Training Course on the IAEA Safety Standards Overview

SSR-1

Site Evaluation for Nuclear Installations

Zeynep Gulerce

External Events Safety Section
Division of Nuclear Installation Safety
Department of Nuclear Safety and Security, IAEA

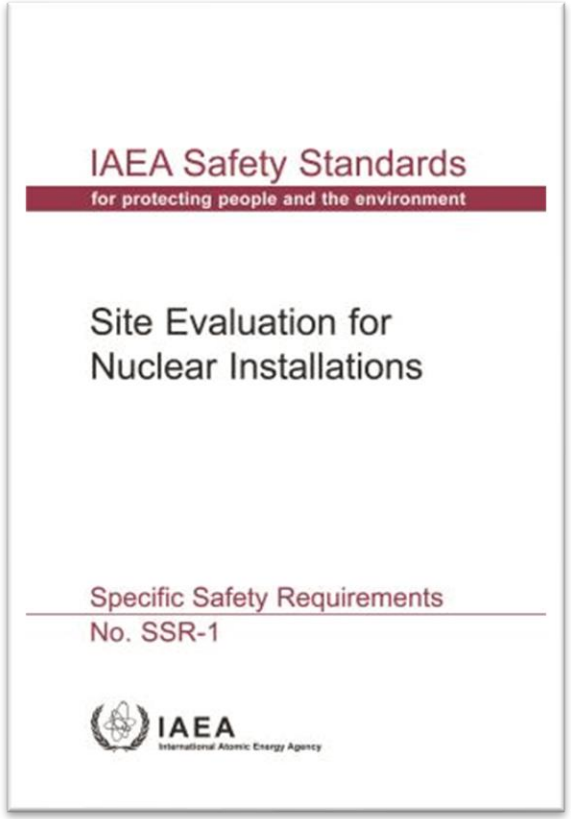
Shinagawa Campus, Tokai University, Tokyo, Japan

17-19, 21 March 2025

This presentation:

… elaborates the requirements given in IAEA Specific Safety Requirements No. SSR-1 “Site Evaluation for Nuclear Installations”.

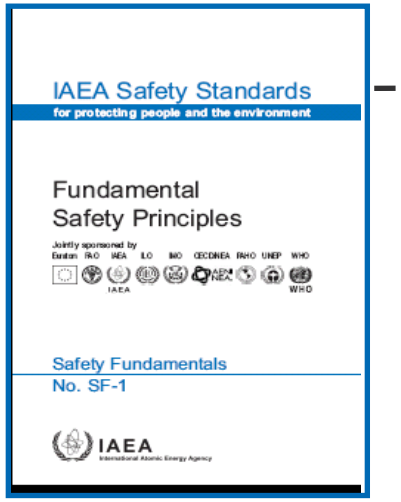
- ✓ NS-R-3 was issued in 2003 and partially revised in 2016 to take the issues highlighted by Fukushima accident into account.
- ✓ SSR-1 was issued in 2019 and supersedes the NS-R-3 (Rev. 1).
- ✓ A new review cycle is starting in 2025.

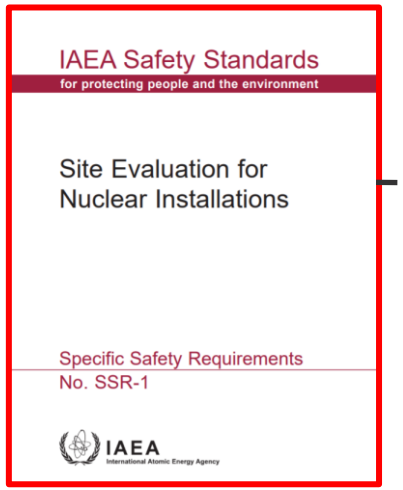


SSR-1 includes:

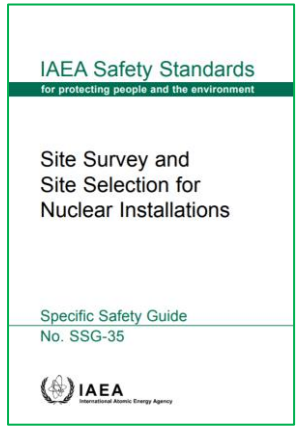
- ✓ Safety principles and concepts applicable to site evaluations
- ✓ Application of the management system for site evaluation
- ✓ General requirements for site evaluation
- ✓ Evaluation of external hazards
- ✓ Evaluation of the potential effects of the nuclear installation on the region
- ✓ Monitoring and periodic review of the site

Place of SSR-1 in IAEA Safety Standards Hierarchy

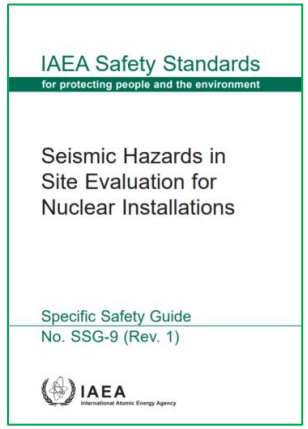




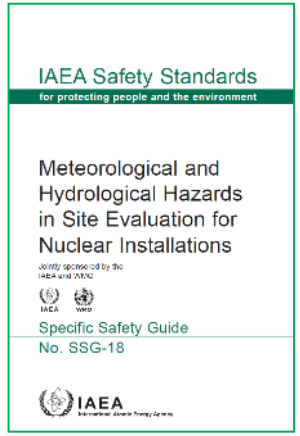
Site Selection ← → Site Characterization



