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Site Survey and Site Selection for Nuclear Installations

Draft Specific Safety Guide No. SSG

DS433

Revision of IAEA Safety Series No. 50-SG-S9 (1984)

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CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. This Safety Guide was prepared under the IAEA's programme for safety standards. It supplements and provides recommendations on meeting the requirements for nuclear installations established in the Safety Requirements publication on Site Evaluation for Nuclear Installations [1] with respect to the safety aspects to be considered during the stages of the selection process of a site for a nuclear installation. This Safety Guide complements other Safety Guides that deal with all safety considerations in site evaluation in respect of the effects of external events occurring in the region of the particular site, the characteristics of the site and its environment that could influence the transfer to persons and to the environment of radionuclides that may be released during the operating lifetime of the installation. The Safety Guide also deals with the population density and population distribution and other characteristics of the external zone in so far as they may affect the feasibility of taking emergency actions over the expected operating lifetime of the installation.

1.2. The IAEA Safety Fundamentals publication, Fundamental Safety Principles [2], establishes that "The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation" (para. 2.1). Principle 8 of Ref. [2] on prevention of accidents states that "All practical efforts must be made to prevent and mitigate nuclear or radiation accidents". Reference [2] establishes that "The primary means of preventing and mitigating the consequences of accidents is 'defence in depth'" (para. 3.31). Defence in depth is provided by an appropriate combination of specified systems and measures, one of which is "Adequate site selection and the incorporation of good design and engineering features providing safety margins, diversity and redundancy" (para. 3.32). To apply this principle, it is required (Ref. [1], para. 2.1) that the suitability of a site for a nuclear installation be evaluated with regard to the following:

(a) The effects of external events occurring in the region of the particular site (such events could be of natural origin or human induced);
(b) The characteristics of the site and its environment that could influence the transfer to people and the environment of radionuclides that haves been released;
(c) The population density and population distribution and other characteristics of the external zone in so far as they may affect the possibility of implementing emergency measures in a nuclear or radiological emergency, and the need to evaluate the risks to individuals, people and society.

1.3. The selection and the evaluation of a site suitable for the nuclear installation are crucial. These tasks can significantly affect the costs, public acceptance and safety of the installation over its operating lifetime. The outcome of this task may even affect the success of the nuclear power project. Poor planning and execution, lack of information and lack of knowledge of international safety standards and recognized good practices could lead to faulty decision making and could cause major delays, either at the construction stage or at the operational stage of a nuclear installation. Faulty decisions made at the site selection stage might necessitate major resource commitments at a much later phase of the project. If the site related design parameters are changed during the operation stage, re-evaluation of and upgrades to the installation during operation may consequently be necessary, possibly necessitating extended shutdown periods and causing considerable costs.

1.4. The selection process for a suitable site, termed 'siting', for a nuclear installation is a multi-faceted process which includes safety considerations. With regard to accident prevention, siting is aimed at preventing accidents by reducing the exposure with external hazards associated to external events. Siting involves a comprehensive process of screening out sites for which external hazards are dominant or could become dominant and additional safety measures in the design would be excessively demanding for site utilization or sites where knowledge is not sufficient to define these measures with a sufficient degree of confidence. With regard to mitigating the consequences of accidents, siting is aimed at reducing the possible impacts of an accident on people and the environment. It involves the selection of a site with favourable dispersion characteristics for radionuclides in the air, and in surface water and sub-surface water, and also with terrain, a population distribution and an infrastructure that would facilitate the implementation of an emergency plan.

1.5. The siting process, from the beginning, has to be guided by a clearly established set of criteria consistent with the relevant regulatory requirements. Such criteria are of particular importance for those factors for which sites can be excluded. A balance has to be established between the characteristics of a site, and specific design features, site protection measures and administrative procedures.

1.6. The Safety Requirements publication on Site Evaluation for Nuclear Installations [1] was published in 2003. That safety standard deals with the requirements for the full characterization of the site for a nuclear installation from the safety point of view, covering the entire process of the site evaluation, from the site selection stage, to the site characterization, the pre-operational and the operational stages. Thus, Ref. [1] does not cover

the initial stage of the siting process, site survey, when studies and investigations at the regional level are performed to identify potential sites from which candidate sites are chosen.

1.7. The previous IAEA Safety Guide on Site Survey for Nuclear Power Plants, IAEA Safety Series No. 50-SG-S9, was published in 1984[1]. The revision was necessary to update the recommendations and guidance and to bring the Safety Guide into consistency with the existing safety requirements established in Refs [1] and [3], particularly as they relate to exclusionary criteria, and with other Safety Guides that provide recommendations relevant to the early stages of site evaluation especially [4–9].

1.8. The TEPCO Fukushima Daiichi nuclear power plant accident in Japan in March 2011 highlighted the importance of proper site selection in a nuclear power programme. The approach in this Safety Guide ensures that issues associated with site safety are considered early in the process and that alternative sites are available in the event that the selected site does not meet the requirements on the basis of the detailed site characterization. It is important that external hazards are identified early to allow for adequate consideration of protective measures that may be necessary to provide sufficient defence in depth.

1.9. Terms in this publication are to be understood as defined and explained in the IAEA Safety Glossary [10], unless otherwise stated.

OBJECTIVE

1.10. The objective of this Safety Guide is to provide recommendations and guidance on meeting the requirements [1] for the consideration of safety in the siting process for a nuclear installation in order to meet the fundamental safety objective of the Safety Fundamentals [2]. Recommendations are provided on criteria and approaches for identifying suitable sites for nuclear installations that comply with established safety requirements. The Safety Guide provides recommendations and guidance on establishing a systematic process for site survey and site selection for a number of preferred candidate sites, from which one could be selected for the construction and operation of a nuclear installation.

1.11. This Safety Guide is intended for use by the organizations having an interest in the siting process, including government bodies, future licensees (generally the operating organizations) and their contractors. This Safety Guide also has an informative role for the regulatory body since siting is a non-regulated process and does not require regulatory actions.

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Site Survey for Nuclear Power Plants, Safety Series No. 50-SG-S9, IAEA, Vienna (1984).

1.12. The site should be deemed to be unsuitable for the purposes of licensing the proposed installation if it is concluded during detailed characterization of external hazards that no engineering solutions exist to design protective measures against those hazards that challenge the safety of the nuclear installation, or there are no adequate measures to protect people against unacceptable radiological risks.

1.13. The future operator of the proposed installation on the site should have an early role to play in reviewing and accepting work done during siting, even if the future operator do not have a direct role in selecting the site.

SCOPE

1.14. This Safety Guide addresses the consideration of safety in the siting process for a nuclear installation. It is recognized that there are other important factors in the siting process, possibly both on safety and non-safety issues, such as nuclear security considerations, technology, economics, land use planning, availability of cooling water, non-radiological environmental impacts and socio-economic impacts, including the opinion of interested parties, including the public. As the siting process progresses, more and more sites are screened out. For the few potential sites that remain, safety considerations will become more pronounced.

1.15. The difference between the investigation processes of site survey and site evaluation may not be very distinct and it will depend on the methodology and technology used. There is a transition between these two stages of assessment. This Safety Guide covers the process that eventually terminates in the selection of a site(s) for one or more nuclear installations. It covers site evaluation only to the extent necessary for understanding in the context.

1.16. As well as providing recommendations and guidance on the siting of a nuclear installation at a new site, this Safety Guide also provides recommendations with regard to the collocation of a new installation at an existing site.

1.17. This Safety Guide addresses a range of types of nuclear installation [2]. The methodologies recommended for nuclear power plants are applicable to other nuclear installations through a graded approach. The recommendations can be tailored to meeting requirements for different types of nuclear installation in accordance with the potential

[2] The term ‘nuclear installation’ includes: nuclear power plants; research reactors (including subcritical and critical assemblies) and any adjoining radioisotope production facilities; spent fuel storage facilities; 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; and nuclear fuel cycle related research and development facilities.

radiological consequences of accidents. The recommended direction of grading is to start with attributes relating to nuclear power plants and if possible to grade down to installations with which lesser radiological consequences are associated[3]. If no grading is performed, the recommendations relating to nuclear power plants (Sections 2–5) are applicable to other types of nuclear installation.

1.18. This Safety Guide does not provide recommendations and guidance on site characterization for a site and does not establish an assessment of the site hazards for use in the design evaluation for licensing purpose. The guidelines for final site characterization or re-evaluation as part of a periodic safety review are given in Ref. [4–9].

1.19. This Safety Guide refers to but does not provide guidance on considerations relating to nuclear security. Nuclear security is covered in the IAEA Nuclear Security Series of publications.

STRUCTURE

1.20. Section 2 addresses the siting and site evaluation processes. Section 3 provides general recommendations for site selection for a nuclear installation. Section 4 describes classification of criteria for the siting process. Section 5 provides recommendations and guidance with regard to investigations necessary for the different stages of the site survey and site selection process (database). Section 6 deals with the site survey and site selection process for a nuclear installations other than a nuclear power plant and recommends a graded approach for dealing with such installations. Section 7 provides recommendations for the management system. The Appendix provides recommendations for the database for the siting process. Annex I presents tables to be used in the siting process, including criteria for screening and ranking. Annex II provides example of criteria for the siting process for nuclear power plants. The numerical values provided in the annexes are examples only of those used in some States.

2. GENERAL DESCRIPTION OF THE SITING PROCESS AND THE SITE EVALUATION PROCESS

2.1. There are two processes relating to the safety considerations for the site of a nuclear installation — siting and site evaluation. These two processes are further split into five stages:

– site survey stage;

[3] For sites at which nuclear installations of different types are collocated, particular consideration should be given to the use of a graded approach so that siting evaluation is commensurate with that for the most potentially hazardous nuclear installations.

– site selection stage;

– site characterization stage (site verification and site confirmation);

– pre-operational stage; and

– operational stage.

The framework for the site survey stage and the site evaluation stage is elaborated in the schematic representation shown in Fig. 1.

2.2. Siting is the process of selecting a suitable site for a nuclear installation. The selection of a suitable site is one of the elements of the concept of defence in depth for preventing accidents as stated in Principle 8 of the Fundamental Safety Principles [2].

2.3. The siting process and the site evaluation process include five different stages. The siting process for a nuclear installation consists of the first two stages of these five, i.e. site survey and site selection (see Fig. 1). In the site survey stage, large regions are investigated to find potential sites and to identify one or more candidate sites. The second stage of the siting process is site selection, in which unsuitable sites are rejected and the remaining candidate sites are assessed by screening and comparing them on the basis of safety and other considerations to arrive at the preferred candidate sites.

