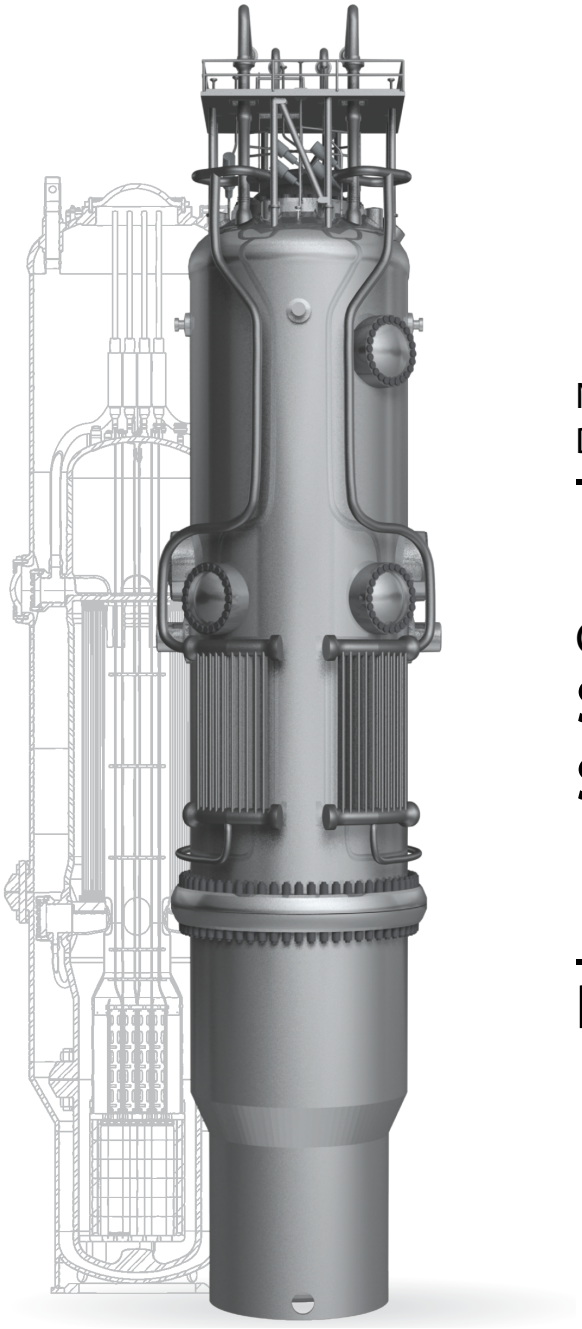

NuScale Standard Plant
Design Certification Application

Chapter Two

# Site Characteristics and Site Parameters

# PART 2 - TIER 2

Revision 0
December 2016

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# CHAPTER 2 SITE CHARACTERISTICS AND SITE PARAMETERS

## 2.0 Site Characteristics and Site Parameters

The NuScale Power Plant design assumes site parameters that envelope conditions at most expected potential plant site locations in the United States. A summary of these parameters is provided in Table 2.0-1.

COL Item 2.0-1: A COL applicant that references the NuScale Power Plant design certification will demonstrate that site-specific characteristics are bounded by the design parameters specified in Table 2.0-1. If site-specific values are not bounded by the values in Table 2.0-1, the COL applicant will demonstrate the acceptability of the site-specific values in the appropriate sections of its combined license application.

