NRRC Technical Regulations

Site Evaluation of Nuclear Facilities

NRRC-R-05 Rev. 0.1

2024

هيئة الرقابة النووية والإشعاعية
Nuclear and Radiological Regulatory Commission

Site Evaluation of Nuclear Facilities

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Regulation

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Preamble

In accordance with the provisions of the Law of Nuclear and Radiological Control issued by Royal Decree No. (M/82) dated 25/7/1439 AH, and NRRC's Statute issued by the Ministers' Cabinet Resolution No. (334) dated 25/6/1439 AH, the NRRC prepared regulations that ensure control over radiological activities and practices as well as nuclear and radiological facilities.

This regulation has been prepared on the basis of International Atomic Energy Agency (IAEA) standards, international best practices, and in accordance with the Kingdom's international commitments. This regulation has been presented in "the Public Consultation Platform" for the public review, comments, and feedback.

This regulation has been approved by the NRRC's Board of Directors Resolution No. (R/1/1/2022) dated 20/04/2022.

This edition, NRRC-R-05 Rev. 0.1 (2024), of the regulation is revised and takes precedence over the previous publication, NRRC-R-05 (2022). In addition, the changes within this revision are editorial.

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Related Regulations

Chapter 1: Objective, Scope, and Definitions

Section 1: Objective

1. The objective of this regulation is to establish the regulatory requirements for the evaluation of the potential site for a nuclear facility. This evaluation is designed to ensure nuclear and radiation safety and protection against site-specific natural phenomena, as well as to protect the people and environment against potentially harmful radiation effects that could arise from a nuclear facility located at the site.

2. This regulation establishes requirements for defining the information to be used in the site evaluation process, assessing the site-specific hazards and the safety-related site characteristics, deriving appropriate site-specific design parameters, and analyzing the characteristics of the population and the region surrounding the site to determine the influence on the transfer of released radioactive material and plan for effective implementation of emergency response actions.

3. The regulatory requirements of this regulation shall be applied to:

    a. Identify external hazards that could affect the safety of the nuclear facility (the external hazards could be of natural origin or human-induced);

    b. Assess the interactions between the site and nuclear facility for operational states and accident conditions throughout the nuclear facility's lifetime, including accidents that could warrant the implementation of emergency response actions.

Section 2: Scope

4. This regulation is concerned with the evaluation of site-related factors that shall be taken into account to ensure that the site-facility combination will not constitute an unacceptable risk to the people or environment over the lifetime of the nuclear facility. The evaluation of a nuclear facility's non-radiological impacts is not considered in this regulation.

5. The requirements for safety design, demonstration of safety regarding site-related factors, and analysis of radiological impacts, including impacts that could warrant emergency response actions, are set forth in the following regulations:

    a. Design of Nuclear Facilities (NRRC-R-06 Rev. 0.1);

    b. Safety Assessment of Nuclear Facilities (NRRC-R-07 Rev. 0.1);

    c. Radiation Safety (NRRC-R-01 Rev. 0.1);

    d. Nuclear Facilities Emergency Preparedness and Response (NRRC-R-14 Rev. 0.1).

6. The external human-induced events considered in this regulation are all accidental origin. Considerations relating to the physical protection of the facility against unauthorized removal of nuclear material or sabotage are outside the scope of this regulation. The interfaces between nuclear safety and nuclear security shall be considered, and synergies have to be developed so that nuclear safety and nuclear security complement and enhance one another

7. The requirements established in this regulation do not apply to the site survey and site selection stages.

8. This regulation does not address underground or offshore nuclear facilities.

Section 3: Definitions

Capable fault

A fault is considered capable, if on the basis of geological, geophysical, geodetic, or seismological data, including palaeoseismological and geomorphological data, one or more of the following conditions apply:

i. The fault shows evidence of past movement or movements (significant surface deformations and/or dislocations) of a recurring nature within such a period that it is reasonable to infer that further movements at or

near the surface could occur. In highly active areas, where both earthquake data and geological data consistently and/or exclusively reveal short earthquake recurrence intervals, periods of the order of tens of thousands of years may be appropriate for the assessment of capable faults. In less active areas, it is likely that much longer periods will be required.

ii. A structural relationship with a known capable fault has been demonstrated such that the movement of one could cause movement of the other at or near the surface.

iii. The maximum potential earthquake associated with a seismogenic structure is sufficiently large and at such a depth that it is reasonable to infer that, in the geodynamic setting of the site, movement at or near the surface could occur.

Capable volcano

A volcano that has a credible likelihood of undergoing future activity and producing hazardous phenomena, including non-eruptive phenomena, during the lifetime of a nuclear facility concerned, which may potentially affect the site of the facility.

External events

Events unconnected with the operation of a facility or the conduct of an activity that could have an effect on the safety of the facility or activity.