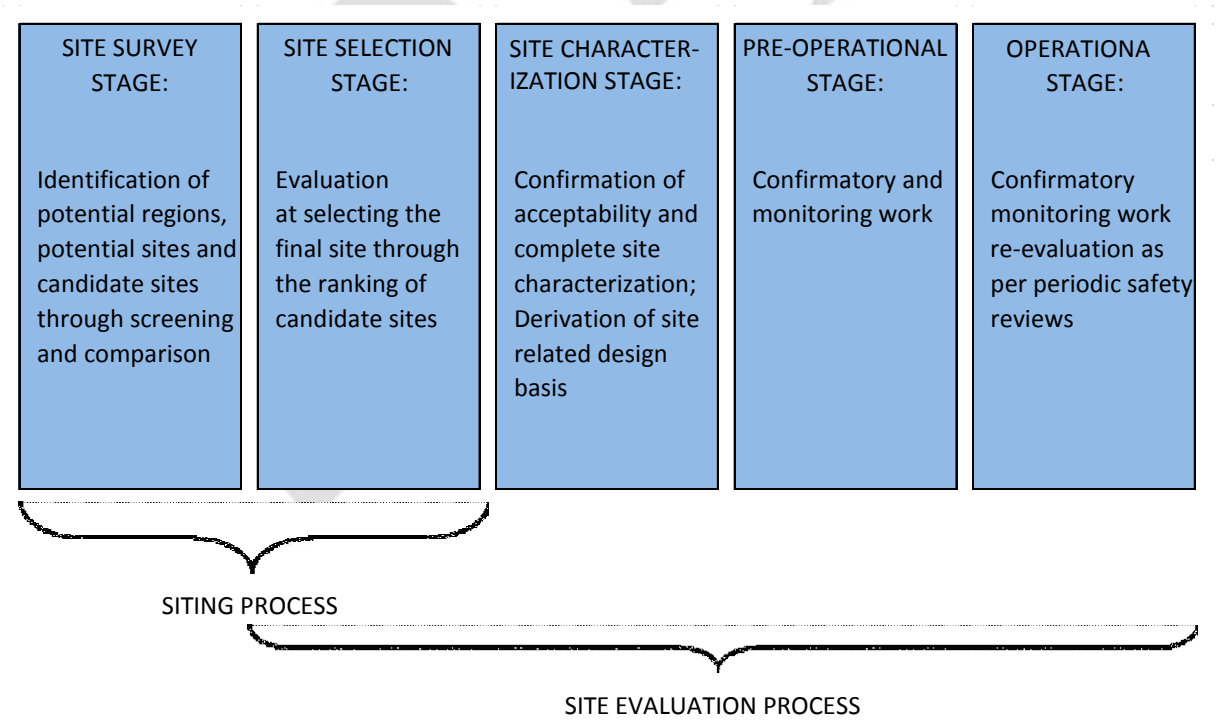

Fig. 1. Siting process and site evaluation processes in the operating lifetime of a nuclear installation.

2.4. Site evaluation[4] is the process that extends from: (a) the last stage of the siting process (i.e. the stage of evaluation of the candidate sites in order to arrive at the preferred candidate site(s)); to (b) the detailed site characterization stage for the selected site to confirm its suitability, its characterization and derivation of the site related design bases for the nuclear installation; to (c) the confirmation and completion of the assessment at the pre-operational stage for the installation (i.e. during the design, construction, assembly and commissioning stages); and finally to (d) the operational stage of the installation included within the framework of periodic safety review (see paras 1.8 and 1.14 of Ref. [1]). Thus, site evaluation continues throughout the operating lifetime of the installation, with appropriate components covered in the final safety analysis report, to take into account changes in site characteristics, the availability of data and information, operational records, regulatory approaches, evaluation methodologies and safety standards [1, 4–9].

2.5. The second stage of the siting process, site selection, includes part of the site evaluation process and is the overlapping stage between the siting process and the site evaluation process (see Figs 1 and 2). After the site selection stage, the suitability of the site is confirmed and a complete site characterization[5] is performed, together with finalizing the derivation of the design bases due to external events during the site characterization stage. This process eventually leads to the preparation of the site evaluation report as a basis for the Site section of the[6] preliminary safety analysis report for the nuclear installation. All the site related activities, involving confirmatory and monitoring work, are taken up in the pre-operational stage[7]. Following the approval of the final safety analysis report for the nuclear installation, the site evaluation at the operational stage[8] starts. This includes all confirmatory, monitoring and re-evaluation work conducted throughout the operational stage and, especially, during periodic safety reviews of the installation. This work is generally reported

[4] Site evaluation is defined as analysis of those factors at a site that could affect the safety of a facility or activity on that site. This includes site characterization, consideration of factors that could affect safety features of the facility or activity so as to result in a release of radioactive material and/or could affect the dispersion of such material in the environment, as well as population and access issues relevant to safety (e.g. feasibility of evacuation, location of people and resources) [10].

[5] The site characterization stage is further subdivided into: site verification, in which the suitability of the site to host a nuclear installation is verified mainly according to predefined site exclusion criteria; and site confirmation, in which the characteristics of the site necessary for the purposes of analysis and detailed design are determined.[10]

[6] Other terms are used in some States, e.g. preliminary safety case.

[7] In the pre-operational stage, studies and investigations begun in the previous stages are continued after the start of construction and before the start of operation of the nuclear installation, to complete and refine the assessment of site characteristics. The site data obtained allow a final assessment of the simulation models used in the final design.

[8] At the operational stage, appropriate safety related site evaluation activities are carried out over the operating lifetime of the nuclear installation, mainly by means of monitoring and periodic safety review.

in periodic safety review reports. Outcomes in comparison with those for the stages of the siting process and the site evaluation process are described in Fig. 2.

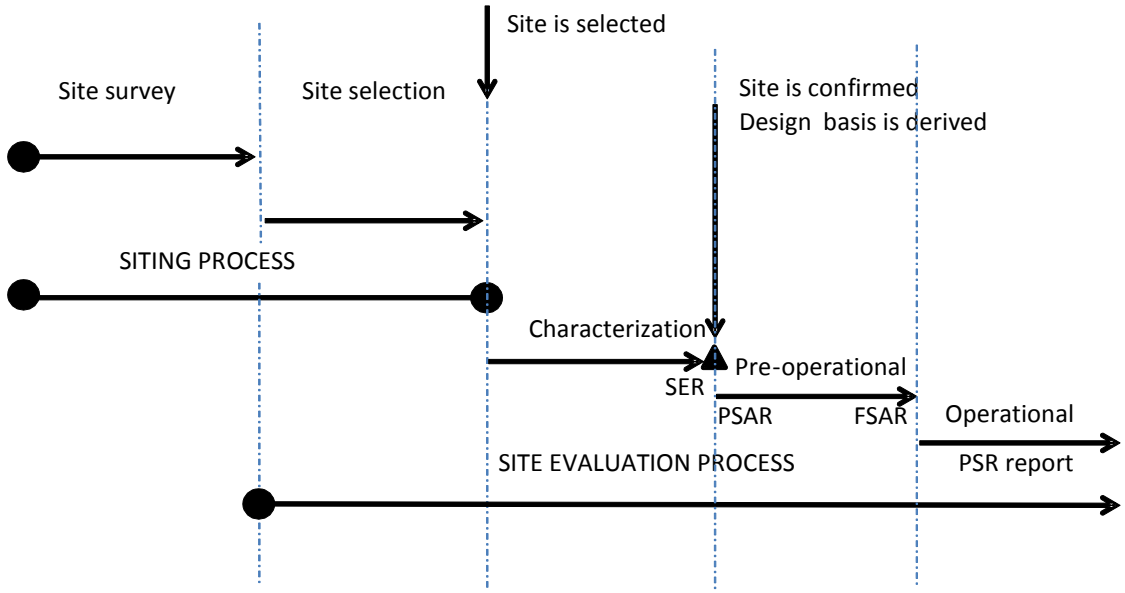

Fig. 2. Outcome of the siting process and site evaluation processes for a nuclear installation. FSAR: final safety analysis report; PSAR: preliminary safety analysis report; PSR: periodic safety review; SER: site evaluation report.

2.6. In most States siting is a non-regulated activity and no licence is required. Siting and site evaluation processes should be consistent with the licensing process as specified by the regulatory body and should be consistent with the applicable IAEA safety standards on this topic [11, 12].

2.7. There are three important steps that should receive input from the site survey, site selection and site evaluation processes before construction starts. These are:

(a) The decision regarding the 'suitability' of the preferred site, i.e. confirmation that the site has no characteristics that would preclude the safe operation of a nuclear installation;

(b) The definition of the site related design basis parameters on the basis of the site evaluation report;

(c) The edition of the preliminary safety analysis report or preliminary safety case which, among other things, demonstrates that the site related design basis parameters have been appropriately taken into account, in particular through the design features of the nuclear installation and the measures to be taken for site protection.

3. GENERAL RECOMMENDATIONS FOR THE SITING PROCESS

SITING PROCESS

3.1. The siting process is aimed to select suitable locations for the envisaged nuclear installation such that its characteristics are compatible with available engineering protective measures for all natural and human induced hazards arising from external events, so that the necessary level of safety can be achieved. Furthermore, the surrounding demographic setting and dispersion characteristics should be such as to limit the exposure of the population for any plant state to as low as reasonably achievable, and allow the implementation of measures for mitigating the consequences in the case of an accidental release of radionuclides over the operating lifetime of the installation.

3.2. The siting process consists of a series of related activities with the objective of selecting suitable sites for a new nuclear installation. The process should systematically and successively apply a number of screening criteria to screen out those sites with attributes which contribute unfavourably to the safety of the installation Details of a siting process for a nuclear installation are given in Fig. 3.

3.3. The siting process has three distinct steps starting with the given region(s) of interest.

(1) *Regional analysis*: This is the first step, in which region(s) of interest are analysed to identify potential sites. All potential sites in a region should be taken to the next step (screening) unless their exclusion can be appropriately justified.

(2) *Screening*: In the second step, the potential sites are screened to choose the candidate sites. The principal objective of this step is to exclude unfavourable sites on the basis of safety related considerations as well as non-safety related considerations.

(3) *Evaluation, comparison and ranking*: The purpose of the third step is twofold: (i) to evaluate the sites in order to ensure that there are no features (at the sites or in their surrounding area) that would preclude the construction and operation of the nuclear installation, and (ii) to compare the candidate sites and to rank them in order of their attractiveness as possible sites for a nuclear installation.

3.4. Detailed examination later, at the site characterization stage, may lead to a candidate site being found unsuitable and thus excluded. In order to cater for such situations, candidate sites should therefore be placed in an order of preference to allow the selection of a potentially suitable alternative site.

