

Training Course on the IAEA Safety Standards Overview

SSR-1

Site Evaluation for Nuclear Installations

Michael W. Salmon

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

Shinagawa Campus, Tokai University, Tokyo, Japan

04-07, August 2026



Objective

- Introduce the IAEA's requirements standard and supporting guides for site selection and site evaluation
- Give you an idea of what is important when siting a nuclear installation
- Review the 16 requirements in SSR-1
- Highlight some of the exclusion criteria listed in SSG-35
- Introduce the concept of grading as it applies to site selection



The purpose of this presentation is to:

Sections

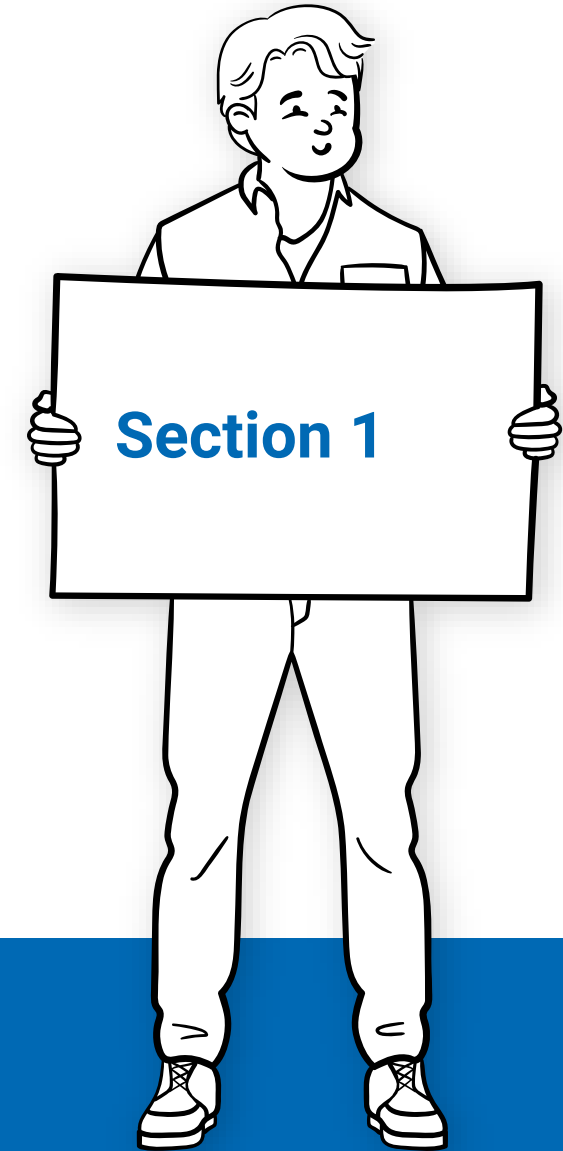
1. Discussion / Brain Storming
2. The IAEA Safety Standards Series
3. Background/Fundamental Objectives of SSR-1
4. Requirements in SSR-1
5. Supporting Safety Guides/Tecdocs



This presentation is delivered in 5 Sections

Discussion/Brain Storming

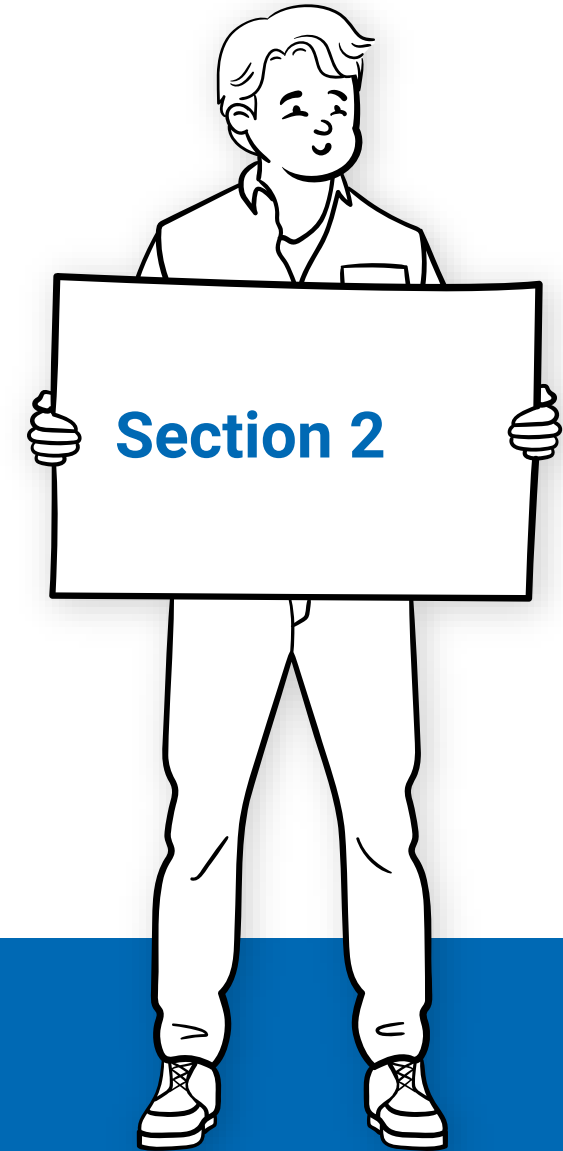
- Do we need nuclear powered electric generating stations? Why or why not?
- What are the risks of nuclear-powered electric generation stations?
- Describe the perfect site for building and operating a nuclear power site
- What do we do with the site and fuel once we've decided to decommission the station?



Start thinking – we are engineers and not AI bots:

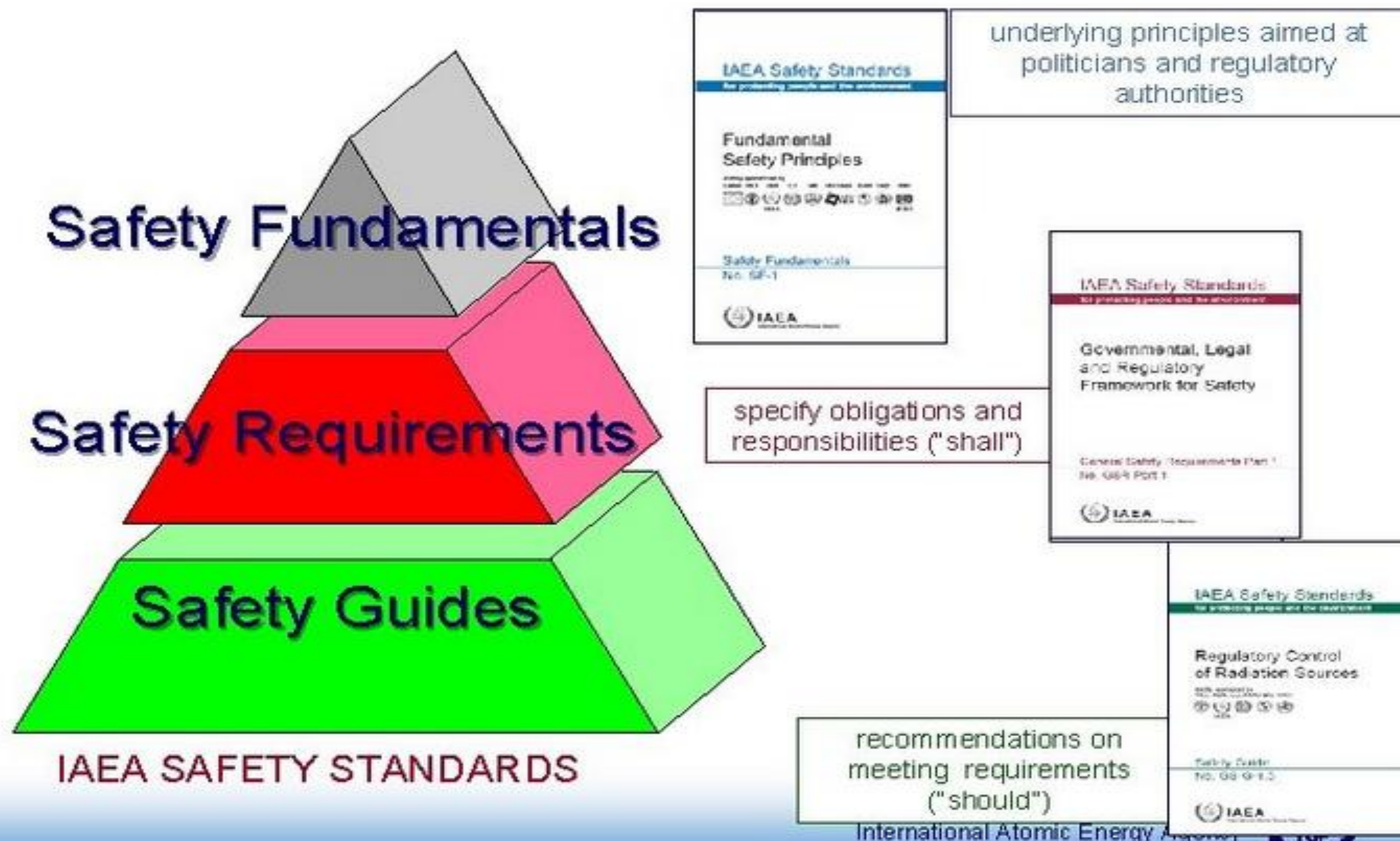
The IAEA Safety Standards Series

- Hierarchy of IAEA Safety Standards
- Where does SSR-1 fit in?
- What are the other guides or documents that can assist a user in trying to meet the requirements



The IAEA Safety Standards have a Hierarchical Order

Safety Standards Hierarchy



Fundamental Safety Principles

The fundamental safety objective is to protect people and the environment from the harmful effects of ionizing radiation.

This objective has to be achieved **without limiting the operation of facilities or activities** that give rise to radiation risks

- **SF-1 P7.** People and the environment, present and future, must be protected against radiation risks.
- **SF-1 P8.** All practical efforts must be made to prevent and mitigate nuclear or radiation accidents.
 - Defence-in-depth is provided by an appropriate combination of ...adequate site selection and the incorporation of good design and engineering features providing safety margins...
- **SF-1 P9.** Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents.

