APR1400
DESIGN CONTROL DOCUMENT TIER 2

CHAPTER 2
SITE CHARACTERISTICS

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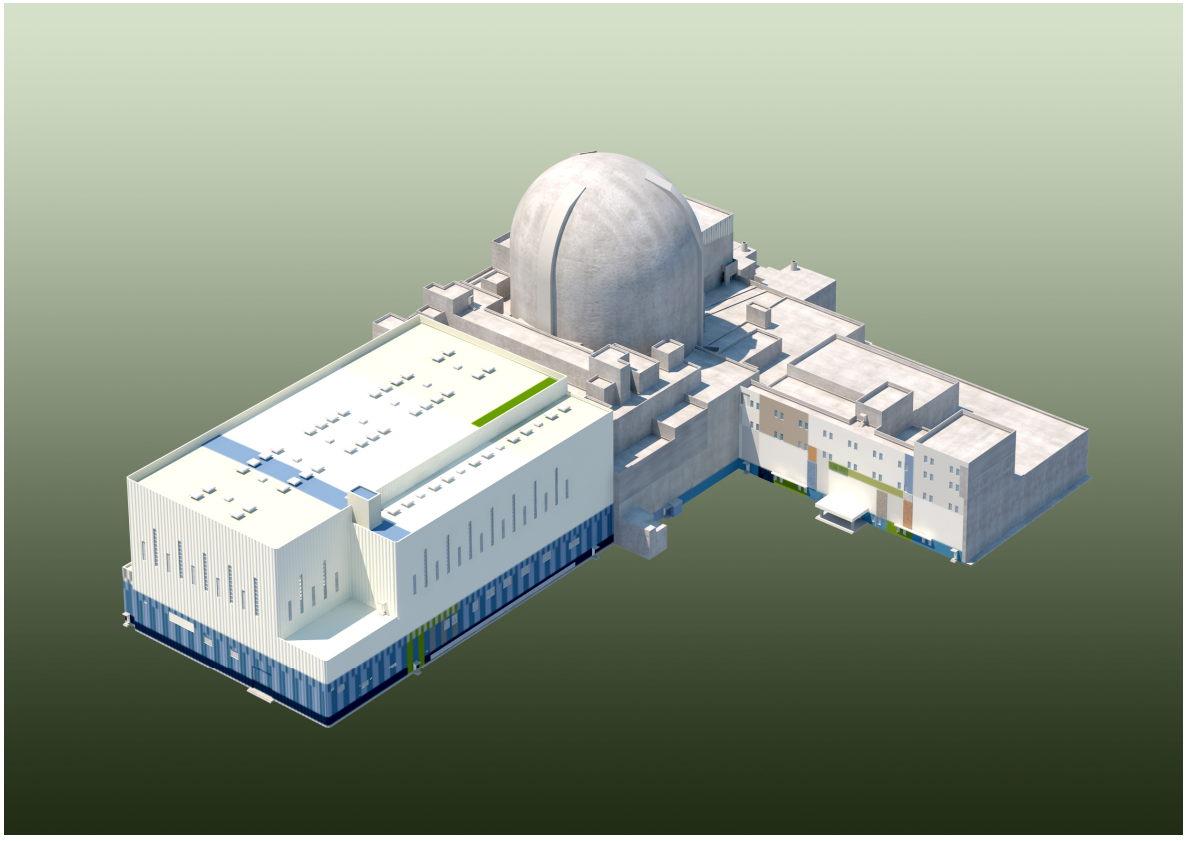

KOREA ELECTRIC POWER CORPORATION
KOREA HYDRO & NUCLEAR POWER CO., LTD

CHAPTER 2 – SITE CHARACTERISTICS

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ACRONYM AND ABBREVIATION LIST

AB	Auxiliary Building
ADV	Atmospheric Dump Valve
CFR	Code of Federal Regulations
COL	Combined License
CSDRS	Certified Seismic Design Response Spectra
CW	Circulating Water
CWS	Circulating Water System
DBE	Design Basis Event
EAB	Exclusion Area Boundary
ESWS	Essential Service Water System
FS	Factor of Safety
GMRS	Ground Motion Response Spectra
HRHF	Hard Rock High Frequency
HVAC	Heating, Ventilation, and Air Conditioning
LPZ	Low Population Zone
LWR	Light Water Reactor
MCR	Main Control Room
MMI	Modified Mercalli Intensity
NI	Nuclear Island
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PMWP	Probable Maximum Winter Precipitation
PSHA	Probabilistic Seismic Hazard Analysis
SSC	Structures, Systems, and Components
SSE	Safe Shutdown Earthquake
UHS	Ultimate Heat Sink

CHAPTER 2 – SITE CHARACTERISTICS

2.0 Site Characteristics

The APR1400 is designed on the basis of a set of assumed site-related parameters. The parameters were selected to include a range of potential nuclear power plant sites in the United States. A summary of the assumed parameters is provided in Table 2.0-1.

Detailed site-related characteristics will be provided in Chapter 2 of the Final Safety Analysis Report for any applications referencing the APR1400 design. These characteristics are to be reviewed and compared to the site parameters in Table 2.0-1. The COL applicant is to demonstrate that the APR1400 design meets the requirements imposed by the site-specific parameters and conforms to all design commitments and acceptance criteria if the characteristics of the site fall outside the assumed site parameters in Table 2.0-1(COL 2.0(1)).

2.0.1 Combined License Information

COL 2.0(1) The COL applicant is to demonstrate that the APR1400 design meets the requirements imposed by the site-specific parameters and conforms to all design commitments and acceptance criteria if the characteristics of the site fall outside the assumed site parameters in Table 2.0-1.

2.0.2 References

1. NRC RG 1.76, “Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants,” Rev. 1, Nuclear Regulatory Commission, March 2007.

2. NRC RG 1.221, “Design-Basis Hurricane and Hurricane Missile for Nuclear Power Plants,” Nuclear Regulatory Commission, October 2011.

Table 2.0-1 (1 of 3)

Site Parameters

Parameter Description	Parameter Value
Maximum Elevation of Groundwater	0.61 m (2 ft) below plant grade(1) in the vicinity of the SSCs important to safety
Maximum Flood Elevation	0.30 m (1 ft) below plant grade in the vicinity of the SSCs important to safety
Precipitation - Maximum Precipitation Rate [1 mi^2] - 100-Year Snowpack Roof Load - Extreme Winter Precipitation Roof Load - Depth of 48-Hour PMWP	 492.7 mm (19.4 in) over 1 hour 157 mm (6.2 in) in 5 minutes 2.873 kPa (60 lbf/ft^2) 5.985 kPa (125 lbf/ft^2) 914.4 mm (36 in)
HVAC Outdoor Design Temperature - 5 % exceedance values · Maximum · Minimum - 1 % exceedance values · Maximum · Minimum - 0 % exceedance values · Maximum · Minimum	 35 °C (95 °F) dry bulb and 25 °C (77 °F) coincident wet bulb -20.6 °C (-5 °F) 43.3 °C (100 °F) dry bulb and 25 °C (77 °F) coincident wet bulb –23.3 °C (–10 °F) 46.1 °C (115 °F) dry bulb and 26.7 °C (80 °F) coincident wet bulb –40 °C (–40 °F)
Ambient Design Temperature for Cooling Tower - Ambient 5 % Exceedance Values for CWS · Maximum · Minimum - Ambient 0 % Exceedance Values for ESWS · Maximum · Minimum	 26.1 °C (79 °F) non-concurrent wet bulb –20.6 °C (-5 °F) 27.2 °C (81 °F) non-concurrent wet bulb –40.0 °C (–40 °F)
Extreme Wind - 50-Year 3-Second Wind Gust Speed - Importance Factor	 64.8 m/s (145 mph) 1.15(2)

Table 2.0-1 (2 of 3)

Parameter Description	Parameter Value
Tornado Parameters - Maximum Horizontal Wind Speed - Translational Speed - Rotational Speed - Radius of Maximum Rotational Speed - Maximum Pressure Differential - Rate of Pressure Drop - Missile Spectra	 102.8 m/s (230 mph) 20.6 m/s (46 mph) 82.2 m/s (184 mph) 45.7 m (150 ft) 8.274 kPa (1.2 psi) 3.447 kPa/s (0.5 psi/s) Table 2 (Region I) of NRC RG 1.76 (Reference 1)
Hurricane Parameters - Maximum 3-Second Wind Gust Speed - Missile Spectra	 116 m/s (260 mph) Table 1 of NRC RG 1.221 (Reference 2)
Accident Release χ/Q Values at EAB · 0-2 hr	 1.00×10^{-3} s/m^3
Accident Release χ/Q Values at LPZ · 0-8 hr · 8-24 hr · 24-96 hr · 96-720 hr	 2.20×10^{-4} s/m^3 1.60×10^{-4} s/m^3 1.00×10^{-4} s/m^3 8.00×10^{-5} s/m^3
Annual Average χ/Q Values at Site Boundary · Undepleted/No Decay · Undepleted/2.26-Day Decay · Depleted/8.00-Day Decay · D/Q	 2.00×10^{-5} s/m^3 1.99×10^{-5} s/m^3 1.84×10^{-5} s/m^3 2.00×10^{-7} 1/m^2
Inventory of Radionuclides that Could Seep into the Groundwater	See Table 11.2-9
Safe Shutdown Earthquake (SSE)	0.3 g peak ground acceleration
Certified Seismic Design Response Spectra Referencing SSE	See Figures 2.0-1 and 2.0-2
Fault Displacement Potential (yes/no)	No
Minimum Allowable Static Bearing Capacity	718.2 kPa (15 ksf)(3)
Minimum Allowable Dynamic Bearing Capacity	2,872.8 kPa (60 ksf)(3)
Minimum Shear Wave Velocity	304.8 m/s (1,000 ft/s)
Liquefaction Potential (yes/no)	No

Table 2.0-1 (3 of 3)

Parameter Description	Parameter Value
Maximum Differential Settlement inside Building	12.7 mm (0.5 in) per 15.24 m (50 ft) in any direction
Maximum Differential Settlement between Buildings	12.7 mm (0.5 in)
Minimum Soil Angle of Internal Friction	35 degrees
Slope Failure Potential (yes/no)	No

(1) Plant grade represents the level of ground adjacent to the nuclear island buildings and is established at a plant elevation 98 ft 8 in.