## Table 2.0-1: Site Design Parameters

| Site Characteristic / Parameter | NuScale Design Parameter | |
|---|---|---|
| **Geography and Demography (Section 2.1)** | | |
| Minimum exclusion area boundary | Security owner controlled area fence | |
| Minimum outer boundary of low population zone | Security owner controlled area fence | |
| **Nearby Industrial, Transportation, and Military Facilities (Section 2.2)** | | |
| External hazards on plant systems, structures, and components (SSC) (e.g., explosions, fires, release of toxic chemicals and flammable clouds, pressure effects) on plant SSC | No external hazards | |
| Aircraft hazards on plant SSC | No design basis aircraft hazards | |
| **Meteorology (Section 2.3)** | | |
| Maximum precipitation rate | 19.4 inches per hour<br>6.3 inches for a 5 minute period | |
| Normal roof snow load | 50 psf | |
| Extreme roof snow load | 75 psf | |
| 100-year return period 3-second wind gust speed | 145 mph (exposure Category C) with an importance factor of 1.15 for Reactor Building, Control Building and Radioactive Waste Building | |
| Design basis tornado<br>maximum horizontal wind speed<br>maximum translational speed<br>maximum rotational speed<br>maximum radius of rotational speed<br>maximum pressure differential<br>maximum rate of pressure drop | <br>230 mph<br>46 mph<br>184 mph<br>150 ft<br>1.2 psi<br>0.5 psi/sec | |
| Tornado missile spectra | Table 2 of Regulatory Guide 1.76, Revision 1, Region 1 | |
| Maximum wind speed design basis hurricane | 290 mph | |
| Hurricane missile spectra | Tables 1 and 2 of Regulatory Guide 1.221, Revision 0 | |
| Summer outdoor design dry bulb temperature | 115°F | |
| Winter outdoor design dry-bulb temperature | -40°F | |
| Summer outdoor wet bulb temperature<br>coincident<br>non-coincident | <br>80°F<br>81°F | |
| Accident airborne effluent release point characteristics for offsite receptors<br>release height<br>adjacent building height<br>adjacent building cross-sectional area | <br>ground level (0 meters)<br>negligible<br>negligible (0.1 square meters) | |
| Accident release $\chi$/Q values at security owner controlled area fence<br>0-2 hr<br>2-8 hr<br>8-24 hr<br>24-96 hr<br>96-720 hr | <br>5.72E-04 s/m$^3$<br>4.85E-04 s/m$^3$<br>2.14E-04 s/m$^3$<br>2.15E-04 s/m$^3$<br>1.95E-04 s/m$^3$ | |
| Accident release $\chi$/Q values at main control room/technical support center door and HVAC intake (approximately 112 feet from source)<br>0-2 hr<br>2-8 hr | <u>Door</u><br>6.50E-03 s/m$^3$<br>5.34E-03 s/m$^3$ | <u>HVAC Intake</u><br>6.50E-03 s/m$^3$<br>5.34E-03 s/m$^3$ |

**Table 2.0-1: Site Design Parameters (Continued)**

| Site Characteristic / Parameter | NuScale Design Parameter |
|---|---|
| 8-24 hr | 2.32E-03 $s/m^3$ 2.32E-03 $s/m^3$ |
| 1-4 day | 2.37E-03 $s/m^3$ 2.37E-03 $s/m^3$ |
| 4-30 day | 2.14E-03 $s/m^3$ 2.14E-03 $s/m^3$ |
| Routine airborne effluent release point characteristics for offsite receptors | |
| release location | Any point on Reactor Building or Turbine Building wall |
| release height | 37.0 meters |
| vent/stack exit velocity | 0.0 meters/second |
| vent/stack inside diameter | 0.0 meters |
| vent/stack exhaust orientation (vertical, horizontal, or other) | not applicable |
| restrictions to exhaust Air flow (e.g., rain caps) | not applicable |
| adjacent building height | 0.0 meters |
| adjacent building cross-sectional area | 0.01 square meters |
| Annual average routine release $\chi/Q$ values at the security owner controlled area fence | 3.64E-04 $s/m^3$ |
| Routine release $\chi/Q$ and D/Q values at site boundary and locations of interest | |
| undepleted/no decay | 5.43E-05 $m/s^3$ |
| undepleted/2.26-day decay | 5.43E-05 $m/s^3$ |
| depleted/8.00-day decay | 5.43E-05 $m/s^3$ |
| D/Q | 5.43E-07 $m^2$ |
| **Hydrologic Engineering (Section 2.4)** | |
| Maximum flood elevation<br>probable maximum flood and coincident wind wave and other effects on max flood level | 1 foot below the baseline plant elevation |
| Maximum elevation of groundwater | 2 feet below the baseline plant elevation |
| Site grading | Site is properly graded and has adequate drainage to prevent localized flooding |
| **Geology, Seismology, and Geotechnical Engineering (Section 2.5)** | |
| Ground motion response spectra /safe shutdown earthquake | See Figures 3.7.1-1 and 3.7.1-2 for horizontal and vertical certified seismic design response spectra.<br>See Figures 3.7.1-3 and 3.7.1-4 for horizontal and vertical high frequency certified seismic design response spectra. |
| Fault displacement potential | No fault displacement potential |
| Minimum soil bearing capacity ($Q_{ult}$) beneath safety-related structures | 75 ksf |
| Lateral soil variability | Uniform site (+/- 20 degree dip) |
| Soil angle of internal friction | 30 degrees |
| Minimum coefficient of static friction (all interfaces between basemat and soil) | 0.58 |
| Minimum shear wave velocity | $\geq$ 1000 fps at bottom of foundation |
| Liquefaction potential | No liquefaction potential |
| Maximum settlement for the Reactor Building, Control Building, and Radioactive Waste Building | |
| total settlement | no limit |
| tilt settlement | 1 inch per 50 feet in any direction |
| differential settlement (between Reactor Building and Control Building) | no limit |
| Slope failure potential | No slope failure potential |