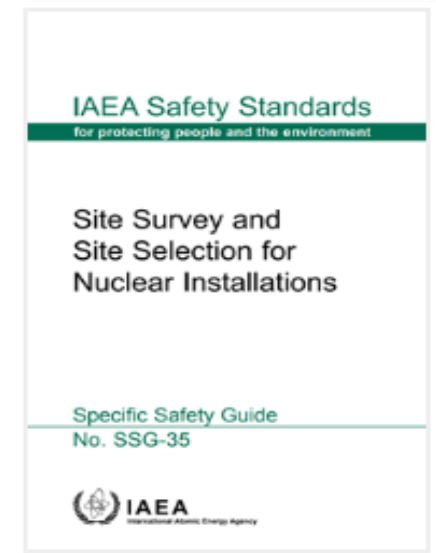
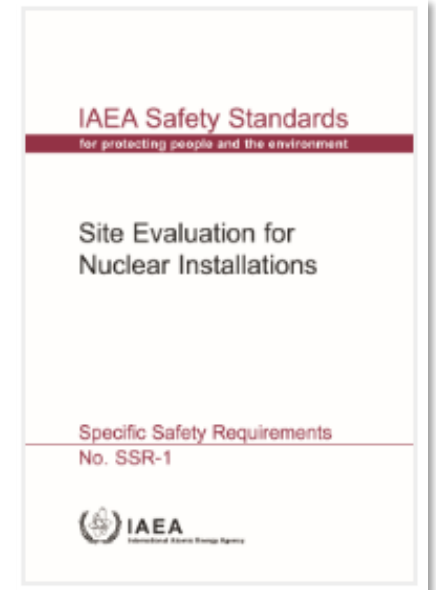
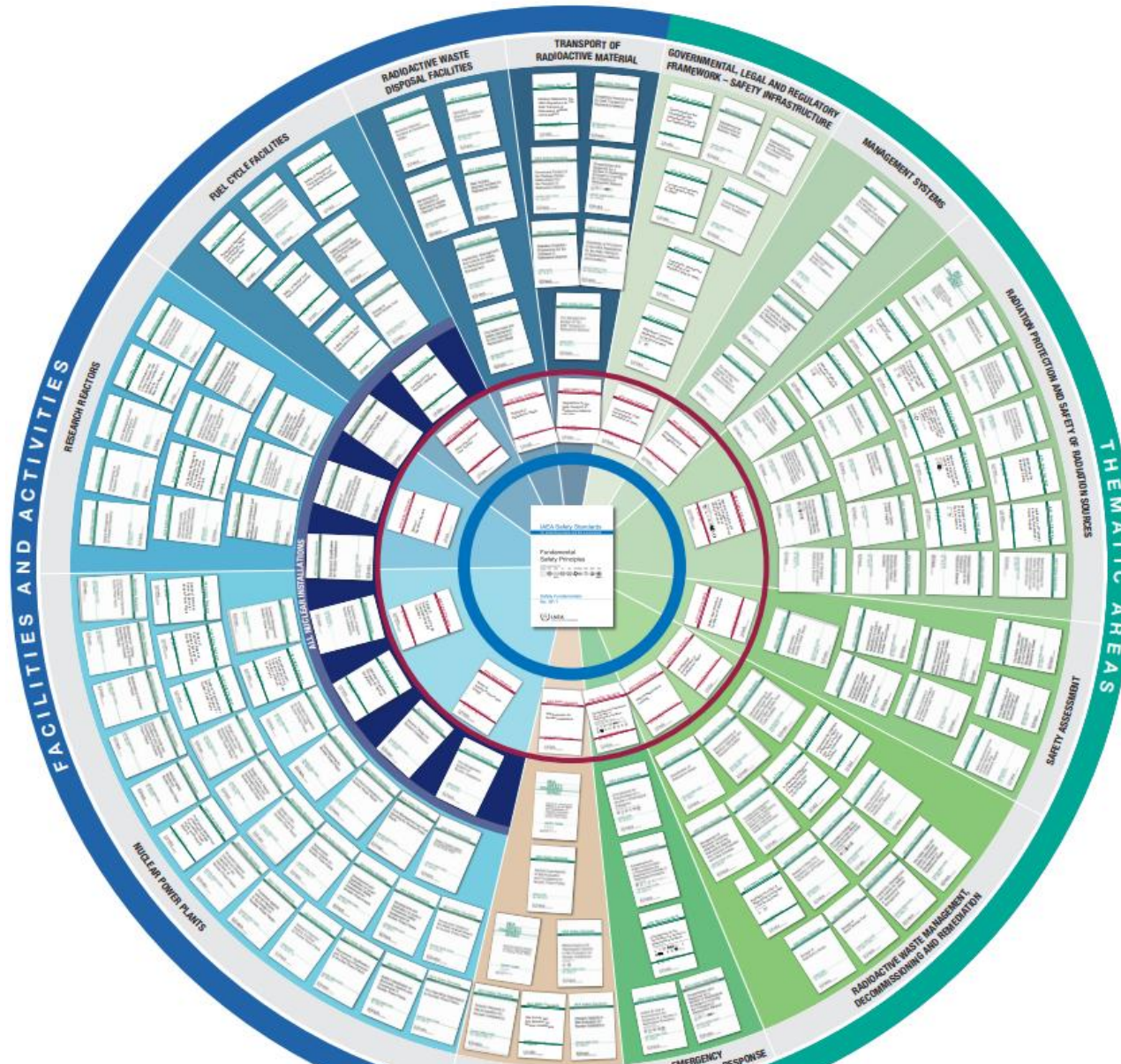


IAEA Safety Standards [SF-1](#) (e-book)

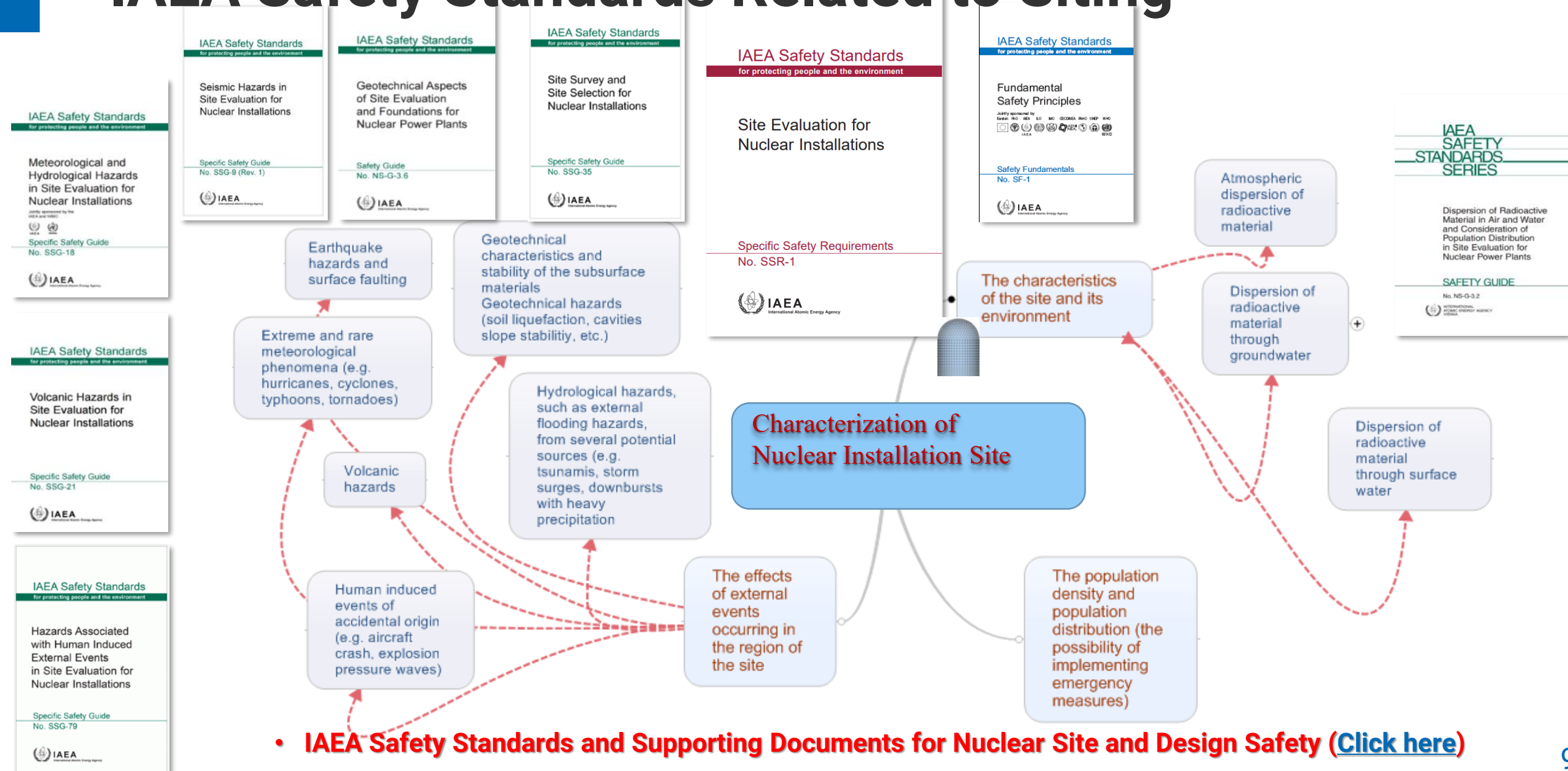
- [Online User Interface](#)

IAEA Safety Standards

protecting people and the environment

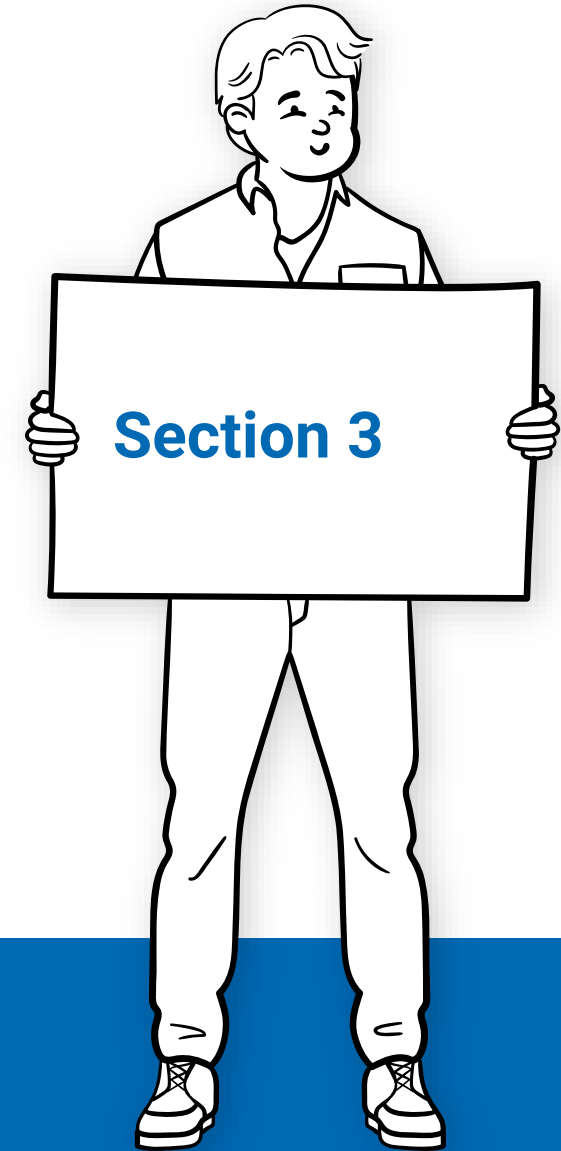


IAEA Safety Standards Related to Siting



Background/Fundamental Objective of SSR-1

- History
- Fundamental Objective

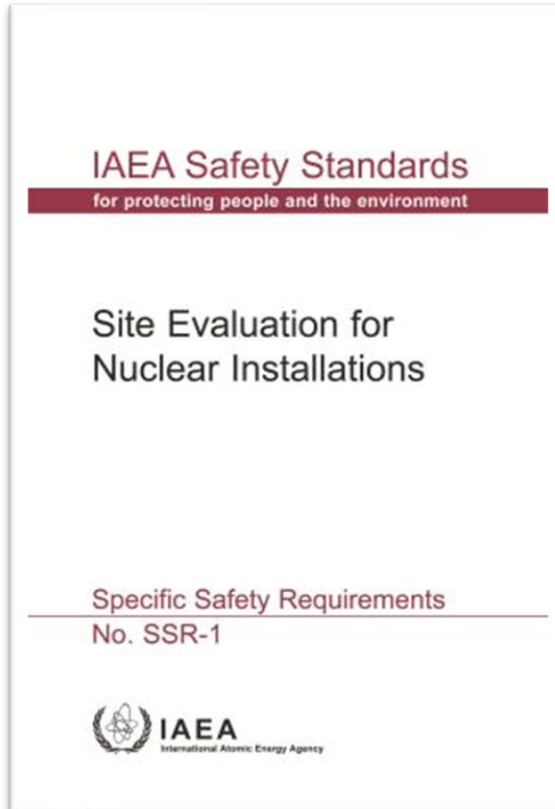


SSR-1 is focused on siting requirements

Background

History

- ✓ 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 revision is currently underway.