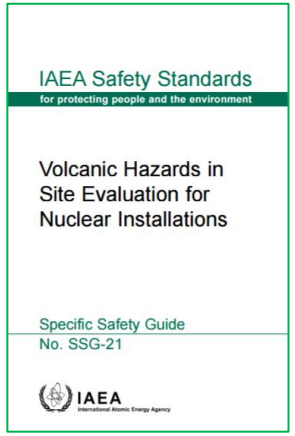
2015



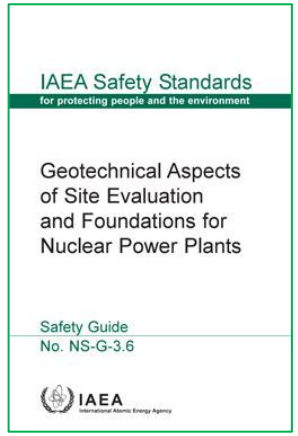
2022



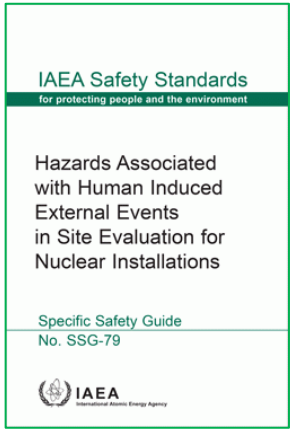
Under revision –DS541



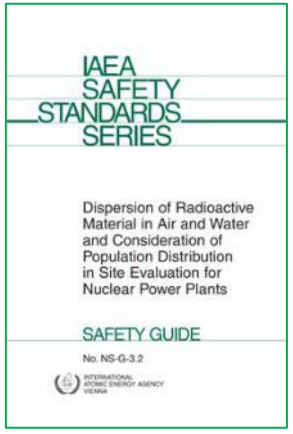
2012



Under revision –DS531



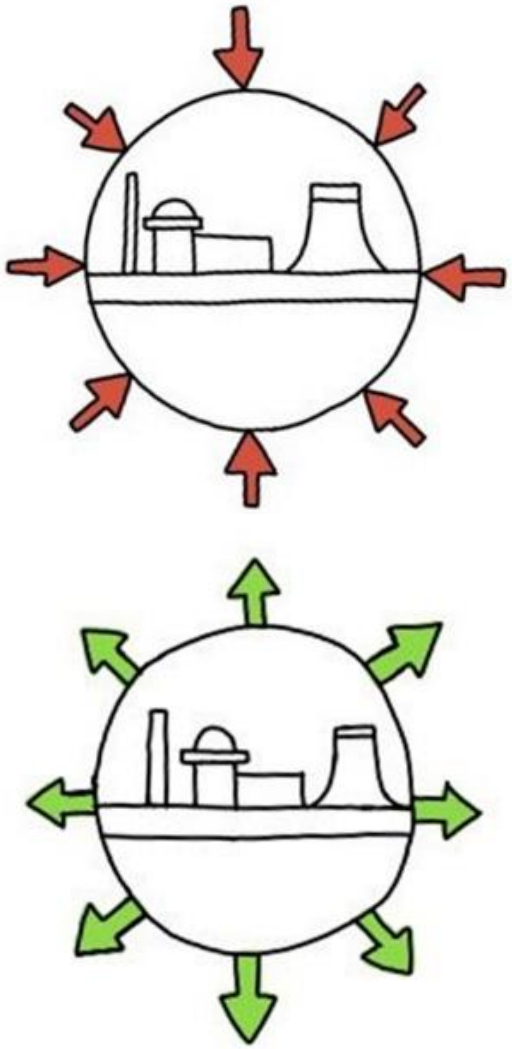
2023



Under revision –DS529

Objectives of SSR-1

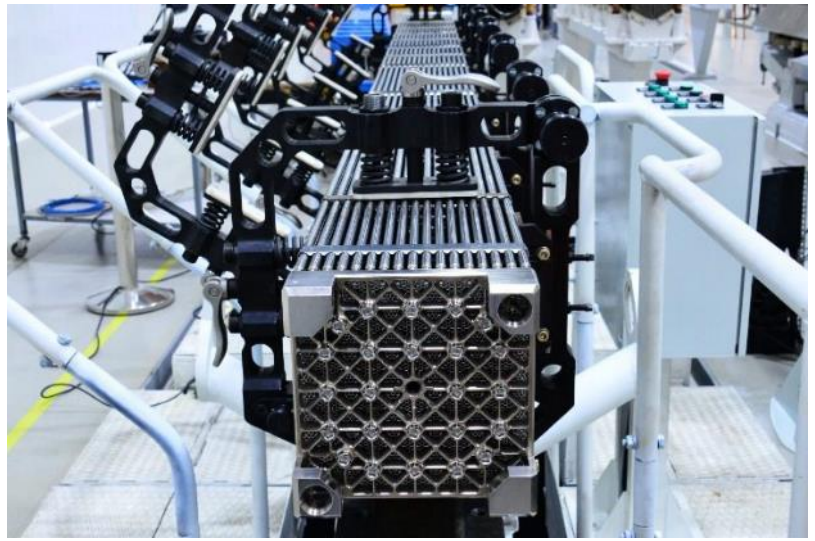
1. **Defining the information** to be used in the site evaluation process.
2. Evaluating a site such that the **site specific hazards** and the **safety related site characteristics** are adequately taken into account, in order **to derive appropriate site specific design parameters**.
3. Analysing the **characteristics of the population and the region surrounding the site** to determine whether there would be significant difficulties in **implementing emergency response actions** effectively.
4. **Identifying the natural and human induced external hazards that could affect the safety** of the nuclear installation.
5. Assessing the **interactions between the site and nuclear installation for operational states and accident conditions**, over the lifetime of the nuclear installation.



Scope of SSR-1

SSR-1 applies to the following nuclear installations:

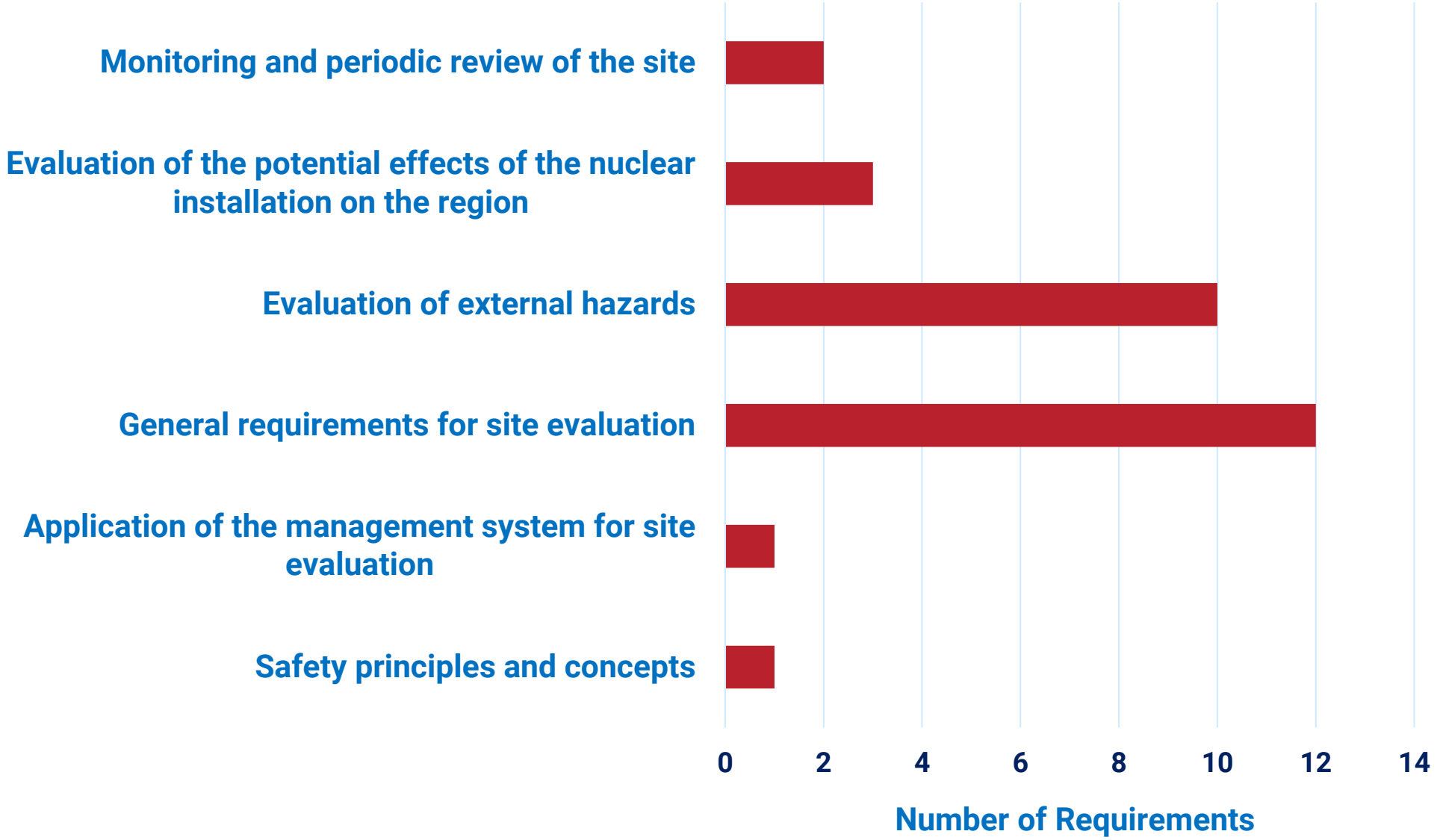
- ✓ Nuclear power plants
- ✓ Research reactors (including subcritical and critical assemblies) and any adjoining radioisotope production facilities
- ✓ Storage facilities for spent fuel
- ✓ Facilities for the enrichment of uranium
- ✓ Nuclear fuel fabrication facilities
- ✓ Conversion facilities
- ✓ Facilities for the reprocessing of spent fuel
- ✓ Facilities for the predisposal management of radioactive waste arising from nuclear fuel cycle facilities
- ✓ Nuclear fuel cycle related research and development facilities



Nuclear fuel, Source: www.tvel.ru

Budapest Research Reactor
Source: https://www.ek-cer.hu/

Distribution of the requirements in SSR-1 by topic



Requirement 1:
Safety objective in site evaluation for nuclear installations

The safety objective in site evaluation for nuclear installations shall be **to characterize the natural and human induced external hazards** that might affect the safety of the nuclear installation, in order **to provide adequate input for demonstration of protection of people and the environment** from harmful effects of ionizing radiation.

