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# **IAEA SAFETY STANDARDS**

**for protecting people and the environment**

**Status: STEP 11**

**Second review by Committees for approval for submission to CSS for endorsement (NUSSC (lead), WASSC and NSGC). Member States comments incorporated.**

## **Safety Aspects in Siting for Nuclear Installations**

**DRAFT SPECIFIC SAFETY GUIDE No.SSG No. x??**  
**DS433**

Revision of Safety Guide No. SG-S9

**IAEA**  
International Atomic Energy Agency

*(Front inside cover)*

**IAEA SAFETY RELATED PUBLICATIONS**

*(to be included later)*

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## **FOREWORD**

**by Yukiya Amano**

**Director General**

The IAEA's Statute authorizes the Agency to "establish or adopt... standards of safety for protection of health and minimization of danger to life and property" — standards that the IAEA must use in its own operations, and which States can apply by means of their regulatory provisions for nuclear and radiation safety. The IAEA does this in consultation with the competent organizations of the United Nations and with the specialized agencies concerned. A comprehensive set of high quality standards under regular review is a key element of a stable and sustainable global safety regime, as is the IAEA's assistance in their application.

The IAEA commenced its safety standards program in 1958. The emphasis placed on quality, fitness for purpose and continuous improvement has led to the widespread use of the IAEA standards throughout the world. The Safety Standards Series now includes unified Fundamental Safety Principles, which represent an international consensus on what must constitute a high level of protection and safety. With the strong support of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its standards.

Standards are only effective if they are properly applied in practice. The IAEA's safety services encompass design, siting and engineering safety, operational safety, radiation safety, safe transport of radioactive material and safe management of radioactive waste, as well as governmental organization, regulatory matters and safety culture in organizations. These safety services assist Member States in the application of the standards and enable valuable experience and insights to be shared.

Regulating safety is a national responsibility, and many States have decided to adopt the IAEA's standards for use in their national regulations. For parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions. The standards are also applied by regulatory bodies and operators around the world to enhance safety in nuclear power generation and in nuclear applications in medicine, industry, agriculture and research.

Safety is not an end in itself but a prerequisite for the purpose of the protection of people in all States and of the environment — now and in the future. The risks associated with ionizing radiation must be assessed and controlled without unduly limiting the contribution of nuclear energy to equitable and sustainable development. Governments, regulatory bodies and operators everywhere must ensure that nuclear material and radiation sources are used beneficially, safely and ethically. The IAEA safety standards are designed to facilitate this, and I encourage all Member States to make use of them.

PROMOTIONAL TEXT FOR THE BACK COVER:

**Safety through international standards**

“Governments, regulatory bodies and operators everywhere must ensure that nuclear material and radiation sources are used beneficially, safely and ethically. The IAEA safety standards are designed to facilitate this, and I encourage all Member States to make use of them.”

Yukiya Amano

IAEA Director General

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**THE IAEA SAFETY STANDARDS**

*(to be included later)*

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## 1. INTRODUCTION

### BACKGROUND

1.1. This Safety Guide was prepared under the IAEA's program 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 the other Safety Guides that deal with all safety aspects of the site evaluation in respect to the effects of the 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 the environment of radioactive material that may be released during the lifetime of the installation. The 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 implementing emergency measures over the predicted life of the installation.

1.2. The IAEA Safety Fundamentals publication on 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] specifies that the prevention of accidents and their mitigation are the way to meet this objective; and 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 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: (a) the effects of external events occurring in the region of the particular site (these events could be of natural origin or human induced); (b) the characteristics of the site and its environment that could influence the transfer to persons and the environment of radioactive material that has been released, and (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 and the need to evaluate the risks to individuals and the population.

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 during its complete lifecycle. The outcome of this task may even affect the final

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success of the program. Poor planning and execution, lack of information and knowledge on applicable international safety standards and recognized practices could lead to faulty decision making and major delays either at the construction or at the operational stages of a nuclear installation. Faulty decisions in the site selection stage might also require major resource commitments at a much later phase of the project, if the site related design parameters are changed during the plant operation stage and, consequently, re-evaluation and upgrades for plants during operation, with eventually extended shutdown periods and considerable costs.

1.4. The selection process of a suitable site, termed as “siting”, for a nuclear installation is a multi-faceted process which includes safety considerations. As for accident prevention, siting aims at decreasing the exposure to external ~~hazards~~ hazards associated to external hazard events. It involves a comprehensive process of screening out sites where external ~~hazards~~ hazards are dominant or could become dominant and additional design safety measures would be excessively demanding for site utilization or sites where knowledge is not sufficient to define these measures with a sufficient degree of confidence. As for accident mitigation, siting aims decreasing the impact of an accident on the people and environment. It involves the selection of a site with favourable dispersion characteristics of radionuclides in the air, surface as well as groundwater, and also terrain, population and infrastructure that would facilitate the successful implementation of an emergency plan.

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1.5. The siting process, from its very beginning, needs to be guided by a clearly established set of criteria consistent with relevant regulatory requirements. This is of particular importance for those aspects that can exclude sites. A global balance should be established between the characteristics of a site on the one hand, and specific design features, site protection measures and administrative procedures on the other hand.

1.6. In 2003, the Safety Requirements publication, “Site Evaluation for Nuclear Installations”, NS-R-3 [1] was published. ~~That is~~ 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, i.e. from the selection stage, to the assessment, the pre-operational and operational stages. Thus, Ref. [1] does not cover the initial stage of the siting process, i.e. the site survey, when studies and investigations at regional scale are performed to identify potential sites from which candidate sites are chosen.