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

Fundamental Safety Objective of SSR-1

SSR-1 Establishes Siting Requirements

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

Two Driving Principles in SSR-1

SSR-1 Supports the Fundamental Safety Objective in SF-1

- “All practical efforts must be made to prevent and mitigate nuclear or radiation accidents” (Principle 8 of SF-1 [1]).

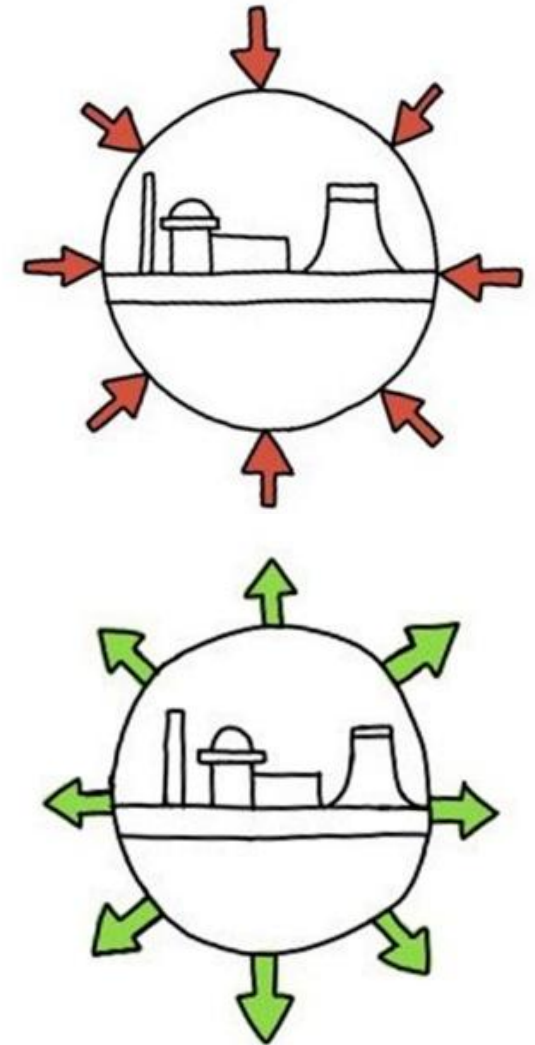
To address Principle 8 of SF-1 [1], site evaluation for a nuclear installation shall characterize the natural and human induced external hazards that could affect the safety of the nuclear installation

- “Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents” (Principle 9 of SF-1 [1]).

To address Principle 9 of SF-1 [1], site evaluation for a nuclear installation shall provide adequate input for demonstration of protection of people and the environment from the consequences of radioactive releases. The site evaluation shall identify the site characteristics that could affect the feasibility of planning effective emergency response actions in the external zone.

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.

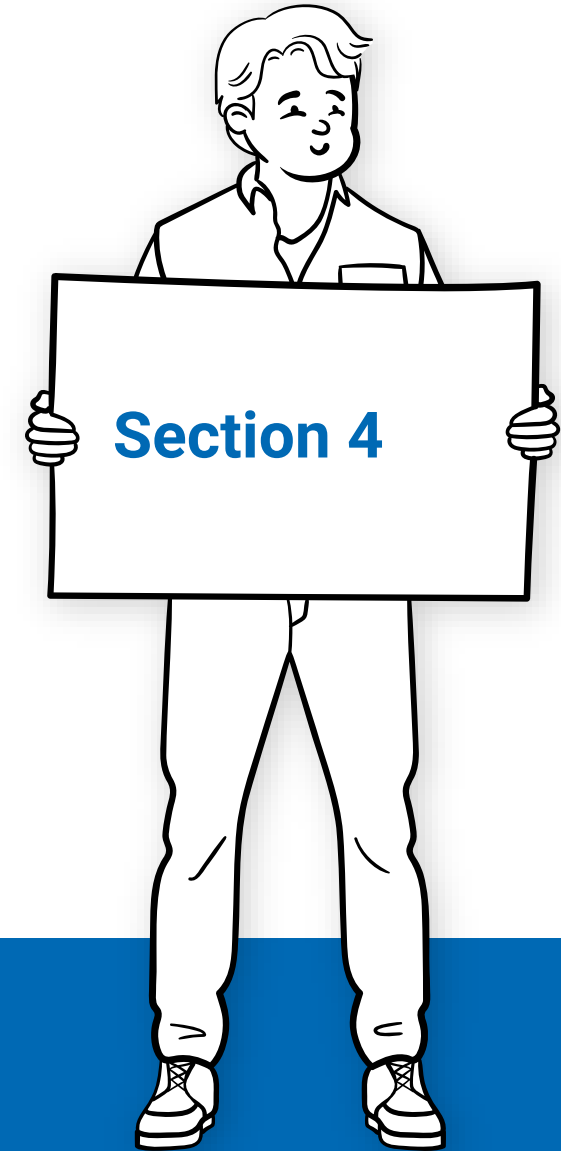


Drawn by J&A Aszódi, 2022, CC BY-SA 4.0

Requirements in SSR-1

- What are the requirements
- How do the requirements ensure that people and the environment are protected?
- How do the requirements ensure that site characteristics are adequately defined to allow for safe evacuation if required?

SSR-1 is written to provide requirements that, if met, support the fundamental safety objective



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

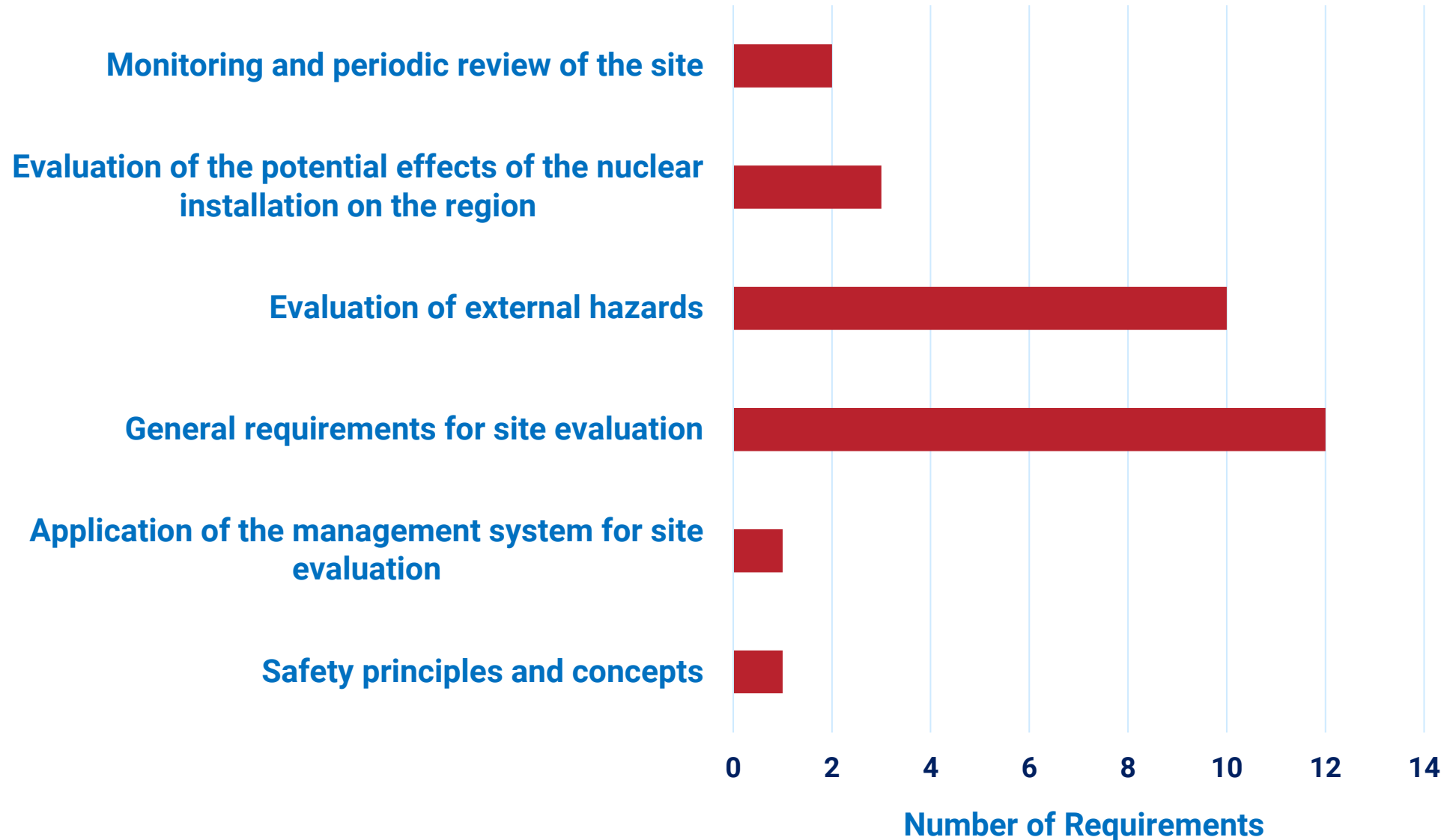


Nuclear fuel, Source: www.tvet.ru



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.



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.

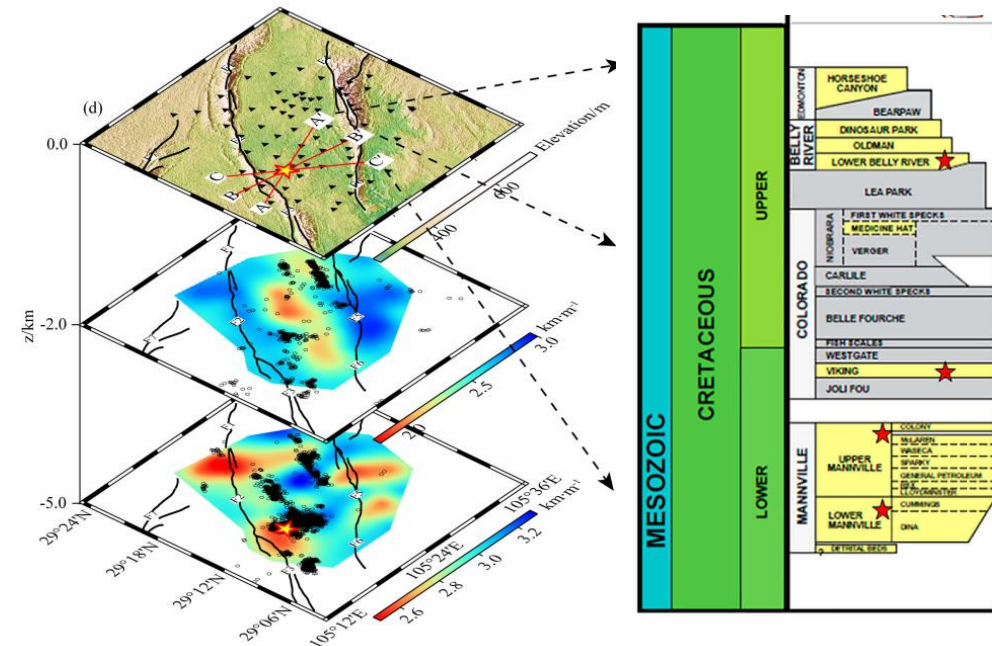
Requirement 3:

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**.