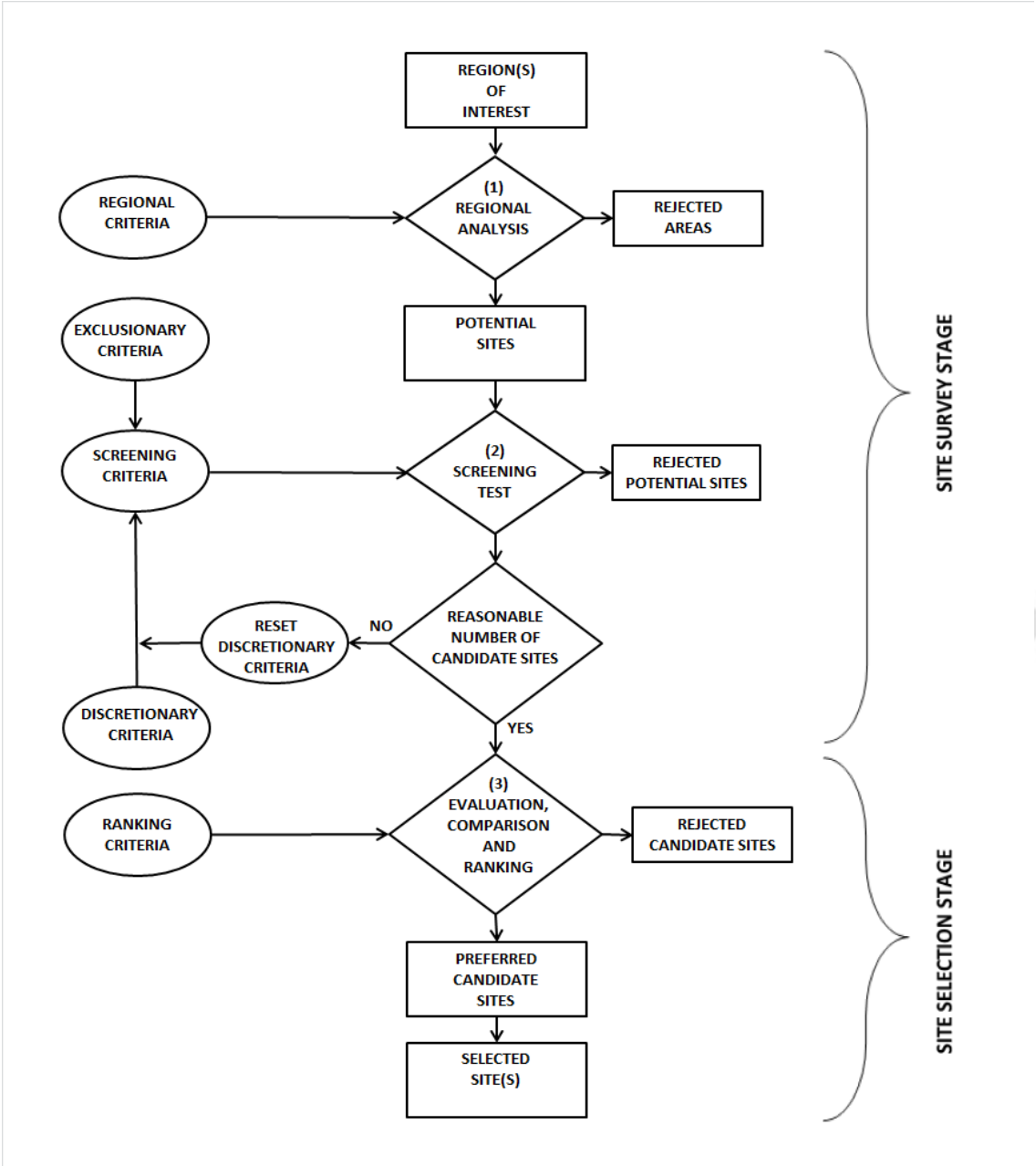

Fig. 3. Flow chart for the siting process for a nuclear installation.

3.5. The siting process is completed once the site on which the nuclear installation will be located is selected from the list of preferred candidate sites. The final selection is generally done by the government or operating organization (future licensee) for the nuclear installation taking input from all the relevant stakeholders. The operating organization/future licensee should be involved from the outset of the siting.

SITING CRITERIA

3.6. Siting criteria are the bases on which decisions are made on the site attributes in the different steps of the siting process. Siting criteria are used to evaluate specific site related issues, events, phenomena, hazards and other considerations after the site has been

investigated and analysed. It is apparent from Fig. 3 that there should be three categories of siting criteria: regional criteria, screening criteria and ranking criteria.

3.7. The regional analysis should be done to identify potential sites using well established regional criteria. Regional criteria are generally related to national domestic policy, national economic policy, national and international environmental protection or other related policies of the State. Technical constraints and the availability of resources (e.g. infrastructural constraints, availability of water) on a regional basis should also be important considerations for regional analysis. The regional criteria should identify all possible potential sites and it is important that none should be discarded without appropriate justification.

3.8. The screening of potential sites should be conducted using screening criteria of two types:

- *Exclusion criteria*: the exclusion criteria are used to discard sites that are unacceptable on the basis of those attributes related to issues, events, phenomena or hazards for which there are no generally practicable engineering solutions.
- *Discretionary criteria*: the discretionary criteria are associated with those attributes relating to issues, events, phenomena hazards, or other considerations, for which protective engineering solutions are available. These criteria, listed in Table I-1 of Annex I, are used to facilitate the selection process through iterative screening to eliminate less favourable sites when there are a large number of possible candidate sites.

3.9. The resulting candidate sites should then be placed in the order of preference through an exercise of comparison and ranking using suitable ranking criteria.

3.10. The screening criteria and ranking criteria consist of both safety related and non-safety-related criteria. Screening criteria and ranking criteria are further elaborated in Annex I.

GENERAL BASIS FOR SCREENING CRITERIA

3.11. Exclusion criteria should be established and used as part of the screening at the site survey stage. Screening by exclusion criteria enables sites with unfavourable characteristics to be excluded from further consideration.

3.12. Exclusion criteria should be selected for the negative attribute of a site characteristic, or for any site related issue, event, phenomena or hazard for which engineering, site protection or administrative measures are not available or are excessively demanding.

3.13. Exclusion criteria encompass not only inherent weaknesses in a site's characteristics, but also the feasibility of engineering solutions to compensate for such weaknesses, either through design or through site protection measures. Therefore, existence of a certain hazard or even the high likelihood of its occurrence should not constitute the sole basis upon which an exclusion criterion is based. Screening out on the basis of an arbitrary criterion may lead to the discarding of a site having otherwise favourable qualities for safety and may finally result in the choice of a site that is less 'safe' than the site that has been discarded.

3.14. Discretionary criteria should be redefined:

- to decrease the number of possible candidate sites if their number is too large to conduct the exercise of comparison and ranking.
- to increase the number of candidate sites if their number is too small or if there are none...

This is generally an iterative process in which criteria may be made more or less strict depending on the desired number of potential sites for further consideration. Attributes related to these criteria are also used for preliminary evaluation of site in the site selection stage of the siting process.

3.15. As a result of the iterative screening of potential sites, a number of candidate sites are identified. If candidate sites are distributed in two or more regions with different attributes, it would preclude the possibility of the elimination of all the candidate sites on the basis of common and regional shortcomings; e.g. for two candidate sites that are geographically widely separated, the seismic hazard may differ widely at the two sites, which reduces the risk of both sites being eliminated later in the siting process owing to concerns over the seismic safety of proposed nuclear installations

3.16. The siting process for a nuclear installation is expected to be completed using existing data. However, at an early stage, especially the site survey stage, it may not always be possible to collect a sufficient amount of good quality data on which such a decision could be based with adequate certainty. In such a case, additional data should be collected to confirm the suitability of the site in the subsequent site selection stage. Some preliminary field investigation, if required, should also be conducted at this stage.

3.17. Data collection in relation to potential and candidate sites should focus in particular on attributes of the sites that are relevant to the exclusion criteria

SPECIFIC SCREENING CRITERIA

3.18. The site safety requirements cited in Ref. [1] are the primary source for establishing the screening criteria. They are reproduced below:

> "2.27. In relation to the characteristics and distribution of the population, the combined effects of the site and the installation shall be such that:
>
> (a) For operational states of the installation the radiological exposure of the population remains as low as reasonably achievable and in any case is in compliance with national requirements, with account taken of international recommendations;
> (b) The radiological risk to the population associated with accident conditions, including those that could lead to emergency measures being taken, is acceptably low. "
>
> "2.28. If, after thorough evaluation, it is shown that no appropriate measures can be developed to meet the above mentioned requirements, the site shall be deemed unsuitable for the location of a nuclear installation of the type proposed".
>
> "2.29. The external zone for a proposed site shall be established with account taken of the potential for radiological consequences for people and the feasibility of implementing emergency plans, and of any external events or phenomena that may hinder their implementation Before construction of the plant is started, it shall be confirmed that there will be no insurmountable difficulties in establishing an emergency plan for the external zone before the start of operation of the plant."
>
> "3.7. Where reliable evidence shows the existence of a capable fault that has the potential to affect the safety of the nuclear installation, an alternative site shall be considered."
>
> "3.35. Geological maps and other appropriate information for the region shall be examined for the existence of natural features such as caverns, karstic formations and human made features such as mines, water wells and oil wells. The potential for collapse, subsidence or uplift of the site surface shall be evaluated.
>
> "3.36. If the evaluation shows that there is a potential for collapse, subsidence or uplift of the surface that could affect the safety of the nuclear installation, practicable engineering solutions shall be provided or otherwise the site shall be deemed unsuitable."

“3.38. The potential for liquefaction of the subsurface materials of the proposed site shall be evaluated by using parameters and values for the site specific ground motion.”

“3.40. If the potential for soil liquefaction is found to be unacceptable, the site shall be deemed unsuitable unless practicable engineering solutions are demonstrated to be available.”

“3.44. The potential for aircraft crashes on the site shall be assessed with account taken, to the extent practicable, of characteristics of future air traffic and aircraft.

“3.45. If the assessment shows that there is a potential for an aircraft crash on the site that could affect the safety of the installation, then an assessment of the hazards shall be made.

“3.46. The hazards associated with an aircraft crash to be considered shall include impact, fire and explosions.

“3.47. If the assessment indicates that the hazards are unacceptable and if no practicable solutions are available, then the site shall be deemed unsuitable.”

“3.49. Hazards associated with chemical explosions shall be expressed in terms of overpressure and toxicity (if applicable), with account taken of the effect of distance.

“3.50. A site shall be considered unsuitable if such activities take place in its vicinity and there are no practicable solutions available.”

“3.51. The region shall be investigated for installations (including installations within the site boundary) in which flammable, explosive, asphyxiant, toxic, corrosive or radioactive materials are stored, processed, transported and otherwise dealt with that, if released under normal or accident conditions, could jeopardize the safety of the installation.... If the effects of such phenomena and occurrences would produce an unacceptable hazard and if no practicable solution is available, the site shall be deemed unsuitable.”

“3.54. Potential natural and human induced events that could cause a loss of function of systems required for the long term removal of heat from the core shall be identified, such as the blockage or diversion of a river, the depletion of a reservoir, an excessive amount of marine organisms, the blockage of a reservoir or cooling tower by freezing or the formation of ice, ship collisions, oil spills and fires. If the probabilities and consequences of such events cannot be reduced to acceptable levels, then the hazards for the nuclear installation associated with such events shall be established.

"3.55. If the hazards for the nuclear installation are unacceptable and no practicable solution is available, the site shall be deemed unsuitable."