Source: https://www.tehrantimes.com/news/465998/Natural-disasters-environment-s-fate-or-revenge

Requirement 2:
Application of the management system for site evaluation

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

Source: https://www.iaea.org

Key issues

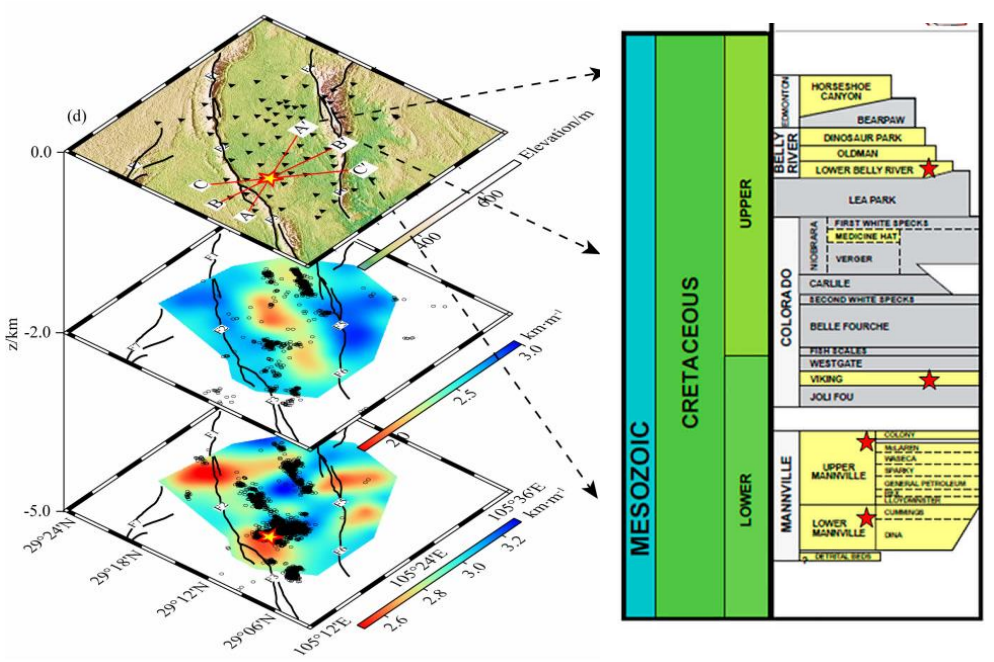
- ✓ An integrated management system that meets the requirements of IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety [12] shall be established.
- ✓ The organization, planning, work control, verification and documentation of activities, qualification and training.
- ✓ Implemented at the earliest possible time.
- ✓ Inspection, testing, verification and validation, the acceptance criteria for each activity
- ✓ Documentation in sufficient detail to permit an independent review.

Requirement 3:
Scope of the site evaluations for nuclear installations

Key issues

- ✓ Scope of the site evaluation shall cover all external hazards, monitoring activities and site specific parameters...
- ✓ The level of detail needed in the evaluation of a site for a nuclear installation shall be commensurate with the risk associated with the nuclear installation…
- ✓ Scope and level of detail shall be determined in accordance with a graded approach, depending on the factors listed in Para. 4.5 (radioactive inventory, associated hazards, thermal power for research reactors, configuration and layout, use of active systems, on-site and off-site consequences, etc...)

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



Requirement 4: Site suitability (See SSG-35 for details)

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 installation.

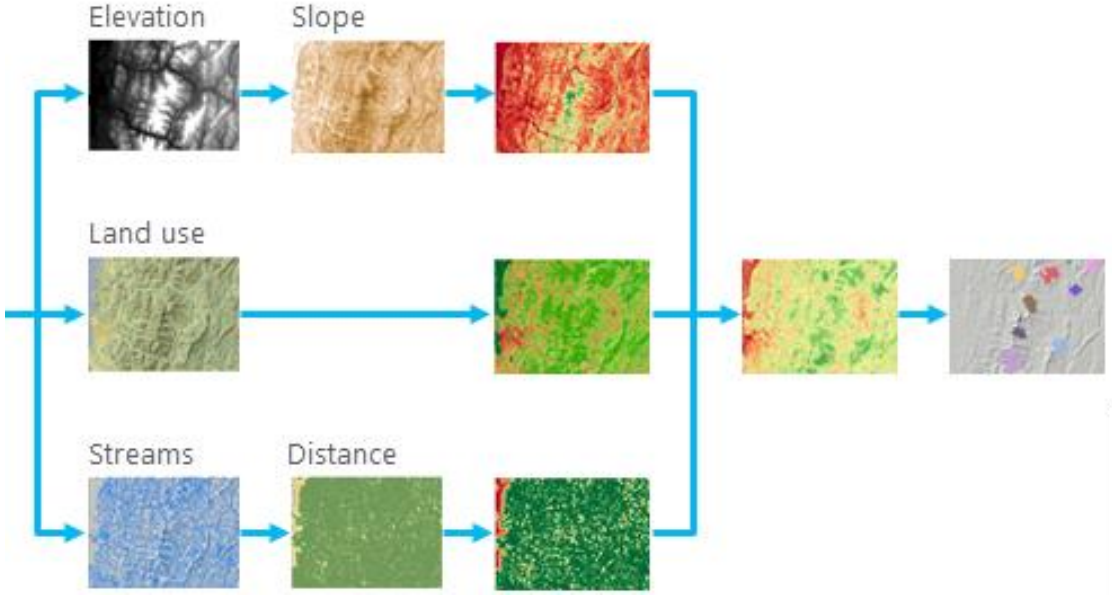
Key issues

- ✓ Address three important aspects:

  (1) effects of natural and human induced external events,
  (2) characteristics of the site and its environment that could influence the transfer of radioactive material
  (3) population density, population distribution and other characteristics of the external zone.

- ✓ Site is unsuitable if one or more of the three aspects above indicates that the site is unacceptable, and the deficiencies cannot be compensated by:

  - **site protection,**
  - **design features** of the nuclear installation and
  - **administrative procedures**.



- ✓ Assess on the basis of relevant current data and methodologies…

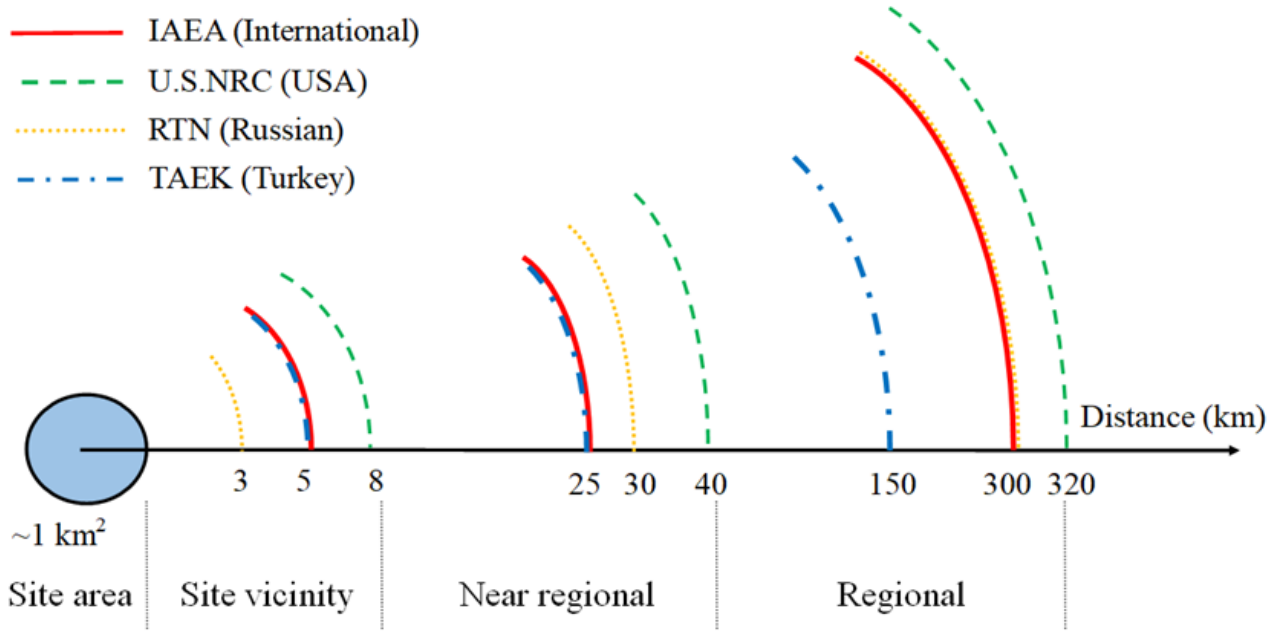
- ✓ Decision based on the characteristics of the nuclear installation, e.g. see previous slide!

Requirement 5: Site and regional characteristics

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

Key issues

- ✓ The size of the region to be investigated shall be defined for each of the natural and human induced external hazards…
- ✓ Quite large regions for tsunami and volcanic hazard assessment!
- ✓ 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 installation.
- ✓ Climate change, changes in the population distribution, present and future use of land and water…



Picture: Courtesy of Mr. Baris Guner

Requirement 6: Identification of site specific hazards

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**.