(2) 100-year recurrence interval: Value to be used for design of seismic Category I and II structures only.

(3) Bearing capacity is defined at the foundation level of the nuclear island structures.

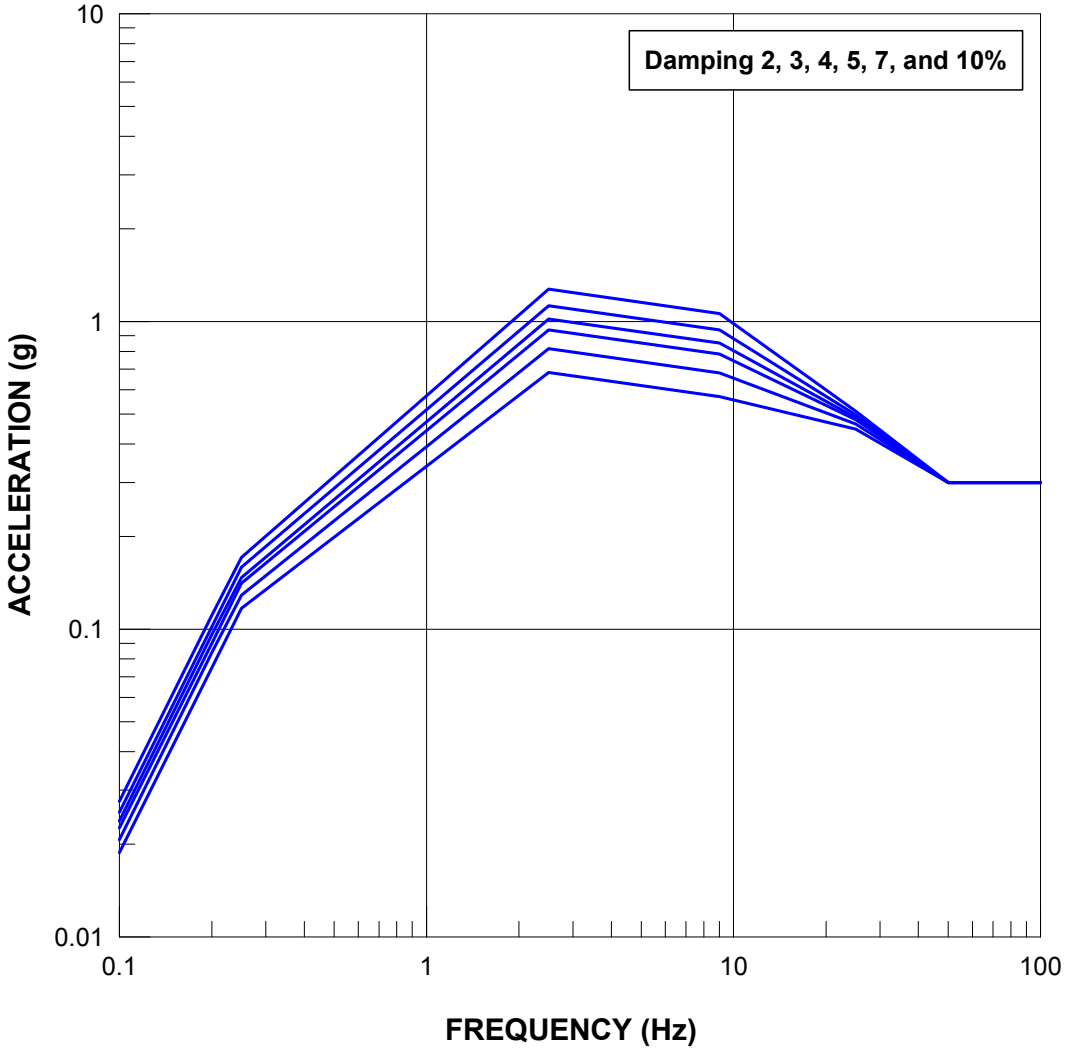

Figure 2.0-1 Horizontal Certified Seismic Design Response Spectra

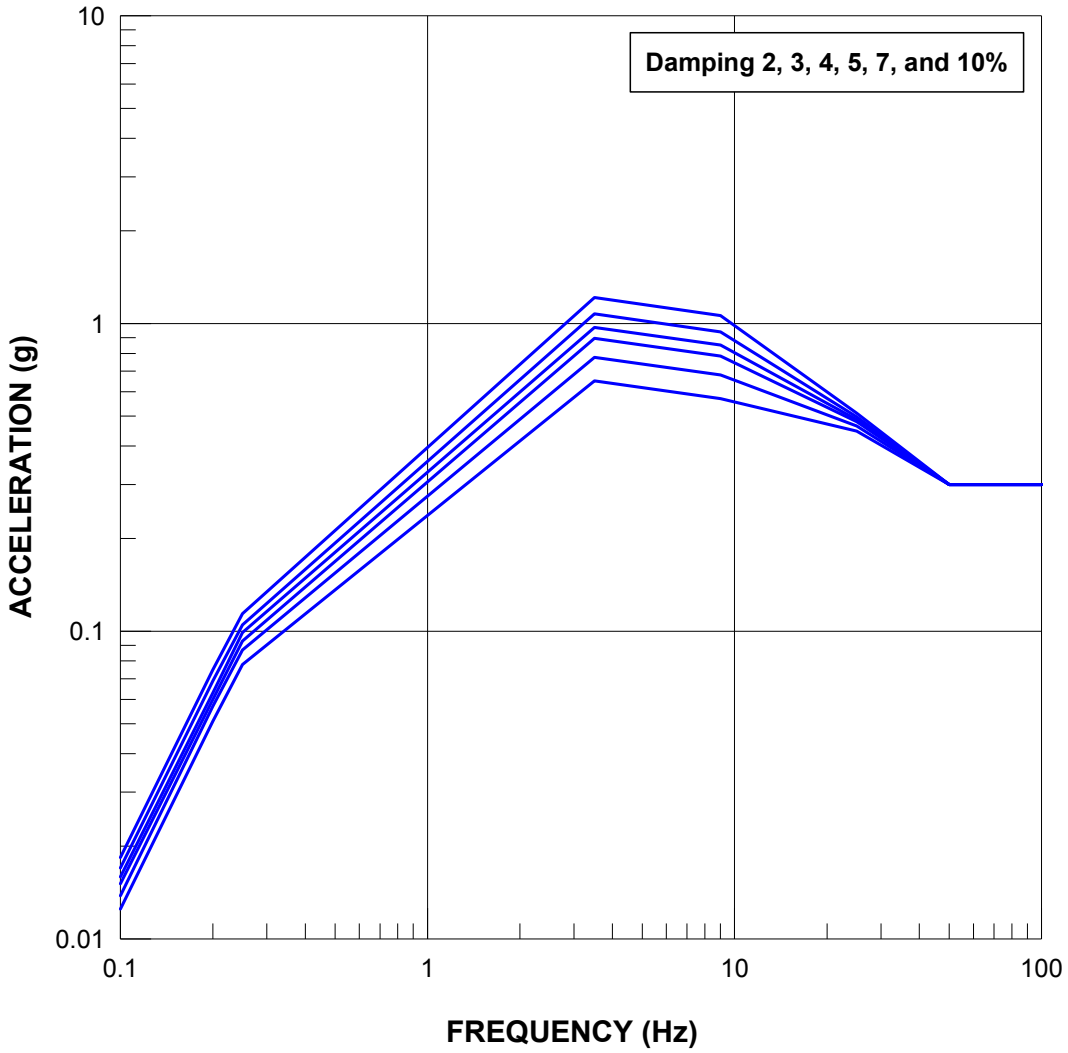

Figure 2.0-2 Vertical Certified Seismic Design Response Spectra

2.1 Geography and Demography

The COL applicant is to provide site-specific information on the site location and a description of the site, exclusion authority and control, and population distribution, as stated in NRC RG 1.206 (Reference 1) and described in the following subsections (COL 2.1(1)).

2.1.1 Site Location and Description

This subsection describes site-specific information on the site location and a description of the site, including:

a. The boundaries of the site

b. The proposed general location of each facility on the site

c. The location and description of any industrial, military, or transportation facilities and routes

d. Prominent natural and manmade features in the site area

2.1.2 Exclusion Area Authority and Control

The owner of the plant has the legal authority to control and determine the activities to be permitted in the land within the exclusion area boundary (EAB), including the exclusion and removal of personnel and property from the area.

A highway, railroad, or waterway may traverse the exclusion area but is not close enough to the facility to interfere with normal operations. In addition, the appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway in the case of an emergency. Residences within the exclusion area are normally prohibited. People who live within the EAB are subject to removal, if necessary. The activities, unrelated to operation of the reactor and do not result in a significant hazard to public health and safety, may be permitted in EAB as described in Reference 2.

2.1.3 Population Distribution

This subsection addresses site-specific information regarding population distribution, population center, and population density as stated in NRC RG 1.206 (Reference 1).

