

## 2 SITE ENVELOPE

This chapter discusses the site envelope for the AP1000 design, and covers geography and demography; nearby facilities; and postulated site parameters for the design, including meteorology, hydrology, geology, seismology, and geotechnical parameters. An applicant for a COL for an AP1000 will establish the actual site characteristics with respect to these matters when it applies for a COL, or will reference an Early Site Permit (ESP) that reflects such characteristics. In either case, the COL applicant will need to show that the site parameters postulated for and considered in the AP1000 design assure that the design is adequate with respect to the actual site characteristics. Should the postulated site parameters not encompass the actual site characteristics, the COL applicant would need to demonstrate by some other means that the proposed facility is acceptable at the proposed site. This might be done by re-analyzing or redesigning the proposed facility.

The evaluation is based on the U. S. Nuclear Regulatory Commission (the NRC or staff) review of the AP1000 design control document (DCD) and the applicant's responses to the NRC staff's request for additional information (RAI).

### 2.1 Geography and Demography

The applicant states in DCD Tier 2 Section 2.1 that the geography and demography are site specific and will be defined by the Combined License (COL) applicant. In addition, DCD Tier 2 Section 2.1.1, "Combined License Information for Geography and Demography," states that COL applicants will provide site-specific information related to site location and description, exclusion area authority and control, and population distribution. Because this information is site-specific and will be provided by the COL applicant, the staff concludes that this is acceptable.

#### 2.1.1 Site Location and Description

Standard Review Plan (SRP) Section 2.1.1, "Site Location and Description," states that the site area which contains the reactors and associated principal plant structures is reviewed to determine the distance from the reactor to the boundary lines of the exclusion area, including the direction and distance from the reactor to the nearest exclusion area boundary line. The location, distance, and orientation of plant structures with respect to highways, railroads, and waterways which traverse or lie adjacent to the exclusion area are reviewed to ensure that they are adequately described to permit analyses (SRP Section 2.2.3) of the possible effects on the plant of accidents on these transportation routes. The description of the restricted area is reviewed to verify that adequate information has been provided to determine general population doses from normal liquid and gaseous releases.

The acceptance criteria for site location and description are based on meeting the relevant requirements of 10 CFR Part 20. An applicant for a standard design certification must postulate values for site parameters as a basis for the plant design.

The applicant states in DCD Tier 2 Section 2.1.1 that site-specific information on any particular site and its location will include political subdivisions, natural and man-made features, population, highways, railways, waterways and other significant features of the area. The DCD includes this as a COL information item and identifies corresponding information discussed in the SRP and specifies that it will be addressed by the COL applicant. Therefore, the COL information item is acceptable.

### 2.1.2 Exclusion Area Authority and Control

SRP Section 2.1.2, "Exclusion Area Authority and Control," states that the applicant's legal authority to determine all activities within the designated exclusion area is reviewed. This review will also establish that proposed activities in the exclusion area unrelated to operation of the reactor do not result in a significant hazard to the public health and safety.

Acceptance criteria are based on meeting the relevant requirements of 10 CFR Part 100 with respect to the applicant's legal authority with respect to the designated exclusion area.

The applicant states in DCD Tier 2 Section 2.1.1 that site-specific information on the exclusion area will include the size of the area and the exclusion area authority and control. Activity that may be permitted within the exclusion area will be included in the discussion. This COL information item identifies corresponding information discussed in the SRP and specifies that it will be addressed by the COL applicant. Therefore, the COL information item is acceptable.

### 2.1.3 Population Distribution

SRP Section 2.1.3, "Population Distribution," states that the staff reviews the population data in the site environs as presented in the DCD to determine whether the exclusion area, low population zone and population center distance for the site comply with the requirements of 10 CFR Part 100.

The acceptance criteria are based on meeting the relevant requirements in 10 CFR Part 100.

The applicant states in DCD Tier 2 Section 2.1.1 states that site-specific information will be included on population distribution. This COL information item identifies the information discussed in the SRP and specifies that it will be addressed by the COL applicant. Therefore, the COL information item is acceptable.