**Table 2.0-1: Site Design Parameters (Continued)**

| Site Characteristic / Parameter | NuScale Design Parameter |
|---|---|
| **Source Terms** | |
| Design basis accident source term | Accident source term is addressed in Section 15.0.3 |
| Inventory of radionuclides that could potentially seep into the groundwater | Potential inventory of radionuclides and compliance with Branch Technical Position 11-06 are described in Sections 11.2.3.2 and 12.2 |

## 2.1 Geography and Demography

The certified design assumes that the Exclusion Area Boundary and Low Population Zone outer boundary are at the Security owner controlled area fence. This fence is shown on Figure 1.2-4. This is the smallest footprint that can be used for these boundaries. This is a key design parameter and included in Table 2.0-1.

COL Item 2.1-1: A COL applicant that references the NuScale Power Plant design certification will describe the site geographic and demographic characteristics.

## 2.2 Nearby Industrial, Transportation, and Military Facilities

The NuScale Power Plant certified design does not postulate any hazards from nearby industrial, transportation or military facilities.

COL Item 2.2-1: A COL applicant that references the NuScale Power Plant design certification will describe nearby industrial, transportation, and military facilities. The COL applicant will demonstrate that the design is acceptable for each potential accident, or provide site-specific design alternatives.

## 2.3 Meteorology

The NuScale Power Plant is designed using meteorological parameters selected to envelope conditions at most potential plant site locations in the United States. These parameters are discussed below and presented in Table 2.0-1.

COL Item 2.3-1: A COL applicant that references the NuScale Power Plant design certification will describe the site-specific meteorological characteristics for Section 2.3.1 through Section 2.3.5, as applicable.

### 2.3.1 Regional Climatology

The design maximum precipitation rate is 19.4 inches per hour and 6.3 inches for a 5 minute period. These values come from NWS HMR #52 (Reference 2.3-1) and address the majority of locations in the United States.

The design normal roof snow load is 50 psf. For the extreme roof snow load, a value of 150 percent of the normal roof snow load, or 75 psf was selected.

The design basis severe wind is a 3-second gust at 33 ft above ground for exposure category C. The wind speed (W) is 145 mph. The wind speed is increased by an importance factor of 1.15 for the design of the site independent structures. These design parameters are based upon ASCE/SEI 7-05 (Reference 2.3-4).

The parameters provided in Table 2.0-1 for the design basis tornado and tornado missiles are the most severe tornado parameters postulated for the continental United States as identified in RG 1.76, Rev. 1. Similarly, the parameters for the design basis hurricane and hurricane missiles are the most severe parameters postulated in RG 1.221, Rev 0.

The design basis dry-bulb and wet bulb temperatures are based on the EPRI Utility Requirements Document (Reference 2.3-2). The maximum and minimum dry bulb temperatures are 115 degrees F and -40 degrees F respectively, and the coincident and non-coincident wet bulb temperatures are 80 and 81 degrees F respectively.

Regional climatology is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.3-1.

### 2.3.2 Local Meteorology

Local meteorology is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.3-1.

### 2.3.3 Onsite Meteorological Measurements Programs

Onsite meteorological measurement programs are site-specific and are addressed by the COL applicant as part of the response to COL Item 2.3-1.

## 2.3.4 Short-Term Atmospheric Dispersion Estimates for Accident Releases

### Accidental Radioactive Releases

Topical Report TR-0915-17565, Revision 0, (Reference 2.3-3) describes the methodology used for establishing source terms and calculating the atmospheric dispersion factors used to determine accident radiological consequences at the technical support center (TSC), main control room (MCR) and offsite locations for the NuScale Power Plant certified design.

Atmospheric dispersion factors ($\chi$/Q values) are determined at the site owner controlled area boundary. This fence is 400 feet from the closest release point and may be used as both the exclusion area boundary (EAB) and as the low population zone (LPZ) outer boundary. These $\chi$/Q values as well as the $\chi$/Q values for the MCR were determined for various sites in the United States using a meteorological database that included multiple years of data across all regions of the United States. This approach determined that the meteorological dataset for Sacramento, California, between 1984-1986, is representative of the bounding 80th to 90th percentile of potential NuScale Power Plant construction sites in the United States. This meteorological data set was used to calculate the $\chi$/Q values for the certified design.