Population distribution is based on the latest census data. Population center as defined in 10 CFR 100.3 (Reference 3) is described in this subsection and includes population, direction, and distance from the reactor. The description includes the distance to the nearest boundary of a population center and the present and projected population distribution and population density within and adjacent to local population groupings.

2.1.4 Combined License Information

COL 2.1(1) The COL applicant is to provide site-specific information on the site location and description of the site, exclusion authority and control, and population distribution as stated in NRC RG 1.206 (Reference 1).

2.1.5 References

1. NRC RG 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," Nuclear Regulatory Commission, June 2007.

2. NRC Standard Review Plan 2.1.2, "Exclusion Area Authority and Control," Rev. 3, NUREG-0800, U.S. Nuclear Regulatory Commission, March 2007.

3. 10 CFR 100.3, "Definitions."

2.2 Nearby Industrial, Transportation, and Military Facilities

The COL applicant is to provide site-specific information on nearby industrial, transportation, and military facilities as required in NRC RG 1.206 (Reference 1) (COL 2.2(1)).

The COL applicant is to identify a design-basis event (DBE) caused by nearby industrial, transportation, and military facilities and determine their design parameters as outlined below (COL 2.2(2)).

2.2.1 Locations and Routes

Site-specific maps, including the location and distance from the site of all significant facilities, are provided in this subsection.

2.2.2 Descriptions

Site-specific information on nearby industrial, transportation, and military facilities is described. The information on each facility includes the primary function; major products; number of employees; materials regularly manufactured, stored, used, or transported in the vicinity of the site; and the hazards that could result from accidents at the facilities.

2.2.3 Evaluation of Potential Accidents

Potential accidents in the vicinity of the plant, including human-caused hazards, are evaluated by analyzing the accident occurrence rate, which includes taking into account site-specific information. A design basis event (DBE) is defined as an event with a probability of occurrence on the order of magnitude of 10^{-7} per year or greater and with severe consequences. Because of the low probability of the events under consideration, valid statistical data are often not available to permit accurate quantitative calculation of probabilities. Accordingly, a conservative calculation showing that the probability of occurrence is approximately of 10^{-6} per year is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower.

If potential accidents having unacceptable probability of severe consequences are identified, description of site-specific steps taken to mitigate the consequences is included.

Examples of mitigation are adding engineered safety feature equipment, reinforcing plant structures, and the provision to reduce the likelihood and severity of the accidents.

2.2.4 Combined License Information

COL 2.2(1) The COL applicant is to provide site-specific information on nearby industrial, transportation, and military facilities as required in NRC RG 1.206 (Reference 1).

COL 2.2(2) The COL applicant is to identify the DBE caused by nearby industrial, transportation, and military facilities and determine its design parameters.

2.2.5 References

1. NRC RG 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," Nuclear Regulatory Commission, June 2007.

2.3 Meteorology

The COL applicant is to provide site-specific information on meteorology including regional climatology, local meteorology, the onsite meteorological measurement program, estimated short-term atmospheric dispersion for accident release, and long-term atmospheric dispersion estimates for routine release as addressed in NRC RG 1.206 (Reference 1) (COL 2.3(1)).

The COL applicant is to perform the radiological consequence analysis and demonstrate that the related dose limits specified in 10 CFR 50.34 (Reference 2) and 10 CFR 50 Appendix I (Reference 3) are not exceeded, if the site-specific χ/Q values exceed the bounding values used in this section (COL 2.3(2)).

2.3.1 Regional Climatology

Site-specific information on the climate in the region includes types of air masses, synoptic features, general airflow patterns, temperature and humidity, precipitation, potential influences from regional topography, and relationships between synoptic-scale atmospheric processes, and regional meteorological conditions including severe weather phenomena (hurricanes, tornadoes, waterspouts, thunderstorms, severe wind events, lightning, hail, and high air pollution potential) as stated in NRC RG 1.206 (Reference 1). Meteorological data used to evaluate the performance of the ultimate heat sink (UHS), with respect to maximum evaporation, drift loss, and minimum water for cooling, are also provided.

All meteorological conditions are classified as climatic site characteristics for consideration in evaluating the design and operation of the proposed facility. The APR1400 is designed based on the meteorological parameters (precipitation, temperature, extreme wind, tornado parameters, hurricane parameters) specified in Table 2.0-1.

2.3.2 Local Meteorology

Local meteorology information includes a local meteorological and topographic description of the site area, both before construction and during the operation of a plant that may be constructed on the proposed site, as required by NRC RG 1.206 (Reference 1). The information includes normal and extreme values for meteorological parameters, potential

influence of the plant and its facilities on local meteorology, and local meteorological conditions for design and operating bases.

2.3.3 Onsite Meteorological Measurements Program

Preoperational and operational programs for measuring meteorological conditions at the site, including offsite satellite facilities, are provided in this subsection in accordance with NRC RG 1.23 (Reference 4). A meteorological tower and instrumentation for onsite meteorological measurements are described in these programs

2.3.4 Short-Term Atmospheric Dispersion Estimates for Accident Releases

The short-term atmospheric dispersion factors (χ/Qs) for offsite locations, such as the exclusion area boundary (EAB) and the outer boundary of the low population zone (LPZ), and onsite locations such as the main control room (MCR) and auxiliary building (AB) air intakes, are conservatively determined as follows:

a. The offsite χ/Qs used for the APR1400 design are listed in Table 2.3-1. In particular, the 2-hour EAB χ/Q of 1.0×10^{-3} sec/m^3 is the conservative value recommended by EPRI URD (Reference 5) for enveloping U.S. sites. The χ/Qs for the outer boundary of the LPZ are also selected to be conservative values applicable to U.S. sites.

b. Onsite χ/Qs for the APR1400 are calculated using the guidance in NRC RG 1.194 (Reference 6), NRC-approved ARCON96 computer code (Reference 7), and representative meteorological data selected from the publicly available meteorological data for some U.S. sites. The results from these analyses were used to establish the χ/Qs for the APR1400 design.

c. The 95th percentile onsite χ/Qs for the MCR and auxiliary building normal air intakes due to post-accident releases from various potential post-accident release locations are summarized in Tables 2.3-2 through 2.3-12. The input variables including source and receptor locations used in calculating the accident χ/Qs are shown in Table 2.3-13 and Figure 2.3-1, respectively.

2.3.5 Long-Term Atmospheric Dispersion Estimates for Routine Releases

The annual average atmospheric dispersion factor (χ/Q) and relative deposition factor (D/Q) can be calculated using site-specific meteorological data. However, because the plant site for the APR1400 in the United States has not been determined in this stage of the Design Certification, there are no site meteorological data. Therefore, for the APR1400 DC application, the bounding conservative χ/Q and D/Q values are reviewed from the U.S. sites.

For conservative estimates of radioactive decay, a half-life of 2.26 days (Xe-133m) is acceptable for short-lived noble gases, and a half-life of 8 days (I-131) for all iodine released to the atmosphere is acceptable, as addressed in NRC RG 1.111 (Reference 8). Therefore, the annual χ/Qs for undepleted/2.26-day decay and depleted/8-day decay are derived from these half-lives and the typical travel time between the release and the receptor points.

The annual average χ/Q values at the site boundary are listed in Table 2.0-1, including the annual average χ/Q for undepleted/no decay, χ/Q for undepleted/2.26 days decay, χ/Q for depleted/8 days decay, and the relative D/Q values.

2.3.6 Combined License Information

COL 2.3(1) The COL applicant is to provide site-specific information on meteorology including regional climatology, local meteorology, onsite meteorological measurement program, estimated short-term atmospheric dispersion for accident release, and long-term atmospheric dispersion estimates for routine release as addressed in NRC RG 1.206.

COL 2.3(2) The COL applicant is to perform the radiological consequence analysis and demonstrate that the related dose limits specified in 10 CFR 50.34 and 10 CFR 50 Appendix I are not exceeded, if the site-specific χ/Q values exceed the bounding values described in Tables 2.3-1 to 2.3-12.

2.3.7 References

1. NRC RG 1.206, “Combined License Applications for Nuclear Power Plants (LWR Edition),” Nuclear Regulatory Commission, June 2007.

2. 10 CFR 50.34, “Contents of Applications, Technical Information.”

3. 10 CFR 50, Appendix I, “Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion ‘As Low as is Reasonably Achievable’ for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents.”

4. NRC RG 1.23, “Meteorological Monitoring Programs for Nuclear Power Plants (LWR Edition),” Nuclear Regulatory Commission, Rev. 1, March 2007.

5. EPRI ALWR Utility Requirements Document, Volume II, 2008.

6. NRC RG 1.194, “Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants,” Nuclear Regulatory Commission, June 2003.

7. NUREG/CR-6331, PNNL-10521, “Atmospheric Relative Concentrations in Building Wakes,” Nuclear Regulatory Commission, Rev. 1, May 1997.

8. NRC RG 1.111, “Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases From Light-Water-Cooled Reactors,” Nuclear Regulatory Commission, Rev. 2, April 1977.