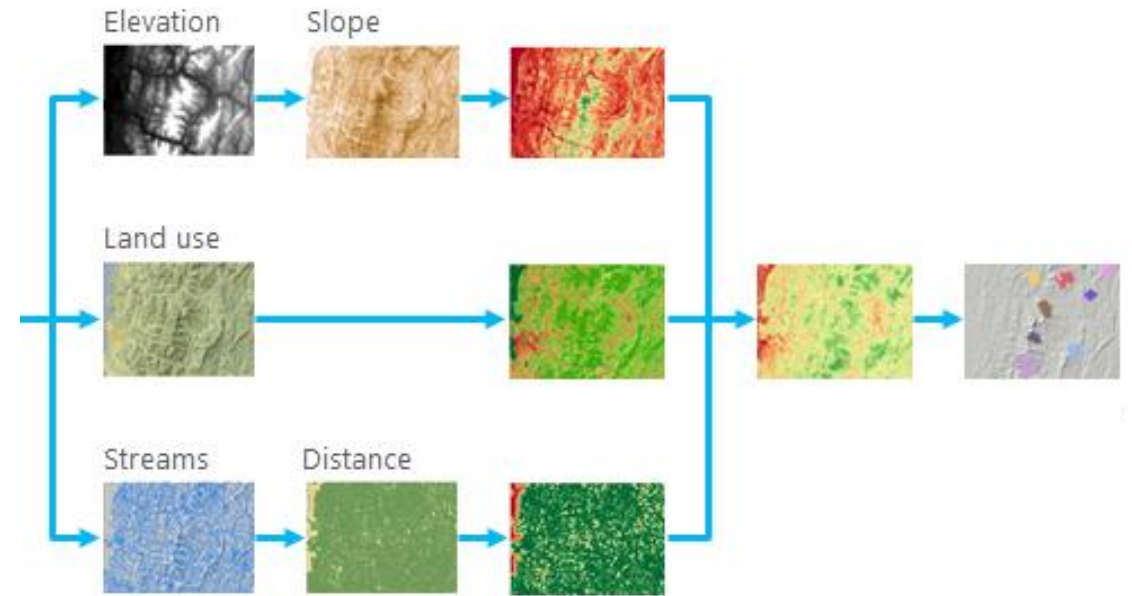


Requirement 4: Site suitability (See SSG-35 for details)

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.**

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.



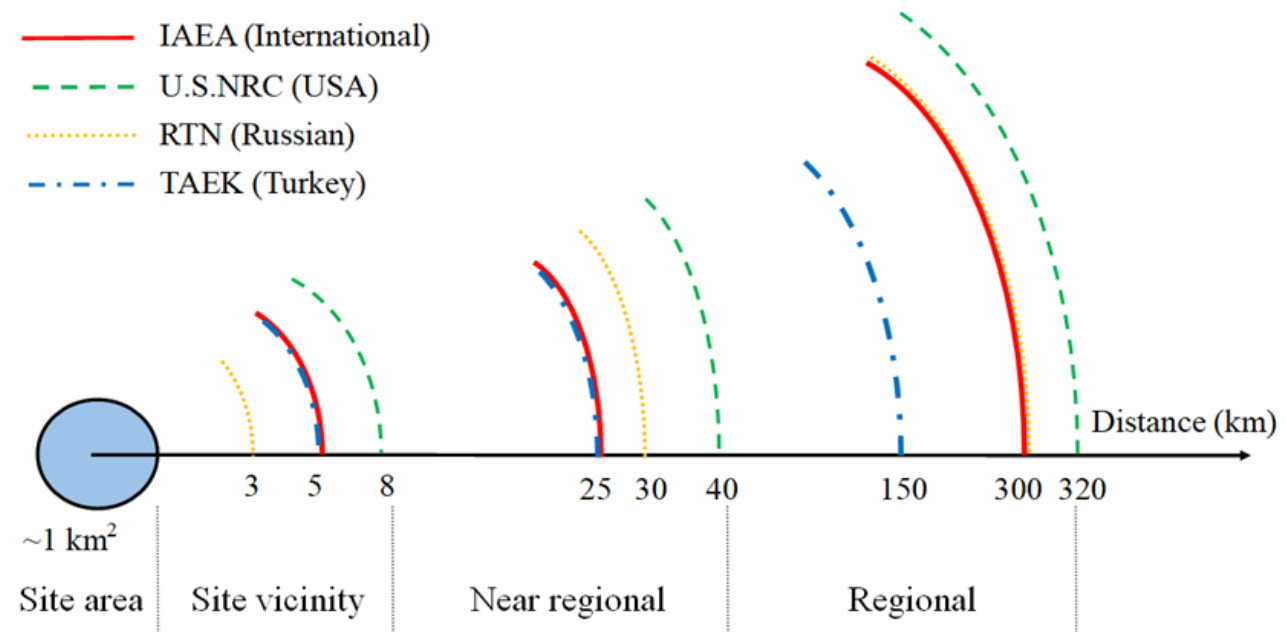
- ✓ Assess on the basis of relevant **current data and methodologies**...
- ✓ Decision based on the characteristics of the nuclear installation, e.g. see previous slide!

Requirement 5: Site and regional characteristics

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...

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.



Picture: Courtesy of Mr. Baris Guner

Requirement 6: Identification of site specific hazards

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)

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**.



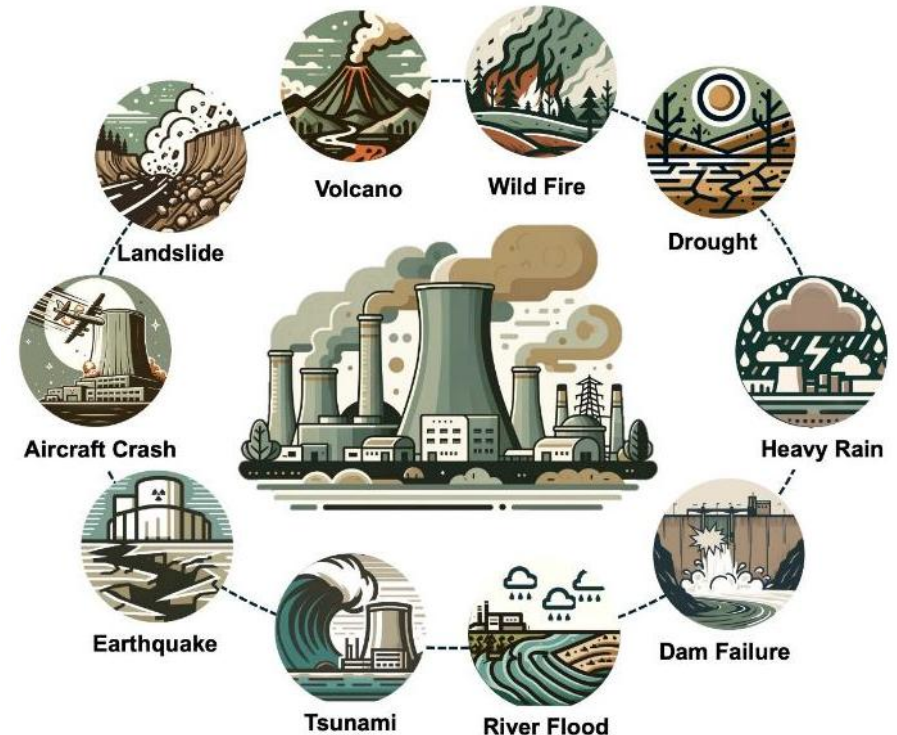
Requirement 7:

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!

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...



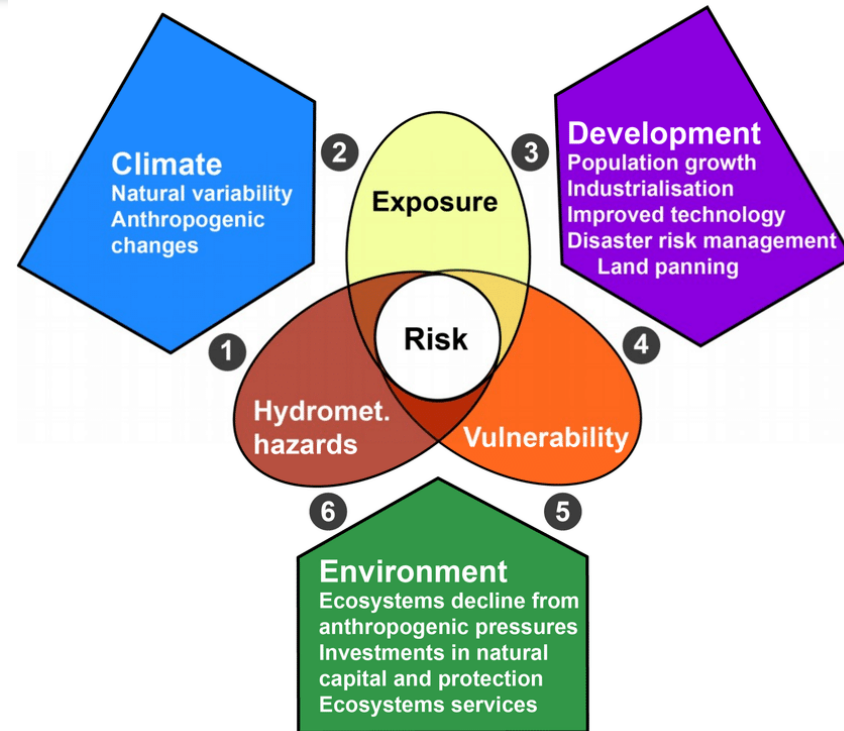
Zaporizhzhia nuclear power plant (Ukraine)

<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.

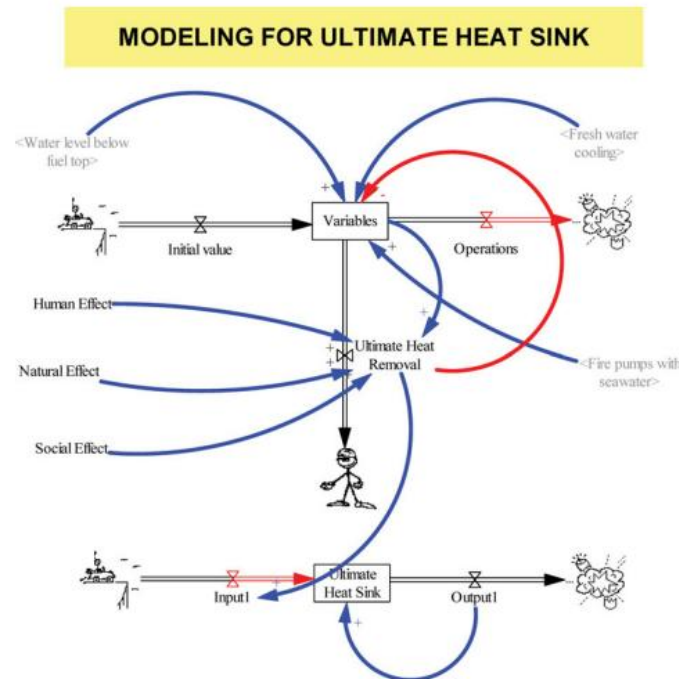


[Source: The Disaster Risk, Global Change, and Sustainability Nexus](#)

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**.



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.