## 2.2 Nearby Industrial, Transportation, and Military Facilities

In DCD Tier 2 Section 2.2, the applicant states that each combined license (COL) applicant referencing the AP1000 will provide analyses of accidents external to the nuclear plant. In particular, the applicant states that COL applicants referencing the AP1000 certified design will provide site-specific information related to the identification of potential accidents and verify the hazards in the vicinity of the site, including an evaluation of potential accidents. The COL

applicant will verify that the total annual frequency of a site-specific potential hazard leading to severe consequences is less than  $1E-6$  per year. Specific site related hazards to be identified and evaluated by the COL applicant include explosions, flammable vapor clouds, toxic chemicals, fires, and airplane crashes. The staff will not limit site safety reviews to the above list of hazards and will consider other site-specific hazards, as appropriate, such as nearby marine traffic in the form of barges or other sizeable vessels potentially impacting plant cooling water intakes. Analyses submitted by COL applicants will be reviewed by the staff using accident frequency and severity review methods and acceptance criteria described in Standard Review Plans (SRPs) 2.2.1-2.2.2 and 2.2.3 of NUREG-0800. On this basis, the staff finds the approach described by the applicant for addressing site-specific hazards to be acceptable.

### 2.3 Meteorology

In DCD Tier 2 Section 2.3, the applicant referenced DCD Tier 2 Table 2-1, which specifies air temperatures, humidity, precipitation, snow, wind, and tornado limits for which the AP1000 is designed. These values, as well as tornado values cited in DCD Tier 2 Section 3.3.2.1, are listed in Table 2.3-1 of this report. The applicant indicated that the COL applicant will provide meteorological information to demonstrate that the site characteristics are bounded within the limits postulated for the design. The staff requested additional information regarding the technical basis for selection of the values which the applicant stated are those cited in the Electric Power Research Institute Advanced Light Water Reactor (ALWR) Utility Requirements Document (URD). However, the applicant was not able to provide the technical basis for the values.

The NRC staff acknowledges that the AP1000 is designed to these values, but does not claim that they are representative of any particular percentile of possible sites in the United States, nor does the staff assert the acceptability of the basis for the choice of the values with respect to siting. For example, the AP1000 is designed for a tornado wind speed of 134.1 m/sec (300 miles per hour) as discussed in SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," April 2, 1993. The staff notes that a letter dated March 25, 1988, from the NRC to the ALWR Utility Steering Committee, cites site-specific wind speeds higher than 134.1m/sec (300 mph) in some parts of the United States. Thus, a particular site might be characterized by tornado wind speeds greater than the 134.1 m/s (300 mph) and this characteristic might not be bounded within that limit. The staff plans to reevaluate the maximum design basis tornado wind speed and other meteorological site parameters used in the design loading calculations.

Table 2.3-1

Meteorological Site Parameters  
Other Than Relative Concentration Values

Air Temperature

Maximum Safety	46.1°C (115°F) dry bulb/26.7°C (80°F) coincident wet bulb 27.2°C (81°F) non-coincident wet bulb
Minimum Safety	-40.0°C (-40°F)
Maximum Normal	37.8°C (100°F) dry bulb/25.0°C (77°F) coincident wet bulb 26.7°C (80°F) non-coincident wet bulb
Minimum Normal	-23.3°C (-10°F)

Wind Speed

Operating Basis	64.8 m/sec (145 mph) (3 second gust); importance factor 1.15 (safety), 1.0 (non-safety); exposure C; topographic factor 1.0
Tornado	134.1 m/sec (300 mph) - maximum wind speed 107.3 m/sec (240 mph) - maximum rotational speed 26.8 m/sec (60 mph) - maximum translational speed 45.7 m (150 ft) - radius of maximum rotational wind from center of tornado 1.38 E4 Pa (2.0 psi) - atmospheric pressure drop 8.27 E3 Pa/sec (1.2 psi/sec) - rate of pressure change

Precipitation

Rain	0.49 m/hr (19.4 in/hr), 16.0 cm/5 min (6.3 in/5 min)
Snow/Ice	3.59 E3 Pa (75 lb/ft <sup>2</sup> ) on ground with exposure factor of 1.0 and importance factors of 1.2 (safety) and 1.0 (non-safety)

2.3.1 Regional Climatology

The applicant specifies in DCD Tier 2 Section 2.3.1 that the regional climatology is site-specific and will be addressed by the COL applicant. The staff finds this acceptable. This is COL Action Item 2.3.1-1.