Table 2.3-1

Short-term Atmospheric Dispersion Factors

Receptor Location	Time Interval (hr)	χ/Q (s/m^3)
EAB	0–2	1.00E-03
LPZ	0–8	2.20E-04
	8–24	1.60E-04
	24–96	1.00E-04
	96–720	8.00E-05

Table 2.3-2

Onsite χ/Q for Reactor Containment Building Release
to MCR North and South Intakes and MCR Roof Centerline

Time Interval (hr)	Onsite χ/Q (s/m^3)		
	Containment Building to		
	MCR North Intake	MCR South Intake	MCR Roof Centerline
0–2	3.73E-04	3.39E-04	3.92E-04
2–8	3.17E-04	1.91E-04	3.00E-04
8–24	1.38E-04	8.42E-05	1.29E-04
24–96	1.02E-04	5.59E-05	9.11E-05
96–720	7.84E-05	3.94E-05	7.05E-05

Table 2.3-3

Onsite χ/Q for Reactor Containment Building Release to Auxiliary Building North Intakes

Time Interval (hr)	Onsite χ/Q (s/m^3)
0–2	2.35E-03
2–8	1.91E-03
8–24	8.18E-04
24–96	6.15E-04
96–720	4.77E-04

Table 2.3-4

Onsite χ/Q for North and South Main Steam Valve Room
Direct Releases to MCR North and South Intakes

Time Interval (hr)	Onsite χ/Q (s/m^3)	
	North Main Stream Valve Room to MCR North Intake	South Main Stream Valve Room to MCR South Intake
0–2	2.68E-03	5.63E-03
2–8	2.10E-03	4.43E-03
8–24	9.17E-04	1.93E-03
24–96	6.38E-04	1.29E-03
96–720	5.06E-04	1.01E-03

Table 2.3-5

Onsite χ/Q for North and South Main Steam Valve Room
Cross Releases to MCR North and South Intakes

Time Interval (hr)	Onsite χ/Q (s/m^3)	
	North Main Stream Valve Room to MCR South Intake	South Main Stream Valve Room to MCR North Intake
0–2	2.33E-04	2.57E-04
2–8	1.32E-04	2.10E-04
8–24	5.48E-05	9.21E-05
24–96	3.58E-05	5.79E-05
96–720	2.72E-05	4.54E-05

Table 2.3-6

Onsite χ/Q for South Main Steam Valve Room
Release to Auxiliary Building South Intakes

Time Interval (hr)	Onsite χ/Q (s/m^3)
0–2	7.80E-03
2–8	6.41E-03
8–24	2.81E-03
24–96	1.94E-03
96–720	1.53E-03

Table 2.3-7

Onsite χ/Q for North and South Atmospheric
Dump Valve Releases to MCR North and South Intakes

Time Interval (hr)	Onsite χ/Q (s/m^3)	
	North ADV to MCR North Intake	South ADV to MCR South Intake
0–2	1.46E-03	2.61E-03
2–8	1.14E-03	2.01E-03
8–24	4.99E-04	8.79E-04
24–96	3.43E-04	5.76E-04
96–720	2.68E-04	4.63E-04

Table 2.3-8

Onsite χ/Q for North and South Main Steam
Safety Valve Releases to MCR North and South Intakes

Time Interval (hr)	Onsite χ/Q (s/m^3)	
	North Main Steam Safety Valves to MCR North Intake	South Main Steam Safety Valves to MCR South Intake
0–2	1.18E-03	1.88E-03
2–8	9.08E-04	1.52E-03
8–24	3.99E-04	6.60E-04
24–96	2.72E-04	4.29E-04
96–720	2.12E-04	3.45E-04

Table 2.3-9

Onsite χ/Q Values for Auxiliary Building
North Exhaust Release to MCR North and South Intakes

Time Interval (hr)	Onsite χ/Q (s/m^3)	
	Auxiliary Building North Exhaust To	
	MCR North Intake	MCR South Intake
0–2	6.88E-04	1.79E-04
2–8	5.16E-04	9.04E-05
8–24	2.27E-04	4.01E-05
24–96	1.58E-04	2.91E-05
96–720	1.25E-04	2.14E-05

Table 2.3-10

Onsite χ/Q for Auxiliary Building South Exhaust Release to MCR North and South Intakes

Time Interval (hr)	Onsite χ/Q (s/m^3)	
	Auxiliary Building South Exhaust To	
	MCR North Intake	MCR South Intake
0–2	1.05E-04	2.12E-04
2–8	8.79E-05	1.68E-04
8–24	3.96E-05	7.37E-05
24–96	2.76E-05	5.04E-05
96–720	2.14E-05	3.92E-05

Table 2.3-11

Onsite χ/Q for Auxiliary Building South Exhaust Release to Auxiliary Building South Intake

Time Interval (hr)	Onsite χ/Q (s/m^3)
0–2	6.78E-04
2–8	5.54E-04
8–24	2.40E-04
24–96	1.70E-04
96–720	1.32E-04

Table 2.3-12

Onsite χ/Q for Fuel Handling Area Exhaust Release to MCR North & South Intakes

Time Interval (hr)	Onsite χ/Q (s/m^3)	
	Fuel Handling Area To	
	MCR North Intake	MCR South Intake
0–2	1.52E-04	2.59E-04
2–8	1.31E-04	2.04E-04
8–24	6.02E-05	8.98E-05
24–96	4.01E-05	5.93E-05
96–720	3.19E-05	4.58E-05

Table 2.3-13 (1 of 6)

Design Input for ARCON96 Calculation

Parameter		Value
Meteorological Data		Prairie Island (1993–1997)
Source Release Category		
< From >	< To >	< Source Type >
Reactor Containment Building	MCR Intakes MCR Roof Centerline Auxiliary Building Intakes	Diffuse Area Source Diffuse Area Source Diffuse Area Source
North and South Main Steam Valve Room	MCR Intakes Auxiliary Building Intakes	Ground Level Point Sources Ground Level Point Sources
North and South Atmospheric Dump Valves	MCR Intakes	Ground Level Point Sources
North and South Main Steam Valves	MCR Intakes	Ground Level Point Sources
North Auxiliary Building South Auxiliary Building South Auxiliary Building	MCR Intakes MCR Intakes Auxiliary Building Intakes	Ground Level Point Sources Ground Level Point Sources Ground Level Point Sources
Fuel Handling Area	MCR Intakes	Ground Level Point Sources
MCR Intake (Receptor)		
Characteristics MCR Intakes MCR Roof Auxiliary Building Intakes (Infiltration Path Way)		 Dual MCR Intakes Single Point at roof center Dual AB Intakes
Reduction of χ/Qs MCR Intakes Auxiliary Building Intakes (Infiltration Path Way)		 Factor of 8 Factor of 2

Table 2.3-13 (2 of 6)

Parameter		Value
Source – Receptor Horizontal Distance		
< From >	< To >	< Distance (m) >
Reactor Containment Building	MCR North Intakes	36.72
	MCR South Intakes	33.92
	MCR Roof Centerline	33.76
	Auxiliary Building North Intakes	26.80
	Auxiliary Building South Intakes	26.80
North Main Steam Valve Room	MCR North Intakes	19.80
South Main Steam Valve Room	MCR South Intakes	12.56
North Main Steam Valve Room	MCR South Intakes	64.43
South Main Steam Valve Room	MCR North Intakes	66.20
North Main Steam Valve Room	Auxiliary Building North Intakes	22.30
South Main Steam Valve Room	Auxiliary Building South Intakes	22.30
North Atmospheric Dump Valves	MCR North Intakes	26.65
South Atmospheric Dump Valves	MCR South Intakes	19.36
North Main Steam Valves	MCR North Intakes	29.86
South Main Steam Valves	MCR South Intakes	22.56
North Auxiliary Building	MCR North Intakes	39.10
North Auxiliary Building	MCR South Intakes	73.35
South Auxiliary Building	MCR South Intakes	109.24
South Auxiliary Building	MCR North Intakes	73.53
South Auxiliary Building	Auxiliary Building North Intakes	101.26
South Auxiliary Building	Auxiliary Building South Intakes	84.42
Fuel Handling Area	MCR North Intakes	88.21
Fuel Handling Area	MCR South Intakes	64.04

Table 2.3-13 (3 of 6)

Parameter		Value
Source – Receptor Direction		
< From >	< To >	< Degree (^{o}) >
Reactor Containment Building	MCR North Intakes	137.57
	MCR South Intakes	35.26
	MCR Roof Centerline	90.00
	Auxiliary Building North Intakes	120.00
	Auxiliary Building South Intakes	60.00
North Main Steam Valve Room	MCR North Intakes	99.75
South Main Steam Valve Room	MCR South Intakes	74.62
North Main Steam Valve Room	MCR South Intakes	10.92
South Main Steam Valve Room	MCR North Intakes	162.86
North Main Steam Valve Room	Auxiliary Building North Intakes	73.20
South Main Steam Valve Room	Auxiliary Building South Intakes	106.80
North Atmospheric Dump Valves	MCR North Intakes	93.60
South Atmospheric Dump Valves	MCR South Intakes	85.03
North Main Steam Valves	MCR North Intakes	93.49
South Main Steam Valves	MCR South Intakes	85.37
North Auxiliary Building	MCR North Intakes	93.80
North Auxiliary Building	MCR South Intakes	26.60
South Auxiliary Building	MCR South Intakes	132.80
South Auxiliary Building	MCR North Intakes	92.52
South Auxiliary Building	Auxiliary Building North Intakes	125.34
South Auxiliary Building	Auxiliary Building South Intakes	101.92
Fuel Handling Area	MCR North Intakes	127.85
Fuel Handling Area	MCR South Intakes	76.79

Table 2.3-13 (4 of 6)