Key issues

Some hazards may be screened, but…

- ✓ …process and associated criteria used in the screening of site specific hazards shall comply with the safety objective…
- ✓ …scope of evaluation of external events in the screening process shall cover the full ranges of severity and frequency of occurrence...
- ✓ External hazards that are not excluded by the screening process shall be evaluated and then used in establishing the site specific design parameters… (see next requirement)

https://geodata.lib.ncsu.edu/fedgov/noaa/commvuln/htm/step1.htm

Requirement 7:
Evaluation of natural and human induced external hazards

Key issues

- ✓ In the evaluation, consider uncertainties, combination of hazards, use appropriate methods (supported by numerical models if needed)
- ✓ 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
- ✓ Results of the evaluation of hazards shall be expressed in terms that can be used as an input for deriving the site specific design parameters…
- ✓ Consider potential for explosion, chemical releases and/or thermal releases that might affect the safety, and the potential for interactions between radioactive and non-radioactive substances…

The impact of natural and human induced external hazards on the safety of the nuclear installation **shall be evaluated over the lifetime of the nuclear installation**.

Requirement 8: Measures for site protection

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

Key issues

- ✓ These are the engineering solutions…
- ✓ In design, uncertainties shall be properly taken into account in the evaluation of extreme values of parameters, considering adequate safety margins!
- ✓ If such engineering solutions are not available, the site shall be deemed unsuitable!

Seawall at the Hamaoka NPS (Japan) https://www.at-s.com/news/article/shizuoka/992478.html

Requirement 9:
Site Evaluation for multiple nuclear installations on the same site or adjacent sites

The site evaluation shall consider the potential for natural and human induced external hazards **to affect multiple nuclear installations on the same site as well as on adjacent sites.**

Key issues

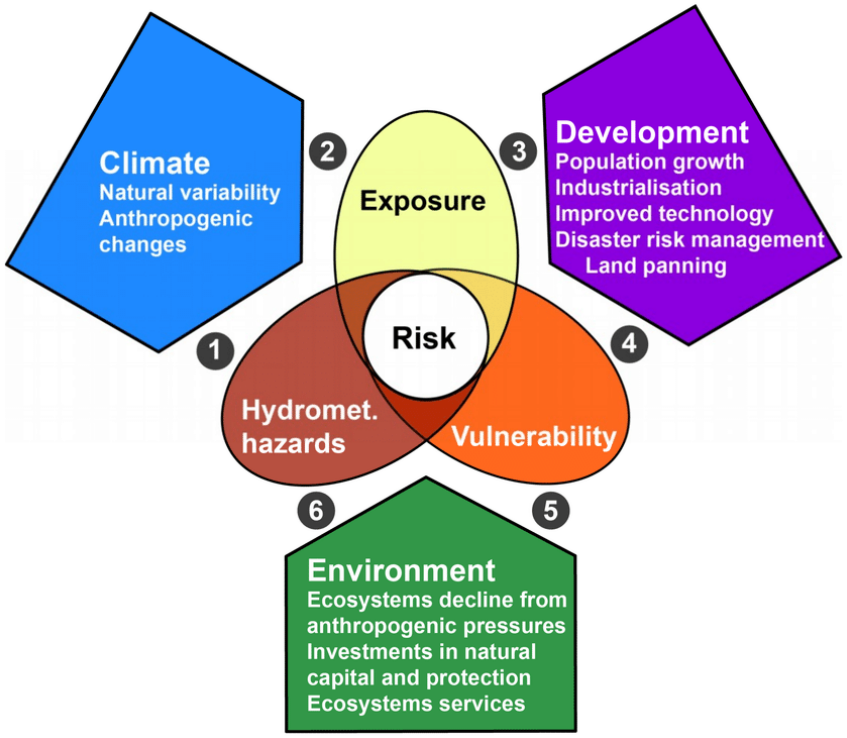
- ✓ Occurrences of natural and human induced external events and their credible combinations that could affect the safety of multiple installations on the same site or installations on adjacent sites…

Zaporizhzhia nuclear power plant (Ukraine)

https://apnews.com/article/russia-ukraine-science-climate-and-environment-33d0f2520ef6c2b1d8f5390dbb2c6873

Requirement 10:
Changes of hazards and site characteristics with time

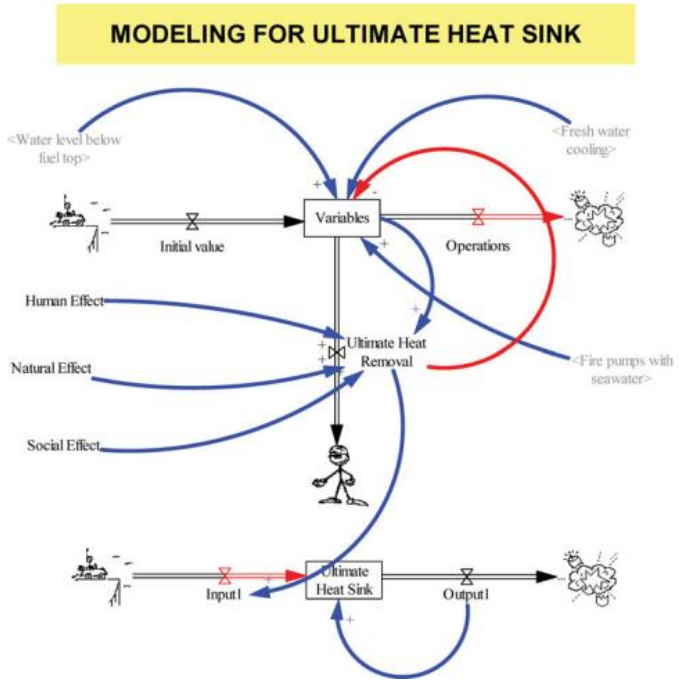
The external hazards and the site characteristics shall be assessed in terms of their **potential for changing over time** and the potential impact of these changes shall be evaluated.



Source: The Disaster Risk, Global Change, and Sustainability Nexus

Requirement 11:
Special considerations for the ultimate heat sink

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



Safety assessment for the ultimate heat sink (UHS) system with non-injection concept in nuclear power plants (NPPs)

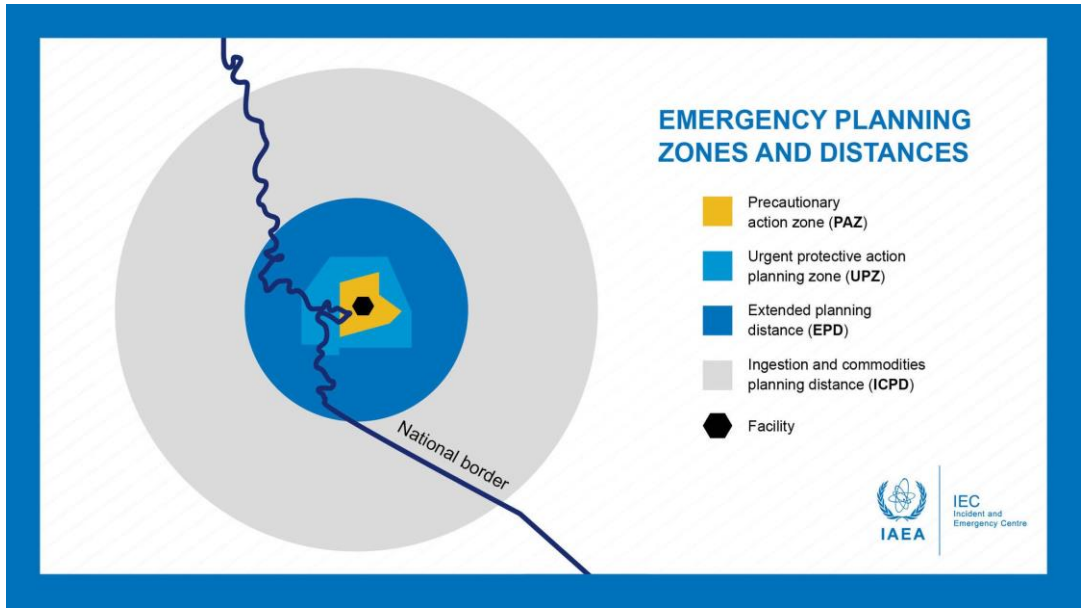
Requirement 12: Potential effects of the nuclear installation on people and the environment

In determining **the potential radiological impact** of the nuclear installation 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,** with account taken of the design of the nuclear installation and its safety features.

Picture: IAEA

Requirement 13:
Feasibility of planning effective emergency response actions

The feasibility of planning effective emergency response actions on the site and in the external zone shall be evaluated, with account taken of 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.