2.3.2 Local Meteorology

The applicant specifies in DCD Tier 2 Section 2.3.2 that the local meteorology is site-specific and will be addressed by the COL applicant. The staff finds this acceptable. This is COL Action Item 2.3.2-1.

2.3.3 Onsite Meteorological Measurements Program

The applicant specifies in DCD Tier 2 Section 2.3.3 that the onsite meteorological measurements program is site-specific and will be addressed by the COL applicant. The staff finds this acceptable. This is COL Action Item 2.3.3-1.

2.3.4 Short-Term (Accident) Atmospheric Relative Concentration

In lieu of site-specific meteorological data, the applicant provided a set of hypothetical reference short-term atmospheric relative concentration ( $\chi/Q$ ) values for the AP1000 design for the exclusion area boundary and low population zone. The applicant states that the values are representative of the 60 to 70<sup>th</sup> percentile of United States operating nuclear power plant sites. The staff acknowledges that the AP1000 is designed to the following  $\chi/Q$  values.

Table 2.3.4-1

EAB and LPZ Relative Concentration Estimates

<u>Location</u>	<u>Time Period</u>	<u>Dilution Factor <math>\chi/Q</math> (sec/m<sup>3</sup>)</u>
EAB	0-2 hours	6.0 E-04
LPZ	0-8 hours	1.35 E-04
LPZ	8-24 hours	1.0 E-04
LPZ	1-4 days	5.4 E-05
LPZ	4-30 days	2.2 E-05

A site selected for an AP1000 facility should have  $\chi/Q$  values equal to or less than the hypothetical reference  $\chi/Q$  values shown in the table above. In the event a site selected for the AP1000 design exceeds the hypothetical reference  $\chi/Q$  values, the COL applicant must demonstrate that the radiological consequences associated with the controlling design-basis accident using its site-specific  $\chi/Q$  values continue to meet the dose requirements pursuant to Title 10 of the Code of Federal Regulations (10 CFR) Section 50.34. The  $\chi/Q$  values shown in Table 2.3.4-1 are not based upon any AP1000 design or operation inputs. Therefore, the methodology, and all inputs and assumptions, will be evaluated during the COL review. This is COL Action Item 2.3.4-1.

The hypothetical reference control room  $\chi/Q$  values calculated by the applicant are listed in Table 15.3-9a of this report. A site selected for an AP1000 facility should have control room  $\chi/Q$  values equal to or less than the hypothetical reference  $\chi/Q$  values shown Table 15.3-9a. In the event a site selected for the AP1000 design exceeds the hypothetical reference  $\chi/Q$  values, the COL applicant should demonstrate that the radiological consequences associated with the design-basis accidents, using its site-specific  $\chi/Q$  values, continues to meet the dose reference values given in GDC 19 of 10 CFR Part 50. The staff initially asked the applicant if the methodology and all inputs and assumptions would be evaluated as part of the COL review. The applicant provided a detailed response stating that the methodology, inputs and assumptions would be provided by the COL applicant and also provided additional information about the analysis. The staff issued a second RAI to inquire if the applicant was seeking certification of any of the AP1000 design values used as inputs to the control room  $\chi/Q$  calculations. The applicant subsequently provided certain design-specific information that was used as input to

the assessment and for which the applicant was seeking certification. The staff review of this topic is ongoing, and may reveal other concerns with respect to  $\chi/Q$ . The staff has identified unresolved issues related to adequate justification for assuming a diffuse release, estimation of initial sigma values, other release assumptions, building cross-sectional areas, and distances between release/receptor pairs. This is Open Item 2.3.4-1 This is also COL Action Item 2.3.4-1 since the resultant  $\chi/Q$  values are also a function of the site-specific meteorology which cannot be reviewed until site selection.

### 2.3.5 Long-Term (Routine) Diffusion Estimates

The applicant specifies in DCD Tier 2 Section 2.3.5 that the long-term diffusion estimates are site-specific and will be addressed by the COL applicant. The applicant provided a hypothetical reference to an annual average site boundary value of  $2.0 \text{ E-}5 \text{ sec/m}^3$  and states that the value is expected to bound most sites in the United States. The staff acknowledges that the AP1000 is designed to the cited value, but does not assert that it is representative of any particular percentile of possible sites in the United States. In the event a site selected for the AP1000 design exceeds the hypothetical reference  $\chi/Q$  value, the COL applicant should demonstrate that the radiological consequences associated with using its site-specific  $\chi/Q$  values comply with 10 CFR Part 20 regarding dose to the public and also maintain doses ALARA as specified in Appendix I to 10 CFR Part 50. The  $\chi/Q$  value shown is not based upon any AP1000 design or operation inputs. Therefore, the methodology, and all inputs and assumptions will be evaluated during the COL review. The staff finds this acceptable. Since the meteorological data input into the assessment are site-specific and will need to be reviewed at the COL phase, this is also COL Action Item 2.3.5-1.