The $\chi$/Q values at the site owner controlled area fence are listed in Table 2.0-1. These $\chi$/Q values are based on the source location and path shown in Figure 2.3-1.

The $\chi$/Q values used for evaluation of doses in the MCR and TSC are determined at the Control Building doors and HVAC inlet and are listed in Table 2.0-1. Figure 2.3-2 and Figure 2.3-3 show the path and distances from the Reactor Building release point to MCR door and HVAC inlet. Assumptions for release point characteristics used for the $\chi$/Q calculations are also listed in Table 2.0-1.

The $\chi$/Q values for the TSC are the same as the MCR because the TSC is located directly above the MCR and shares the same HVAC inlet and outside doors.

The COL applicant will determine site specific $\chi$/Q values for the EAB, LPZ outer boundary, MCR and present that information as part of the response to COL item 2.3-1.

### Hazardous Material Releases

As stated in Section 2.2, the NuScale Power Plant certified design does not postulate any hazards from on-site sources or nearby industrial, transportation, or military facilities.

The COL applicant will provide discussion of site specific hazardous material releases as part of the response to COL item 2.3-1.

## 2.3.5 Long-Term Atmospheric Dispersion Estimates for Routine Releases

Site boundary annual average atmospheric dispersion factors ($\chi$/Q values) and relative deposition factor (D/Q) values provided in Table 2.0-1 are used to calculate the site boundary release concentrations for comparison to the activity release limits in 10 CFR 20 as discussed in Section 11.3.

Table 2.0-1 provides the annual average relative concentration ($\chi$/Q values) at the site owner controlled area fence.

Annual average atmospheric dispersion factors ($\chi$/Q values) and deposition factor (D/Q) values at the site boundary and at locations of interest are site-specific and are developed by the COL applicant as part of the response to COL Item 2.3-1.

## 2.3.6 References

2.3-1 National Oceanic and Atmospheric Administration Hydrometeorological Report Number 52, "Application of Probable Maximum Precipitation Estimates-United States East of the 105th Meridian," Washington DC, August 1982.

2.3-2 Electrical Power Research Institute, "Advanced Nuclear Technology: Advanced Light Water Reactor Utility Requirements Document," Revision 13, 2014.

2.3-3 NuScale Power LLC, Licensing Topical Report TR-0915-17565-P "Accident Source Term Methodology," Rev. 0, December 2015

2.3-4 American Society of Civil Engineers/Structural Engineering Institute, "Minimum Design Loads for Buildings and Other Structures," ASCE/SEI 7-05, Reston, VA, 2005.