External zone

The area immediately surrounding a proposed site area in which the population distribution and density, as well as land and water uses, are considered with respect to their impact on planning effective emergency response actions.

Region

The area surrounding the site that is normally intended to include more than the external zone. The size of this region will be defined for each specific external hazard.

Site area

A geographical area that contains an authorized facility, authorized activity, or source and within which the management of the authorized facility, authorized activity, or first responders may directly initiate an emergency response.

Site vicinity

A smaller than the region and larger than the site area (covering a geographical area not less than 5 km in radius or as prescribed by the NRRC).

Chapter 2: Safety Principles

Section 4: Safety Objective in Site Evaluation for Nuclear Facilities

9. The applicant shall characterize the natural and human-induced external hazards that might affect the safety of the nuclear facility to provide adequate input for demonstrating the protection of the people and the environment from the harmful effects of ionizing radiation.

Chapter 3: Management System

Section 5: Application of the Management System for Site Evaluation

10. Site evaluation shall be conducted in a comprehensive, systematic, planned, and documented manner in accordance with a management system.

11. An integrated management system shall be established, as specified in the Regulation on Leadership and Management for Safety (NRRC-R-04 Rev. 0.1), to control the effectiveness of the execution of the site investigations and assessments

and engineering activities performed in the different stages of the site evaluation for the nuclear facility.

12. The management system shall cover the organization, planning, work control, verification, and documentation of the activities and personnel qualification and their training to ensure that the required quality of work is achieved at each stage of the site evaluation.

13. Since activities for the site investigation are normally initiated long before the establishment of a nuclear project, the management system shall be established at the earliest possible time, consistent with its application, in the conduct of site evaluation activities for the nuclear facility.

14. A management system shall include appropriate quality assurance arrangements for each activity that may have an effect on safety or the derivation of site-specific design parameters and other safety-related site characteristics. The quality assurance arrangements shall be consistent with regulatory requirements and their application shall be commensurate with the importance of the activity under consideration to safety.

15. The applicant shall specify the acceptance criteria and the responsibilities for performing each site evaluation activity, including inspection, testing, verification, and validation.

16. The results of studies and investigations shall be adequately documented to permit an independent review.

17. An independent review shall be made of the evaluation of the natural and human-induced external hazards, the site-specific design parameters, and the evaluation of the potential radiological impact of the nuclear facility on the people and the environment.

Chapter 4: General Requirements

Section 6: Scope of the Site Evaluation for Nuclear Facilities

18. The scope of the site evaluation shall encompass site-related factors and factors relating to the interaction between the site and the facility for all operational states and accident conditions, including accidents that could warrant emergency response actions.

19. The site evaluation's scope shall include all external hazards, monitoring activities, and site-specific parameters relevant to the safety of the nuclear facility. In determining the scope of the site evaluation, a graded approach shall be applied commensurate with the radiation risk posed to the people and the environment.

20. The site evaluation provides input to both the preliminary safety analysis report and the final safety analysis report. Site evaluation continues throughout the operational stage of the nuclear facility and includes monitoring, periodic safety reviews, and other activities to confirm the site-specific design parameters as well as safety re-evaluations based on the outcome of periodic safety reviews.

21. The application of the safety requirements for site evaluation for nuclear facilities shall be commensurate with the potential hazards associated with the nuclear facility.

22. The level of detail required in the evaluation of a site for a nuclear facility shall be commensurate with the risk associated with the nuclear facility and the site, which will differ depending on the type of nuclear facility.

23. The scope and level of detail of the site evaluation process necessary to support the safety demonstration for the nuclear facility shall be determined in accordance with a graded approach.

Section 7: Site Suitability

24. The suitability of the site shall be assessed at an early stage of the site evaluation and shall be confirmed for the lifetime of the planned nuclear facility.

25. In the assessment of the suitability of a site for a nuclear facility, the following aspects shall be addressed at an early stage of the site evaluation:

    a. The effects of natural and human-induced external events occurring in the region that might affect the site;

    b. The characteristics of the site and its environment that could influence the transfer of radioactive material released from the nuclear facility to the people and to the environment;

    c. The population density, population distribution, and other characteristics of the external zone, which could affect the feasibility of planning effective emergency response actions and the need to evaluate the risk to individuals and to the population.

26. The site shall be deemed unsuitable for a nuclear facility if one or more of the three aspects listed in Article 25 indicate that the site is unacceptable and the deficiencies cannot be compensated for by means of a combination of measures for site protection, design features of the nuclear facility, and administrative procedures.

27. Site suitability shall be assessed on the basis of relevant current data and methodologies. If relevant, conservative criteria shall be developed in relation to site-specific accident scenarios, and the consistency of such criteria with the overall site suitability shall be demonstrated.

28. A decision regarding the suitability of the site shall be based on the characteristics of the nuclear facility, including planned operations at the site, the amount and nature of potential radioactive releases, and their impact on the people and the environment.