Parameter		Value
Building Wake Area		
< From >	< To >	< Area (m^2) >
Reactor Containment Building	MCR North Intakes	3,167
	MCR South Intakes	3,167
	MCR Roof Centerline	3,167
	Auxiliary Building North Intakes	3,167
	Auxiliary Building South Intakes	3,167
North Main Steam Valve Room	MCR North Intakes	880
South Main Steam Valve Room	MCR South Intakes	406
North Main Steam Valve Room	MCR South Intakes	3,167
South Main Steam Valve Room	MCR North Intakes	3,167
North Main Steam Valve Room	Auxiliary Building North Intakes	1,878
South Main Steam Valve Room	Auxiliary Building South Intakes	1,241
North Atmospheric Dump Valves	MCR North Intakes	880
South Atmospheric Dump Valves	MCR South Intakes	406
North Main Steam Valves	MCR North Intakes	880
South Main Steam Valves	MCR South Intakes	406
North Auxiliary Building	MCR North Intakes	880
North Auxiliary Building	MCR South Intakes	3,167
South Auxiliary Building	MCR South Intakes	3,167
South Auxiliary Building	MCR North Intakes	406
South Auxiliary Building	Auxiliary Building North Intakes	3,167
South Auxiliary Building	Auxiliary Building South Intakes	406
Fuel Handling Area	MCR North Intakes	3,167
Fuel Handling Area	MCR South Intakes	406

Table 2.3-13 (5 of 6)

Parameter		Value
Release Height		
< From >	< To >	< Height (m) >
Reactor Containment Building	MCR North Intakes MCR South Intakes MCR Roof Centerline Auxiliary Building North Intakes Auxiliary Building South Intakes	54.0 54.0 54.0 54.0 54.0
North Main Steam Valve Room South Main Steam Valve Room North Main Steam Valve Room South Main Steam Valve Room North Main Steam Valve Room South Main Steam Valve Room	MCR North Intakes MCR South Intakes MCR South Intakes MCR North Intakes Auxiliary Building North Intakes Auxiliary Building South Intakes	25.3 25.3 25.3 25.3 25.3 25.3
North Atmospheric Dump Valves South Atmospheric Dump Valves	MCR North Intakes MCR South Intakes	24.0 24.0
North Main Steam Valves South Main Steam Valves	MCR North Intakes MCR South Intakes	24.0 24.0
North Auxiliary Building North Auxiliary Building South Auxiliary Building South Auxiliary Building South Auxiliary Building South Auxiliary Building	MCR North Intakes MCR South Intakes MCR South Intakes MCR North Intakes Auxiliary Building North Intakes Auxiliary Building South Intakes	34.8 34.8 24.4 24.4 24.4 24.4
Fuel Handling Area Fuel Handling Area	MCR North Intakes MCR South Intakes	17.0 17.0

Table 2.3-13 (6 of 6)

Parameter	Value
Intake Height from ground level	
MCR Intakes	25.8 m
MCR Roof Centerline	24.4 m
Auxiliary Building Intakes (Infiltration Path Way)	32.0 m
Surface Roughness Length	0.2 m
Minimum Wind Speed	0.5 m/s
Average Sector Width Constant	4.3
Lower Measurement Height for Meteorological Data	10.0 m
Intermediate Measurement Height for Meteorological Data	60.0 m
Wind Speed Units for Meteorological Data	Miles per hour (mph)
Vertical Diffusion Area Coefficient (σ_{Z0})	
Reactor Containment Building – MCR Intakes	0.0 m
Reactor Containment Building – MCR Roof Centerline	0.0 m
Reactor Containment Building – Auxiliary Building Intakes	0.0 m
Horizontal Diffusion Area Coefficient[(1)] (σ_{Y0})	
Reactor Containment Building – MCR Intakes	8.0 m
Reactor Containment Building – MCR Roof Centerline	8.0 m
Reactor Containment Building – Auxiliary Building Intakes	8.0 m

(1) Width of Diffuse Area $\times \frac{1}{6}$: Horizontal diffusion area coefficients are calculated by this equation described in Reference 6

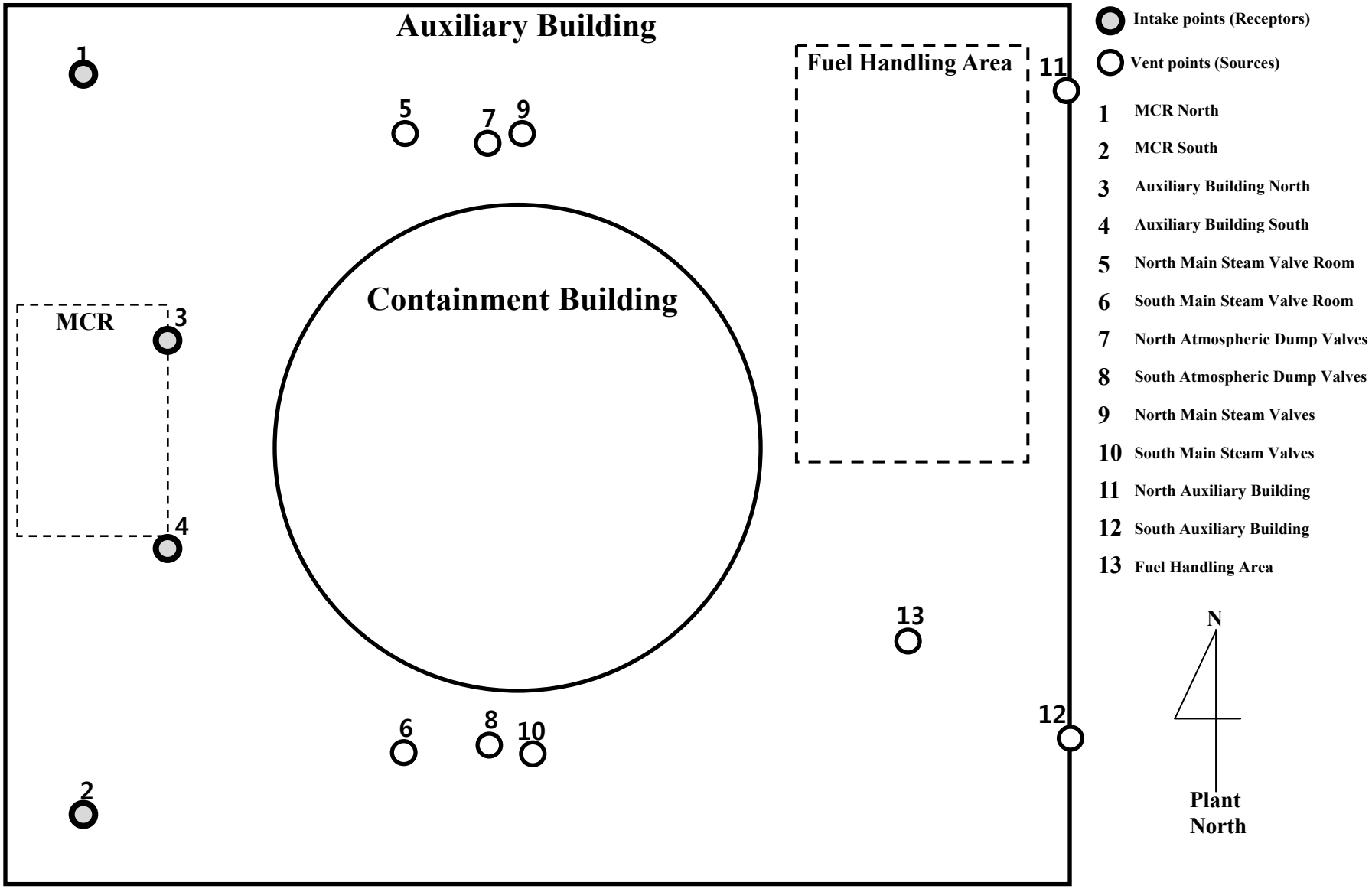

Figure 2.3-1 Design Features with Source and Receptor Locations

2.4 Hydrologic Engineering

The site grade level is established at least 0.30 m (1 ft) above the maximum flood level. The probable maximum precipitation (PMP) defined as maximum precipitation rate (1-hour, 1- mi^2) in Table 2.0-1 is 492.7 mm (19.4 in) for a flooding hazard analysis.

The COL applicant is to provide site-specific hydrologic information on probable maximum precipitation (PMP), probable maximum flood (PMF) on streams and rivers, potential dam failures, probable maximum surge and seiche flooding, probable maximum tsunami hazards, ice effects, cooling water canals and reservoirs, channel diversions, flood protection requirements, low water considerations, groundwater, potential accidental release of liquid effluents in ground and surface water, Technical Specifications, and emergency operation requirements in accordance with NRC RG 1.206 (Reference 1), NRC RG 1.59 (Reference 2), and NRC JLD-ISG-2012-06 (Reference 3)(COL 2.4(1)), as described below.

2.4.1 Hydrologic Description

2.4.1.1 Site and Facilities

Hydrologic information about the site and facilities includes all safety-related elevations, structures, exterior accesses, equipment, and systems related to hydrology (both surface and subsurface) and a topographic map of the site that shows any proposed changes to natural drainage features.

2.4.1.2 Hydrosphere

Site-specific hydrospheric-related information includes the location, size, shape, and other hydrologic characteristics of streams, lakes, shore regions, and groundwater environments that influence plant siting and a description of the existing and proposed water control structures, both upstream and downstream, that could influence conditions at the site.

2.4.2 Floods

Site-specific flood-related information includes flood history, flood design considerations, and the effects of local intense precipitation due to PMP.

2.4.2.1 Flood History

Site-specific flood history information includes the date, level, peak discharge, and related information for major historical flood events in the site region.

2.4.2.2 Flood Design Considerations

Site-specific flood-design-related information includes the capability of safety-related facilities, systems, and equipment to withstand floods and flood waves, including the characteristics of how any possible flood condition, up to and including the highest and most critical flood level resulting from any of several different events, affects the basis for the design protection level for safety-related components and structures of the plant.