BASIS FOR RANKING CRITERIA

3.19. Ranking criteria are necessary to provide bases for comparison among the candidate sites so as to arrive at a list of preferred candidate sites. For safety related issues, comparison within topical areas is generally quite straightforward. For example, sites with a relatively higher seismic hazard would be penalized in comparison with those in more geologically stable areas. What is more difficult is comparison between topics, in other words to compare a site with a higher seismic hazard but lower flood hazard with another site having a higher flood hazard but lower seismic hazard.

3.20. Ranking criteria are generally developed by using considerations relating to discretionary criteria together with relevant non-safety-related considerations.

3.21. A sufficient amount of data should be collected before a comparison is made between two (or more) sites with regard to the same topic. To the extent possible the amount and quality of the data upon which the comparison is to be based should be similar for the regions or possible sites being compared.

3.22. The candidate sites should be ranked in order to determine the preferred candidate site or several preferred candidate sites. Ranking involves cross comparison of sites with respect to all their attributes, both safety related attributes and non-safety-related attributes. This may involve the weighting of various attributes in a matrix form. It is also possible to quantify the differences of each site with regard to a reference combination of site and installation. For many of the attributes to be considered, there exist more than one quantification parameter (e.g. the differential cost or cost–benefit estimation with respect to a reference combination of site and installation) as the basis for comparison and ranking.

3.23. One criterion for ranking candidate sites may be the likelihood that the specific site parameters are within the standard plant parameter envelope of potential suppliers for nuclear installations. Suppliers of technologies for nuclear installations typically offer non-site-specific generic design information for consideration in cases of bounding envelopes being used in siting process. This information identifies some of the design bases for cases of site related loads. Such information should be used either to screen out candidate sites or to decide where design changes may be necessary to bring the design parameters within the site bounding envelope.

SITING OF NEW NUCLEAR INSTALLATIONS AT EXISTING SITES

3.24. The siting process, as discussed in the foregoing, is for the construction and operation of a new nuclear installation at a new site. A similar process should be used for the siting of a new installation at an existing site with certain special considerations, as discussed in the following. The presence of an existing nuclear installation should not warrant an assumption that the site is suitable for a new nuclear installation. The site evaluation process should be conducted at the same level of rigour as for a new site and it should depend on the implications of the new installation for safety.

3.25. There are several issues that should be given special attention, such as:

- when a site that was selected in the context of an earlier project for a nuclear installation project is to be reassessed to confirm that it meets safety requirements;
- when a site that was discarded is to be reconsidered for a project for a new nuclear installation.

Such issues include the completion of data, considerations for new regulations and standards, considerations for new methods of analyses and lessons to be learned from recent external events, if relevant.

3.26. If a new site under consideration is close to or adjacent to the site of an existing nuclear installation, the effects of the existing site on the new site and the effects of the new site on the existing site should be considered. In certain cases, owing to age, technology, design, etc., plants on the same site could have different licensing requirements". The effects of a new installation on or near to an existing site should be assessed on the basis of the following considerations:

(a) Any design/construction and/or operational restrictions arising from the way in which the existing installation is operated. For example, the heat sink requirements for the operation of existing installations may have significant bearing on the design of the heat sink system for a new installation.

(b) The nuclear or radiological hazards arising from accidents on the existing installations or new installations involving the release of radioactive material and/or direct radiation 'shine'.

(c) Conventional hazards arising from accidents on the existing site involving, such as the release of toxic chemicals, explosions, missiles or flooding.

(d) Interactions between the emergency arrangements for new sites and existing sites.

(e) Relevant hazardous events, such as loss of power supply from the electricity grid, and most external hazards can initiate common cause failures on several or all of the nuclear installations on the site, and the effects of such common cause faults should be accounted for.

(f) Hazards arising from accidents on both new and existing installations and consequential impacts.

(g) Compliance with dose constraints and risk constraints from the combined sites in both operational states (normal operation and anticipated operational occurrences) and accident conditions:

(ii) Where the new installation forms part of an existing site, the net effects of both installations in terms of safety should be considered with regard to:

- *Exposure of members of the public and environmental impacts in normal operation*: It is to be expected that radiological consequences in operational states for members of the public may increase since the new installation will have an additional source term. It should be established whether this additional source term necessitates additional protection over what would be expected if the new installation were on an isolated site.
- *Exposures and risks in accident conditions*: The new installation provides a contribution to exposure of and risks to members of the public in accident conditions. Where there are independent accidents at each installation, the increase in risk is likely to be small. The net combined contribution to risk should be determined, however. Where the accident initiator is a common cause event (e.g. a flood), then both exposure of and risks to members of the public should be assessed. It should be taken into consideration that all installations at the site may be simultaneously challenged by a common cause event and consequences may be higher for the combined site. This may warrant additional safety measures being applied to the new nuclear installation or to both installations to meet dose constraints and risk constraints, and in order to keep exposures and risks as low as reasonably achievable.

(iii) Where the new installation occupies a separate site immediately adjacent to, or very close to, an existing site, it is to be expected that exposures and risks for people outside both sites will be similar to those mentioned in (ii) above. Additional safety measures may still be necessary at one or both sites to keep exposure and risks as low as reasonably achievable.

3.27. The operating organization for the new site should provide the operating organization for the existing site with information on the issues mentioned above. It is therefore beneficial for both operating organizations to establish a good working relationship early on, so that relevant information can be made available to either operating organization as and when it is necessary.

4. CLASSIFICATION OF SITING CRITERIA

4.1. Criteria used in the siting process for a nuclear installation are classified as follows:

- Safety related criteria;
- Criteria relating to nuclear security;
- Non-safety-related criteria.

Such criteria may be screening criteria (i.e. exclusionary or discretionary criteria) or ranking criteria.

SAFETY RELATED CRITERIA

4.2. Safety related criteria to be considered in the siting process should be consistent with the requirements established in Ref. [1] and with the associated Safety Guides relating to site evaluation for nuclear installations. From a thematic perspective, these criteria are classified into four sets.

4.3. The first set of criteria is related to the potential impact of natural hazards on the safety of the nuclear installation. In this context, the following natural hazards should be considered:

(a) Capable faults (i.e. faults that may cause surface displacement near the nuclear installation);
(b) Vibratory ground motion due to earthquakes;
(c) Volcanic hazards;
(d) Coastal flooding or low water intake level (considering water flooding as well as receding due to wave action, storm surges, seiches or tsunamis);
(e) River flooding (overtopping of banks due to failure of water retaining structures such as dykes or dams) or low water intake level due to low river flow or drought;
(f) Blockage of intake channels (e.g. due to marine organisms, ice, debris, ship collisions, oil spills or fires)
(g) Combinations of coastal and river flooding (e.g. in estuaries), and flash floods due to intense precipitation or downbursts;

(h) High winds — both straight winds such as hurricanes and tropical storms and rotational winds such as tornadoes

(i) Local phenomena such as sand storms and dust storms;

(j) Other extreme meteorological events such as droughts, extreme precipitation, including snow pack, extreme hail, lightning and extreme temperatures, including the temperature of the source of cooling water.

(k) Geotechnical hazards such as slope instability, soil liquefaction, landslides, rock fall, avalanche, permafrost, erosion processes, subsidence, uplift and collapse;

(l) Forest fires;

(m) Credible combinations of events (i.e. combinations of both dependent and independent events that potentially could lead to more severe consequences than for a single hazard; e.g. a seismic event together with flooding, or wind together with snow).

4.4. The second set of criteria is related to the potential impacts of human induced events and nuclear security events on the safety of the nuclear installation. In this context and in accordance with the recommendations of Ref. [3], the following origins of potential human induced hazards should be considered:

(a) Stationary sources:

  (i) Other nuclear installations, oil and gas operations, chemical plants, processing of hazardous materials, e.g. commercial facilities for manufacturing or storing munitions, broadcasting and communication networks, mining or quarrying operations, high energy rotating equipment and hydraulic engineering structures;

  (ii) Military facilities (permanent or temporary), especially shooting ranges and arsenals;

(b) Mobile sources:

  (i) Surface transportation (e.g. railways, roads, oil and gas and other pipelines, etc.);

  (ii) Airport zones and harbour zones (military and civilian);

  (iii) Air traffic corridors and flight path zones (military and civilian).

(c) Electromagnetic interference

4.5. The third set of criteria is related to the characteristics of the site and its environment that could influence the transfer of radioactive material released from the nuclear installation to people and the environment. In this context, the following phenomena should be considered:

(a) Atmospheric dispersion of radioactive material;
(b) Dispersion of radioactive material in surface water;
(c) Dispersion of radioactive material in groundwater;
(d) Population density and population distribution and distance to centres of population, including projections for the operating lifetime of the nuclear installation.

4.6. The fourth set of criteria is linked to the third set but it relates mainly to the demonstration of the feasibility of implementation of the emergency plan for the nuclear installation. In this context, the following phenomena should be considered:

(a) Physical characteristics of the site that could hinder implementation of the emergency plan (in particular geographical features such as islands, mountains and rivers);
(b) Infrastructural characteristics relating to the implementation of the emergency plan (especially local transport infrastructure and communications networks);
(c) Considerations of population, (e.g. special population groups with regard to protective actions in the event of a nuclear or radiological emergency, such as elderly and disabled persons and hospital patients and prisoners) and land and water use considerations;
(d) Specific requirements of the regulatory body for special zones, such as emergency zones and distances
(e) Industrial facilities that could involve potentially hazardous activities;
(f) Impacts of concurrent external hazards on infrastructure.

4.7. Examples of criteria for the siting process are presented in Annex II.

CRITERIA RELATING TO NUCLEAR SECURITY

4.8. At the siting phase nuclear security aspects should be considered following the IAEA Nuclear Security Series [13–15] and involving national competent agencies. The following criteria should be taken into account when considering the nuclear security aspects:

(a) The site is sufficient in size for the establishment of secure boundaries (e.g. with a controlled area, supervised area and vital areas) having enough spatial separation between each boundary for the implementation of associated security measures. It should also accommodate the installation of security equipment and facilitate security measures such as physical barriers, emergency planning zones and distances, equipment at the perimeter for detection and assessment of intrusion, vehicle search areas, and the implementation of a strategy and systems and measures for physical protection.

(b) Site characteristics that might require measures to be taken to control the approaches to the installation.

(c) The evaluation of site characteristics (e.g. location, size and proposed site layout) for safety measures that could compromise security measures and security measures that could compromise safety measures.

(d) Results from threat assessments for the location of the proposed site.

4.9. The criteria relating to nuclear security that are used in the siting process are generally discretionary and are also used for ranking purposes.

NON-SAFETY-RELATED CRITERIA

4.10. In the site survey and site selection process another set of criteria are concerned with considerations that are not directly related to nuclear safety (e.g. cooling water, topography, access to grid etc.). Such non-safety-related criteria should be considered together with the considerations relating to nuclear safety, especially in the ranking of the candidate sites [16].