29. For nuclear power plants, the entire nuclear capacity to be installed at the site shall be determined at the first stages of the siting process. If it is later determined or anticipated that the installed nuclear capacity or its impact has increased to a level significantly above the previously determined to be acceptable, the site shall be re-evaluated considering the higher capacity or impact.

30. In the overall evaluation of site suitability, site-specific attributes, such as cooling water availability or extreme environmental conditions, and their potential role in affecting the safe and continuous operation of the nuclear facility shall also be addressed.

Section 8: Site and Regional Characteristics

31. The site and the region shall be investigated with regard to the characteristics that could affect the nuclear facility's safety and the potential radiological impact of the nuclear facility on the people and the environment.

32. Natural phenomena and human activities in the region with the potential to induce hazards at the site that might affect the safety of the nuclear facility shall be identified and evaluated. The extent of this evaluation shall be commensurate with the safety significance of the potential hazards at the site.

33. The characteristics of the natural environment in the region that could be affected by the potential radiological impact of the nuclear facility shall be investigated and assessed for all operational states, accident conditions, and all stages of the lifetime of the nuclear facility.

34. The size of the region to be investigated shall be defined for each of the natural and human-induced external hazards. Both the magnitude of the hazard and the distance from the source of the hazard to the site shall be considered in determining the size of the region to be investigated. It shall be ensured that the size of the region that is investigated is sufficiently large to address the potential effects at the site.

35. The site and the region shall be studied to evaluate the present and foreseeable future characteristics that could have an impact on the safety of the nuclear facility. This includes potential changes in the severity and/or the frequency of natural external events, changes in the population distribution in the region, the present and future use of land and water, the further development of existing nuclear facilities, or the construction of other facilities that could affect the safety of the nuclear facility or the feasibility of planning effective emergency response actions.

Section 9: Identification of Site-Specific Hazards

36. Potential external hazards associated with natural phenomena, human-induced events, and human activities that could affect the region shall be identified through a screening process.

37. The process and associated criteria used in the screening of site-specific hazards shall comply with the safety objective for site evaluation and shall be properly justified and documented.

38. The scope of evaluation of external events in the screening process shall cover the full ranges of severity and frequency of occurrence relevant to the design and the safety assessment of the nuclear facility, including events of high severity with low probability that could contribute to the overall risk.

39. An event might be screened out if it is enveloped by a set of events. However, it shall be ensured that all potential effects of the screened-out event are bounded by this set of events.

40. External hazards that are not excluded by the screening process shall be evaluated and then used in establishing the site-specific design parameters and in the re-evaluation of the site, in accordance with the significance of these hazards to the safety of the nuclear facility.

Section 10: Evaluation of Natural and Human-Induced External Hazards

41. The impact of natural and human-induced external hazards on the safety of the nuclear facility shall be evaluated over its lifetime.

42. The site evaluation for a nuclear facility shall consider the frequency and severity of natural and human-induced external events, including the potential combinations of such events that could affect the safety of the nuclear facility.

43. Information on the frequency and severity of external events derived from the characterization of the hazards shall be used in establishing the site-specific design parameters. Adequate account shall be taken of both aleatory uncertainties and epistemic uncertainties in the establishment of site-specific design parameters.

44. Appropriate methods, supplemented where necessary by numerical models, shall be used to characterize the hazards relevant to the site evaluation and the design of the nuclear facility. A thorough uncertainty analysis of the method and input data shall be performed as a part of the hazard evaluation.

45. The decision to use deterministic and/or probabilistic methodologies in hazard evaluation shall be based on the nature of the hazard, the availability of data, and the applicable requirements for safety assessment.

46. Special consideration shall be given to the use of applicable probabilistic methodologies and the use of probabilistic hazard curves representing external events as input to the probabilistic safety assessment for external hazards. Such probabilistic hazard curves shall be developed with reference to the site-specific conditions.

47. The evaluation of hazards shall address the possibility that external events can occur in combination, simultaneously or within short time frames. Interrelationships and causality between external events shall be evaluated.

48. The results of the evaluation of hazards shall be expressed in terms that can be used as input for deriving the site-specific design parameters; that is, appropriate parameters indicating the severity of the effects of the hazards shall be selected or developed.

49. The potential for explosion, chemical releases, and/or thermal releases that might affect the safety of the nuclear facility or the dispersion of radioactive material shall be considered in the site evaluation process.

50. The potential for interactions between radioactive and non-radioactive substances, such as those caused by heat or chemicals in radioactive liquid effluents, shall be considered.

Section 11: Measures for Site Protection

51. If the projected design of the nuclear facility is not able to safely withstand the impact of natural and human-induced external hazards, the need for site protection measures shall be evaluated.

52. The need for protection of the site against the effects of specific phenomena associated with natural and human-induced external hazards shall be evaluated considering adequate safety margins.