## 2.4 Hydrology

This section of the safety evaluation is based on the staff's review of Revision 3 of the DCD, and the applicant's responses to the RAI 240-001. COL applicants referencing the AP1000 certified design will be required to provide site specific information related to hydrological engineering, as discussed in the following sections.

### 2.4.1 Hydrological Description

The AP1000 is a standard design with a plant configuration that assumes a normal water level at 0.6 m (2 ft) below the grade, and a flood level at the design plant grade of 30.5m (100 ft). The actual grade level will be a few inches lower to prevent surface water ingress through the doorways. This provision is in recognition of the fact that the URD states that the maximum flood (or tsunami) level site envelope parameter is 0.3m (1 ft) below grade. Although the AP1000 design flood level of 30.5 m (100 ft) does not meet the URD flood level criterion explicitly, it will accommodate the intent of the URD.

The staff had a concern regarding the effect of probable maximum precipitation (PMP) at the plant site. Without adequate site drainage, the design flood level could be exceeded. The plant design is based on a PMP of 49.3cm/hour (19.4 inch/hour) and 16.0 cm/5 minute (6 inch/5 minute). This aspect of local intense precipitation is the limit for this standard design. The staff identified a concern that COL applicants should demonstrate that the PMP at the site

does not exceed the design value, and that there is adequate site drainage to prevent the maximum flood level from exceeding the design elevation of 30.5 m (100 ft).

The staff also determined that future COL applicants should indicate whether or not the proposed PMP drainage system is gravity fed or employs active measures to ensure operational safety under the COL by proposing inspection and maintenance standards for the PMP drainage systems. In its response to the staff concern, the applicant reiterated that the COL applicant will provide adequate site drainage, since it is a site specific condition. The staff accepts the applicant's justification. The staff also noted that the adequacy of the local drainage is a safety feature that the standard design relies on. The normal water level, the PMP, and the maximum flood level are the design bases for this standard design, and are incorporated into the plant postulated site parameter envelope as specified in DCD Tier 2 Table 2-1. The COL applicant will provide detailed site specific information on all other hydrological safety related issues indicated below, including the effects of intense local precipitation:

- Floods
- PMP on Streams and Rivers
- Potential Dam Failures
- Probable Maximum Surge and Seiche Flooding
- Probable Maximum Tsunami Flooding
- Ice Effects
- Cooling Water Canals and Reservoirs
- Channel Diversions
- Flooding Protection Requirements
- Cooling Water Supply
- Groundwater
- Accidental Releases of Liquid Effluents in Ground and Surface Waters
- Technical Specifications and Emergency Operation Requirements

The COL applicant should present the supporting information in accordance with the SRP to demonstrate the suitability of a specific site to locate the AP1000 design. The flood level and the ground water level design assumptions are practical and reasonable. The requirements for site parameters for a design are contained in 10 CFR 52.47(a)(1)(iii). An applicant for design certification is required to provide the site parameters used in the design, and an analysis and evaluation of the design in terms of these parameters. The information provided in the AP1000 DCD Tier 2 meets this requirement. These plant design parameters are compatible with the URD and suitable for siting at most, but not all, potential sites for future plants in the United States. Accordingly, the staff finds the hydrological information provided by the applicant in the DCD reasonable and acceptable. The staff will apply the acceptance criteria from its review standards in reviewing any future COL application that references the AP1000 standard design, should it be certified.