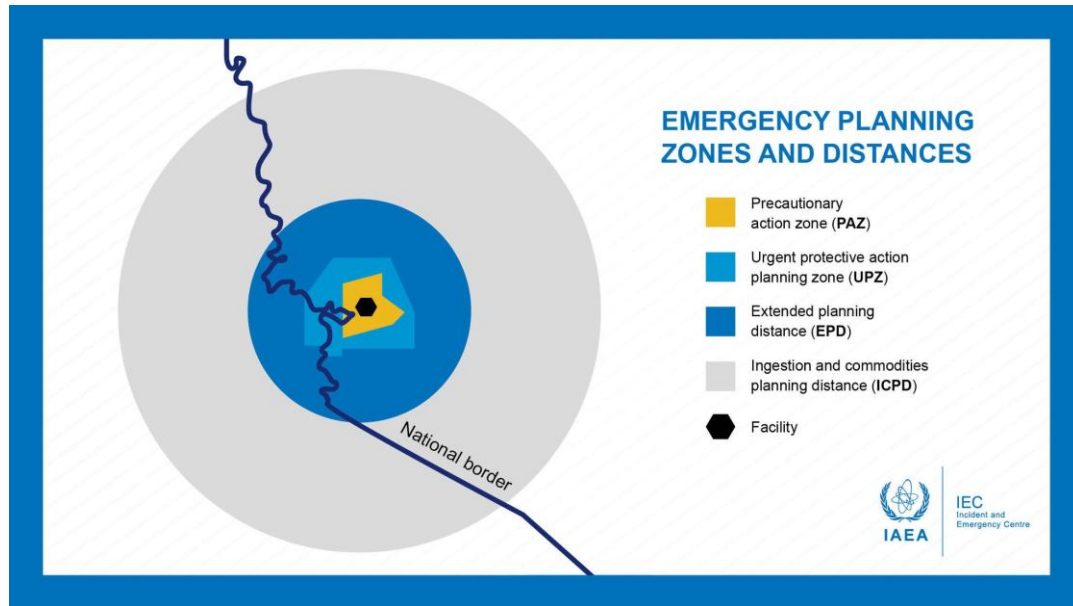


Picture: IAEA

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>

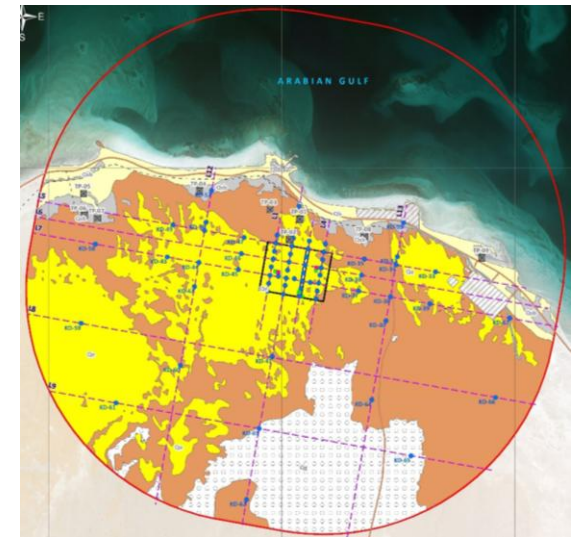
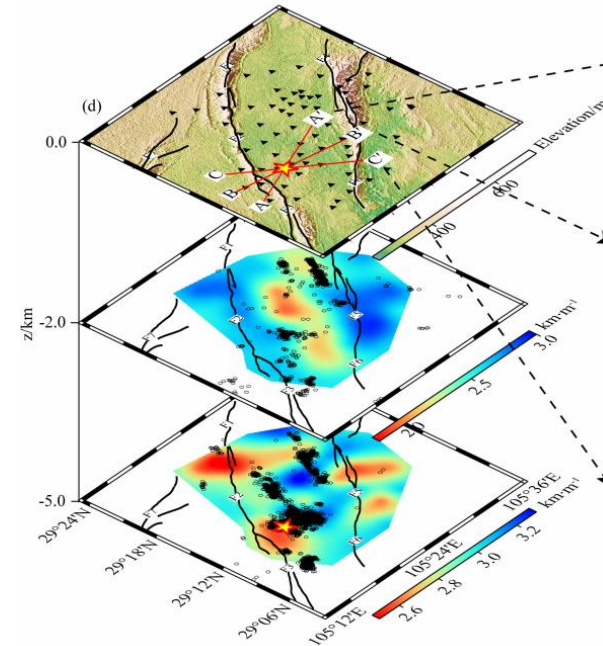
Requirement 14:

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.

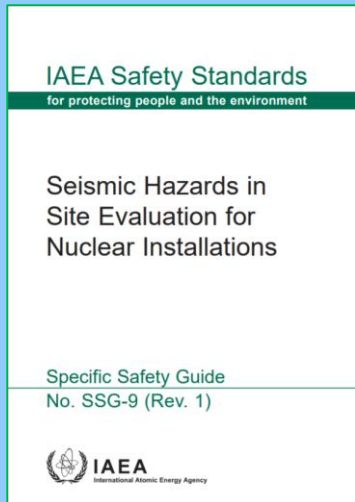


Picture: Courtesy of Mr. Arda Ozacar

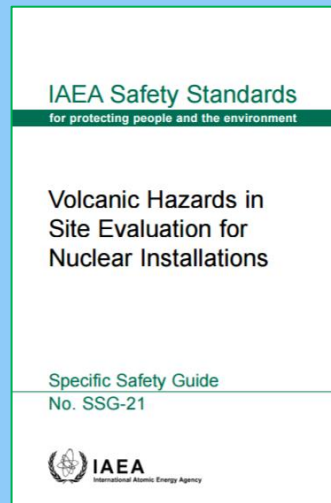
Requirements 15-24: Evaluation of external hazards and supporting safety guides

Requirement 15:
Evaluation of fault
capability

Requirement 16:
Evaluation of
ground motion
hazards



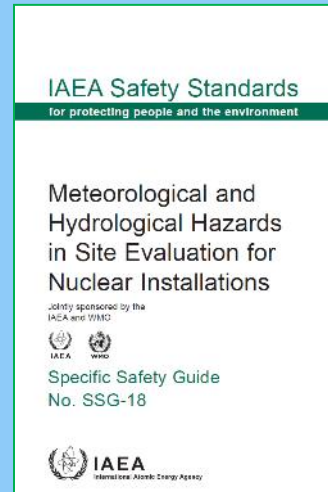
Requirement 17:
Evaluation of
volcanic hazards



Requirement 18:
Evaluation of extreme
meteorological hazards

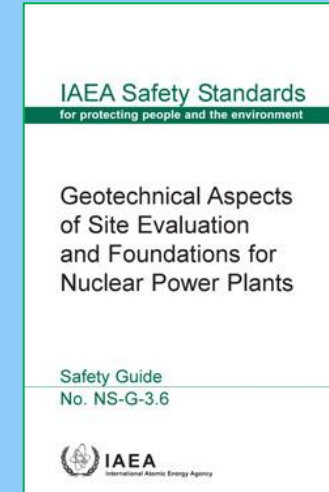
Requirement 19:
Evaluation of rare
meteorological events

Requirement 20:
Evaluation of flooding
hazards

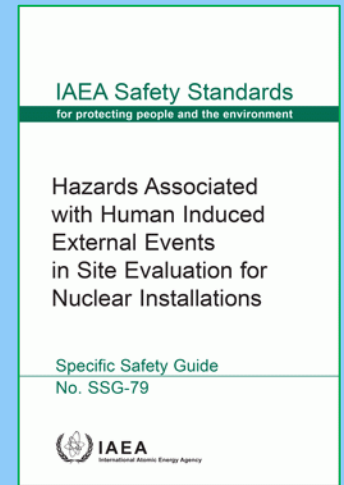


Requirement 21:
Geotechnical
characteristics and
geological features of
subsurface materials

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

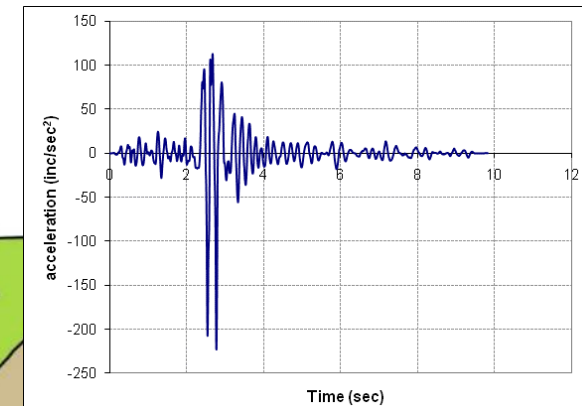
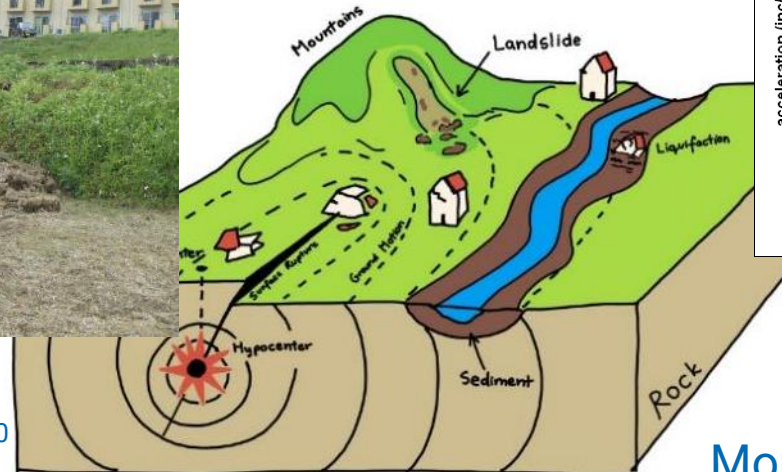
Requirements 15 and 16:

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

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...

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



<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

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



Rare meteorological events are:

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

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.

Requirement 20: Evaluation of flooding hazards

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.

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

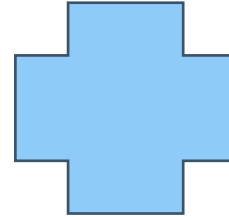


Fort Calhoun plant on June 16, 2011 during the 2011 Missouri River Floods;
<https://energynews.us/2020/08/31/report-climate-risks-compound-financial-challenges-for-midwest-nuclear-plants/>

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.



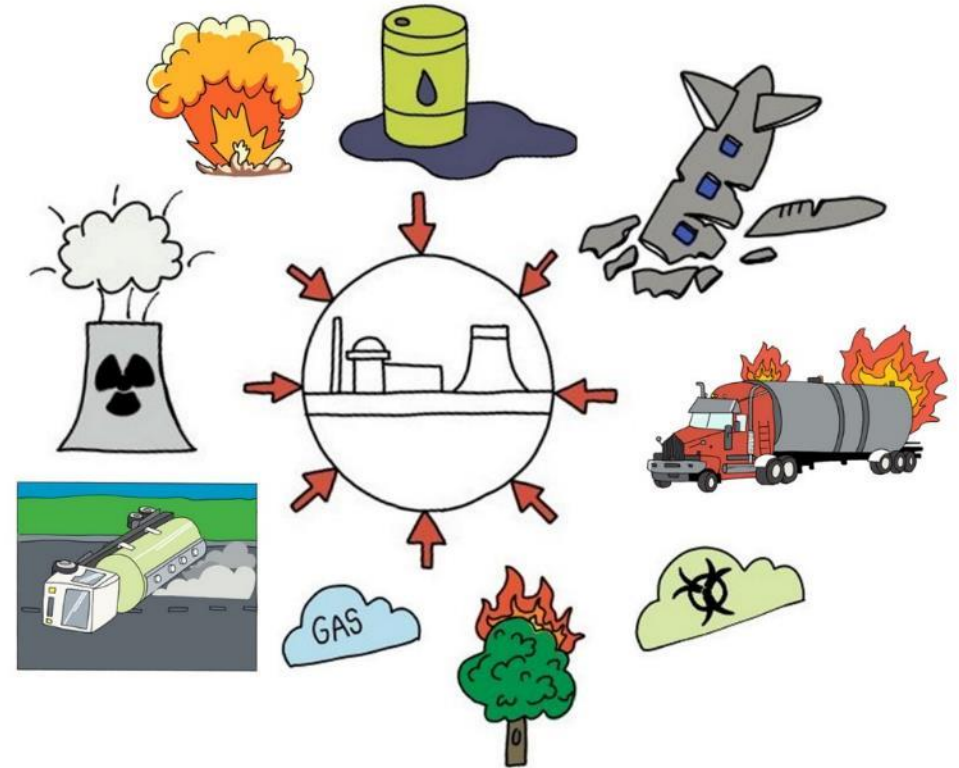
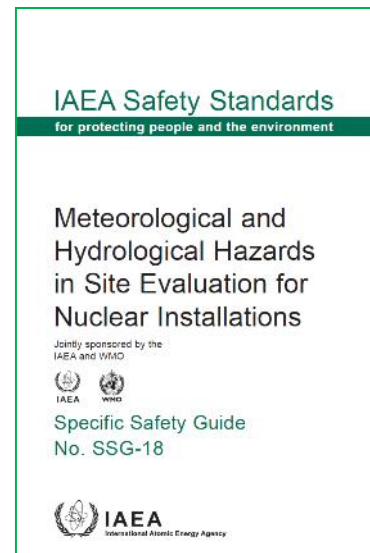
Pictures: By Mr. K. Nagasawa and Mr. K. O. Cetin

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.