53. The availability of adequate engineering solutions for implementing measures to ensure site protection shall be evaluated. If such engineering solutions are not available, then the site shall be deemed unsuitable.

54. If site protection measures are required to be implemented, uncertainties shall be properly taken into account in the evaluation of extreme values of parameters with regard to describing the severity of natural and human-induced external hazards. Measures for site protection shall be classified, designed, built, maintained, and operated in accordance with their safety significance.

Section 12: Multiple Nuclear Facilities on the Same Site or Adjacent Sites

55. The site evaluation shall consider the potential for natural and human-induced external hazards to affect multiple nuclear facilities on the same site and/or adjacent sites.

56. Occurrences of natural and human-induced external events and their credible combinations that could affect the safety of multiple facilities on the same site or facilities on adjacent sites shall be considered. The potential for hazards originating from one nuclear facility location to affect other nuclear facilities located on the same site or adjacent sites shall be assessed.

57. For identified accident scenarios, the combined effects of these accidents on the people and the environment at nuclear facilities located on the same site or at adjacent and nearby sites shall be evaluated.

Section 13: Changes of Hazards and Site Characteristics with Time

58. The external hazards and the site characteristics shall be assessed in terms of their potential for changing over time, as well as the potential impact of these changes shall be evaluated.

59. The site's characteristics and natural and human-induced external hazards that can change over time and could affect the safety of a nuclear facility shall be identified. The potential consequences of such changes shall be thoroughly evaluated during the lifetime of the nuclear facility.

60. Due account shall be taken with regard to uncertainties in the projections of any potential changes of the external hazards and site characteristics over time by means of appropriate safety margins in the related site-specific design parameters.

Section 14: Special Considerations for the Ultimate Heat Sink for Nuclear Facilities

61. The evaluation of site-specific natural and human-induced external hazards for nuclear facilities that require an ultimate heat sink shall consider hazards that could affect the availability and reliability of the ultimate heat sink.

62. As appropriate for the ultimate heat sink under consideration, data for the following shall be evaluated:

    a. Air temperature and humidity;

    b. Water depth and temperature;

    c. Water quality characteristics, including turbidity, suspended solids, floating debris, and chemical and biochemical changes (both natural and human-induced changes);

    d. Availability and sustainability of the water flow, minimum and maximum water level, and the time period during which safety-related supplies of cooling water are at a minimum level, taking into account the potential for failure of water control structures.

63. All external natural and human-induced events that could cause a loss of the ultimate heat sink shall be identified and evaluated.

Section 15: Nuclear Facilities Potential Effects on the People and the Environment

64. In determining the potential radiological impact of the nuclear facility on the region for operational states and accident conditions, including accidents that could warrant emergency response actions, appropriate estimates shall be made of the potential releases of radioactive material, taking into account the nuclear facility's design and safety features.

65. The potential effects of the nuclear facility on the people and the environment shall be estimated by considering the postulated accident scenarios (including the resulting source terms) and taking into account the feasibility of planning effective emergency response actions at the site and in the external zone. These estimates shall be confirmed when the design of the nuclear facility and safety features has been established.

66. The direct and indirect pathways by which radioactive releases from the nuclear facility could potentially affect the public and the environment shall be identified and evaluated. In this evaluation, specific regional and site characteristics, including the population distribution in the region, shall be taken into account, with special attention paid to the transport and accumulation of radionuclides in the biosphere.

67. It shall be demonstrated that the information provided to assess the potential effects on the population associated with accident conditions, including accidents that could warrant emergency response actions being taken in the external zone, is consistent with achieving the safety objective for site evaluation.

Section 16: Feasibility of Planning Effective Emergency Response Actions

68. The feasibility of planning effective emergency response actions on the site and in the external zone shall be evaluated, taking into account the characteristics of the site and the external zone as well as any external events that could hinder the establishment of complete emergency arrangements prior to operation.

69. An assessment shall be made for the feasibility of planning effective emergency response actions in accordance with the Regulation on Nuclear Facilities Emergency Preparedness and Response (NRRC-R-14 Rev. 0.1). Nuclear facilities on the same site, as well as those adjacent or nearby sites, shall be considered in the assessment, with special emphasis on nuclear facilities that could experience concurrent accidents.

70. Any causal relationships between external events and the condition of the infrastructure on the site and in the external zone shall be considered when evaluating the feasibility of planning effective emergency response actions.

Section 17: Data Collection in Site Evaluation for Nuclear Facilities

71. The data necessary to perform an assessment of natural and human-induced external hazards and to assess both the impact of the environment on the safety of the nuclear facility and the impact of the nuclear facility on the people and the environment shall be collected.

72. Data on natural and human-induced external hazards with the potential to affect the safety of the nuclear facility shall be collected throughout the lifetime of the nuclear facility. Data shall be confirmed to be relevant (spatially and temporally) to the site. Site-specific data shall be used in site evaluation. If such data is unavailable, data from other regions that are sufficiently relevant to the region of interest may be used in the determination of hazards.