### 2.5 Geological, Seismological, and Geotechnical Engineering

This section of the safety evaluation is based on the staff's review of Revision 3 of the DCD, and the applicant's responses to the related RAIs 241-001 through 241-003 together with the information received from the applicant during the audit of April 2 - 4, 2003. The AP1000

standard design is based on seismic and geotechnical design assumptions that consist of the following:

- The free field peak ground acceleration is 0.3 g for the safe shutdown earthquake.
- The design ground motion is characterized by the free field ground response spectra for both horizontal and vertical directions given in DCD Tier 2 Figures 3.7.1-1 and 3.7.1-2.
- The seismic margin earthquake has a free field peak ground acceleration value of 0.5 g. It is the level at which there is 95 percent confidence that there is only a 5 percent chance of failure of a structure or a system or a component.
- The foundation material for locating the plant must be hard rock to ensure that the Nuclear Island structure will behave as though it is fixed at the base during a seismic excitation.
- For the purpose of characterizing hard rock, the material must have a minimum shear wave velocity of 2438 meters per second (8000 ft per second) based on low strain properties over the entire footprint of the nuclear island at its foundation level.
- The average allowable bearing capacity of the foundation material is indicated in the DCD to be 402KPa (8,400 psf) under static loading and is indicated in the applicant's response to the RAIs listed above to be 21.55MPa (450,000 psf) for hard rock under dead plus seismic load conditions.
- Based on the calculations reviewed during the April 2-5, 2003 audit, the peak toe pressure at the foundation level is limited to 4.07MPa (85,000 psf) for the dead plus seismic load conditions when the equivalent static analyses including calculation of potential liftoff effects were performed.
- The site must not have any liquefaction potential.

The requirements of 10 CFR Part 52, Subpart A allow applications for an early site permit (ESP) separate from certification of the plant design. The relevant requirements are specified in 10 CFR Part 52. A COL applicant, holding an ESP for the site at which it proposes to construct an AP1000, will have an approved set of site parameters that would be compared against the postulated site parameters used in this certified design to demonstrate that the design of the facility falls within the characteristics specified in the ESP. COL applicants referencing the AP1000 design, without an ESP, will be required to provide site specific information related to basic geological, seismological, and geotechnical characteristics of the site and the region, as discussed in the following sections.

### 2.5.1 Basic Geologic and Seismic Information

COL applicants referencing the AP1000 certified design, and without an ESP, should provide site specific geological, seismological and geophysical information related to tectonic or seismic, non-tectonic deformation, conditions caused by human activities in the region of the site, and

areas local to the site. With respect to site geology, it is necessary to determine whether geologic features underlying the site affects of the foundation design as they relate to:

- dynamic behavior during prior earthquakes
- zones of alteration, irregular weathering, or zones of structural weakness
- unrelieved residual stresses in bedrock
- materials that could be unstable because of their mineralogy or unstable physical properties
- effect of human activities in the area

The DCD Tier 2 information, while listing certain site specific aspects of basic geologic and seismic information to be provided by a COL applicant referencing the AP1000 certified design, does not include some of the attributes discussed above. This issue was discussed with the applicant during the April 2-5, 2003 audit. This is Open Item 2.5.1-1.

### 2.5.2 Vibratory Ground Motion

COL applicants referencing the AP1000 certified design, without an ESP, should provide site specific information related to seismicity, geologic and tectonic characteristics of the site and region, correlation of earthquake activity with seismic sources, probabilistic seismic hazard analysis, controlling earthquakes, seismic wave transmission characteristics of the site, and the safe shutdown earthquake ground motion. The DCD Tier 2 information lists a number of these criteria; however, it should include probabilistic seismic hazard analysis, including the definition of controlling earthquakes. This issue was discussed with the applicant during the April 2 through 5, 2003 audit. This is Open Item 2.5.2-1.

The AP1000 is designed for a safe shutdown earthquake (SSE) defined by a free field peak ground acceleration value of 0.3 g, and an associated set of ground motion response spectra for horizontal and vertical directions, as shown in DCD Tier 2 Figures 3.7.1-1 and 3.7.1-2. These response spectra are applied at the foundation level (Elevation 60') in the free field for the analysis and design of the AP1000. This design ground motion is higher than the SSE for any of the currently licensed nuclear power plants east of the Rocky Mountains. These design ground motion spectra are compatible with the URD and suitable for siting at most, but not all, potential sites for future plants in the United States. COL applicants will compare site specific earthquake ground motions to the ground motions used as input for the design certification. COL applicants will demonstrate that the site specific response spectra at the foundation level 18.3m (60 ft) below the free surface in the free field) are enveloped by the ground motion spectra used as input for the design certification (as shown in DCD Tier 2 Figures 3.7.1-1 and 3.7.1-2). The site specific response spectra should be developed at 18.3m (60 ft) below the free surface in the free field taking into account the site specific soil amplification. In addition, COL applicants should assure that the site specific response spectra at the foundation level 18.3m (60 ft) below the finished plant grade in the free field are less than or equal to those given in DCD Tier 2 Figures 3.7.1-1 and 3.7.1-2.