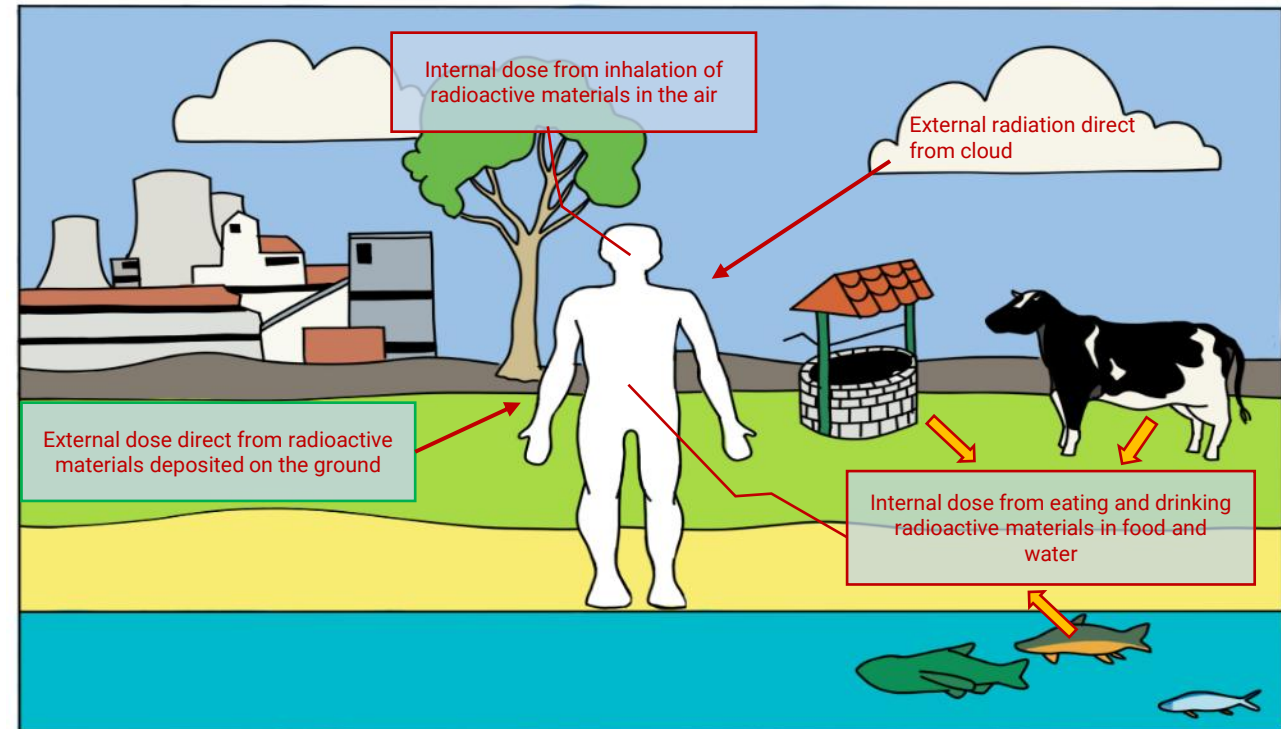
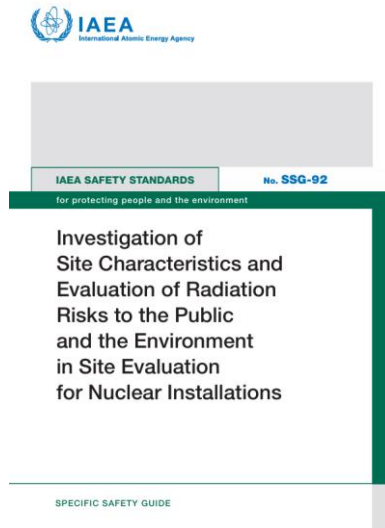


Requirement 25: Dispersion of radioactive material

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.

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

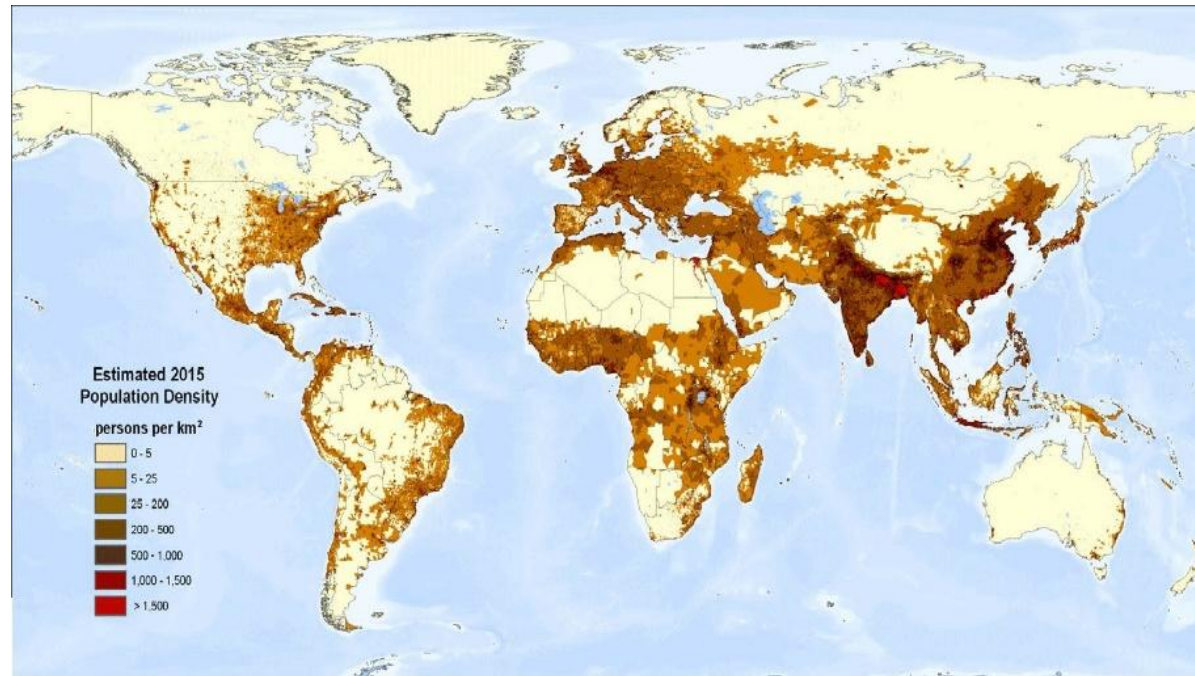


Drawn by J&A Aszódi, 2022, CC BY-SA 4.0
using inspirations from Maria del Rosario Perez et.al., WHO, 2013

Requirement 26:

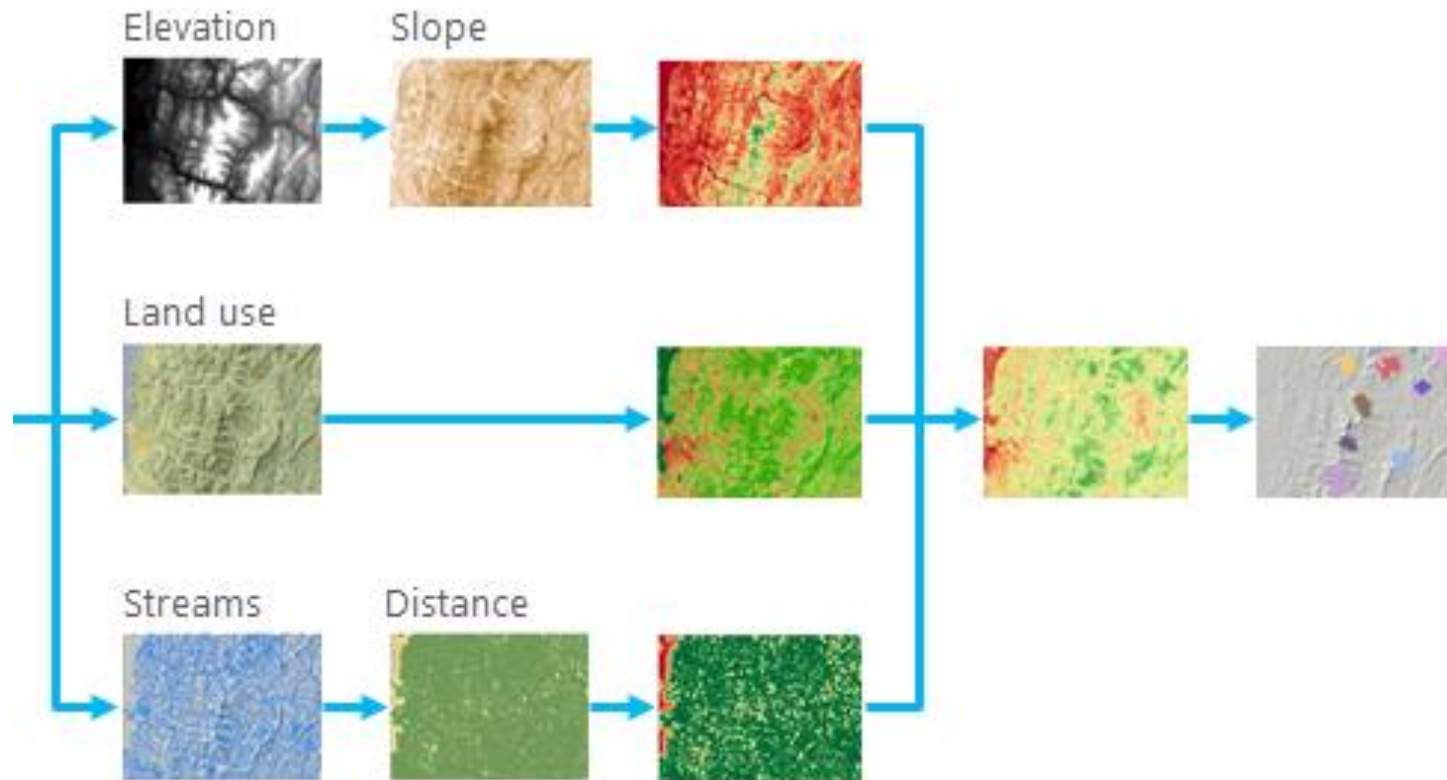
Population distribution and public exposure

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.