73. The extent, objectives, and scope of the data collection process shall be defined on the basis of the safety objective for site evaluation and shall be commensurate with the hazard posed by the nuclear facility to the people and the environment.

74. At a minimum, the data collection process shall include the following:

    a. Information on natural and human-induced external hazards, including information on sources of hazards, propagation of hazards, and the potential effects on the nuclear facility and on the people and the environment;

    b. Information describing the site's conditions and regional environmental conditions;

    c. Information on the proposed engineering and administrative measures for the site's protection and mitigation measures;

d. Information on the potential impact of the nuclear facility on the people and the environment for operational states and accident conditions;

e. Information required for planning effective emergency response actions on and off the site in all environmental conditions and for all states of the nuclear facility;

f. Information on the site's access conditions and information for supporting the design and development of the site's infrastructure.

75. Information and records, if available, of the occurrence and severity of important prehistoric, historical, and recent natural phenomena shall be obtained as appropriate for the hazard to be evaluated and shall be analyzed for reliability, accuracy, temporal and spatial relevance, and completeness.

76. The data shall be maintained and reviewed periodically as prescribed by the NRRC and/or as necessary as part of a review of the site evaluation within the framework of the periodic safety review of the nuclear facility.

77. The data collected for site investigations shall be of sufficient quality and quantity to support the selected methodology for hazard evaluation.

78. The details of the information collected for each hazard shall be appropriate for the distance between the source of the hazard and the site and accounting for the potential impact on the site. The sources of uncertainties relating to data collection shall be documented.

Chapter 5: Evaluation of External Hazards

Section 18: Seismic Hazards

Faults

79. The geological faults that are significant to safety shall be evaluated to identify if these faults are to be considered capable faults. For capable faults, potential challenges to the safety of the nuclear facility in terms of ground motion and/or fault displacement hazards shall be evaluated.

80. Capable faults shall be identified and evaluated. The evaluation shall consider the fault characteristics in the site vicinity. The methods used and the investigations carried out shall be sufficiently detailed to support safety-related decisions.

81. The potential effect of fault displacement on safety-related structures, systems, and components shall be evaluated. The evaluation of fault displacement hazards shall include detailed geological mapping of excavations for safety-related engineered structures to enable the evaluation of fault capability for the site.

82. The proposed site shall be considered unsuitable when reliable evidence shows the existence of a capable fault that has the potential to affect the safety of the nuclear facility and which cannot be compensated for by means of a combination of measures for site protection and design features of the nuclear facility. If a capable fault is identified in the site vicinity of an existing nuclear facility, the site shall be deemed unsuitable if the safety of the nuclear facility cannot be demonstrated.

Ground motion

83. An evaluation of ground motion hazards shall be conducted to provide the input required for the seismic design or safety improvements of the structures, systems, and components of the nuclear facility, as well as the input for performing the

deterministic and/or probabilistic safety analyses required during the lifetime of the nuclear facility.

84. Hazards resulting from earthquake-induced ground motion shall be assessed by means of appropriate methods. The potential for seismicity due to human activities and the effect of the vibratory ground motion in combination with other seismically induced events, if any, shall be considered.

Section 19: Volcanic Hazards

85. Hazards associated with volcanic activity that have the potential to affect the safety of the nuclear facility shall be evaluated.

86. Capable volcanoes shall be identified and evaluated. The evaluation shall consider the volcanic characteristics of a region of sufficient size to ensure that potentially hazardous volcanic phenomena are considered appropriately.

87. The hazards of capable volcanoes shall be evaluated to provide the input required for determining the site-specific design parameters or for re-evaluating the site, as well as for deterministic and/or probabilistic safety analyses performed during the lifetime of the nuclear facility.

88. The proposed site shall be considered unsuitable if reliable evidence shows the existence of a capable volcano that has the potential to affect the safety of the nuclear facility and which cannot be compensated for by means of a combination of measures for site protection and design features of the nuclear facility.

89. Volcanic hazards shall be evaluated using appropriate information, methods, and models with adequate account taken of the uncertainties.

90. The effect of volcanic phenomena in combination with other volcanically induced hazards shall be considered. This shall include consideration of volcanic ash fall.

Section 20: Meteorological Hazards

91. Extreme meteorological hazards and their possible combinations that have the potential to affect the safety of the nuclear facility shall be evaluated.

92. The potential for the occurrence of rare meteorological events, including information on their severity and frequency, shall be evaluated.

93. Meteorological phenomena such as wind, precipitation, air and water temperature, humidity, storm surges, sand or dust storms, lightning, tornadoes, cyclones, and other meteorological events, as well as their credible combinations, shall be evaluated for their extreme values based on available records. If necessary, efforts shall be made to expand the database on meteorological hazards.

94. Appropriate methods shall be applied for the evaluation of meteorological hazards, taking into account the amount of data available, both measured and historical, and known past changes in relevant characteristics of the region.

