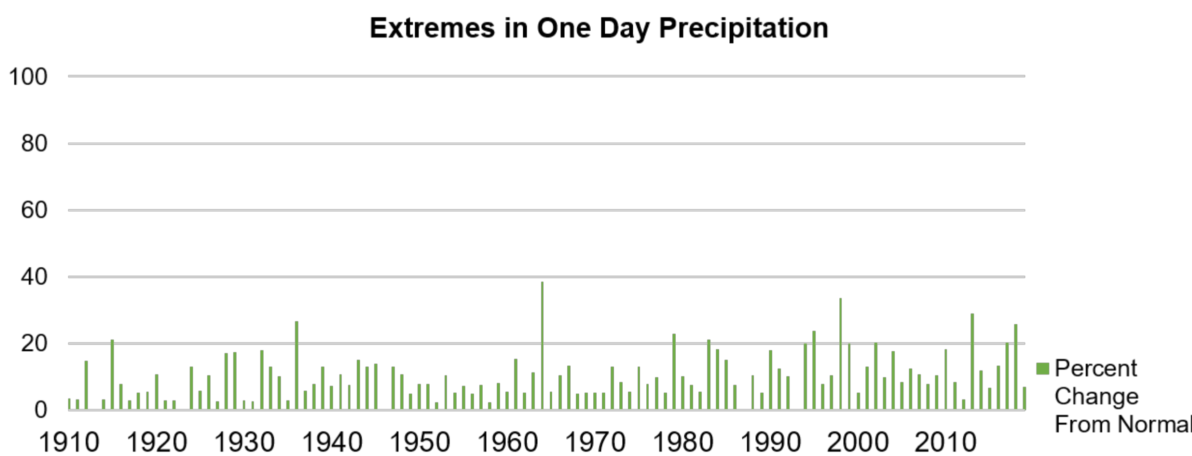


Figure E-12: Percent change from normal for the one-day precipitation rates between 1910 to 2019 for the Southeast Region.

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