COL applicants should also verify that the shear wave velocity of the bedrock is greater than or equal to 2438m/sec (8000 ft/sec). In addition, COL applicants should demonstrate that the lateral earth pressures from the site specific construction technique does not exceed the AP1000 certified design values as specified in the interface requirement (see Open Item

3.8.5.4-2). This is further discussed below in the section on excavation. Except for Open Item 2.5.2-1, which is described above, the staff concludes that the information provided in the DCD on vibratory ground motion is reasonable and acceptable because it is in accordance with probabilistic seismic hazard analysis criteria incorporated in the SRP and RG 1.165, Identification and Characteristics of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion.”

### 2.5.3 Surface Faulting

The AP1000 DCD Tier 2 information provides for COL applicants referencing the AP1000 certified design to address surface and subsurface geological and geophysical information including the potential for surface or near-surface faulting affecting the site. The presence or absence of any surface faulting at a specific site will affect its seismic hazard and the basic seismic characteristics of the site. It would be the responsibility of the COL applicant to demonstrate that the proposed site is suitable for siting a specific standard design in accordance with 10 CFR 52.79, “Contents of Applications; Technical Information.” This regulatory requirement states, in part, in 52.79(a)(1) that in general, if the application references an ESP, the application need not contain information or analyses submitted to the Commission in connection with the early site permit, but must contain, in addition to the information and analyses otherwise required, information sufficient to demonstrate that the design of the facility falls within the parameters specified in the early site permit. The AP1000 clearly identifies the site related parameters for which the design was analyzed and evaluated. These design parameters are reasonable and suitable for most available sites in the United States, and the influence and effects of surface faulting on the controlling site parameters for the AP1000 design are specific to a site. These plant design parameters are compatible with the URD and suitable for siting at most, but not all, potential sites for future plants in the United States. This is acceptable to the staff.

An applicant for design certification is required to provide postulated the postulated site parameters used in the design, and an analysis and evaluation of the design in terms of these parameters. AP1000 DCD Tier 2 information has met this requirement. The NRC staff will apply the acceptance criteria from its review standards in reviewing any future COL application that reference the AP1000 standard design, should it be certified.

### 2.5.4 Stability of Subsurface Materials and Foundations

In the DSER, the staff requested the applicant to indicate in the DCD Tier 2 information, that the COL applicant will provide site specific information related to the geotechnical characteristics of the site to demonstrate that they bound the design analyses assumptions given in DCD Tier 2 Table 2-1. The COL applicant's submittal should address the criteria provided in Section 2.5.4 of the SRP. The applicant has discussed its standard design attributes related to the following:

- Excavation
- Bearing capacity
- Settlement
- Liquefaction
- Subsurface uniformity

The DCD describes the need for establishing a vertical face below the grade with lateral support of the adjoining undisturbed soil or rock and suggests the use of soil nailing to stabilize the vertical soil surface as an alternative method for achieving this provision. The stability of the nailed soil surface will depend on the length and depth of the soil anchors or nails. One result of this proposed construction technique is that the soil immediately surrounding the nuclear island (NI) consists of natural in-situ materials only, which have relatively continuous properties in the horizontal and vertical directions. Because this configuration conforms to the assumptions made in the seismic analyses performed to assess the seismic responses of the NI structures, the proposed excavation method is considered acceptable to the NRC staff. However, during discussions with the applicant during the November 2002 meeting, it was noted that the COL applicant should also show that the existing in-situ soil satisfies the minimum conditions (in terms of soil parameters) assumed for the design of the AP1000 foundation and exterior walls. In addition, if the in-situ soils are not appropriate for the use of soil nailing excavation techniques, the COL applicant should show that any other construction method planned for the excavation satisfies the assumptions of the design of the NI. If any other construction technique that requires excavation and backfill of large areas surrounding the NI is proposed, the procedures and criteria for installing the backfill should also be submitted by the COL applicants for review and approval. In addition, an evaluation of the effect of any alternative construction procedures on the seismic responses of the NI structures should be performed. The amount of lateral passive pressure used in the design of the NI needs to be specified as an interface requirement for the COL applicant. This issue was discussed with the applicant during the April 2-5, 2003, audit. This is Open Item 2.5.4-1.