High temperatures

95. The potential for high air and cooling water temperatures in the region of the site, their extreme values, frequency, and duration shall be assessed on the basis of all relevant available information.

Sand and dust storms

96. The potential for the occurrence and the frequency and severity of sand and dust storms shall be evaluated for the site on the basis of all relevant available information. The assessment of the missiles and airborne dust and sand that could be associated with sandstorms shall be considered.

Lightning

97. The potential for the occurrence and the frequency and severity of lightning shall be evaluated for the site vicinity.

Tornadoes and cyclones

98. The potential for the occurrence and the frequency and severity of tornadoes, cyclones, and associated missiles, airborne dust, and airborne sand shall be evaluated for the site. The hazards associated with tornadoes and cyclones shall be derived and expressed in terms of parameters such as rotational wind speed, translational wind speed, radius of maximum rotational wind speed, pressure differentials, and rate of change of pressure.

Section 21: Flooding Hazards

99. Hazards due to flooding, considering natural and human-induced events, including their credible combinations, shall be evaluated.

Floods due to precipitation and other natural causes

100. The potential for flooding in the region surrounding the site due to one or more natural causes, such as storm surge, wind-generated waves, meteorological tsunamis or seiches, extreme precipitation, or a combination of such events that have a common cause or a relatively high frequency of occurrence, shall be evaluated.

101. Appropriate meteorological, hydrological, and hydraulic models shall be developed to derive the flooding hazards for the site, including secondary effects such as debris and sediments. Where available, relevant information from studies of historic and prehistoric floods shall be used to inform estimates of the frequency and magnitude of floods.

102. The potential for instability of a coastal area or watercourse due to erosion or sedimentation shall be investigated.

Water waves induced by earthquakes or other geological phenomena

103. The potential for tsunamis or seiches in the region that could affect the safety of the nuclear facility shall be evaluated. The potential for tsunamis or seiches from

phenomena other than seismic sources shall be evaluated as appropriate for the region.

104. The hazards associated with tsunamis or seiches shall be derived from historical records and any available information on prehistoric floods, as well as from physical and/or analytical modeling. Such hazards shall include potential draw-down and run-up that could result in physical effects on the site.

105. The hazards associated with tsunamis or seiches shall be evaluated as appropriate for the region, using nearshore bathymetry and coastal topography, taking into account any amplification due to the coastal configuration, including artificial structures.

Floods and waves caused by failure of water control structures

106. Upstream water control structures such as dams shall be analyzed to determine the potential hazard associated with the failure of one or more upstream structures, including the combination of flooding from other causes.

107. If a preliminary examination indicates that the nuclear facility would not be able to safely withstand the effects of the failure of one or more of the upstream water control structures, then the hazards associated with the nuclear facility shall be evaluated with the inclusion of such effects. Alternatively, such upstream structures shall be analyzed using methods equivalent to those used in determining the hazards associated with the nuclear facility to demonstrate that the upstream structures could survive the event concerned.

108. Flooding and associated phenomena caused by an accumulation of water due to a blockage of the watercourse upstream or downstream or to a change in land use shall be considered.

Section 22: Geotechnical Hazards and Geological Hazards

109. The geotechnical characteristics and geological features of subsurface materials shall be investigated, and a soil and rock profile for the site that considers the variability and uncertainty in subsurface materials shall be derived.

110. The static and dynamic geotechnical characteristics and geological features of subsurface materials at the site, including any backfill, shall be established. Laboratory and field-based methods shall be used, in conjunction with appropriate sampling techniques and sufficient repetition of each test, to characterize each parameter of the subsurface materials at the site.

111. The stability and bearing capacity of foundation materials shall be assessed, including consideration of the potential for excessive settlement under static and seismic loading.

112. The physical and geochemical properties of the soil and groundwater shall be studied using appropriate methods and taken into account in the evaluation of the subsurface material at the site.

113. Geotechnical hazards and geological hazards, including slope instability, collapse, subsidence or uplift, and soil liquefaction, and their effect on the safety of the nuclear facility shall be evaluated.

Slope instability

114. The site and the site vicinity shall be evaluated to determine the potential for slope instability caused by natural or human-induced phenomena, which could affect the safety of the nuclear facility. In the evaluation of slope instability, the configuration of the site during and after site preparation activities shall be addressed. The evaluation of slope stability shall also take into account extreme meteorological conditions and rare meteorological events.

115. The potential for slope instability resulting from seismic loading shall be evaluated using parameters appropriate for describing the seismic hazards and the soil and groundwater characteristics at the site.

Collapse, subsidence, or uplift of the site surface

116. The potential for collapse, subsidence, or uplift of the surface that could affect the safety of the nuclear facility over its lifetime shall be evaluated using a detailed description of subsurface conditions obtained from reliable methods of investigation.