Source: https://x.com/IAEANS/status/1515248630818480129

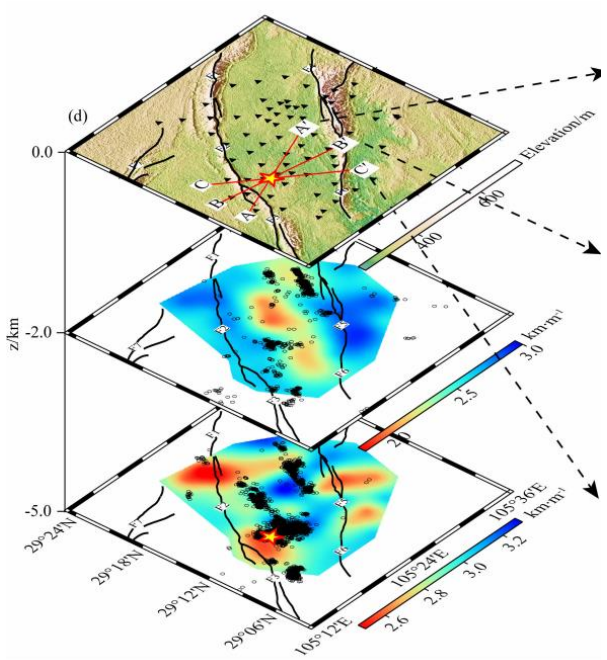
Source: https://www.iaea.org/newscenter/news/emergencies-dont-sleep-iaea-and-sweden-test-response-arrangements-to-simulated-nuclear-accident

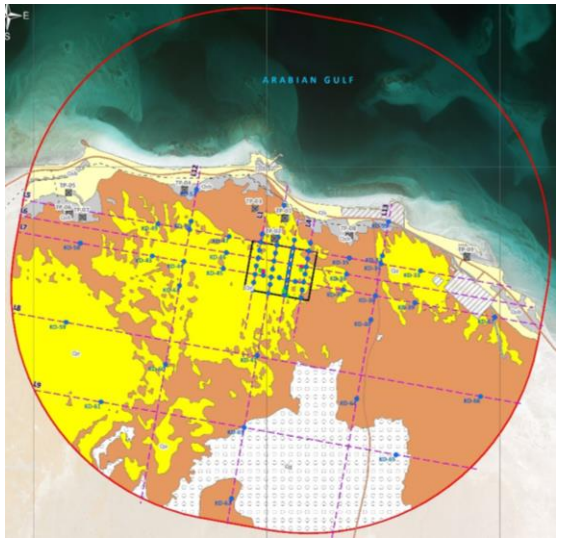
Requirement 14:
Data collection in site evaluation for nuclear installations

Key issues

- ✓ **When:** throughout the lifetime of the nuclear installation
- ✓ **What:** extent, objectives and scope of the data collection process shall be defined on the basis of the safety objective. Minimums are listed in Para. 4.46 of SSR-1…
- ✓ … of sufficient quality and quantity to support the selected methodology for hazard evaluation…
- ✓ Data shall be maintained and reviewed periodically, and/or as necessary as part of a review of the site evaluation within the framework of the periodic safety review of the nuclear installation…

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 installation** and **the impact of the nuclear installation on people and the environment shall be collected**.



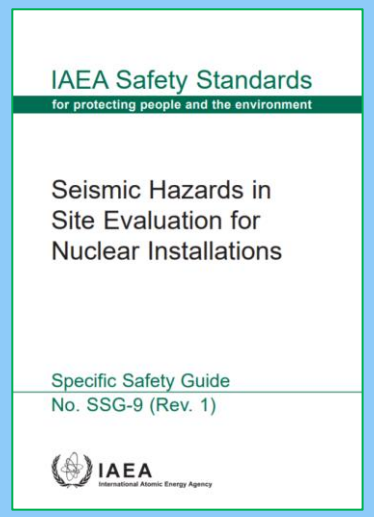


Picture: Courtesy of Mr. Arda Ozacar

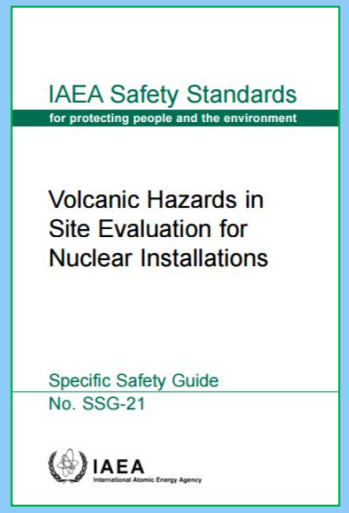
Requirements 15-24: Evaluation of external hazards and supporting safety guides

Requirement 15: Evaluation of fault capability

Requirement 16: Evaluation of ground motion hazards



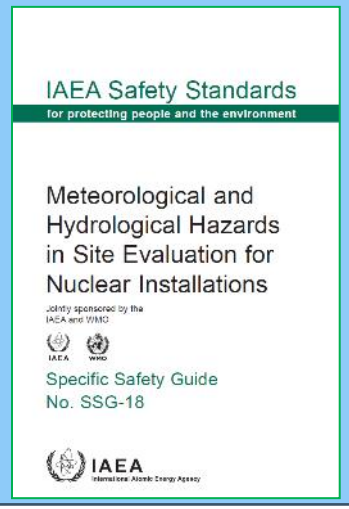
Requirement 17: Evaluation of volcanic hazards



Requirement 18: Evaluation of extreme meteorological hazards

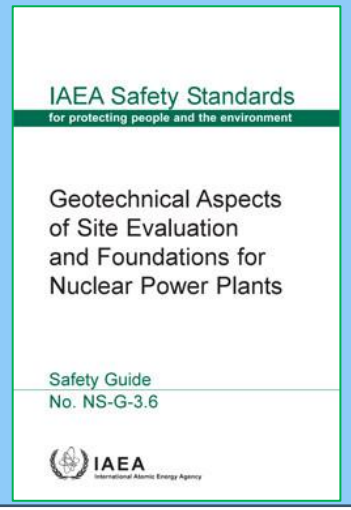
Requirement 19: Evaluation of rare meteorological events

Requirement 20: Evaluation of flooding hazards



Requirement 21: Geotechnical characteristics and geological features of subsurface materials

Requirement 22: Evaluation of geotechnical hazards and geological hazards



Requirement 23: Evaluation of other natural hazards

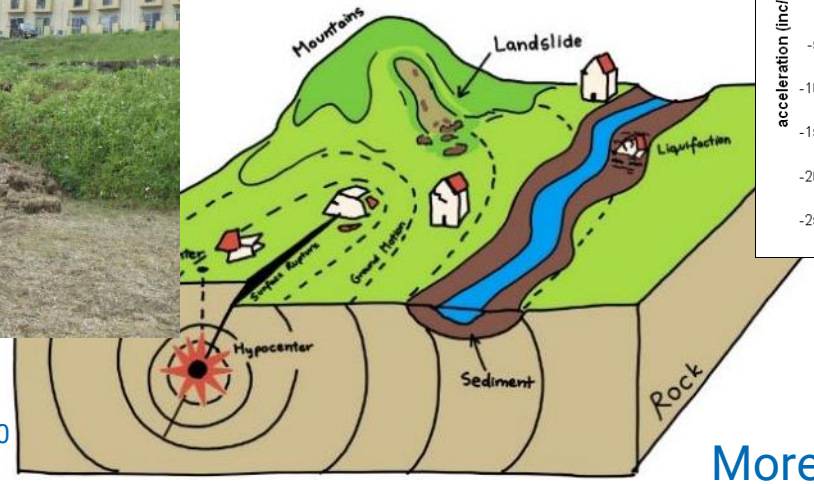
Requirement 24: Evaluation of hazards associated with human induced events

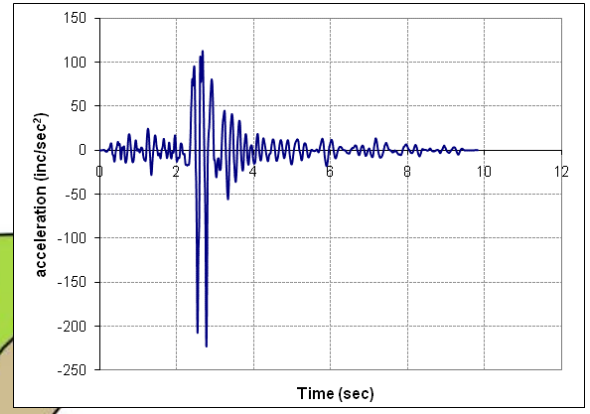
Requirements 15 and 16: Evaluation of fault capability and ground motion hazards

Geological faults larger than a certain size and within a certain distance of the site and that are significant to safety shall be evaluated to identify whether these faults are to be considered **capable faults**.