Except for Open Item 2.5.4-1 which is described above, the staff will be able to conclude that the information provided in the DCD on stability of subsurface materials and foundations is reasonable and acceptable.

#### 2.5.4.1 Bearing Capacity

The bearing capacity of the subgrade is a fundamental design parameter for this standard design. In the design of the foundation of a large structure it is important to ensure that under normal operating conditions, the average pressure on the subgrade is less than the allowable average bearing capacity of the foundation material, and that the peak subgrade pressure caused by the load combination with the SSE imposing the largest toe pressure at the edge of the foundation is also within the allowable capacity of the subgrade. The allowable bearing capacity of the subgrade is governed by settlement or crushing. Under relatively soft soil conditions, short term soil movement due to water table fluctuation and long term settlement due to the super imposed loading affect the allowable bearing capacity. Under hard rock subgrade conditions, the bedding direction of rock layers and the level of cracking and other discontinuities in the matrix of the rock material can limit the allowable average and allowable peak bearing capacity. The response to the RAIs indicates that the bearing capacity at a hard rock site will exceed 21.55MPa (450,000 pounds per square ft). During the April 2 through 5, 2003 audit, the staff requested the applicant to clearly specify, in the DCD, that this standard design is based on an allowable average and an allowable peak bearing capacity, and should specify what these values are. This is Open Item 2.5.4-2.

Except for Open Item 2.5.4-2 which is described above, the staff will be able to conclude that the information provided in the DCD on bearing capacity is reasonable and acceptable.

#### 2.5.4.2 Settlement

As stated in DCD Tier 2 Section 3.2, the nuclear island is the only seismic Category I structure in the AP1000 standard design. Differential settlement between the nuclear island foundation and the foundations of adjacent buildings does not have any adverse effect on the safety-related functions of structures, systems and components. Differential settlement under the nuclear island foundation could cause the basemat and the building to tilt. In the narrow direction, the NI foundation width is 49.8 meters (163 feet and 6 in.) and the height above the bottom of the basemat is 83.3 meters (273 ft 3 in.). Assuming a basemat tilt of 10.2 centimeters (4 in.), the rigid body tilt at the highest point can be between 15 and 18 centimeters (6 and 7 in.). Under seismic excitation there will be an elastic deformation relative to the base. When these two effects are added, the annular space between the shield building and the containment structure will be diminished, and the functionality of the crane inside the containment and other sensitive components could also be affected. The DCD does not provide any quantitative justification as to why a basemat tilting of a few inches will not affect functionality of structures, systems and components. This issue was discussed with the applicant during the April 2-5, 2003, audit. This is Open Item 2.5.4-3.

Upon resolution of Open Item 2.5.4-3, the staff will be able to conclude that the information provided in the DCD on settlement is reasonable and acceptable.

#### 2.5.4.3 Liquefaction

The DCD clearly states that the COL applicant will demonstrate that the potential for liquefaction is negligible. The design site condition is hard rock with a minimum shear wave velocity of 2438 meters per second (8000 ft per second) at the foundation level, so the subgrade at the foundation level has no liquefaction potential. The need for the COL applicant to demonstrate that there is negligible soil liquefaction potential at the site applies to the grade level at the free field at the SSE level of 0.3 g peak ground acceleration (PGA), as well as the margin level earthquake of 0.5 g PGA. In DCD Tier 2 Table 2-1, the applicant states that sites will have no liquefaction potential at the site specific SSE level. This is acceptable to the staff. COL applicants should demonstrate that no liquefaction potential exists at the SSE level for the site for soils under and around all seismic Category I structures. COL applicants should also justify the selection of the soil properties, as well as the magnitude, duration, and number of excitation cycles of the earthquake used in the liquefaction potential evaluation (e.g., laboratory tests, field tests, and published data). The testing methods should be documented and subject to review and approval by the staff. In addition, COL applicants should perform a soil liquefaction evaluation at 1.67 times the site specific SSE ground motion. This would ensure that there will be no adverse impact of any potential failure of the foundations of the turbine building or the waste processing building that are adjacent to the NI. The staff finds the information provided by the applicant in the DCD on liquefaction reasonable and acceptable.