Soil liquefaction

117. The potential for liquefaction and non-linear effects of the subsurface materials at the site shall be evaluated using parameters appropriate for describing the seismic hazards and geotechnical properties of the subsurface materials at the site.

118. The evaluation of soil liquefaction shall include the use of accepted methods for field and laboratory testing in combination with analytical methods to assess the hazards.

Seashore and salted sediment layers (Sabkha)

119. The potential effects of seashore and salted sediment layers shall be evaluated using parameters appropriate for describing the soil characteristics and geotechnical properties at the site.

Section 23: Human-Induced Events

120. The hazards associated with human-induced events related to the site and the region shall be evaluated.

121. Human-induced events to be addressed shall include, but shall not be limited to:

    a. Events associated with nearby land, watercourse, sea, or air transport;

    b. Fire, explosions, missile generation, and releases of hazardous gases from industrial facilities near the site;

c. Electromagnetic interference.

122. Human activities that might influence the type or severity of natural hazards, such as resource extraction or other significant re-contouring of land or water or reservoir-induced seismicity, shall also be considered.

Aircraft crashes

123. The potential for accidental aircraft crashes affecting the site shall be assessed with account taken, to the extent practicable, of potential changes in future air traffic and aircraft characteristics.

Chemical hazards

124. Current or foreseeable activities in the region surrounding the site that involve the handling, processing, transport, and/or storage of chemicals having a potential for explosions or producing gas clouds capable of deflagration or detonation shall be addressed.

125. Hazards associated with chemical explosions or other releases shall be expressed in terms of heat, overpressure, and toxicity (if applicable), taking into account the effect of distance and non-favorable combinations of atmospheric conditions at the site. In addition, the potential effects of such events on workers located on the site shall be evaluated.

Section 24: Other Hazards

126. Other natural and human-induced phenomena that are specific to the region and which have the potential to affect the safety of the nuclear facility shall be investigated so that the site-specific design parameters for these hazards can be derived.

Chapter 6: The Potential Effects of the Nuclear Facility on the Region

Section 25: Dispersion of Radioactive Material

127. The dispersion in air and water of radioactive material released from the nuclear facility during operational states and accident conditions shall be assessed.

Atmospheric dispersion of radioactive material

128. The analysis of the atmospheric dispersion of radioactive material shall take into account the orography, land cover, and meteorological features of the region, including parameters such as wind speed and direction, air temperature, precipitation, humidity, atmospheric stability parameters, prolonged atmospheric inversions and any other parameters required for modeling of atmospheric dispersion. If possible, long-term meteorological data for nearby locations shall be obtained, evaluated for quality, and applied.

129. A program for meteorological measurements shall be developed and carried out at or near the site using instrumentation capable of measuring and recording the main meteorological parameters at appropriate elevations, locations, and sampling intervals. Data representative of at least one full year shall be collected and used in the analyses of atmospheric dispersion, together with any other relevant data available from other sources of information. The meteorological data shall be expressed using appropriate meteorological parameters.

Dispersion of radioactive material through surface water and groundwater

130. A survey program shall be developed to gather relevant data to characterize the hydrogeological and hydrological parameters at the site and in the region to permit the assessment of the potential movement of radionuclides through surface water and groundwater and the assessment of the subsequent radiological impact. This measurement program shall be carried out for at least one full year prior to hydrogeological investigations, and the data shall be expressed in terms of appropriate parameters for surface hydrology and groundwater.

131. A program of surface water investigations, including the interactions between surface water and groundwater, for the region shall be developed. The description of surface water shall include the main physical and chemical characteristics of the water bodies, both natural and artificial, the major structures for water control, the locations of water intake structures, and information on water use in the region.

132. A program of hydrogeological investigations for the region shall be developed, including descriptions of the main characteristics of the water-bearing formations and their interaction with surface water, as well as data on the uses of groundwater in the region.

133. The program of hydrogeological investigations for the region shall include investigations of the migration and retention characteristics of radionuclides in groundwater and investigations of the associated exposure pathways.

134. The hydrogeological and hydrological investigations shall determine, to the extent necessary, the dilution and dispersion characteristics of water bodies, the re-concentration ability of sediments and biota, the migration and retention characteristics of radionuclides, the transfer mechanisms for radionuclides in the hydrosphere, and the associated exposure pathways.

Section 26: Population Distribution and Public Exposure

135. The existing and projected population distribution within the region over the lifetime of the nuclear facility shall be determined, and the potential impact of radioactive releases on the public during both operational states and accident conditions shall be evaluated and periodically updated.

136. Information on the existing and projected population distribution in the region, including the resident population and, to the extent possible, the transient population, shall be collected and kept up to date over the lifetime of the nuclear facility. Special attention shall be paid to vulnerable populations and residential

institutions when evaluating the potential impact of radioactive releases and considering the feasibility of implementing protective actions.