**Figure 2.3-1: Limiting Analytical Distance to Site Owner Controlled Area Fence**

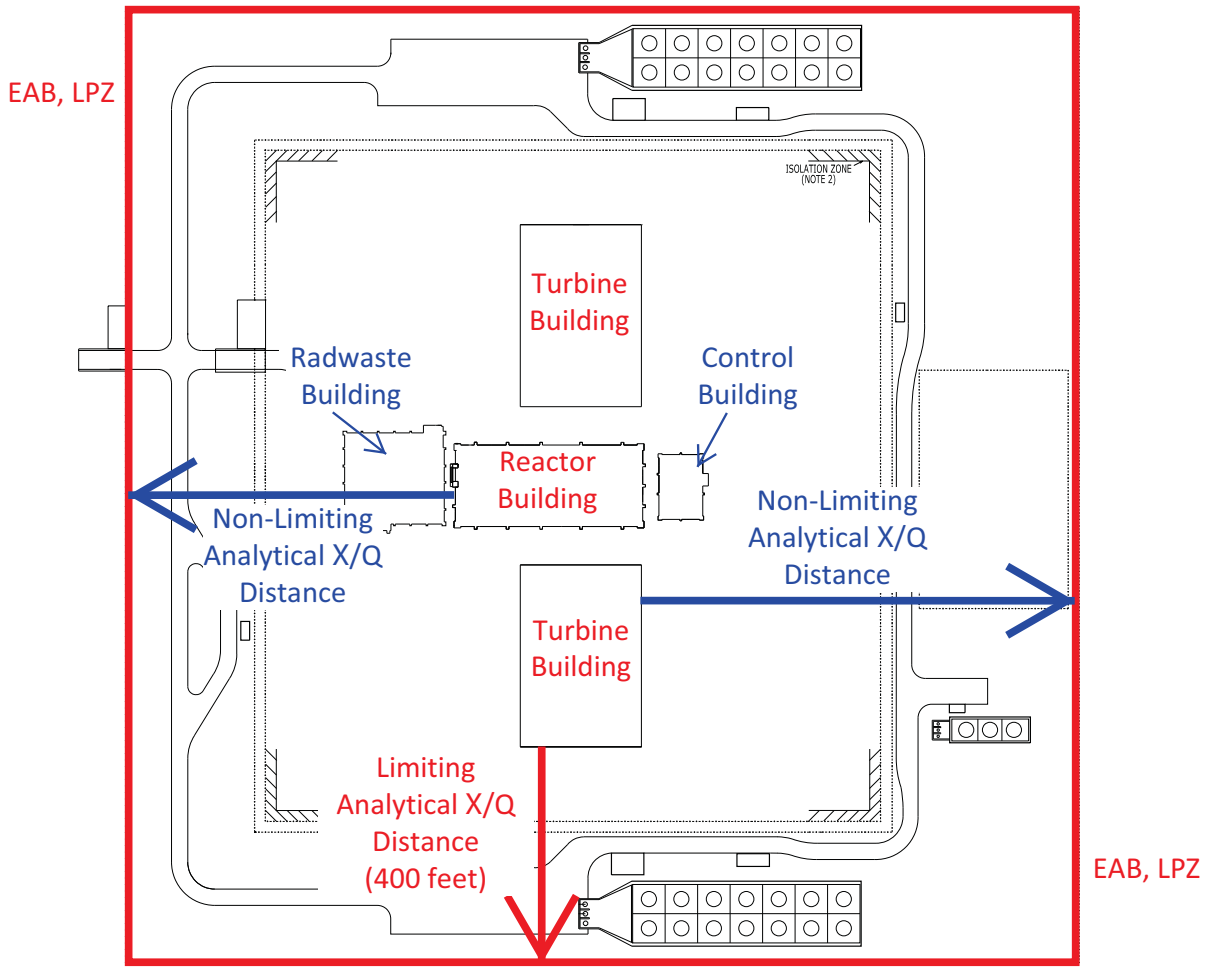
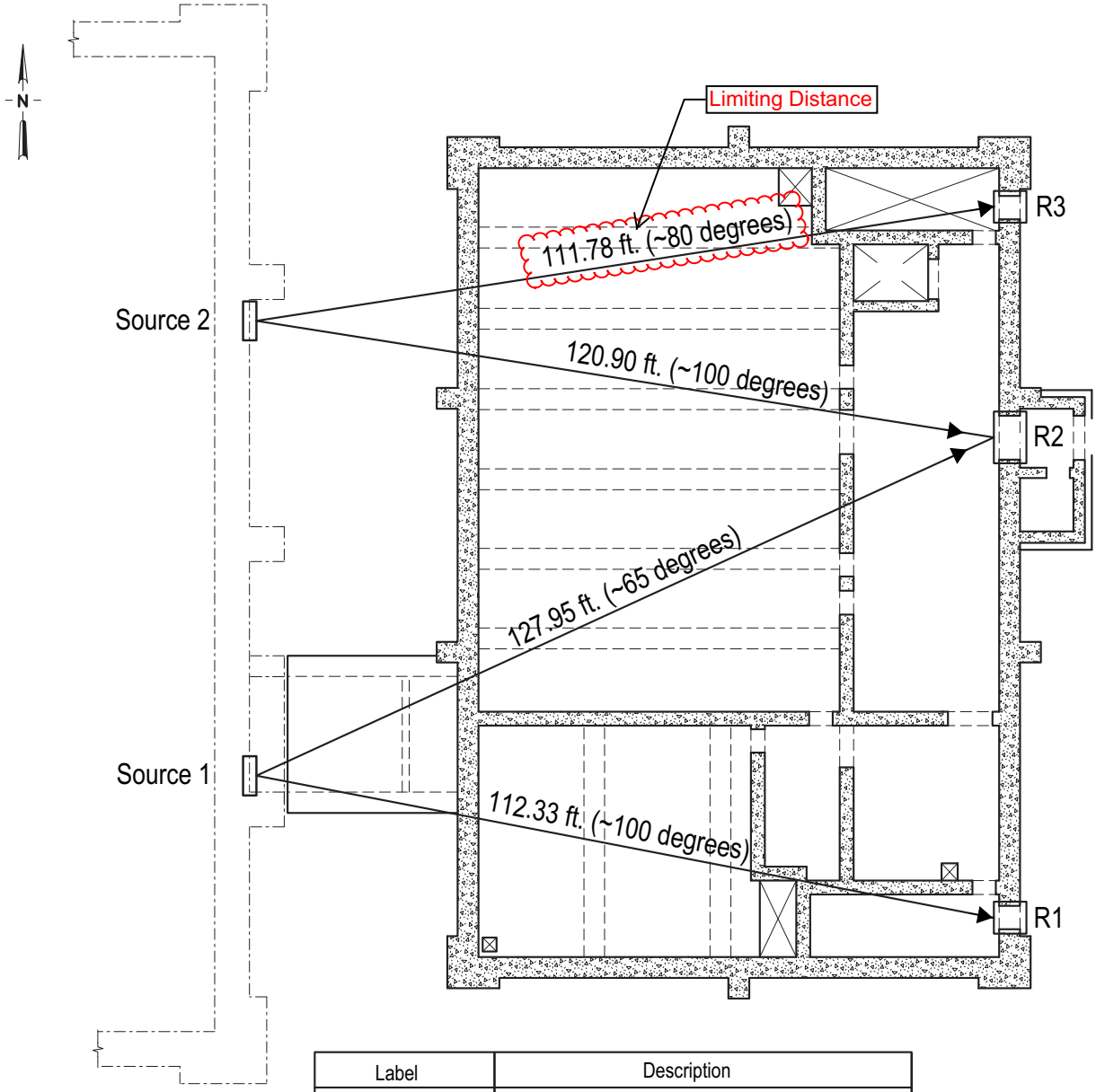
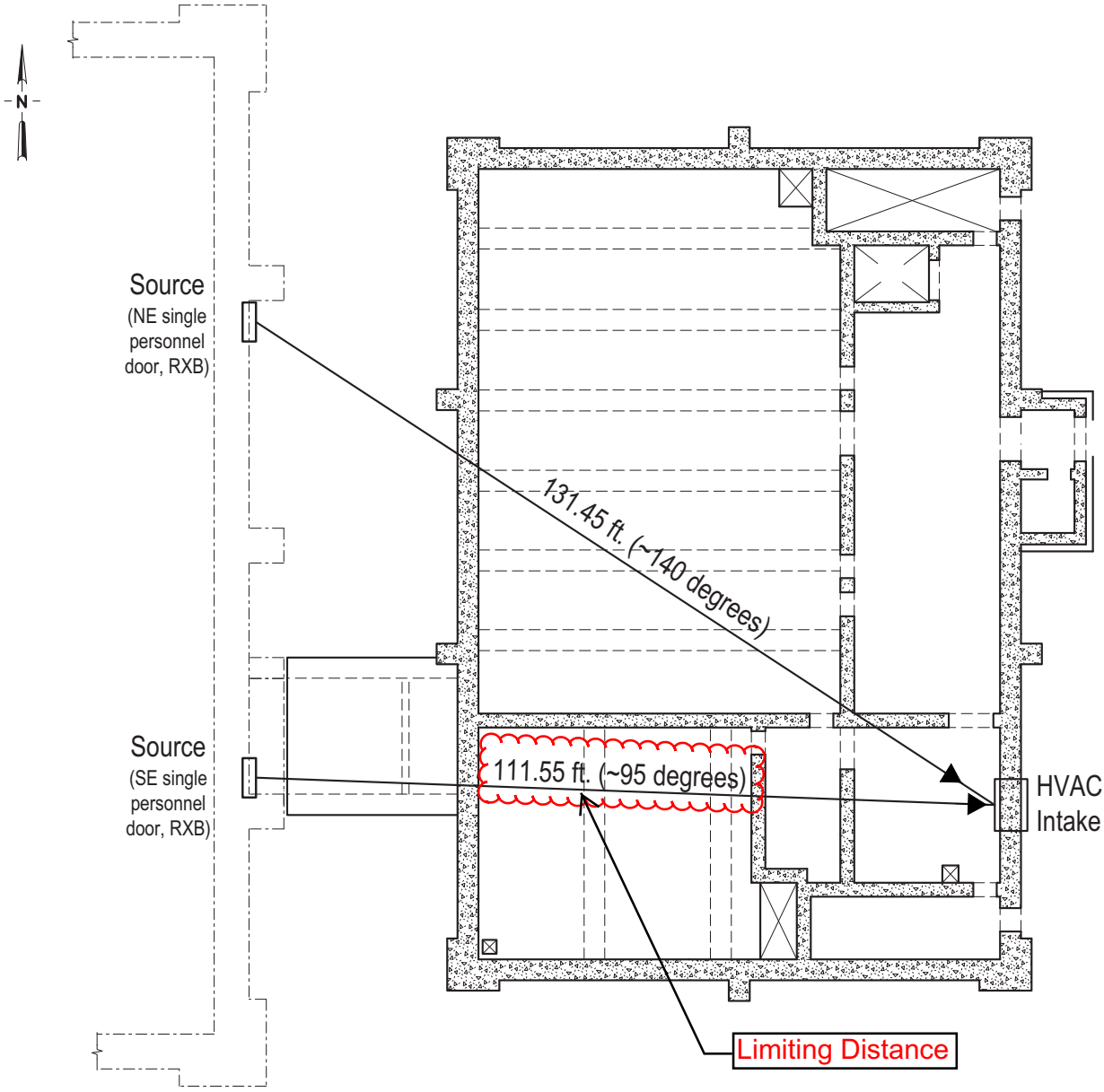