5. DATA NECESSARY AT DIFFERENT STAGES OF THE SITING PROCESS

5.1. Site selection should make use of an increasingly detailed process of data collection and evaluation. In particular, the site survey stage should be based on information and data collected principally from existing sources such as available records, satellite images, topographic sheets and information available from local authorities and other institutions. It may be that a potential site could not satisfy all the screening criteria on the basis of information collected at the site survey stage, but that it is likely to be able to satisfy these screening criteria with the help of additional study and investigation. In this case, such additional study and investigation and the related screening test should be initiated as soon as possible so that the results are available in the next stage, i.e. the site selection stage. The input information and data collected during the site survey are important and should be considered for all site related activities prior to construction.

5.2. The siting process for a nuclear installation starts on a regional basis and each step is focused on selecting potential sites and candidate sites. The data acquisition and processing for these stages should be in line with this purpose. Accordingly, these stages should generally start with the consideration of regional data presented on a large scale (coarser data; data of low resolution) and proceed to the consideration of local data presented on a smaller scale (finer data; data of higher resolution).

5.3. For each topic under consideration, the data should be collected in a coordinated manner, in consideration of interfaces with other topics. The level of detail of the different sets of data should be consistent with the aims for the specific steps of the siting process.

5.4. In the analyses performed on the basis of the data collected, the operating lifetime of the nuclear installation should be considered. Appropriate projections should be made, especially in relation to parameters that may show significant variation with time. Data that may change gradually should also be considered. In this context the potential impact of climate change on site related hazards should be considered, as recommended in Ref. [7], especially in terms of the possibility of increased incidence and intensity of extreme meteorological and hydrological phenomena. Uncertainties associated with these phenomena should be taken into account.

5.5. The general approach to site surveys and site selection should be directed towards reducing the uncertainties at various steps of the siting process in order to obtain reliable results based on the data. Experience shows that the most effective way of achieving this is to collect a sufficient amount of reliable and relevant data. There is generally a trade-off between the time and effort necessary to compile a detailed, reliable and relevant database and the degree of uncertainty that the analyst should take into consideration at each step of the process.

5.6. The acquisition and processing of data to be used in relation to siting criteria should be performed subject to the requirements on quality management, as recommended in Section 7.

5.7. All data on the site should be collected in a systematic, transparent, retrievable and traceable manner. The use of tools such as a geographical information system should be considered, especially for the data collected in relation to the preferred candidate sites.

5.8. There should be a site specific database, containing all relevant site characteristics, established during the siting process. This database should include the following categories of data which are further elaborated in detail in the Appendix:

(a) Geological;

(b) Hydrogeological;

(c) Seismological;

(d) Fault displacement;

(e) Volcanological;

(f) Geotechnical;

(g) Coastal flooding including tsunamis;

(h) River flooding;

(i) Meteorological Events;

(j) Human induced events;

(k) Population, land use, water use and environmental impacts.

5.9. For the screening and ranking criteria, the site characteristics should be used as a basis for the decision on whether a site should be kept or screened out, and if a site is kept, how it should be ranked with respect to other candidate sites. The decision for keeping or screening out a site could be based on conclusions drawn from one or more category of the site characteristics, as it is not always necessary to consider all categories for every criterion. Each of the categories of site characteristics is described in the Appendix, and criteria associated with the data are listed in Table I-1.

5.10. A two-stage process for siting is recommended in Sections 2 and 3. It is intended that a graded approach to data collection is adopted for this process. In the initial site survey stage, readily available data[9] should be collected from relevant national and local authorities and other organizations. Such data could include contextual maps for undertaking a qualitative desktop study in order to establish relatively quickly whether the site can be screened in with respect to exclusionary criteria, and the likely impacts on the contextual maps of the site of discretionary screening and ranking criteria.

5.11. In the second stage (site selection), it is intended to conduct a more detailed examination of how the site fares against the ranking criteria. The objective at this stage is to provide sufficient information and analysis to enable confident judgements to be made using the ranking criteria. It is anticipated that at the end of this stage, a firm decision, with reasoning, on site selection should be made by the site owner and/or operating organization.

5.12. To enable the activities at the second stage to be conducted, it is anticipated that more data will be required. Data should be collected and analytical work should be undertaken. For example, comprehensive surveys of the relevant literature and, in some cases, specific fieldwork will be required (e.g. to identify local sub-map-scale topographical features of significance or to confirm geological features from local rock exposures).

[9] The necessary extent of data collection and analysis cannot be specified in this Safety Guide since they are likely to be specific to the State and to the site concerned.

5.13. Although the data on some external hazards are likely to be limited and of variable quality, it is anticipated that some analyses will be required and should be undertaken, such as for the following:

(a) Hazards associated with accidental aircraft crashes;

(b) Effects of nearby industrial facilities on the proposed site; for example, impacts of fires and chemical explosions and effects of dispersion for hazardous airborne releases that could affect the site;

(c) More detailed analysis of local fault displacement capability;

(d) Estimation of the seismically induced soil liquefaction potential at the site;

(e) Generation of a set of hazard curves for extreme meteorological and flooding events, e.g. in relation to wind, precipitation, temperature, and sea and river flooding, covering return periods appropriate to the nuclear installation in question.

5.14. The judgements made at this stage should be sufficiently robust to provide a high degree of confidence that they will not be called into question by further data collected or by further analysis in the site evaluation process.

6. SITING FOR NUCLEAR INSTALLATIONS OTHER THAN NUCLEAR POWER PLANTS

6.1. The graded approach mentioned in para. 1.16 provides guidance for siting (site survey and site selection) for a broad range of nuclear installations other than nuclear power plants. These installations include:

(a) Research reactors and laboratories in which nuclear material is handled;

(b) Installations for storage of spent nuclear fuel (collocated with either nuclear power plants or independent installations), including:

  (i) Installations for spent fuel storage for which active cooling is required;

  (ii) Installations for spent fuel storage that require only passive or natural convection cooling.

(c) Installations for processing for nuclear material in the nuclear fuel cycle, e.g. conversion facilities, uranium enrichment facilities, fuel fabrication facilities and facilities for the reprocessing of spent fuel.

(d) Installations for the predisposal management of radioactive waste arising from nuclear fuel cycle facilities.

6.2. For the purpose of siting, these installations may be graded on the basis of their potential radiological hazards, and non-radiological hazards, e.g. the presence of flammable, explosive, toxic or corrosive materials.

6.3. Prior to categorizing an installation, if adopting a graded approach, a conservative process should be applied to estimate the consequences of a radiological release associated with a maximum hypothetical event (accident). The analysis should use the worst case radioactive inventory expected over the operating lifetime of the installation and should not include any mitigating factors associated with siting (e.g., atmospheric dispersion), unless those factors are included in the final site selection acceptance criteria.

6.4. The possibility that an external event will give rise to radiological consequences will depend on characteristics of the nuclear installation (e.g. its purpose, layout, design, construction and operation) and on the external event itself. Such characteristics should include the following factors:

(a) The amount, type, form (e.g. solid, liquid or gas) and status of the radioactive inventory at the site (e.g. whether solid or fluid, processed or only stored);
(b) The intrinsic hazard associated with the physical processes (e.g. nuclear chain reactions) and chemical processes (e.g. those for fuel processing purposes) that take place at the installation;
(c) The thermal power of the nuclear installation, if applicable;
(d) The configuration of the installation for activities of different kinds;
(e) The concentration of radioactive materials in the installation (e.g. for nuclear power plants or research reactors, most of the radioactive inventory will be in the reactor core and the fuel storage pool, whereas in fuel processing facilities and fuel storage facilities it may be distributed throughout the installation);
(f) The changing nature of the configuration and layout for installations designed for experiments (activities in regard of which may be unpredictable);
(g) Characteristics of engineered safety features for the prevention of accidents and for mitigation of the consequences of accidents;
(h) The characteristics of the processes or the safety features that might show a cliff edge effect[10] in the event of an accident;

[10] A cliff edge effect in a nuclear installation is an instance of severely abnormal system behaviour caused by an abrupt transition from one system status to another following a small deviation in a system parameter, and thus a sudden large variation in system conditions in response to a small variation in an input.

(i) The characteristics of the site that would be relevant to the consequences of the possible dispersion of radioactive material to the atmosphere and the hydrosphere (e.g. the size, the demographics of the region);

(j) The potential for on-site and off-site contamination;

(k) Monitoring instruments, and the response time of control systems and trip systems.

6.5. Some or all of the abovementioned factors should be considered, depending on the national requirements. For example, fuel damage, radioactive releases or exposures may be the conditions or parameters of interest.

6.6. The grading process should be based on the following information:

(a) The generic preliminary safety analysis report for the installation, if one is available, which should be the primary source of information;

(b) The results of a preliminary probabilistic safety assessment, if available;

(c) The characteristics specified in para. 6.4.

(d) National regulatory criteria, if any

6.7. As a result of this process, three or more categories of installation may be defined on the basis of national practices and criteria. As an example, the following categories may be defined:

(a) The lowest hazard category includes those nuclear installations for which national building codes for conventional facilities (e.g. essential facilities such as hospitals) or for hazardous facilities (e.g. petrochemical plants or chemical plants), as a minimum, should be applied.

(b) The highest hazard category includes installations for which standards and codes that establish an equivalent level of quality to those used for nuclear power plants should be applied.

(c) There may often be one or more intermediate categories of nuclear installation.

6.8. The graded approach should generally be applied to the extent and level of detail of the data to be collected and analysed at each step. These considerations should be taken into account when setting up the screening criteria for nuclear installations other than nuclear power plants.

6.9. It should be taken into consideration that criteria not directly associated with safety (para. 4.1) may be very different for other types of nuclear installation.

7. APPLICATION OF THE MANAGEMENT SYSTEM

GENERAL RECOMMENDATIONS

7.1. As a function of the management system, a quality management programme should be established by the operating organization (future licensee), and the contractors that carry out the work for selection of the site for a nuclear installation

7.2. The management system, in accordance with Refs [17, 18], should cover organization, planning, work control, personnel qualification and training, verification and documentation for all the activities concerned to ensure adequate performance of these tasks and adequate reporting.

7.3. The siting process should be addressed in the overall management system for the nuclear installation project. The management system for siting should be established at the earliest possible time consistent with its implementation in the conduct of activities for the site survey and site selection stages of the nuclear installation. See Refs [17, 18] for requirements, recommendations and guidance on the management system.

7.4. The results of the activities for site investigation should be compiled in a report that documents the results of all in situ work, laboratory tests and geotechnical analyses and of more general safety related evaluations.

7.5. The studies and investigations should be documented in sufficient detail to permit their independent review.

7.6. Records should be kept of the work carried out in the activities for site selection for the nuclear installation.

7.7. In developing the part of the management system dealing with the siting process, the following should be considered:

(a) The intended end uses of the knowledge, information and data that result from the activities in the siting process, in particular in terms of their consequences for safety;
(b) The capability to demonstrate, test or repeat the results;
(c) The scale and technical complexity of the activities in the siting process, whether it is a new or proven concept or a model that is being applied or an extension of a new application;
(d) The managerial complexity of the activity and the involvement and coordination of personnel in multiple disciplines, work units or internal or external organizations, with divided or contingent objectives and responsibilities;

(e) The extent to which other site characterization work, or later work, depends on the results of the siting activities;
(f) The desired use or application of the results.