2.4.2.3 Effects of Local Intense Precipitation

Site-specific information on the effects of local intense precipitation includes the design of adjacent drainage areas and site drainage systems, including drainage from the roofs of structures, to prevent flooding of safety-related facilities.

2.4.3 Probable Maximum Flood on Streams and Rivers

Site-specific information related to the probable maximum flood (PMF) on streams and rivers includes precipitation losses, runoff and stream course models, PMF flow, water level determinations, coincident wind-wave activity, and hydrological site characteristics that pose any potential hazard to the safety-related facilities as a result of the effects of a PMF on streams and rivers.

2.4.3.1 Probable Maximum Precipitation

Site-specific PMF information includes storm configuration, maximized precipitation amounts, time distributions, orographic effects, storm centering, seasonal effects, antecedent storm sequences, antecedent snowpack, and any snowmelt model that is used to determine the PMP.

2.4.3.2 Precipitation Losses

Site-specific precipitation loss information includes the absorption capability of the basin, including initial losses, infiltration rates, and antecedent precipitation.

2.4.3.3 Runoff and Stream Course Models

Site-specific information related to runoff and stream course models includes hydrologic response characteristics of the watershed to precipitation, verification from historical floods or synthetic procedures, and methods adopted to account for nonlinear basin response at high rainfall rates.

2.4.3.4 Probable Maximum Flood Flow

Site-specific PMF flow information includes a controlling PMF runoff hydrograph at the plant site resulting from rainfall (and snowmelt if pertinent).

2.4.3.5 Water Level Determinations

Water level determinations include the translation of the estimated peak PMP discharge to the elevation using cross-sectional and profile data, reconstitution of historical floods, standard step methods, transient flow methods, roughness coefficients, bridge and other losses, extrapolation of coefficients for the PMF, estimates of PMF water surface profiles, and flood outlines.

2.4.3.6 Coincident Wind Wave Activity

Site-specific information on coincident wind wave activity includes the setup, significant and maximum wave heights, runup, and resultant static and dynamic effects of wave action on each safety-related facility from wind-generated activity that could occur coincidently with the peak PMF water level.

2.4.4 Potential Dam Failures

Site-specific information related to potential dam failures includes potential hazards to safety-related facilities due to the failure of upstream and downstream water control structures, dam failure permutations, unsteady flow analysis of potential dam failures, and water level at the plant site.

2.4.4.1 Dam Failure Permutations

Site-specific information related to dam failure permutations includes the locations of dams, potential modes of failure, and results of seismically induced dam failures that could cause the most critical conditions with respect to the safety-related facilities for such a PMF.

2.4.4.2 Unsteady Flow Analysis of Potential Dam Failures

Site-specific information related to the effect of dam failures on the site includes how the analytical methods that are presented are applicable to artificially large floods with appropriately acceptable coefficients and flood waves through reservoirs downstream of failures.

2.4.4.3 Water Level at the Plant Site

Site-specific information related to water level at the plant site includes backwater, unsteady flow, or other computational method used to estimate the water elevation for the most critical upstream dam failures.

2.4.5 Probable Maximum Surge and Seiche Flooding

Site-specific information related to the probable maximum surge and seiche flooding includes the extent to which safety-related plant systems require protection, surge and seiche water levels, wave action, resonance, and protective structures, if applicable.

2.4.5.1 Probable Maximum Winds and Associated Meteorological Parameters

Site-specific information related to probable maximum winds and associated meteorological parameters includes wind speed and pressure drop.

2.4.5.2 Surge and Seiche Water Levels

Site-specific information related to surge and seiche water levels includes historical data on surges, seiches, and hurricanes; frontal (cyclonic) type windstorms; moving squall lines; and surge mechanisms that are possible and applicable to the site.

2.4.5.3 Wave Action

Site-specific information related to wave action includes the wind-generated wave activity that can occur independently or coincidently with a surge or seiche.

2.4.5.4 Resonance

Site-specific information related to resonance includes the possibility of oscillations of waves at natural periodicity, such as lake reflection and harbor resonance phenomena, and any resulting effects at the site.

2.4.5.5 Protective Structures

Site-specific information related to protective structures includes the location of, and design criteria for, any special facilities for the protection of intake, effluent, and other safety-related facilities against surges, seiches, and wave action.

2.4.6 Probable Maximum Tsunami Hazards

Site-specific information related to probable maximum tsunami hazards includes probable maximum tsunami, historical tsunami record, source generator characteristics, tsunami water levels, hydrography, harbor or breakwater influences on tsunamis, and the effects on safety-related facilities.

2.4.6.1 Probable Maximum Tsunami

Site-specific information related to probable maximum tsunami includes the determination of the probable maximum tsunami, including the most reasonably severe geoseismic activity possible in determining the limiting tsunami-producing mechanism; verification of the orientation of the site relative to the earthquake epicenter or generating mechanism; shape of the coastline; offshore land areas; hydrography; the stability of the coastal area; and how these factors are considered in the probable maximum tsunami analysis.

2.4.6.2 Historical Tsunami Record

Site-specific information related to the historical tsunami record includes regional historical tsunami information, including any relevant paleo-tsunami evidence.

2.4.6.3 Source Generator Characteristics

Site-specific information related to source generator characteristics includes detailed geoseismic descriptions of the controlling local and distant tsunami generators, including location, source dimensions, fault orientation (if applicable), and maximum displacement.

2.4.6.4 Tsunami Analysis

Site-specific information related to the tsunami analysis includes a description of the analysis procedure used to calculate tsunami wave height and period at the site and of all models used in the analysis, including the theoretical bases of the models, their verification, and the conservatism of all input parameters.

2.4.6.5 Tsunami Water Level

Site-specific information related to tsunami water level includes estimates of maximum and minimum (low water) tsunami wave heights from both distant and local generators and a description of the ambient water levels, including tides, sea level anomalies, and wind waves assumed to be coincident with the tsunami.

2.4.6.6 Hydrography and Harbor or Breakwater Influences on Tsunami

Site-specific information related to hydrography and harbor or breakwater influences on tsunami includes the routing of the controlling tsunami, including breaking wave formation, bore formation, and any resonance effects that result in the estimate of the maximum tsunami runup on each pertinent safety-related facility.

2.4.6.7 Effects on Safety-Related Facilities

Site-specific information related to the effects on safety-related facilities includes the effects of the controlling tsunami on safety-related facilities and the design criteria for measures to protect against and mitigate the effects of tsunami.

2.4.7 Ice Effects

Site-specific information related to ice effects includes potential icing effects and design criteria for protecting safety-related facilities from the most severe ice sheets, ice jam floods, wind-driven ice ridges, or other ice-produced effects and forces that are reasonably

possible and that could affect safety-related facilities with respect to adjacent water bodies such as streams or lakes for both high and low water levels. Additional site-specific information includes the potential for formation of frazil and anchor ice at the site and the effects of an ice-induced reduction in the capacity of water storage facilities as they affect safety-related SSCs.

2.4.8 Cooling Water Canals and Reservoirs

Site-specific information related to cooling water canals and reservoirs includes the design bases for the capacity and operating plan for safety-related cooling water canals and reservoirs. Site characteristics include the emergency storage evacuation of reservoirs, verified runoff models, flood routing, spillway design, and outlet protection if required.

2.4.9 Channel Diversions

Site-specific information related to channel diversions includes the potential for upstream diversion or rerouting of the source of cooling water with respect to seismic, topographical, geologic, and thermal evidence in the region. Alternative safety-related cooling water sources in the event are to be described if available.

2.4.10 Flooding Protection Requirements

Site-specific information related to flooding protection requirements includes the static and dynamic consequences of all types of flooding on each pertinent safety-related facility, including the various types of flood protection used and the emergency procedures to be implemented (where applicable).

2.4.11 Low Water Considerations

Site-specific information related to low water considerations includes low flow in rivers and streams; low water resulting from surges, seiches, or tsunami; historical low water; future controls; plant requirements; and heat sink dependability requirements.

2.4.11.1 Low Flow in Rivers and Streams

Site-specific information related to low flow in rivers and streams includes the design basis for the flow rate and water level resulting from the most severe drought considered reasonably possible in the region if such conditions could affect the ability of safety-related facilities, particularly the ultimate heat sink (UHS), to perform adequately. Additional information includes non-safety-related water supplies and the supply adequacy during a 100-year drought.

2.4.11.2 Low Water Resulting from Surge, Seiches, or Tsunami

Site-specific information related to low water resulting from surge, seiches, or tsunami includes the surge-caused, seiche-caused, or tsunami-caused low water level that could occur from probable maximum meteorological or geoseismic events if such levels could affect the ability of safety-related features to function adequately.

2.4.11.3 Historical Low Water

Site-specific information related to historical low water includes historical low water flows and levels and their probabilities if statistical methods are used to extrapolate flows or levels to probable minimum conditions.

2.4.11.4 Future Controls

Site-specific information related to future controls includes the estimated flow rate, durations, and levels for drought conditions, considering future uses if such conditions could affect the ability of safety-related facilities to function adequately.

2.4.11.5 Plant Requirements

Site-specific information related to plant requirements includes the minimum safety-related cooling water flow, the sump invert elevation and configuration, the minimum design operating level, pump submergence elevations (operating heads) and design bases for effluent submergence, mixing, and dispersion.

2.4.11.6 Heat Sink Dependability Requirements

Site-specific information related to heat sink dependability requirements includes all sources of normal and emergency shutdown water supply and related retaining and conveyance systems, the facility's ability to provide sufficient warning of impending low-flow or low-water levels to allow switching to alternative sources when necessary and any other uses of water drawn from the UHS such as fire water or system charging requirements.