Requirement 27: Uses of land and water in the region

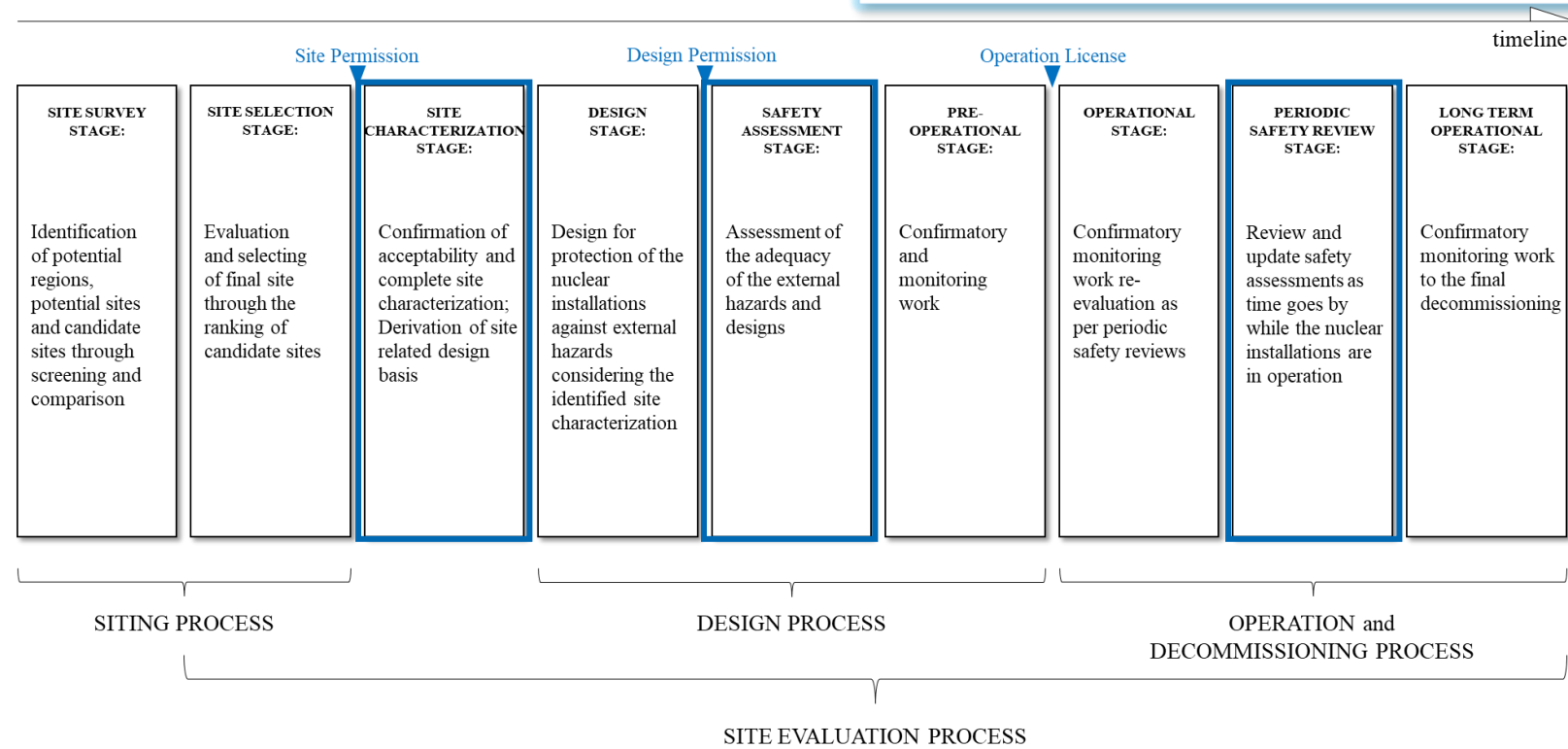
The uses of land and water shall be characterized in order to assess the potential effects of the nuclear installation on the region.



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

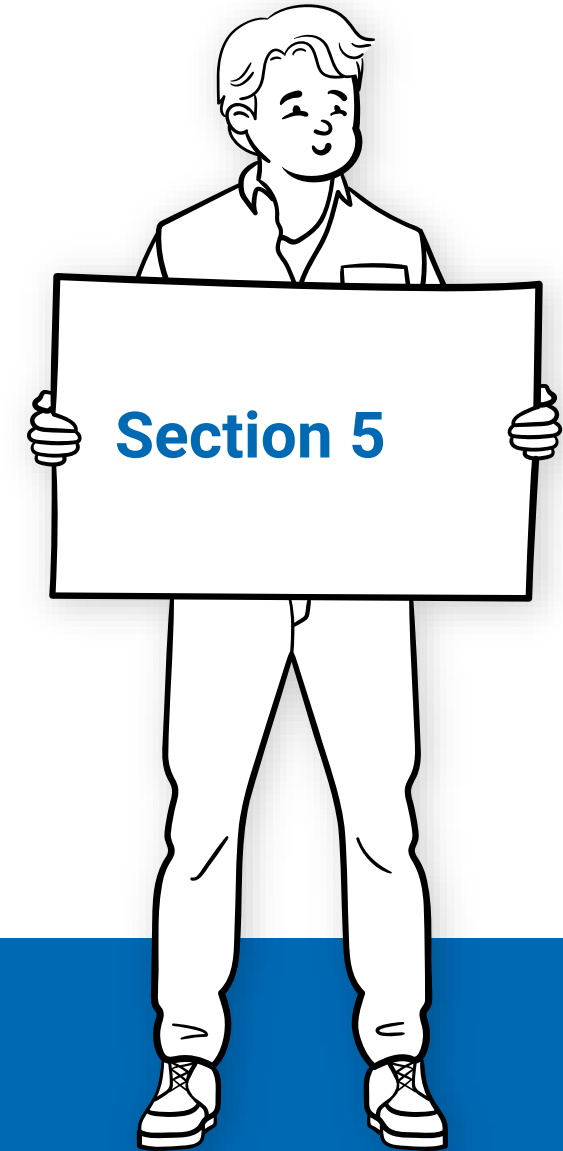
All natural and human induced external hazards and site conditions that are relevant to the licensing and safe operation of the nuclear installation shall be **monitored over the lifetime** of the nuclear installation.

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.



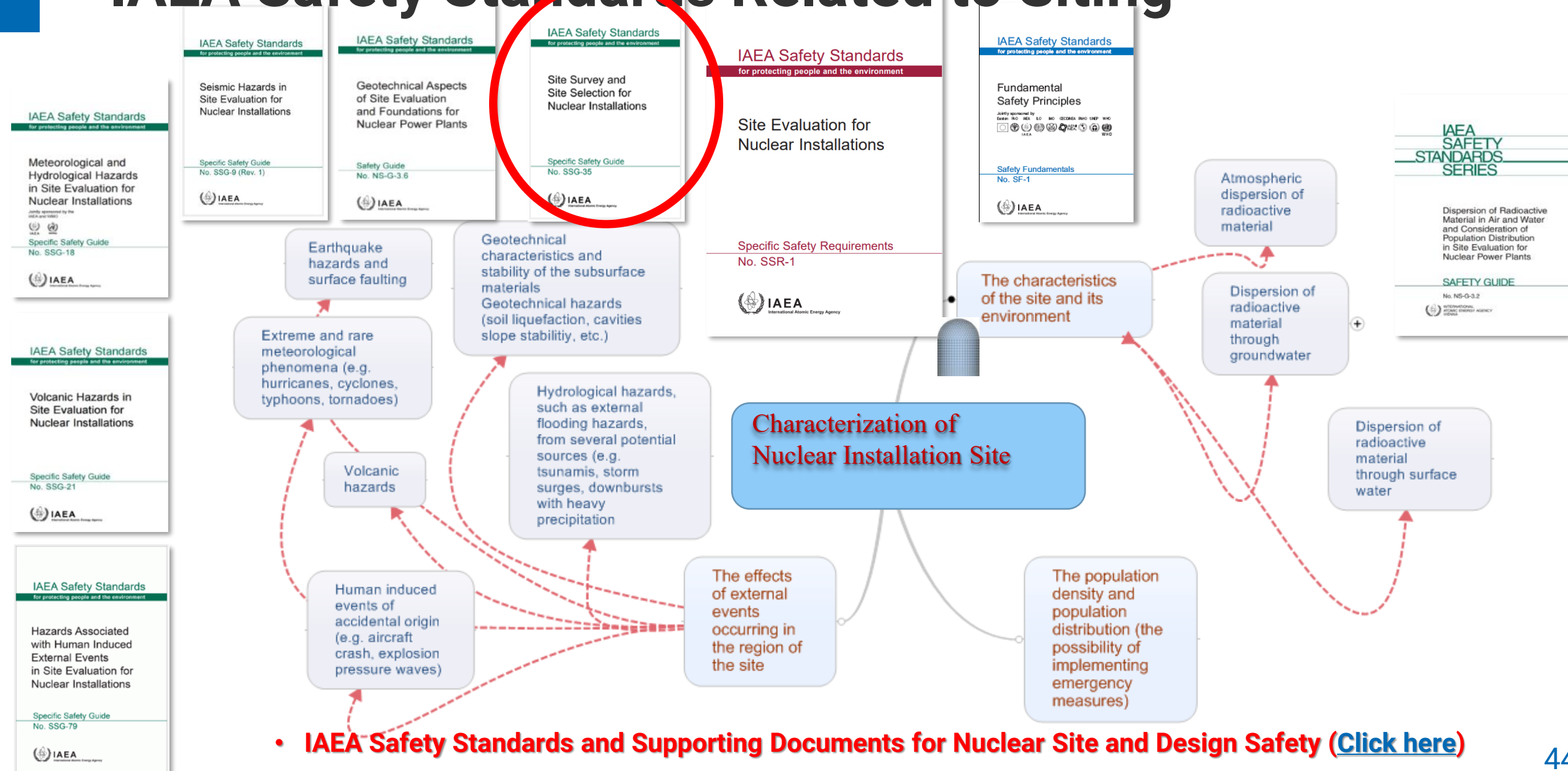
Supporting Guides

- SSR-1 provides the requirements that a regulator would check to see if a site has been properly characterized
- It is up to the owner/operator to demonstrate how the requirements have been met
- IAEA has companion guides/TECDOCs that provide more prescriptive guidance or methods



SSR-1 is focused on siting requirements, there are companion documents that provide guidance