For capable faults, potential challenges to the safety of the nuclear installation in terms of **ground motion** and/or **fault displacement** hazards shall be evaluated.

An evaluation of ground motion hazards shall be conducted **to provide the input needed for the seismic design** or safety upgrading of the structures, systems and components of the nuclear installation, as well as the input for performing the deterministic and/or probabilistic safety analyses necessary during the lifetime of the nuclear installation.





Pictures: By Mr. K. Nagasawa and Ms. Z. Gulerce
Middle: Drawn by J&A Aszódi, 2022, CC BY-SA 4.0

More in next presentation!

Requirement 17: Evaluation of volcanic hazards

Hazards due to **volcanic activity** that have the potential to affect the safety of the nuclear installation shall be evaluated.

Key issues

- ✓ Capable volcanoes shall be identified and evaluated. Definition of capable volcano is given in SSR-1.
- ✓ A proposed new 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 installation…
- ✓ …focus on determining the geological characteristics of volcanic phenomena and their spatial extent will usually be more certain than one focusing on an estimation of the likelihood of occurrence of hazardous phenomena…
- ✓ Consider volcanic ash fall…

http://www.qsr.mlit.go.jp/unzen/gallery/index.html

Requirements 18 and 19: Evaluation of extreme meteorological hazards and rare meteorological events

Extreme meteorological hazards (parameters) are:

- ✓ Wind
- ✓ Precipitation
- ✓ Snow and ice
- ✓ Air and water temperature
- ✓ Humidity
- ✓ Storm surges
- ✓ Sand or dust storms

Rare meteorological events are:

- ✓ Tornadoes, cyclones and associated missiles
- ✓ Lightnings
- ✓ Parameters such as rotational wind speed, translational wind speed, pressure, etc.

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

The potential for the occurrence of rare meteorological events such as **lightning, tornadoes and cyclones**, including information on their severity and frequency, shall be evaluated.

https://www.themoscowtimes.com/2013/05/24/tornado-caught-on-tape-over-worlds-first-nuclear-plant-video-a24336

Requirement 20: Evaluation of flooding hazards

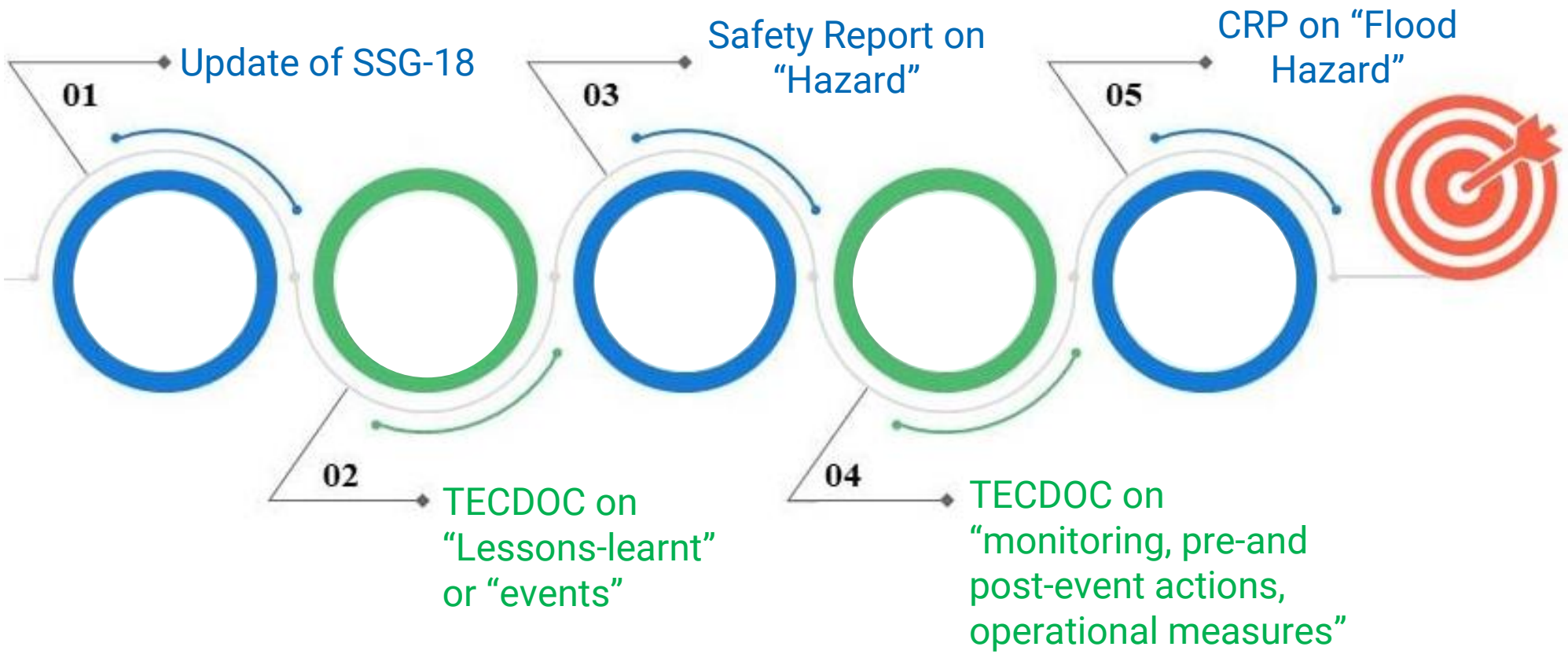
Hazards due to **flooding**, considering **natural and human induced events** including their possible combinations, shall be evaluated.

Key issues

- ✓ Floods due to precipitation and other natural causes such as storm surge, wind generated waves, meteorological tsunamis or seiches, or extreme precipitation.
- ✓ Water waves induced by earthquakes or other geological phenomena
- ✓ Floods and waves caused by failure of water control structures (e.g., upstream water control structures such as dams).
- ✓ A critical topic because of the changes in the practice due to climate change.

Fort Calhoun plant on June 16, 2011 during the 2011 Missouri River Floods; https://energynews.us/2020/08/31/report-climate-risks-compound-financial-challenges-for-midwest-nuclear-plants/

EESS Project:
Climate Change Impacts on Nuclear Installations



Requirements 21 and 22: Geotechnical and geological characteristics and hazards

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.

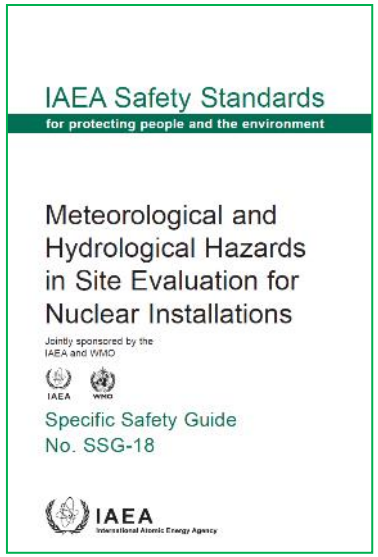
Geotechnical hazards and geological hazards, including **slope instability**, **collapse**, **subsidence** or **uplift**, and **soil liquefaction**, and their effect on the safety of the nuclear installation, shall be evaluated.

Pictures: By Mr. K. Nagasawa and Mr. K. O. Cetin

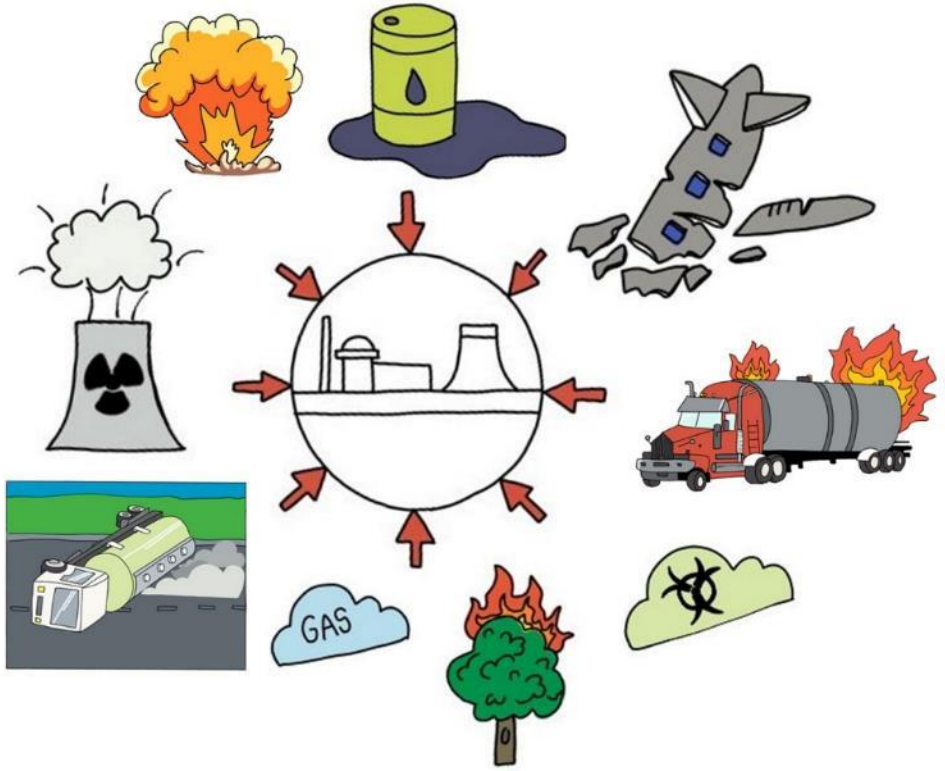
Requirements 23 and 24: Evaluation of other natural hazards and hazards associated with human induced events

Other natural phenomena that are specific to the region and which have the potential to affect the safety of the nuclear installation shall be investigated.