#### 2.5.4.4 Subsurface Uniformity

This standard design is based on the assumption of uniform hard rock conditions with a minimum shear velocity of 2438m/sec (8000 ft/sec) and negligible liquefaction potential. The AP1000 DCD indicates that the NI structures, consisting of the containment building, shield building, and auxiliary building are founded on a common 1.8 m (6 ft) thick, cast-in-place,

reinforced concrete basemat foundation (see Section 3.8.5 of this report for a discussion of the foundation design). The top of the foundation is specified to be at elevation 20.3 m (66.5 ft) with the bottom of the basemat being at 18.4m (60.5 ft), assuming the nominal elevation of the free grade surface is at elevation 30.5m (100 ft).

The AP1000 NI houses all Category I structures and is supported on a single foundation mat with exterior and interior walls rigidly connecting the shield building (including the reactor containment vessel and containment internal structures) and auxiliary buildings to the foundation mat. This system of interconnected vertical shear walls and horizontal floor slabs or diaphragms results in a monolithic reinforced concrete structure design such that all loads applied to the structure engage all parts of the structure. The seismic and dead loads generated from the auxiliary and the shield buildings are then transferred to the foundation mat. The critical foundation mat panels are designed on the basis of the assumption of uniform subgrade reaction.

A fixed base seismic analysis has been used to analyze the seismic loads and is suitable for hard rock sites with no soil structure interaction effect. The assumption of uniformity of the subgrade reaction is inherent in the design of the foundation mat. Although the DCD specifies a minimum shear wave velocity of 2438mps (8000 fps), the subgrade reaction values were kept uniform. Any effect of hard spot areas in the subgrade potentially causing higher subgrade reactions during the mat uplift and slap down under seismic loading, has not been incorporated in the mat design. Consequently, the COL applicant should demonstrate that the subgrade is uniform at the foundation level.

The discussion in the DCD about site investigation for non-uniform sites describes in detail the types of investigation that will be necessary on the part of the COL applicant when special site conditions exist, such as sloping bedrock sites, undulatory bedrock sites and geologically impacted sites. This elaboration provides greater assurance of the adequacy of the site characterization necessary for this standard design. Careful consideration has been given to the COL information that will be needed in DCD Tier 2 Section 2.5.4.6 to ensure suitability of the subgrade below the foundation mat, as well as the over burden material that will be in contact with the walls below the finished grade. Each attribute of the necessary COL information corresponds to the design assumptions of AP1000. These standards are in addition to the generic guidelines for site investigation provided in the SRP Section 2.5.4.

An applicant for design certification is required to provide the postulated site parameters used in the design, and an analysis and evaluation of the design in terms of these parameters. AP1000 DCD Tier 2 information has met this requirement. The NRC staff will apply the acceptance criteria from its review standards in reviewing any in reviewing any future COL application that references the AP1000 standard design, should it be certified. The staff finds the information provided by the applicant in the DCD on subsurface uniformity reasonable and acceptable because it conforms to the need for site parameter information needed to satisfy the regulation.

### 2.5.5 Stability of Slopes

The AP1000 DCD provides for the COL applicant to address site-specific information about static and dynamic stability of soil and rock slopes, the failure of which could adversely impact the safety of the nuclear island. An applicant for design certification is required to provide the

postulated site parameters used in the design, and an analysis and evaluation of the design in terms of these parameters. The AP1000 DCD Tier 2 information has met this requirement. The NRC staff will apply the acceptance criteria from its review standards in reviewing a future COL application that references the AP1000 standard design, should it be certified. The staff finds the information provided by the applicant in the DCD on stability of slopes reasonable and acceptable because the standard design application is independent of any site specific condition.

### 2.5.6 Embankments and Dams

The AP1000 DCD provides for the COL applicant to address site-specific information about embankments and dams, the failure of which could adversely impact the safety of the nuclear island. An applicant for design certification is required to provide the site parameters used in the design, and an analysis and evaluation of the design in terms of these parameters. The AP1000 DCD Tier 2 information has met this requirement. The NRC staff will apply the acceptance criteria from its review standards in receiving any future COL application that references the AP1000 standard design, should it be certified. The staff finds the information provided by the applicant in the DCD on embankments and dams reasonable and acceptable because the standard design application is independent of any site specific condition.