2.4.12 Ground Water

Site-specific information related to ground water includes water source, subsurface pathways, monitoring or safeguard requirements, and site characteristics for subsurface hydrostatic loading.

2.4.12.1 Description and Onsite Use

Site-specific information related to the description and onsite use of ground water includes regional and local ground water aquifers, formations, sources, and sinks as well as the type of ground water use, wells, pumps, storage facilities, and flow requirements of the plant.

2.4.12.2 Sources

Site-specific information related to the sources of ground water includes present and projected future regional water uses such as existing users (amounts, water levels and elevations, locations, and drawdown), the history of ground water or piezometric level fluctuations and contour maps of aquifers beneath and in the vicinity of the site.

2.4.12.3 Subsurface Pathways

Site-specific information related to subsurface pathways includes a conservative analysis of critical ground water pathways for a liquid effluent release at the site and an evaluation (where applicable) of the dispersion, ion exchange, and dilution capability of the ground water environment with respect to present and projected users. Potential pathways of contamination to nearby ground water users and to water bodies such as springs, lakes, and streams are identified.

2.4.12.4 Monitoring or Safeguard Requirements

Site-specific information related to monitoring or safeguard requirements includes the plans, procedures, safeguards, and monitoring programs to be used to protect present and projected ground water users.

Site ground water monitoring systems are designed to support the early detection of leakage and contaminant migration in compliance with NRC RG 4.21 (Reference 4).

2.4.12.5 Site Characteristics for Subsurface Hydrostatic Loading

Site-specific information on subsurface hydrostatic loading includes the maximum operational ground water level for ground-water-induced hydrostatic loadings on the subsurface portions of safety-related SSCs.

2.4.13 Accidental Releases of Radioactive Liquid Effluents in Ground and Surface Waters

Site-specific information related to accidental releases of radioactive liquid effluents in ground and surface waters includes the ability of the ground water and surface water environments to delay, disperse, dilute, or concentrate liquid effluents, as related to existing or potential future water users.

Additional information includes the bases used to determine dilution factors, dispersion coefficients, flow velocities, travel times, adsorption, and pathways of liquid contaminants and provide references to the locations, users of surface waters, and release points.

The analysis related to the accidental release of liquid effluents is described in Subsection 11.2.3.2.

2.4.14 Technical Specification and Emergency Operation Requirements

Site-specific information related to technical specification and emergency operation requirements includes any emergency protective measures designed to minimize the impact of adverse hydrology-related events on safety-related facilities. The emergency requirements are incorporated into the appropriate Technical Specifications and emergency procedures, and the need for any Technical Specifications for plant shutdown to minimize

the consequences of an accident resulting from hydrologic phenomena such as floods or degradation of the UHS is described.

If emergency procedures are used to meet safety requirements associated with hydrologic events, the event is identified and the appropriate available water levels and lead times are provided.

Details on controlling hydrological events are developed to provide reasonable assurance of plant safety, such as the amount of time needed to initiate and complete emergency procedures and the relevant Technical Specifications, if any.

2.4.15 Combined License Information

COL 2.4(1) The COL applicant is to provide the site-specific hydrologic information on probable maximum precipitation (PMP), probable maximum flood (PMF) on streams and rivers, potential dam failures, probable maximum surge and seiche flooding, probable maximum tsunami hazards, ice effects, cooling water canals and reservoirs, channel diversions, flood protection requirements, low water considerations, ground water, potential accidental release of liquid effluents in ground and surface water, and Technical Specifications and emergency operation requirements in accordance with NRC RG 1.206 (Reference 1), NRC RG 1.59 (Reference 2), and NRC JLD-ISG-2012-06 (Reference 3).

2.4.16 References

1. NRC RG 1.206, “Combined License Applications for Nuclear Power Plants (LWR Edition),” Nuclear Regulatory Commission, June 2007.

2. NRC RG 1.59, “Design Basis Floods for Nuclear Power Plants,” Nuclear Regulatory Commission, August 1977.

3. NRC JLD-ISG-2012-06, “Guidance for Performing a Tsunami, Surge, or Seiche Hazard Assessment,” Nuclear Regulatory Commission, November, 2012.

4. NRC RG 4.21, “Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning,” Nuclear Regulatory Commission, June 2008.

2.5 Geology, Seismology, and Geotechnical Engineering

The combined license (COL) applicant is to provide site-specific information on geology, seismology, and geotechnical engineering as required in NRC RG 1.206 (Reference 1) and described below (COL 2.5(1)). The site-specific information includes the geological, seismological, geophysical, and geotechnical investigations and evaluations procedures to estimate the site-specific ground motion response spectra (GMRS), as well as the geotechnical engineering aspects of the site and slope stability.

2.5.1 Basic Geologic and Seismic Information

Geological, seismological, geophysical, and geotechnical characteristics of the region within 320 km (200 mi) of the site are described. The details of the investigations are increased as the radius of the investigation decreases. The site characteristics based on the investigation results are described in accordance with U.S. Nuclear Regulatory Commission (NRC) Regulatory Guides (RGs) 1.206, 1.132, 1.138, and 1.208 (References 1 through 4, respectively).

2.5.2 Vibratory Ground Motion

Information to determine the site-specific GMRS and to compare the GMRS to the seismic design response spectra for the APR1400 is described. The design spectra for the APR1400 referred to as the certified seismic design response spectra (CSDRS) are presented in Figures 3.7.1-1 and 3.7.1-2.

The APR1400 is evaluated for hard rock high frequency (HRHF) input using the response spectra specified in Subsection 3.7.1.

2.5.2.1 Seismicity

A complete list of historically reported earthquakes is included in the site-specific data. The list includes earthquakes of Modified Mercalli Intensity (MMI) greater than or equal to IV or a magnitude greater than or equal to 3.0 reported within 320 km (200 mi) of the site. Large earthquakes outside the area that could affect the SSE are included.

2.5.2.2 Geologic and Tectonic Characteristics of the Site and Region

The geologic and seismotectonic characteristics of the region that constitute the basis for defining the seismic source zones that potentially contribute to the seismic hazard at the site are described. The investigation for seismic sources is performed for the region within a 320 km (200 mi) radius of the site. Other significant sources beyond this radius are considered if the sources have the potential to affect the seismic hazard at the site.

2.5.2.3 Correlation of Earthquake Activity with Seismic Sources

The possible correlation between earthquake activity records and the geologic structure and regional tectonic model is described along with site-specific information. Detailed accounts of the rationale for the association are provided based on the information regarding the geologic and geophysical data, seismicity, and tectonic history.

2.5.2.4 Probabilistic Seismic Hazard Analysis (PSHA) and Controlling Earthquake

The procedures, technical bases of inputs, and results of the probabilistic seismic hazard analysis (PSHA) are described. Based on the PSHA results, the seismic hazard curves for the site and uniform hazard response spectra for mean annual frequency of exceedance for 10^{-4}, 10^{-5}, and 10^{-6} are provided. The controlling earthquakes determined from the de-aggregation of seismic hazards are also described.

2.5.2.5 Seismic Wave Transmission Characteristics of the Site

The site response analyses using the site-specific geophysical and geotechnical data for each stratum under the site are described. The data include thickness, compressional and shear wave velocities, bulk densities, soil index properties and classification, shear modulus and damping variations with strain level, and water table elevation and its variations. The method to account for the uncertainty and variation in velocity profiles and site properties is also described.

2.5.2.6 Ground Motion Response Spectrum (GMRS)

The site-specific horizontal and vertical GMRS and methodology used to determine the GMRS are described. For a site with competent surface material (i.e., low-strain shear wave velocity equal to or greater than 304.8 m/s (1,000 ft/s)), the GMRS are determined in

the free field on the ground surface. For a site with low-strain shear wave velocity of less than 304.8 m/s (1,000 ft/s), the submaterials are completely excavated to expose competent material with a low-strain shear wave velocity equal to or greater than 304.8 m/s (1,000 ft/s), and the GMRS are defined as a free-field motion on the hypothetical outcrop after the excavation. For a site where the nuclear island is located on hard rock with a shear wave velocity greater than 2,804 m/s (9,200 ft/s), the site-specific GMRS are defined at the foundation level.

The COL applicant is to confirm that the site meets the following requirements:

a. For a site with a low-strain shear wave velocity greater than 304.8 m/s (1,000 ft/s) at the finished grade in the free field, the site-specific GMRS at the finished grade are completely enveloped by the APR1400 CSDRS shown in Figures 3.7-1 and 3.7-2. In addition, the site-specific GMRS transferred to the bottom elevation of the nuclear island are completely enveloped by the CSDRS-compatible free-field response motions at the bottom elevation of the nuclear island shown in Figures 3.7A-12 through 3.7A-14 (COL 2.5(2)).

b. For hard rock sites with a low-strain shear wave velocity of supporting medium for the nuclear island greater than 2,804 m/sec (9,200 ft/s), the site-specific GMRS at the bottom elevation of the nuclear island are completely enveloped by the CSDRS (COL 2.5(2)).

c. For soil sites, the lower bound of the site-specific strain-compatible soil profile is greater than the lower bound of the generic strain-compatible soil profiles used in the APR1400 seismic analyses shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11 (COL 2.5(3)).

d. For a site with a low-strain shear wave velocity of supporting medium for the nuclear island higher than 1,494 m/s (4,900 ft/s) overlaying a hard rock with a low-strain shear wave velocity greater than 2,804 m/s (9,200 ft/s), the site-specific GMRS determined at the finished grade are completely enveloped by the APR1400 hard rock high frequency (HRHF) response spectra shown in Figures 3.7-12 and 3.7-13 (COL 2.5(4)).

e. If the requirements a, b, and c listed above are not satisfied, a site-specific seismic analysis is performed to generate in-structure response spectra at key locations using the procedure described in Appendix 3.7A. The site-specific in-structure

response spectra generated is compared with the corresponding in-structure response spectra provided in Appendix 3.7A (COL 2.5(5)). In addition, if the site-specific GMRS determined at the finished grade are not enveloped by the HRHF response spectra, site-specific seismic response analyses is performed using the procedure described in Appendix 3.7B and in the EPRI White Paper, "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions" (Reference 5) (COL 2.5(6)).