Other natural external hazards, such as **wildfires, drought, hail, frazil ice formation, diversion of a river, debris avalanche and biological hazards (e.g. jellyfish, small animals and barnacles)** shall be identified and assessed so that the site specific design parameters for these hazards can be derived.



The hazards associated with human induced events on the site or in the region shall be evaluated.



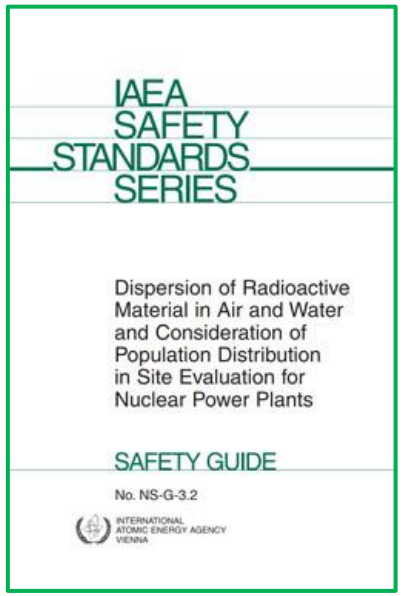
Drawn by J&A Aszódi, 2022, CC BY-SA 4.0

Requirement 25: Dispersion of radioactive material

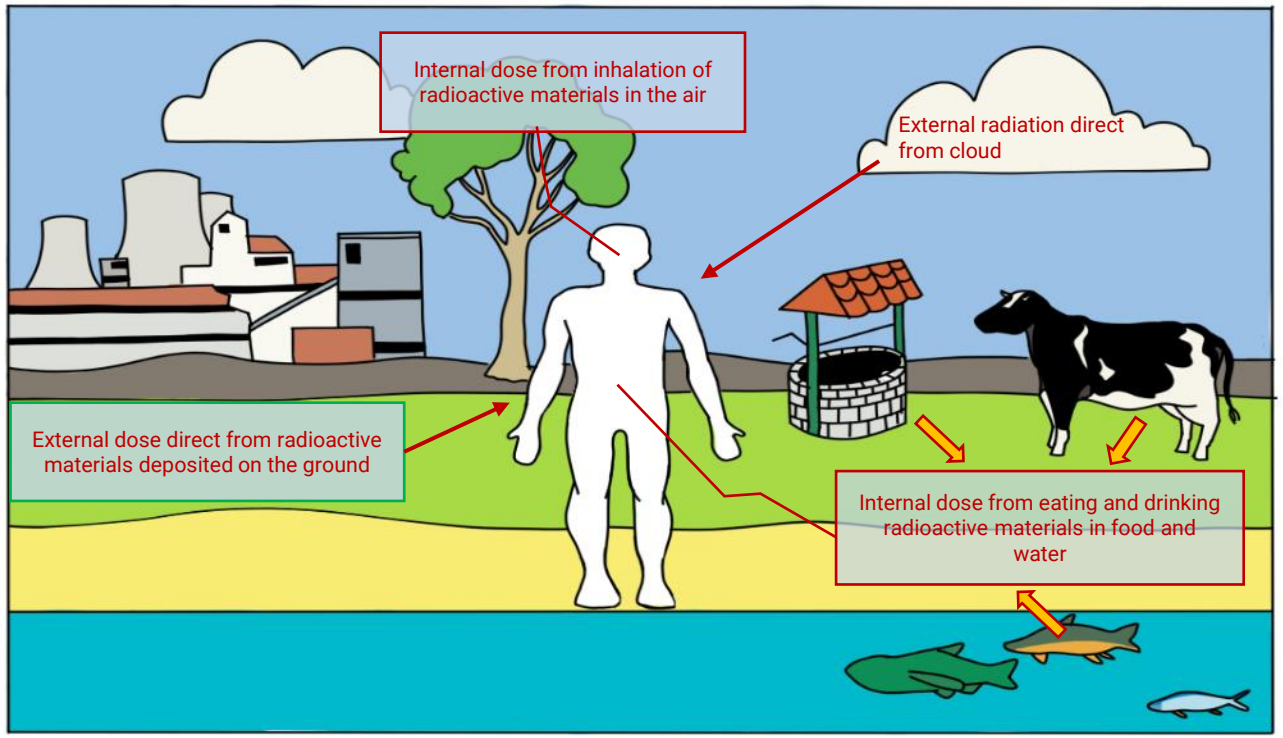
The dispersion in air and water of radioactive material released from the nuclear installation in operational states and in accident conditions shall be assessed.

Key issues

- ✓ The analysis of the atmospheric dispersion of radioactive material shall take into account the orography, land cover and meteorological features of the region. A programme for meteorological measurements shall be prepared and carried out at or near the site.
- ✓ A survey programme shall be designed to gather relevant data to characterize the hydrogeological and hydrological parameters at the site and in the region.



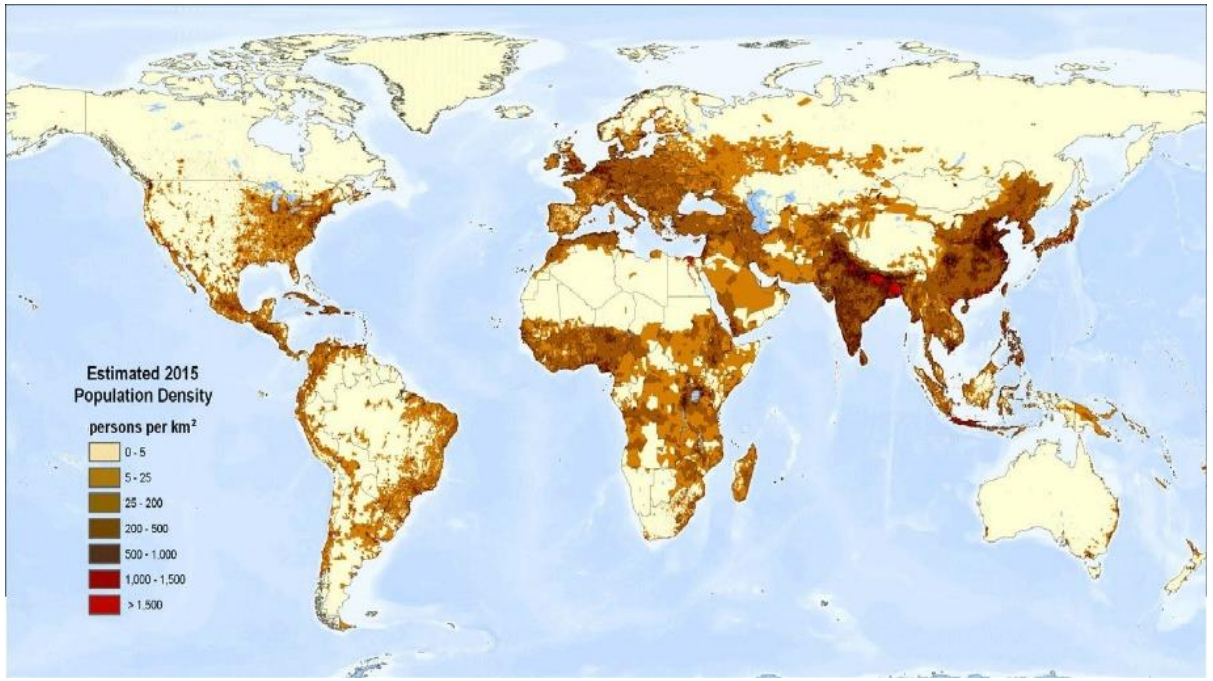
Under revision
(DS529)
TBP 2025



Drawn by J&A Aszódi, 2022, CC BY-SA 4.0
using inspirations from Maria del Rosario Perez et.al., WHO, 2013