**Figure 2.3-2: Source to Control Building Door Distances**




| Label | Description |
|---|---|
| R1 | SE single personnel door (RWB) |
| R2 | Double personnel door (RWB) |
| R3 | NE single personnel door (RWB) |
| Source 1 | SE single personnel door (RXB) |
| Source 2 | NE single personnel door (RXB) |

**Figure 2.3-3: Source to Control Building HVAC Intake Distance**



## 2.4 Hydrologic Engineering

The NuScale Power Plant design does not rely upon an external water supply for the ultimate heat sink or safety-related makeup water. This design reduces the influence local hydrologic features have on plant safety. Design parameters selected to represent site conditions are presented in Table 2.0-1.

COL Item 2.4-1: A COL applicant that references the NuScale Power Plant design certification will investigate and describe the site-specific hydrologic characteristics for Section 2.4.1 through Section 2.4.14, as applicable.

### 2.4.1 Hydrologic Description

The local hydrology is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

### 2.4.2 Floods

The design assumes that the maximum flood elevation (including wind-induced wave run-up) is one foot below baseline plant elevation. The baseline plant elevation is the top of concrete of the ground floor of the Reactor Building. A second, related, design assumption is that the site is properly graded and has adequate drainage to prevent localized flooding from the maximum precipitation event. These are key design parameters.

The potential for flooding is site-specific and is addressed by the COL applicant as part of part of the response to COL Item 2.4-1.

### 2.4.3 Probable Maximum Flood (PMF) on Streams and Rivers

The probable maximum flood (PMF) is site-specific and is addressed by the COL as part of the response to COL Item 2.4-1.

### 2.4.4 Potential Dam Failures

The presence of dams is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

### 2.4.5 Probable Maximum Surge and Seiche Flooding

The potential for surge or seiche flooding is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

### 2.4.6 Probable Maximum Tsunami Hazards

The potential for tsunamis is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

### 2.4.7 Ice Effects

The design does not rely upon a safety-related intake structure as a makeup source for the reactor pool, which acts as the ultimate heat sink. Therefore, ice effects do not affect safety related cooling.

### 2.4.8 Cooling Water Canals and Reservoirs

The design does not rely upon safety-related cooling water canals or reservoirs as a makeup source for the reactor pool, which acts as the ultimate heat sink.

### 2.4.9 Channel Diversions

The design does not rely upon a safety-related makeup water source. Therefore, upstream channel diversions would not adversely affect safety-related cooling.

### 2.4.10 Flood Protection Requirements

The design assumes that the baseline plant elevation is one foot above the maximum flood level. Therefore there are no flood protection requirements.

### 2.4.11 Low Water Considerations

The design does not rely upon a safety-related source of makeup water. Low flow from surges, seiches, tsunamis, downstream dam failures, future water controls, ice effects, upstream channel diversions, or other sources of low water would not adversely affect safety-related cooling.

The potential effects of low water levels on nonsafety-related water supplies is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

### 2.4.12 Groundwater

The design does not employ a permanent dewatering system. Groundwater is assumed to be a minimum of two feet below site grade. High groundwater has an adverse effect on stability. This is a key design parameter.

Groundwater is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

### 2.4.13 Accidental Releases of Radioactive Liquid Effluents in Groundwater and Surface Waters

Dilution factors, dispersion coefficients, flow velocities, travel times, adsorption, and pathways of liquid contaminants for radioactive liquid effluents from accidental releases into groundwater or surface water is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

### 2.4.14 Technical Specifications and Emergency Operation Requirements

The design does not require emergency protective measures to minimize the impact of adverse hydrology-related events on safety-related facilities.