137. The most recent census data for the region, or information obtained by extrapolation of the most recent data on the resident population and the transient population, shall be used to obtain the population distribution. In the absence of reliable data, a special study shall be carried out.

138. The data shall be analyzed to obtain the population distribution in terms of the direction and distance from the site. This information shall be used to carry out an evaluation of the potential radiological impact of normal discharges and accidental releases of radioactive material, including reasonable consideration of releases due to severe accidents, with the use of site-specific design parameters and models as appropriate.

Section 27: Uses of Land and Water in the Region

139. The uses of land and water shall be characterized in order to assess the potential effects of the nuclear facility on the region.

140. The characterization of the uses of land and water shall include investigations of land, surface water, and groundwater resources that might be used by the population or that serve as a habitat for organisms in the food chain.

Chapter 7: Monitoring and Periodic Review of the Site

Section 28: Monitoring of External Hazards and Site Conditions

141. All natural and human-induced external hazards and site conditions that are relevant to the licensing and safe operation of the nuclear facility shall be monitored over the lifetime of the nuclear facility.

142. The monitoring of external hazards and site conditions shall commence as soon as practically possible but no later than the start of construction and shall continue until decommissioning.

143. The monitoring plan shall be developed as part of the objectives and scope of the site evaluation and shall include the parameters to be monitored, the type of data to be collected, the methodology for data collection (including the location and frequency of data collection), the necessary resolution and precision of any measurements, data backup requirements, and requirements for data processing and analysis.

144. Prior to the start of the nuclear facility's commissioning, the levels of background radioactivity in the atmosphere, hydrosphere, lithosphere, and biota in the region shall be measured to provide baseline information and to facilitate determining any additional radioactivity due to the operation of the nuclear facility.

Section 29: Review of External Hazards and Site Conditions

145. All natural and human-induced external hazards and site conditions shall be periodically reviewed by the operating organization as part of the periodic safety review and as appropriate throughout the lifetime of the nuclear facility, with due account taken of operating experience and new safety-related information.

146. As part of periodic safety reviews (or safety assessments), natural and human-induced external hazards and site conditions shall be reviewed throughout the lifetime of the nuclear facility using updated information. Such reviews shall be performed on a regular basis, no less frequently than once every ten years or as defined by the NRRC, and in the event of any of the following:

    a. Updates of the regulatory requirements;

    b. Indications of inadequate design against external hazards;

    c. New technical findings, such as the vulnerability of particular structures, systems, and components to external hazards;

d. Considerations of new information, experience, and lessons learned from the occurrence of actual external events that affected the safety of another nuclear facility or an industrial facility;

e. Changes of hazards over time for which new information and assessments have become available;

f. Demonstrations of additional confidence that there are sufficient margins to prevent cliff-edge effects, as appropriate;

g. As part of a program for long-term operation or in support of an application for an extension to the operating license for the nuclear facility;

h. Applications of new methods to analyze hazards that substantially improve earlier estimates.

147. The site-specific external hazards and the site conditions shall be re-evaluated, as necessary, based on the outcome of the periodic review of site-specific hazards or because of new data relevant to the radiological environmental impact assessment or the safe operation of the nuclear facility.

Chapter 8: Licensing

Section 30: Licensing Practice and Documentation

148. The site evaluation shall be developed, and adequate information shall be submitted to the NRRC pursuant to the licensing procedure and the content of the site evaluation report as described in the Regulation on Licensing and Regulatory Oversight of Nuclear Facilities (NRRC-R-03 Rev. 0.1).

149. A preliminary site evaluation report shall be submitted to the NRRC for approval in conjunction with the site licensing application. The preliminary site evaluation report shall characterize the site and its environment in sufficient detail to assess

the suitability of the site for the construction of the planned nuclear facility or facilities.

150. Following the issuance of the site license, the site's detailed investigations and evaluation shall be continued. The results shall be presented in a final site evaluation report. The report shall include site-related design parameters of the planned facility. The report shall be submitted to the NRRC for approval.

151. An application for a construction license can be submitted only after the site-related design parameters have been approved by the NRRC.

152. When applying for the construction license of a nuclear facility, the main characteristics of the site and the site-related design parameters of the facility shall be presented in the preliminary safety analysis report (PSAR).

153. During the construction of a nuclear facility, the site-related information shall be monitored, and the preliminary safety analysis report shall be updated as appropriate.

154. If significant new information regarding the site is obtained during the construction, the new information shall be described in the final safety analysis report (FSAR), and the adequacy of the design parameters shall be justified accordingly. The final safety analysis report is submitted to the NRRC along with the operating license application.

155. Site-related information shall be monitored during operation, and the updated information shall be presented in conjunction with the periodic safety reviews. Review after a shorter interval shall be considered in the event of evidence of potentially significant changes in hazards.

156. In case new information with a significant safety impact on the plant arises during operation, the need for safety improvements or other actions shall be assessed.

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