2.5.3 Surface Faulting

Detailed surface and subsurface geological, seismological, and geophysical investigations performed around the site are compiled on a site-specific basis. Sufficient surface and subsurface information, supported by detailed investigations, either confirms the absence of surface tectonic deformation (i.e., faulting) or, if surface deformation is present, demonstrates the age of its most recent displacement and ages of previous displacements.

If tectonic deformation is present in the site vicinity, the geometry, amount, and sense of displacement, recurrence rate, and age of the latest movement are defined.

Structure and generic relationship between site area faulting or other tectonic deformation and the regional tectonic framework are described on a site-specific basis. For regions with active tectonics, any detailed geologic and geophysical investigations are conducted and described to demonstrate the structural relationships of the site area faults and regional faults known to be seismically active.

2.5.4 Stability of Subsurface Materials and Foundations

Site-specific information is presented on the properties of soil and rock formations and their stability under static and dynamic conditions based on evaluations of the site conditions and geologic features that may affect the nuclear power structures or their foundations.

Static properties of subsurface material such as bearing capacity, settlement, and dynamic properties including liquefaction and soil-structure interaction, are also described.

When the general plant layout is determined, the foundation for the nuclear island block of APR1400 is arranged to locate buildings on the proper rocks (better than weathered rock) and to remove any unsuitable materials for foundation. Therefore, opportunities to

provide additional reinforcement for the static and dynamic behaviors of the foundation are not available.

The acceptability of soil materials, if they exist at the foundcetion, is to be provided to assure that the assumptions in Subsection 3.7.1 are consistent.

2.5.4.1 Geologic Features

Site-specific geologic features underlying the site, as well as descriptions, maps, and profiles of the site stratigraphy, lithology, structural geology, geologic history, and engineering geology are described.

2.5.4.2 Properties of Subsurface Materials

The static and dynamic engineering properties of the foundation soil and rock in the site area are provided. Procedures and methods of site investigations follow NRC RG 1.132, "Site Investigations for Foundations of Nuclear Power Plants." Laboratory testing follows NRC RG 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants."

Subsurface materials are grouped in terms of origin, geologic stratigraphy, and weathering. The representative values for each group are determined.

The site-specific engineering properties include the following:

a. Physical properties (e.g., density, deformation modulus, Poisson's Ratio)

b. Mechanical properties (e.g., strength, bearing capacity)

c. Dynamic properties (e.g., P-wave velocity, S-wave velocity, dynamic deformation modulus, dynamic shear modulus, dynamic Poisson's Ratio)

2.5.4.3 Foundation Interfaces

NRC RG 1.132, "Site Investigation for Foundation of Nuclear Power Plant," defines procedures for and the extent of field investigations to determine the engineering properties of soil and rock materials.

The spacing and minimum depth of sounding as defined in NRC RG 1.132 are followed. The results of investigations are presented as forms of cross sections and profiles with a proper scale. Piezometers and other monitoring instruments for settlement or tilting, if needed, are installed at a proper location to represent the site conditions.

2.5.4.4 Geophysical Surveys

A description is provided of the geophysical investigations performed at the site to determine the dynamic characteristics of the soil or rock, including geophysical methods used to determine foundation conditions. The results of compressional and shear wave velocity surveys and electric resistivity surveys performed to evaluate the occurrence and characteristics of the foundation soils and rocks are provided in tables and profiles.

2.5.4.5 Excavations and Backfill

Site-specific information is provided for excavation and backfill, including properties of borrow and backfill materials, extent (horizontally and vertically) of all seismic Category I excavations, compaction specifications, dewatering, excavation methods, and control measures of ground water during excavation.

2.5.4.6 Ground Water Conditions

Basic ground water conditions are described in Section 2.4. In this subsection, the ground water conditions relative to foundation stability of the safety-related facilities, plans for dewatering during construction, and plans for analysis of seepage and potential piping conditions during construction are provided. Records of field and laboratory permeability tests and history of ground water fluctuations are provided.

2.5.4.7 Response of Soil and Rock to Dynamic Loading

Site-specific information is provided on the response of soil and rock to dynamic loading, including investigations to determine the effects of prior earthquakes on the soils and rocks, compressional and shear wave velocity profiles determined from field seismic surveys, and the results of dynamic tests in the laboratory on samples of the soil and rock.

2.5.4.8 Liquefaction Potential

As specified in Table 2.0-1, potential liquefaction is not taken into account in the APR1400 certified design. The foundations for the nuclear island block of the APR1400 are located on proper rocks (better than weathered rock), and all unsuitable materials including loose soil are removed. Therefore, there is no possibility of liquefaction under the nuclear island block. An appropriate analysis of the potential for liquefaction at the site is conducted if the foundation materials are saturated soils with the seismic level of the site-specific SSE.

2.5.4.9 Earthquake Site Characteristics

The earthquake site-specific characteristics are described in Subsection 2.5.2.

2.5.4.10 Static Stability

Bearing capacity analysis and settlement computation using stratigraphic conditions, strength and elastic parameters of the rock mass, building loads, and structural interfaces are provided.

An evaluation of lateral earth pressures and hydrostatic ground water loads acting on plant facilities is provided. Foundation information on seismic Category I structures is provided in Subsection 3.8.5.

An analysis is conducted using 2-dimensional or 3-dimensional model.

2.5.4.11 Design Criteria

The criteria for the Factor of Safety (FS) for the safety analysis of foundation rock and slope that may affect seismic Category I facilities are as follows:

Criterion	Factor of Safety
Bearing Capacity	
Ultimate Capacity	$FS \geq 3.0$
Transient Loading	$FS \geq 2.0$
Maximum Localized Stress	$FS \geq 1.2$
Slope	
Static Condition	$FS \geq 1.5$
Dynamic Condition	$FS \geq 1.2$

The design criteria used in the stability studies of all safety-related facilities including a description of the computer programs used in the analyses and the soil loads are described.

2.5.4.12 Techniques to Improve Subsurface Conditions

If necessary to improve subsurface conditions, the plans, summaries of specifications, and methods of quality control will be described in the site-specific information.

2.5.5 Stability of Slopes

No assumptions in regard to slope stability are used in the evaluation of the APR1400 standard design.

The stability of all natural and manmade slopes, including embankments and dams, that are vital to the safety of APR1400 are included in site-specific information.

2.5.6 Combined License Information

COL 2.5(1) The combined license (COL) applicant is to provide the site-specific information on geology, seismology, and geotechnical engineering as required in NRC RG 1.206 (Reference 1).

COL 2.5(2) The COL applicant is to confirm that the site-specific GMRS transferred to the bottom elevation of the nuclear island are completely enveloped by the CSDRS-compatible free-field response motions at the bottom elevation of the nuclear island for a site with the low-strain shear wave velocity greater than 304.8 m/s (1,000 ft/s) at the finished grade in the free field. Alternately, the COL applicant is to confirm that the site-specific GMRS at the bottom elevation of the nuclear island are completely enveloped by the CSDRS for a hard rock site with a low-strain shear wave velocity of supporting medium for the nuclear island greater than 2,804 m/s (9,200 ft/s).

COL 2.5(3) The COL applicant is to confirm that the lower bound of the site-specific strain-compatible soil profile for a soil site is greater than the lower bound of the generic strain-compatible soil profiles used in the APR1400 seismic analyses.

COL 2.5(4) The COL applicant is to confirm that the site-specific GMRS determined at the finished grade are completely enveloped by the hard rock high frequency (HRHF) response spectra for a site with a low-strain shear wave velocity of supporting medium for the nuclear island higher than 1,494 m/s (4,900 ft/s) overlaying a hard rock with a low-strain shear wave velocity greater than 2,804 m/s (9,200 ft/s).

COL 2.5(5) The COL applicant is to perform a site-specific seismic analysis to generate in-structure response spectra at key locations using the procedure described in Appendix 3.7A if COL 2.5(2) and COL 2.5(3) above are not met. In addition, the COL applicant is to confirm that the site-specific in-structure response spectra so generated are enveloped by the corresponding in-structure response spectra provided in Appendix 3.7A.

COL 2.5(6) The COL applicant is to perform a site-specific seismic response analysis using the procedure described in Appendix 3.7B and the EPRI White Paper "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions" (Reference 5), if COL 2.5(4) is not met.

2.5.7 References

1. NRC RG 1.206, "Combined License Applications for Nuclear Power Plants," Nuclear Regulatory Commission, June 2007.

2. NRC RG 1.132, "Site Investigations for Foundations of Nuclear Power Plants," Rev. 2, Nuclear Regulatory Commission, October 2003.

3. NRC RG 1.138, "Laboratory Investigations of Soils and Rocks for Engineering Analysis and Design of Nuclear Power Plants," Rev. 2, Nuclear Regulatory Commission, December 2003.

4. NRC RG 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion," Nuclear Regulatory Commission, March 2007.

5. "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions," EPRI White Paper, June 2007.