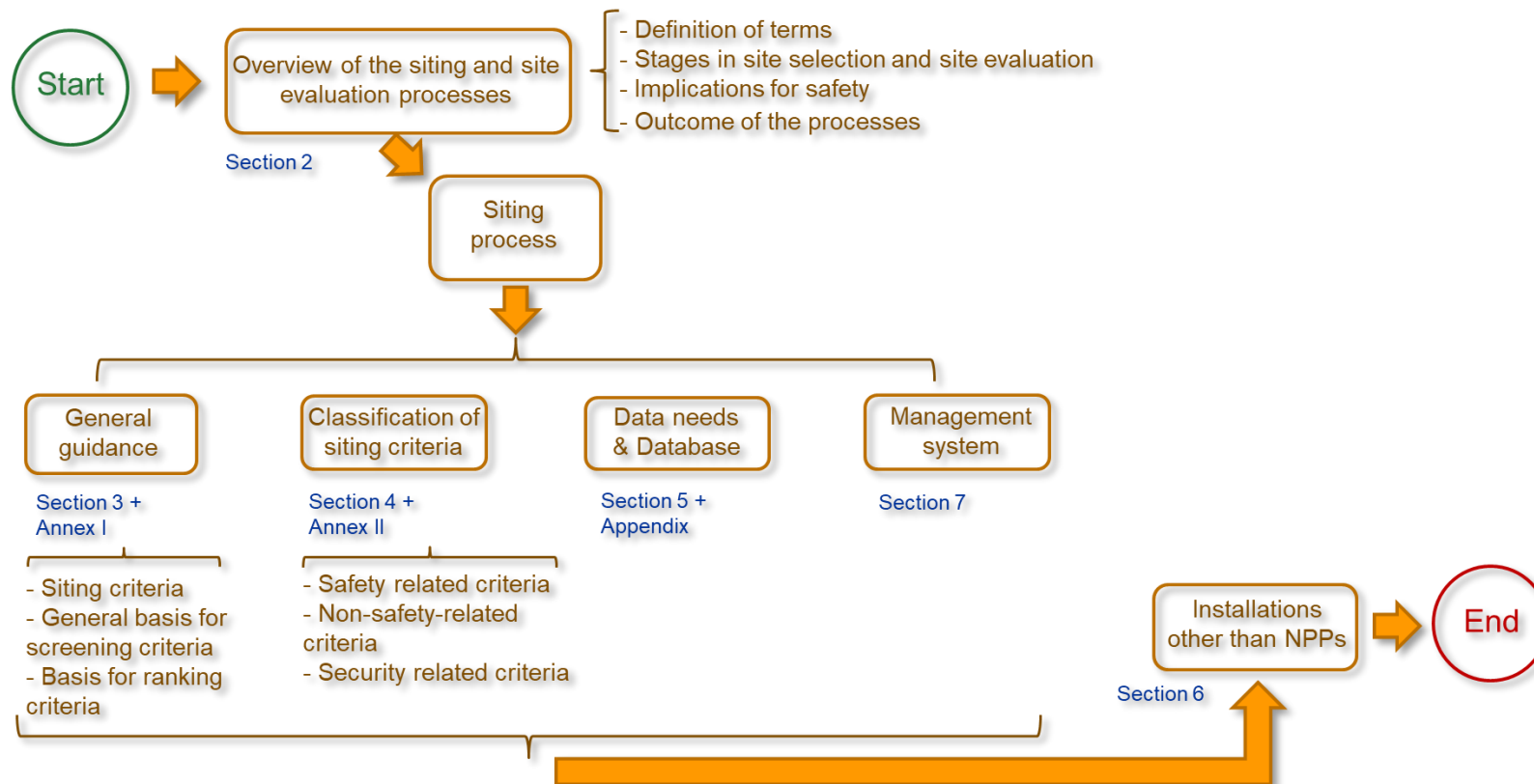
IAEA Safety Standards Related to Siting



IAEA Specific Safety Guide SSG-35

SSG-35 Site survey and site selection for nuclear installations provides guidance to address requirements in SSR-1 in relation with:

- Establishing a systematic process for site survey and site selection for a number of candidate sites
- Consideration of safety in the selection of a site



IAEA Safety Standards [SSG-35](#) ([e-book](#))

- [Online User Interface](#)

IAEA Specific Safety Guide SSG-35

The General Framework for site selection follows two processes, split into five stages

- Site Survey stage
- Site Selection stage
- Site Characterization stage (site verification and confirmation)
- Pre-Operational stage
- Operational Stage

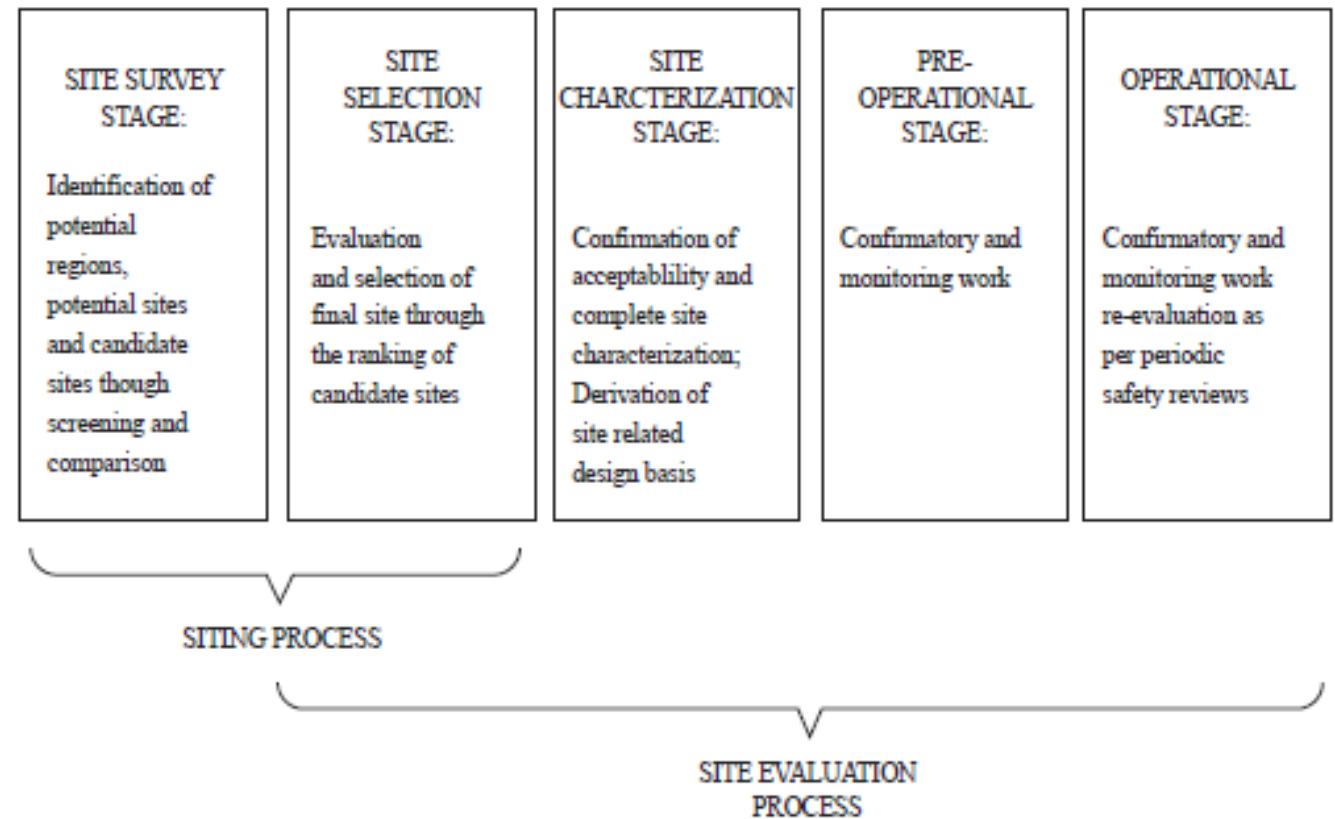


FIG. 1. Stages in the siting process and site evaluation process in the operating lifetime of a nuclear installation.

SSG-35

The siting process include separate sets of criteria that can be used for ranking or screening sites from further consideration

- Steps in Site Selection
 - Regional Analysis
 - Screening
 - Ranking
- Exclusion Criteria
 - Surface rupture
 - Liquefaction
 - Destructive Flow

Exclusion criteria are used discard sites that are unacceptable on the basis of attributes relating to issues, events, phenomena or hazards for which there are no generally practicable engineering solutions.

Some examples are given in Annex II

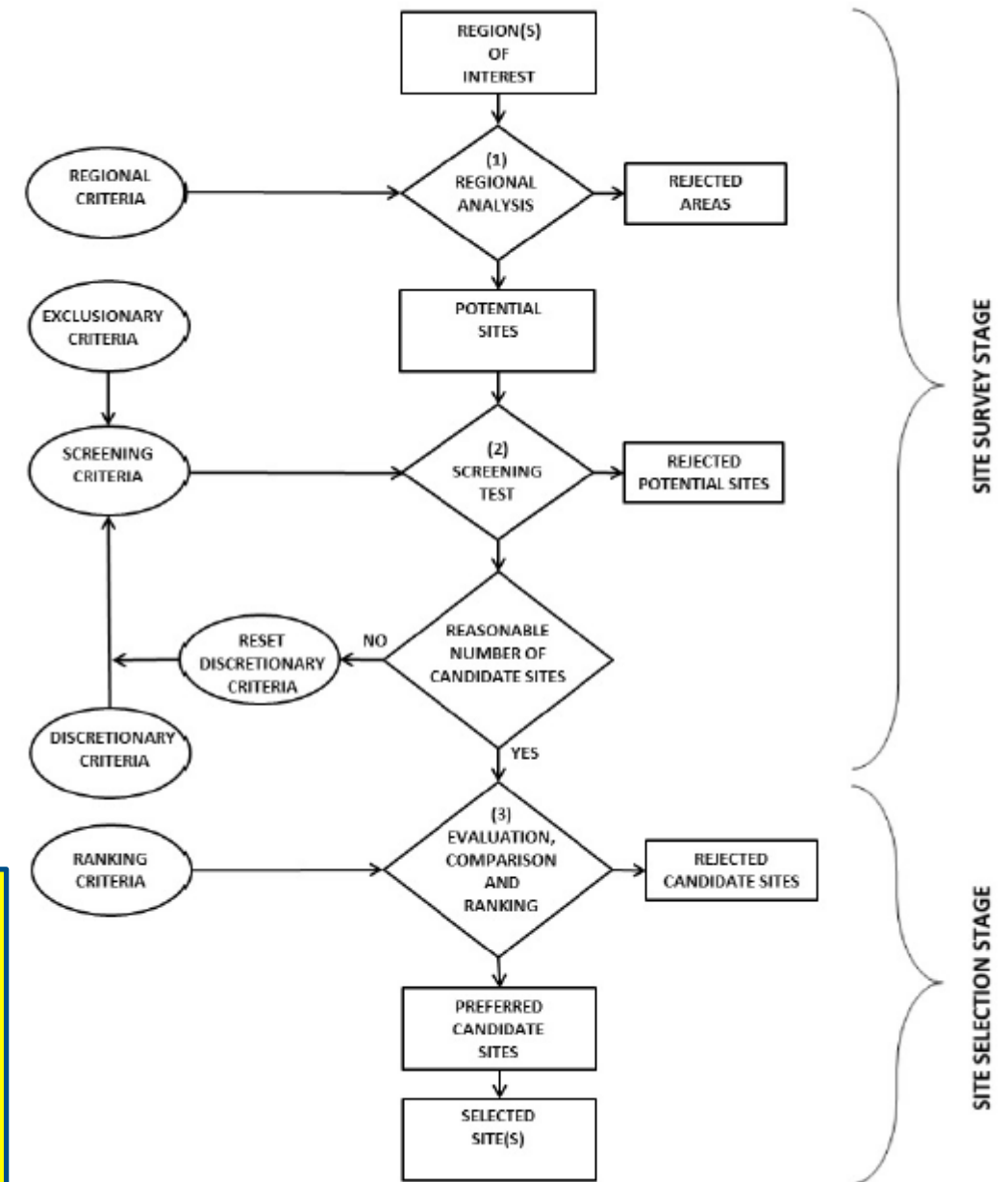


FIG. 3. Flow chart for the siting process for a nuclear installation.

Summary

1. Discussion / Brain Storming
2. The IAEA Safety Standards Series
3. Background/Fundamental Objectives of SSR-1
4. Requirements in SSR-1
5. Supporting Safety Guides/Tecdocs
6. Exclusion Criteria



What have you learned?



Thank you!

Safety-Standards.Contact-Point@iaea.org