SPECIFIC RECOMMENDATIONS

7.8. A project work plan should be prepared prior to, and as a basis for, the execution of the siting project, i.e. the project relating to site survey and site selection. The work plan should convey the complete set of general requirements for the nuclear installation (such as the total power generation capacity of the nuclear power plant, including applicable regulatory requirements. In addition to general requirements through reference to the overall management system if relevant, the work plan should delineate the following specific elements: personnel and their responsibilities; work breakdown and project tasks; schedule and milestones; and deliverables and reports.

7.9. A programme should be established, implemented and documented under the management system to cover all activities for data collection and data processing, field and laboratory investigations, analyses and evaluations that are within the scope of this Safety Guide.

7.10. Results of the activities during the site survey and site selection stages should include all outputs indicated in the work plan. The reporting of the site survey and site selection should be specified in sufficient detail in the work plan.

7.11. To make the activities of the site selection process traceable and transparent to the public, users and reviewers, the related documentation should provide the following:

- a description of all elements of the process;
- identification of the participants in the study and their roles; and
- background material that comprises the documentation of the analysis, including raw and processed data, computer software and input and output files, reference documents, results of intermediate calculations and sensitivity studies.

7.12. This material should be maintained in an accessible, usable and auditable form by the responsible organization. Documentation or references that are readily available elsewhere should be cited where appropriate. All elements of the site survey and site selection should be addressed in the documentation.

7.13. The documentation should identify all sources of information used in the site survey and site selection, including information on where to find important citations that may be difficult to obtain. Unpublished data that are used in the analysis should be included in the documentation in an appropriate accessible and usable form.

7.14 If earlier studies for site survey and site selection for the same region are available, studies should be made to demonstrate how different approaches or different data affect the earlier conclusions. These should be documented in a way that allows their review.

7.15. In view of the fact that various investigations are carried out (in field, laboratory and office), technical procedures that are specific to the activity concerned should be developed to facilitate the execution and verification of these tasks, and a peer review of the process should be conducted.

7.16 Requirements for the application of a management system should be established by the responsible organizations to ensure that the processes of and inputs from their contractors are appropriate. The responsible organization for siting should identify the quality assurance standards that should be met. Applicable requirements, recommendations and guidance on the management system are provided in Refs [17, 18]. Special provisions should be specified to address document control, analysis control, software, validation and verification, procurement and audits, and non-conformance and corrective actions. Work related documents should be prepared to cover all the activities under the programme mentioned in para. 7.9.

Appendix

DATABASE FOR THE SITING PROCESS

A.1. The extent of the work necessary to develop an appropriate database for the siting process will depend on the nature of the site, on how easy it is to meet the site selection criteria (especially the exclusion criteria) and on the level of effort necessary for the comparison and ranking between the candidate sites.

A.2. The database for the siting process should be comprehensive and up to-date, and should be compiled so as to support the evaluation and judgement of the relevant number of topics as recommended in Section 5.

GEOLOGICAL AND HYDROGEOLOGICAL DATABASE

A.3. The objective for the geological and hydrogeological database is to collect all the data necessary to enable judgements of site suitability to be made confidently on the basis of the criteria mentioned above. The requirements for detailed data (for the final site selection process) are the same as those for nuclear safety purposes and are specified in the relevant IAEA Safety Guides [5, 8]. The extent and quality of data collection may vary depending on the stage in the site survey and site selection process for which the data are used. The radius of the relevant region to be studied is typically 150–300 km and depends on the seismotectonic setting of the site, the type of installation and the method or approach of the hazard assessment.

A.4. The following summarizes the data necessary at different stages.

Site survey stage

A.5. Use should be made of existing data available from national and local archives such as the following:

(a) Regional geological maps, including those which contain data on stratigraphy, i.e. with appropriate cross-sections;
(b) Tectonic maps;
(c) Hydrogeological maps;
(d) Regional geophysical maps, indicating gravity and magnetic anomalies;
(e) Satellite imagery.

Site selection stage

A.6. At this stage the data as already indicated should be augmented with more detailed information. This may require more detailed and site specific information such as existing borehole logs and geophysical surveys to be obtained and studies of the site to be undertaken such as by means of geological fieldwork to confirm its geological and hydrogeological characteristics.

SEISMOLOGICAL DATABASE

A.7. The ground motion to be considered in the site selection process should be determined as appropriate for the installation under consideration by postulating the ground motion to occur with a very low probability over its operating lifetime. Geological, seismological and geotechnical characteristics of the potential site and candidate sites should be considered. The requirements for detailed data (for the final site selection process) are the same as those for nuclear safety and are specified in the relevant IAEA Safety Guide [5].

Site survey stage

A.8. Major earthquakes that may have had significant impacts on the proposed site should be selected by using available earthquake catalogues, with account taken of the characteristics of causative faults. This preliminary information will be used for identification of the seismic active zones and for preliminary estimation of seismicity for the potential sites to be used in the screening process.

Site selection stage

A.9. Available information on prehistorical, historical and instrumentally recorded earthquakes in the region and paleoseismological data if available should be collected and documented. A catalogue should be compiled that includes all information on earthquakes developed for the project covering all those temporal scales. In particular, all available 'pre-instrumental' historical data on earthquakes (that is, events for which no instrumental recording was possible) should be collected, extending as far back in time as possible.

DATABASE RELATING TO FAULT DISPLACEMENT

A.10. The fault displacement hazard arises when an earthquake event on a fault close to or beneath safety related nuclear installation structures causes displacement to occur that may directly affect the safety of the installation. This hazard is also referred to as a capable fault hazard. A clear definition of a capable fault is given in another IAEA Safety Guide together with a listing of recommended site investigations in relation to potential capable faults [5].

Site survey stage

A.11. The capable faults should be thoroughly investigated by integrating geomorphological, geological, geodetic and geophysical methods to make clear their locations, shapes, activity and characteristics, and also in consideration of their distance from the proposed site. At this stage the available site specific data may not be sufficient but a literature survey relating to the suspect features would be a reasonable source of information.

Site selection stage

A.12. An in-depth investigation should be made on the capable faults within site vicinity area (5km) that combines the survey of existing reference materials, tectonic geomorphological investigation, investigation of surface geological features, and geophysical and other investigations

VOLCANOLOGICAL DATABASE

A.13. Volcanic products such as lava flows, pyroclastic flows, lahars and ash fall (among many others) may affect the safe operation of a nuclear installation. The effects of such products should be evaluated for potential and candidate sites if they are in volcanic regions.

Site survey stage

A.14. The volcanological database should include descriptions of any volcanic products at the site. For Holocene period and younger volcanoes, including those that are known to be currently active, if the volcanic products could have an impact on the safe operation of a nuclear installation under consideration, the entire geological history of the volcano should be investigated.

Site selection stage

A.15. An evaluation of the uncertainty in age determinations should be included in this assessment. For example, the stratigraphy of pyroclastic units is commonly complex and incomplete. Assessment of the completeness of the geological record should be attempted, even if not all volcanic deposits can be mapped. The ages of volcanic deposits should be quantified if possible to describe the history of volcanic activity. Detailed data requirements are similar to those recommended in Ref. [7].

DATABASE ON GEOTECHNICAL HAZARDS

A.16. Investigation of the subsurface conditions at the site of a nuclear installation should be carried out at all stages of the site selection and site evaluation processes. The purpose of this

investigation is to provide information or basic data for decisions on the nature and suitability of the subsurface materials. At each stage of the process, the investigation programme should be used to provide the necessary data for an appropriate characterization of the subsurface. The specific requirements will vary greatly from stage to stage.

Site survey stage

A.17. The various methods of investigation — that is, the use of current and historical documents, geophysical and geotechnical exploration in situ and laboratory testing — are applicable not only to the site survey stage but also, to varying extents, to all stages of the site evaluation process.

Site selection stage

A.18. The purpose of an investigation at the site selection stage is to determine the suitability of sites and to identify issues that may be used in comparing the site with other potential sites or candidate sites. Subsurface information for this stage is usually obtained from current and historical documents and by means of field reconnaissance, including geological and geomorphological surveys, with a limited amount of site specific field investigations in order to investigate the following:

(a) Unacceptable subsurface conditions;
(b) Classification of sites;
(c) Groundwater regimes;
(d) Foundation conditions.

Detailed data requirements are similar to those recommended in Ref. [8].

DATABASE ON COASTAL FLOODING

A.19. The coastal flooding database provides information describing the sea flooding characteristics of the candidate site. The extent and quality of data collection can vary depending on the stage of the site survey and site selection process for which the information is used, as discussed above. This section includes all forms of flooding, including tsunami hazards.

A.20. At both the site survey stage and the site selection stage, the suitability of the site is not determined solely by whether the site is inundated or not in events of a particular return frequency. In many cases engineering solutions can be effected that can safeguard the site. The installation grade could be built at a sufficiently elevated platform level to support the safety related structures and equipment for protection against extreme events of a particular

return frequency. The practicality of employing these defensive measures against floods should be considered together with the flood level predictions when deciding whether the coastal flooding is acceptable on the basis of the criteria noted above.

A.21. Similar investigations should be conducted on shore line stability.

Site survey stage

A.22. The potential for flooding due to storm surges, seiches, tides and wind waves should be investigated. To determine the flooding potential for the site in these cases, it is necessary to know the extreme sea levels from storm surges, seiches, tidal waves and wind waves and the topography of the land around the site. At the site survey stage a good approximation for evaluating flood levels can be made by using tidal data. Tidal data are usually available from national or local authorities and/or other national or local institutions. However, these data alone are frequently not sufficient for assessing the highest astronomical tides or the combined effects of storm surge, seiche and wind wave effects. This is because data may be available for a few decades only.

A.23. Once an estimate of extreme sea levels has been made, an approximate flood level at the site can be determined from the local topology of the land in and around the site. It may be possible to screen out the site at this stage if the flood level is too high. However, if the likelihood of coastal flooding is not clear, especially at longer return periods, then more detailed work is required and the judgement of site suitability should be carried to the next stage.

A.24. Consideration should also be given to the potentially detrimental effects of extreme low water levels as well as of other related hazards (such as jellyfish and algae).

A.25. Flooding from tsunami hazards arises because of the effects of earthquakes, volcanic activity or landslides on the ocean floor. Relevant data should be collected from national authorities if they are available. There may also be historical records of large scale flooding in the region that can be associated with one of the initiators mentioned above. Ref. [6] provides simple screening criteria that can be employed for which the data requirements will be only minimal. If the proposed site does not satisfy the conditions for applying the screening criteria in Ref. [6], then there may not be enough data for a simple desk-top study to be made.

Site selection stage

A.26. The potential for flooding from storm surges, seiches, tidal and wind waves should be investigated. More detailed work is required to provide better estimates for flood levels at the

site. A preliminary analytical technique may be used at this stage to determine the extreme sea levels that are appropriate for longer return periods and for the nuclear installation under consideration.