Site-specific emergency protective measures are addressed by the COL applicant as part of the response to COL Item 2.4-1.

## 2.5 Geology, Seismology, and Geotechnical Engineering

The NuScale Power Plant is designed using geologic, seismologic, and geotechnical engineering parameters selected to envelope conditions expected at a broad range of United States nuclear power plant sites. These parameters are presented in Table 2.0-1.

COL Item 2.5-1: A COL applicant that references the NuScale Power Plant design certification will describe the site-specific geology, seismology, and geotechnical characteristics for Section 2.5.1 through Section 2.5.5, below.

### 2.5.1 Basic Geologic and Seismic Information

Basic regional and site geologic and seismic information is site-specific and addressed by the COL applicant as part of the response to COL Item 2.5-1.

### 2.5.2 Vibratory Ground Motion

There are two design basis earthquakes for the evaluation of structures that are included in the certified design: the certified seismic design response spectra (CSDRS) and the certified seismic design response spectra - high frequency (CSDRS-HF). These spectra were developed by reviewing earthquake design data from the U.S. nuclear industry and are intended to bound most of the central and eastern U.S. as well as sites in less seismically active portions of the western U.S.

The CSDRS and CSDRS-HF are discussed in Section 3.7.1. The CSDRS is shown in Figure 3.7.1-1 and Figure 3.7.1-2. The CSDRS-HF is shown in Figure 3.7.1-3 and Figure 3.7.1-4. The CSDRS and CSDRS-HF are key design parameters.

Local vibratory ground motion, including development of a safe shutdown earthquake is site-specific and addressed by the COL applicant as part of the response to COL Item 2.5-1.

### 2.5.3 Surface Faulting

The design analysis assumes that there is no fault displacement potential under the plant structures. This assumption is a key design parameter.

Detailed surface and subsurface geological, seismological, and geophysical information, including surface faulting, is site-specific and addressed by the COL applicant as part of the response to COL Item 2.5-1.

### 2.5.4 Stability of Subsurface Materials and Foundations

The design analysis assumes the following parameters:

- The minimum shear wave velocity is 1000 fps. Competent material is generally considered to be in situ material having a minimum shear wave velocity of 1,000 fps.
- The minimum ultimate bearing capacity ($Q_{ult}$) is 75 ksf. This bearing capacity is sufficient to provide a factor of safety greater than 3.0 for the static bearing pressure

and greater than 2.0 for dynamic bearing pressure. Bearing pressures for the Reactor Building and Control Building are provided in Section 3.8.5.

- The soil column is uniform (i.e., the site layers dip less than 20 degrees). As described in NUREG/CR-0693, the use of horizontal layers for soil-structure interaction analysis is acceptable if the layers dip less than 20 degrees.
- There is no potential for soil liquefaction. This analysis may be performed with the site-specific safe shutdown earthquake.
- The minimum coefficient of static friction at all interfaces between the basemat and the soil is 0.58. The friction is defined between concrete and clean gravel, gravel-sand mixture, or coarse sand with a friction angle of 30 degrees (Reference 2.5-1).
- The minimum soil angle of internal friction is 30 degrees.

Settlement is not a concern for the NuScale Power Plant design. There are no rigid safety-related connections between the structures and no safety-related connections to other site structures. A settlement tilt limit of 1 inch per 50 feet has been established. This tilt (< 0.1 degree) is small enough that it does not affect the structural analysis.

The following are key design parameters:

- minimum shear wave velocity
- minimum ultimate bearing capacity
- uniformity of soil layers
- potential for soil liquefaction
- minimum coefficient of static friction
- minimum soil angle of internal friction
- settlement tilt

Characteristics of the subsurface materials are site-specific and are discussed by the COL applicant as part of the response to COL Item 2.5-1.

## 2.5.5 Stability of Slopes

The standard plant layout assumes a uniform, graded site as shown in Figure 1.2-4. Therefore, no slope failure potential is a key design parameter.

Stability of slopes on or near the site are confirmed by the COL applicant as part of the response to COL Item 2.5-1. This analysis may be performed with the site-specific safe shutdown earthquake.

## 2.5.6 References

2.5-1 Department of the Navy, "Design Manual 7.2 - Foundation and Earth Structures," NAVFAC DM-7.2, Alexandria, VA, May 1982.