Requirement 26:
Population distribution and public exposure

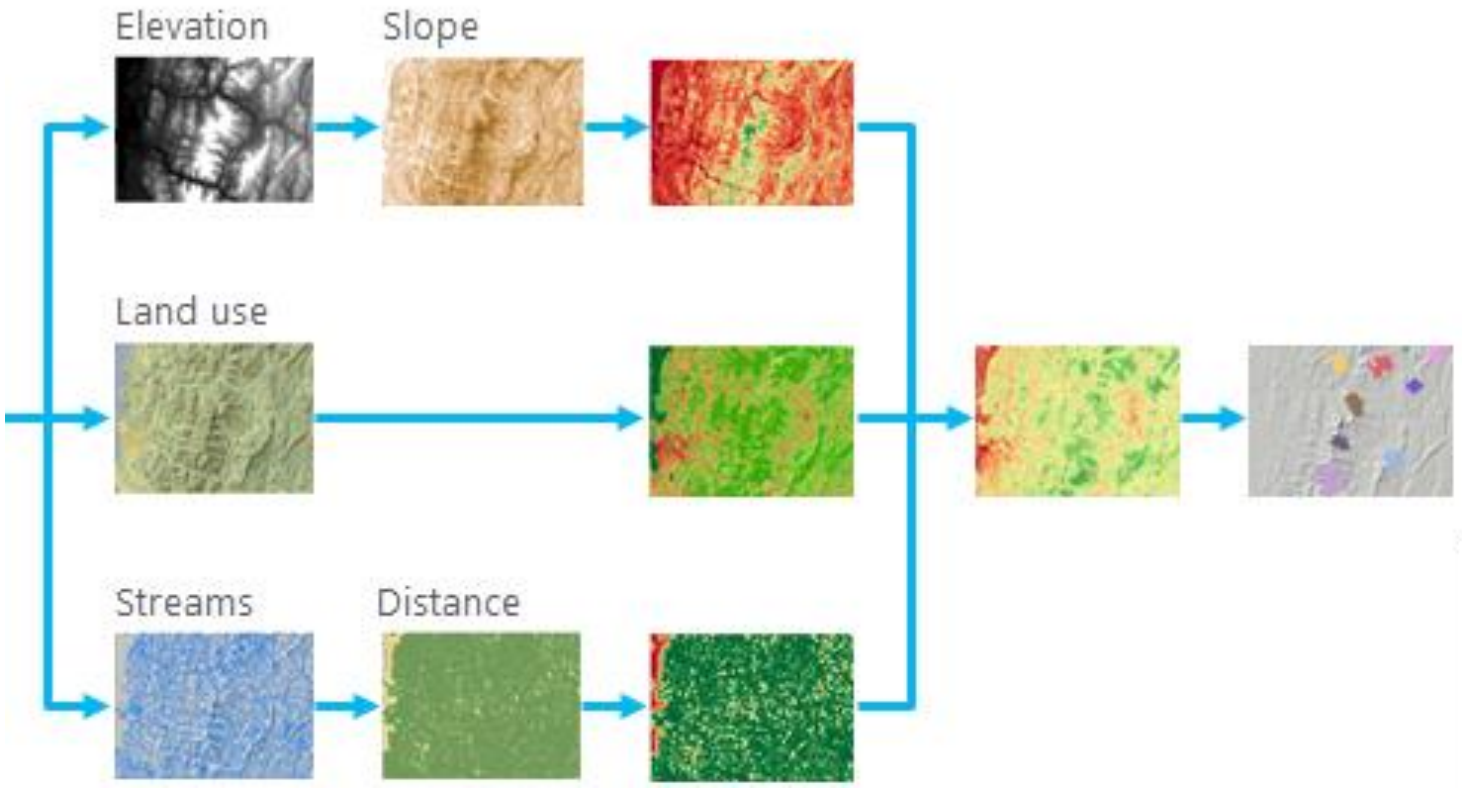
The existing and projected population distribution within the region over the lifetime of the nuclear installation shall be determined and the potential impact of radioactive releases on the public, in both operational states and accident conditions, shall be evaluated and periodically updated.



https://www.thegeographeronline.net/1-population-and-economic-development-patterns.html

Requirement 27:
Uses of land and water in the region

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

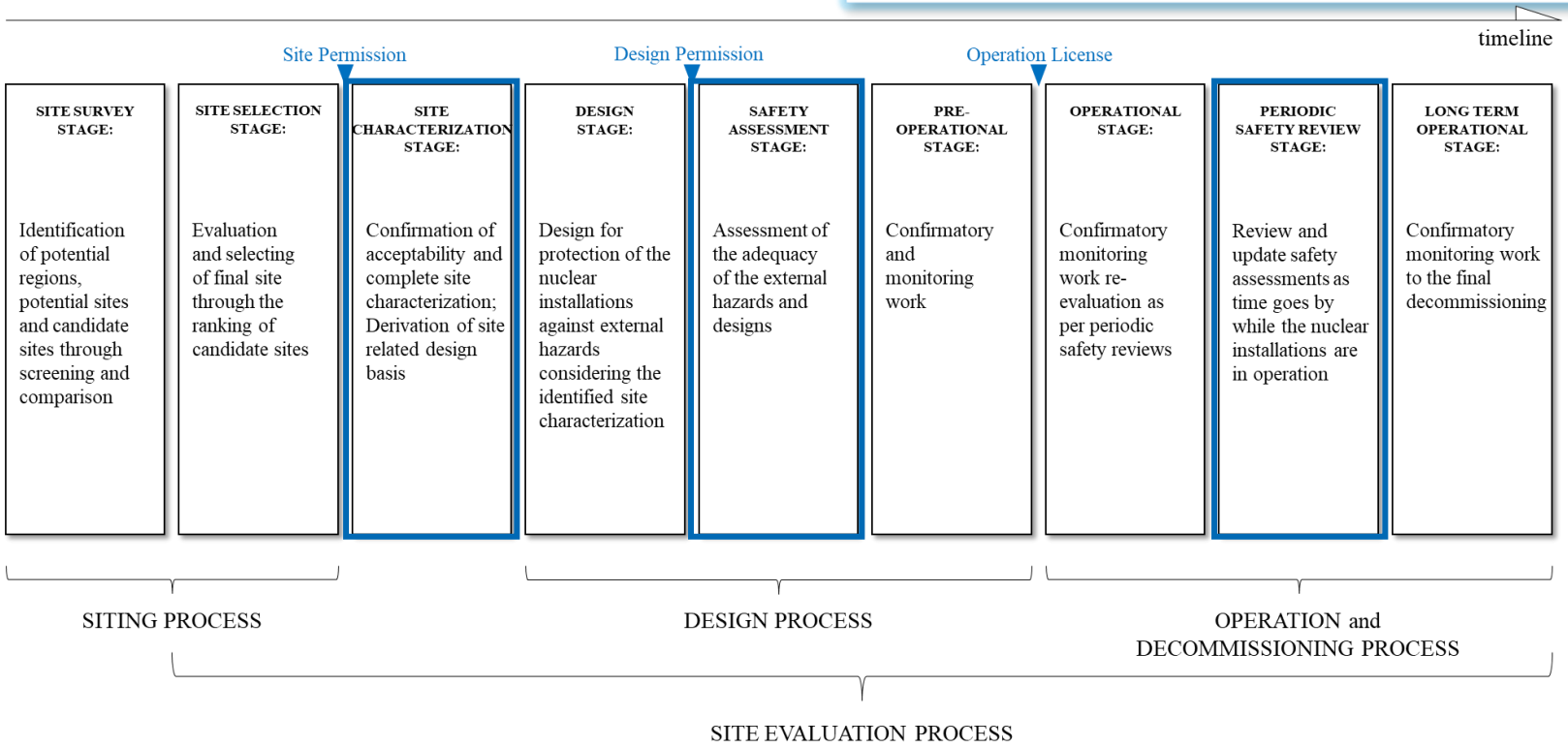


Using the conceptual model to create a suitability map—ArcMap | Documentation

Requirements 28 and 29: Monitoring and Review of External Hazards and Site Conditions

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

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 installation, with due account taken of operating experience and new safety related information.



All aspects discussed in the presentation:

Thank you!

Safety-Standards.Contact-Point@iaea.org