A.27. The potential for flooding from tsunami should be investigated. A preliminary evaluation of the tsunami hazard should be undertaken at this stage. A preliminary analytical technique may be used at this stage to determine the extreme sea levels that are appropriate for longer return periods and for the nuclear installation under consideration. Information provided in Ref. [6] will be useful for further work in this area.

DATABASE ON RIVER FLOODING

A.28. The database on river flooding provides information describing the characteristics for river flooding and the characteristics for storm water flash floods of the proposed site, including changes in river courses, changes in the stability of river banks and changes in upstream land use. The extent and quality of data collection can vary depending on the stage in the site selection process for which the data are used. The data on flood levels alone are not sufficient for screening a site from further consideration since it may be possible to provide flood defences to protect the site. This should be taken into account when making judgements on site selection.

Site survey stage

A.29. River flooding can arise directly from rivers that have overtopped their banks or flood defences following heavy precipitation and snow melt upstream of the site or the failure of an upstream dam. The following information and data, normally available from national or local authorities, should be obtained at the site survey stage:

(a) Regional and local maps of watercourses, rivers, lakes, streams, wadis and so on and local topographic maps of the site should be obtained. All watercourses that could credibly flood the site should be identified. Characteristics of topographic features such flood plains and the locations and sizes of existing flood protection systems such as dykes and levees should be established.

(b) For major rivers, data on discharge rates versus river level should be obtained. The possibility of ice hazard, including frazil ice, should be considered. Historical data on river levels, extent of flooding and so on should be obtained.

(c) Information on water retaining structures, especially upstream of the site, should be collected.

(d) The potentially detrimental effects of low levels of river water should also be considered and relevant information should be collected.

Site selection stage

A.30. For the site selection stage it may be necessary to undertake preliminary flood hazard analysis to estimate flood water levels at the site and the potential for flood water to interfere with safety related equipment. Simple dam break scenarios should be considered for upstream water retaining structures. A statistical analysis of flood data to determine flood levels at longer return periods will also be required and this should be made if it was not previously available. Recommendations and guidance is provided in Ref. [6] for further work on this area.

DATABASE ON EXTREME AND RARE METEOROLOGICAL EVENTS

A.31. The database on meteorological events provides information describing meteorological events that could affect the potential site or candidate sites. The extent and quality of data collection can vary depending on the stage in the site selection process for which the data are used. The meteorological data alone are not sufficient for screening a site from further consideration since it is often possible to provide defences to protect safety related equipment at the site.

Site survey stage

A.32. Meteorological data are usually collected on a regional basis by national authorities, although local authorities and, in some cases, particular industrial sectors, may collect specific data for special reasons. The following data should be obtained:

(a) Data on the regional and local history of extreme values, both extreme highs and extreme lows, of meteorological parameters relating to temperature, humidity, atmospheric pressure, wind speed, precipitation, icing, ice storms, sand storms, dust storms, and so on. Similar regional and local data on rare meteorological events, such as storms, tornadoes, cyclones and lightning should also be collected.

(b) The site drainage characteristics should be ascertained, e.g. the natural drainage routes for surface water, the height of the water table and the ability of water to flow onto the site. Consideration should be given to the fact that in-ground works of the nuclear installation can have a significant effect on the site drainage characteristics.

Site selection stage

A.33. For the site selection stage it may be necessary to undertake a preliminary analytical exercise to determine historical meteorological data to establish hazard versus frequency curves for the various meteorological variables. The suitability of the site will also depend on the extent to which measures can be put in place to protect safety related structures, systems and components. In particular the drainage requirements for the site should be evaluated in detail. The geotechnical features of the site should be determined, at least approximately, and their sensitivity to extremes of precipitation, temperature and drought should be established. Recommendations and guidance provided in Ref. [6] will be useful for further work in this area.

DATABASE ON HUMAN INDUCED EVENTS

A.34. The database on human induced events provides information describing the type, severity and frequency of past human induced events in the vicinity of the site and their relationship to the potential site and candidate sites. The extent and quality of data collection can vary depending on the stage in the site selection process for which the data are used. At both the site survey stage and site selection stages, the suitability of the site in relation to human induced events is not determined solely by the site's proximity to human induced events: the credible physical protection measures that can be taken should also be considered. For example, protective barriers can usually be erected to protect safety related equipment against vehicle impacts.

Site survey stage

A.35. To determine the potential of human induced events that could affect the site, information about human activities around the site should be collected and how these activities may change over the operating lifetime of the installation should be analysed. There are a large number of potentially hazardous human activities that could affect a site. Activities in the following general categories should be considered for their hazard potential:

(a) Collocated nuclear installations;
(b) Nearby industries, especially industries using quantities of toxic and/or explosive chemicals, or involving exothermic reactions or high pressure or high temperature processes, and industries that use ionization or strong electromagnetic fields;
(c) Nearby military facilities;
(d) Transport systems, including road, rail, air, shipping and pipeline transport;

(e) Land use activities such as activities that influence water courses or the stability of slopes affecting the site, such as upstream dams, major users of river water abstraction and industries that could deposit large amounts of debris into a river upstream of the site.

These potentially hazardous human activities can present a range of hazards and hazardous events, including:

(a) flooding hazards;
(b) forest fires and other external fires;
(c) missiles and impact hazards;
(d) toxic clouds;
(e) explosions;
(f) ground disturbance on or under the proposed site.

Information on local industrial hazards and land use hazards should be available from local government authorities or local planning authorities. Data on the locations and movements of air traffic and other forms of transport should be available from local authorities and from relevant national authorities. Information on military facilities will be available from relevant national government authorities.

A.36. Data on human induced events and potentially hazardous human activities can be used with local and regional maps showing transport routes and industrial locations and so on and local topographical maps to make an initial determination of whether the candidate site should be screened out or not on the basis of screening distance values for the origins of human induced events. It is anticipated that many of the hazards listed in the foregoing can be eliminated on the basis that their consequences would be very local to the source and would be unlikely to affect the site directly (such as missiles from small scale pressurized systems), or could easily be protected against (such as impacts from road traffic or rail vehicles). Other hazards might necessitate a more detailed analysis at the next stage before a judgement could be made in respect of site selection.

Site selection stage

A.37. In the site selection stage, more detailed estimates of the severity and the likelihood of human induced events affecting the site or that may affect the site in the future should be provided. For several hazards listed in the foregoing, a simple analysis made on the basis of site survey data alone might not be sufficient for making a judgement on site selection. For example, it is anticipated that this proviso will apply to the following:

(a) Aircraft traffic (data collected for an aircraft crash of accidental origin can also be used to some extent for the evaluation of the site for an aircraft crash as a nuclear security event or other unauthorized act).

(b) Toxic hazards or explosive hazards from nearby industries using or storing very large quantities of toxic or explosive materials, e.g. oil and gas operations, large petrochemical factories, or local quarrying or mining activities under the site.

For such situations it is likely that an expert analysis will be necessary to determine the severity of the hazard, its likely impact at the site and the frequency associated with the hazard. Further recommendations and guidance on undertaking these analyses are provided in Ref. [3].

DATABASE ON POPULATION, LAND USE AND ENVIRONMENTAL IMPACTS

A.38. The criteria for the database on population, land use and environmental impacts should relate to the potential radiological and other impacts of the nuclear installation on workers, the population and the environment due to normal operation and accident conditions. Furthermore, the feasibility of the implementation of emergency plans should also be addressed through this database over the operating lifetime of the installation.

Site survey stage

A.39. One of the most common parameter that should be considered at this stage is related to either population density in the site vicinity or the distance of the potential site or candidate sites from population centres (or both). This type of parameter] is easy to use because generally such data are readily available. Care should be taken to use reasonable numbers for screening values. It should also be noted that these values are country dependent. The population density projections for the operating lifetime of the installation should also be considered in the assessment of site suitability.

A.40. In relation to protection of the environment, bio-sensitive areas (including protected species), natural reservations, monuments and tourist spots should be identified.

Site selection stage

A.41. Depending on the regulatory requirements of the State, this process for population, land use and environmental impacts may be more or less involved. Attention should be paid mainly to the feasibility of implementation of the emergency plan.

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Annex I

TABLES TO BE USED IN THE SITING PROCESS

I-1. Table I-1 provides an indication of the type of criteria that are generally associated with various issues relating to the siting process. There may be cases that are not consistent with Table I-1 owing to the specific conditions at certain sites. Table I-1 should therefore be used as a reference only.

I-2. Table I-2 cross references IAEA safety standards that are relevant to the siting related issues that are under consideration in this Safety Guide. Recommendations and guidance provided in the safety standards will be useful for issues relating to the evaluation of candidate sites. In particular cases, explicit guidance may be provided by the Safety Standards indicated in Table I-2.

TABLE I-1. SCREENING AND RANKING CRITERIA FOR PURPOSES OF SITE SELECTION

Criteria		Category		
Primary	Type	Screening		Ranking
		Exclusionary	Discretionary	
Earthquake	Ground vibration		✓	✓
	Surface rupture	✓		
Geotechnical	Slope instability (massive) landslide)	✓		
	Slope instability (minor)		✓	✓
	Subsidence		✓	✓
	Massive liquefaction	✓		
	Liquefaction		✓	✓
	Karst (massive)	✓		
Volcanism	Lava flow	✓		
	Pyroclastic flow	✓		
	Ground deformation	✓		
	Tephra fall		✓	✓
	Volcanic gases		✓	✓
	Lahars(massive)	✓		
Flooding	River		✓	✓
	Dam break		✓	✓
	Coastal (storm surges, waves, etc.)		✓	✓
	Tsunami		✓	✓
Extreme meteorological events	High straight winds		✓	✓
	Tornados		✓	✓
	Tropical storms		✓	✓
	Precipitation		✓	✓
	Sand storms and dust storms		✓	✓
Human induced events	Aircraft crashes		✓	✓
	Explosions		✓	✓
	Gas releases		✓	✓
	External fires		✓	✓
	Electromagnetic interference		✓	✓
Nuclear security			✓	✓
Dispersion	In air and water		✓	✓
Feasibility of implementation of emergency plan		✓		
Implementation of emergency plan			✓	✓
Non-safety	Topography		✓	✓
	Availability of cooling water	✓	✓	✓
	Access to water		✓	✓
	Availability of transport		✓	✓
	Access to national or regional electricity grid		✓	✓
	Non-radiological environmental impacts	✓	✓	✓
	Socio-economic impacts		✓	✓
	Land-use planning		✓	✓

TABLE I-2. SITE SELECTION ISSUES CROSS REFERENCED TO IAEA SAFETY STANDARDS

Site selection issue		Safety Requirements	Safety Guides relevant to site evaluation						Safety Guides relevant to design	
Primary	Effect	NS-R-3	NS-G-3.1	NS-G-3.2	SSG-9	SSG-18	SSG-21	NS-G-3.6	NS-G-1.5	NS-G-1.6
Earthquake	Ground vibration	✓			✓					✓
	Surface rupture	✓			✓					
Geotechnical	Slope instability	✓						✓		
	Subsidence	✓						✓		
	Soil Liquefaction	✓						✓		
	Extensive oil and gas extraction history	✓						✓		
Volcanism		✓					✓			
Flooding	River	✓				✓			✓	
	Dam break	✓				✓			✓	
	Coastal	✓				✓			✓	
	Tsunami	✓				✓			✓	
Extreme meteorological events	High straight winds	✓				✓				
	Tornadoes	✓				✓			✓	
	Precipitation	✓				✓			✓	
Human induced events	Aircraft crashes	✓	✓						✓	
	Explosions	✓	✓						✓	
	Gas releases	✓	✓						✓	
	External fires	✓	✓						✓	
Population	Density	✓		✓						
	Distance from centres	✓		✓						
Dispersion	In air	✓		✓						
	In water	✓		✓						
Feasibility of the emergency plan		✓		✓						

Annex II

EXAMPLES OF CRITERIA FOR THE SITING PROCESS FOR A NUCLEAR POWER PLANT

GENERAL CONSIDERATIONS

II-1. This annex provides certain information that could serve as examples of attributes and related criteria to be considered in the siting process for a nuclear power plant. The annex is intended to be used by interested parties associated with the siting process for a nuclear power plant. The annex was prepared by compiling information on practices in different States and guidance from relevant IAEA safety standards. Examples are given in relation to on external natural hazards as well as external human induced events.

II-2. A number of attributes (issues, events, phenomena, hazards and specific considerations) are related to the siting process in addition to general information on the site. These attributes are grouped into five thematic sets in Section 4. These five sets are:

- External natural hazards;
- External human induced events;
- Radiological impacts on the public and on the environment;
- Emergency planning;
- Considerations not directly related to nuclear safety.

The last set, considerations not directly related to nuclear safety, is considered to have a major bearing on the effectiveness of the siting process.

II-3. This annex further expands these five sets of attributes, providing examples of issues, events, phenomena, hazards and considerations that are to be taken into account in the siting process for a nuclear power plant. Screening values for some of these attributes serve as useful siting criteria. Examples of such screening values are provided. The candidate sites undergo preliminary evaluation which is useful for comparison and ranking in the second stage of the siting process. Examples of discretionary criteria with respect to some of these issues, events, phenomena and hazards are also provided. Finally, the annex provides examples of the content of emergency procedures that would serve as useful information for examination of the feasibility of emergency planning.

EXAMPLES OF ATTRIBUTES CONSIDERED IN THE SITING PROCESS

II-4 General site related information:

(1) Maps of site area at suitable scale:

(i) Site boundary and emergency planning zones: typically these are zones demarcating 5 km, 16 km, 25 km (or more) and 80 km from reactors [II-1, II-2, II-3], although these distances vary between States.

(ii) Population distribution and location of existing industrial, commercial, institutional, recreational and residential buildings and areas, including projections of relevant developments for the expected operating lifetime of the nuclear power plant.

II-5 External natural hazards:

(1) Geology:

(i) Properties of sub-surface strata, depth and type of bed rock;

(ii) Characteristics of sub-surface material;

(iii) Groundwater.

(2) Natural events:

(i) Seismic and geological considerations:

(a) Capable faults;

(b) Vibratory ground motion due to earthquakes;

(ii) Volcanism;

(iii) Meteorological events and variables:

(a) High wind events, such as tropical cyclones, tornadoes and water spouts;

(b) Precipitation;

(c) Storms;

(d) Snow;

(e) Lightning;

(f) Dust storms and sand storms;

(g) Hail;

(h) Freezing precipitation and frost related phenomena;

(i) Air temperature;

(iv) Coastal flooding:

(a) Storm surges;

(b) Seiches;

(c) Tsunamis;

(d) Tides;

(e) Wave action;

(f) Combinations of tides: variations and extremes in sea water levels;

(g) Combination of flooding with relevant meteorological events

(v) Inland (river) flooding:

(a) Overtopping of banks;

(b) Failure of upstream or downstream water control structures such as dykes or dams;

(c) Blockage of a river or other drainage channel;

(d) Combination of flooding with relevant meteorological events

(vi) Combination of coastal and inland flooding for sites on an estuary;

(vii) Geological and geotechnical hazards:

(a) Slope instability;

(b) Soil liquefaction;

(c) Rock fall;

(d) Permafrost;

(e) Soil erosion processes;

(f) Collapse, subsidence;

(g) Expansion, uplift;

(h) Karst;

(i) Avalanches;

(j) Stability of foundation;

(viii) Shoreline erosion.

(3) Change of hazard with time:

(i) Change due to climatic evolution: regional climatic change with global climatic change;

(ii) Changes in physical geography of a drainage basin, including estuaries, off shore bathymetry, coastal profile, catchment area, etc.;

(iii) Changes in land use and water use.

II-6 External human induced hazards:

(1) Stationary sources:

(i) Oil and gas operations (e.g. refineries);

(ii) Industrial plants and operations and other facilities processing hazardous substances;

(iii) Facilities for the storage of hazardous substances;

(iv) Broadcasting and communication networks (for electromagnetic interference hazards);

(v) Mining or quarrying operations;

(vi) Other nuclear installations;

(vii) High energy rotating equipment;

(viii) Military facilities (permanent or temporary), especially shooting ranges and arsenals;

(ix) Collocated installations (such as installations for the reprocessing of spent fuel, the storage of fresh fuel and the storage of spent fuel);

(2) Mobile sources:

(i) Railway trains and wagons;

(ii) Road vehicles;

(iii) Ships and barges;

(iv) Pipelines;

(v) Air traffic corridors and flight zones (both civilian and military);

(vi) Transport of fresh fuel and spent fuel and of other nuclear material and other radioactive material.

(3) Other characteristics:

(i) Oil slick;

(ii) Transportation of over dimension consignment (ODC).

II-7 Radiological impact:

(1) Meteorology:

(i) Wind speed and direction;

(ii) Rain and other precipitation;

(iii) Atmospheric temperature;

(iv) Humidity;

(v) Atmospheric stability;

(vi) Sand storms and dust storms;

(2) Use of land and water;

(3) Population considerations;

(4) Dispersion of radioactive material:

(i) In the atmosphere;

(ii) In sub-surface water;

(iii) In surface water.

(5) Management of radioactive waste in operational states:

(i) Radioactive solid waste:

(a) Characteristics of the waste;

(b) Quantity;

(c) Level of activity;

(d) Management strategy;

(ii) Radioactive liquid waste:

(a) Characteristics of the waste:

(b) Quantity;

(c) Level of activity;

(d) Management strategy;

(iii) Discharges radioactive gases:

(a) Characteristics of the waste;

(b) Quantity;

(c) Level of activity;

(d) Management strategy.

(6) Management of radioactive releases in accident conditions;

(7) Ambient radiation;

(8) Monitoring.

II-8 Emergency management:

(1) Physical characteristics and site characteristics that may hinder emergency plans;

(2) Emergency procedures;

(3) Infrastructural characteristics relating to the implementation of emergency plans:

(i) Evacuation routes and access routes;

(ii) Sheltering;

(iii) Transport;

(4) Special requirements prescribed by the regulatory body for special zones, if any, such as the exclusion boundary, low population zones etc.;

(5) Population considerations within emergency planning zones outside the site area boundary of the nuclear installation;

(6) Additional statutory requirements of the:

(i) National or federal government;

(ii) State, provincial or territorial government;

(iii) Local government;

II-9 Considerations not directly related to safety:

(1) Topography:

(i) Salient features;

(ii) Contour maps for the region up to 30 km;

(2) Accessibility:

(i) Nearest railway lines;

(ii) Nearest national highways and major roads;

(iii) Nearest sea ports;

(3) Availability of industrial infrastructure and construction facilities:

(i) Construction materials;

(ii) Construction power;

(iii) Construction water;

(iv) Infrastructural facilities;

(4) Proximity to load centres

(5) Availability of and conditions of access to cooling water:

(i) Condenser cooling;

(ii) Fresh water for consumption;

(6) Townships:

(i) Locations;

(ii) Distances from the nuclear power plant site;

(iii) Expected populations;

(7) Proximity to load centres:

(i) Lines for the power distribution grid;

(ii) Locations of major power consuming units, facilities and populations;

(8) Non-radiological environmental impacts, including ecological considerations:

(i) Heat sinks: water bodies and atmosphere;

(ii) Presence of bio-sensitive areas adjacent to the site;

(iii) Natural reserves, monuments or tourist spots;

(iv) Restrictions by statutory bodies on:

(a) Thermal pollution:

- Temperature differential between the intake and outfall points of the condenser cooling water;
- Effects on aquatic life of discharges of condenser water;

(b) Discharge of chemical pollutants.

(9) Socioeconomic impacts including public acceptance:

(i) Type of area adjacent: urban or rural;

(ii) General source of income for local population: large scale industry, small scale industry, agriculture and agro-industries;

(iii) General economic conditions of the surrounding population with respect to national averages (e.g. per caput incomes);

(iv) Level of acceptance of the installation by the public.

EXAMPLE OF SCREENING VALUES

II-10 The screening values of different characteristics of a site could be used as exclusion criteria or discretionary criteria at the site survey stage. Examples of such screening values are given in Table II-1. These values are typical and may vary between States. If a site does not satisfy any one or a combination of screening values, it could still be considered acceptable provided that engineering solutions are available, i.e. design features, measures for physical protection of the site or administrative procedures.

TABLE II-1. EXAMPLES OF SCREENING VALUES

No.	Characteristics	Screening values	Remarks
1.	Distance from capable fault	8.0 km [II-3]	Exclusion criterion
2.	Distances from flight paths approaching an airport	4.0 km [II-4]	Discretionary criterion
3.	Distance from airport with attributes of Type 2 event[a]	7.5 km [II-4]	Discretionary criterion
4.	Distance from small airports	10.0 km [II-4]	Discretionary criterion
5.	Distance from large airport: – for yearly flight operations > 500 d^2 – for yearly flight operations > 1000 d^2	< (d=)16.0 km > (d=)16.0 km [II-4]	Discretionary criterion
6.	Distance from military installations or air space usage such as practice, bombing and firing ranges	30.0 km [II-4]	Discretionary criterion
7.	Distance from military installations storing ammunition etc.	8.0km [II-4]	Discretionary criterion
8.	Distance from facilities for storing or handling of flammable, toxic, corrosive or explosive material	5.0 km [II-4]	Discretionary criterion
9.	Sources of hazardous clouds	8.0 km [II-4]	Discretionary criterion
10.	Natural reserves, bio-sensitive regions and forests	Exclusion zone	Exclusion criterion
11.	Tsunami	10 km from sea or ocean shoreline or 1 km from lake or fjord shoreline, or 50 m above mean water level [II-5]	Discretionary criteria

[a] Accidental aircraft crash at the site such as in a take-off or landing operation at a nearby airport.

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