1.7. There is now the need to update the previous IAEA Safety Guide, “Site Survey for Nuclear Power Plants”, 50-SG-S9, published in 1984 [17] in view of an increasing interest from Member States. The revision is necessary to bring the Safety Guide into consistency

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with the existing safety requirements in Refs [1] and [16], particularly as they relate to exclusionary criteria, and with other Safety Guides that provide recommendations relevant to the early stages of site evaluation—especially Refs [3 to 8] and [15].

1.8. The TEPCO's Fukushima Daiichi NPPs accident highlighted the importance of site selection in a nuclear power programme. The approach in this Safety Guide ensures that obvious 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 necessary requirements during detailed assessment. It is important that safety challenges from external hazards are identified early to allow adequate consideration of protective measures that may be needed to provide sufficient defence in depth.

~~1.8.1.9.~~ Terms in this publication are to be understood as defined and explained in the IAEA Safety Glossary [14], unless otherwise stated.

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## OBJECTIVE

~~1.9.1.10.~~ The objective of this Safety Guide is to provide guidance on the siting of a nuclear installation meeting the safety objectives of the safety fundamentals [2] and in compliance with the safety requirements [1]. Recommendations on criteria and approaches are provided in order to identify suitable sites for nuclear installations complying with established safety requirements. The Safety Guide also has the objective of providing guidance on establishing a logical process for siting and establishing a suite of preferred candidate sites any of which could be selected for the construction and operation of a nuclear installation.

~~1.10.1.11.~~ This Safety Guide is intended for use by the organizations, interested in the siting, such as government bodies, future licensees (generally the operating organizations) and their contractors. This Safety Guide also has an informative role to the nuclear regulatory authority since the site survey and selection does not require a license from the regulatory body.

1.12. The site should be deemed to be unsuitable for the purposes of licensing the proposed facility 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 the peoples against unacceptable radiological risk. ~~During detailed assessment (evaluation) of external hazards if it is concluded that no engineering solutions exist to design protective measures against those hazards that challenge the safety of the nuclear installation or there are no~~

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~~adequate measures to protect the peoples against unacceptable radiological risk, the site is not suitable and is not licensable. The Siting process is intended to reduce such a late unfavourable conclusion from a safety point of view. The nuclear safety of selected sites will be confirmed during the detailed site assessment stage.~~

~~1.11.1.13. The future operator of the proposed facility on the site should have an early role to play in reviewing and accepting work done during siting, even if the future operator does not have a direct role in selecting the site.~~

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## SCOPE

~~1.12.1.14. This Safety Guide explicitly addresses the safety aspects of the siting process of nuclear installations. It is recognized that there are other aspects that play an important role in the siting process, possibly both on safety issues and non-safety issues, such as nuclear security aspects, technology, economics, land use planning, cooling water availability, non-radiological environmental impact, and socio-economic aspects including public opinion.~~

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~~1.13.1.15. 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. As the siting process progresses, more and more sites are to be screened out (and therefore only a few sites remain) and the importance of safety aspects becomes more pronounced.~~

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~~1.14.1.16. The separation between the investigation processes of site survey and site evaluation may not be very distinct and will depend on the methodology and technology used. There is a transition between these two stages of work and this Safety Guide addresses the process that eventually terminates with the selection of site(s) for one or more nuclear installations.~~

~~1.15.1.17. As well as considering the siting of nuclear installations at new sites, this Safety Guide provides recommendations regarding the collocation of new installations at existing sites.~~

~~1.16.1.18. This Safety Guide addresses a range of nuclear installations<sup>1</sup>. The methodologies recommended for nuclear power plants are applicable to other nuclear installations through a graded approach, whereby these recommendations can be tailored to suit the needs of different types of nuclear installations in accordance with the potential~~

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<sup>1</sup> The new definition of '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<sup>2</sup>. Therefore, if no grading is performed, the recommendations relating to nuclear power plants (chapters 2-5) are applicable to other nuclear installations.

~~1.17.1.19.~~ This Safety Guide does not provide guidance on the final evaluation or characterization of a site nor establish an assessment of the site hazard for use in the design evaluation for licensing purposes. The guidelines for final site evaluation or re-evaluation as part of periodic safety reviews are given in Ref. [3,4, 5, 6, 7 and 8].

## STRUCTURE

~~1.18.1.20.~~ Section 2 addresses the siting and site evaluation process. Section 3 provides general recommendations for the site selection of nuclear installations. Section 4 describes classification of criteria for the siting process. Section 5 provides information and investigations necessary for the different stages of the site survey and site selection process (database). Section 6 deals with site survey and site selection process for nuclear installations other than nuclear power plants providing a graded approach for dealing with these installations. Section 7 provides recommendations for management systems, ~~and quality assurance requirements~~. Appendix A provides recommendations for the database for the siting process. Annex I presents tables to be used in the siting process, including screening and ranking criteria. Annex II provides example of criteria for the siting process of nuclear power plants. The numerical values provided in the annexures are examples only and used in some Member States.

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

2.1. There are two processes related to the safety aspect of a nuclear installation site – siting and site evaluation. Further these two processes split into five stages;

- site survey,
- site selection,
- site assessment,

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<sup>2</sup> 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 to the most hazardous nuclear installations.

- pre-operational, and
- operational.

The framework for the site survey and site evaluation stages 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 using adequate criteria. The selection of a suitable site is one of the elements of the concept of defence in depth for preventing accidents as set out in Principle 8 of Fundamental Safety Principles [2].

2.3. Siting and Site Evaluation process includes 5 different stages. The siting process for a nuclear installation consists of the first two stages, i.e. site survey and site selection, Fig.1. In the site survey stage, large regions are investigated to identify potential available sites and to choose one or more candidate sites. The second stage of siting process is site selection during which the candidate sites are evaluated to arrive at the preferred candidate sites.

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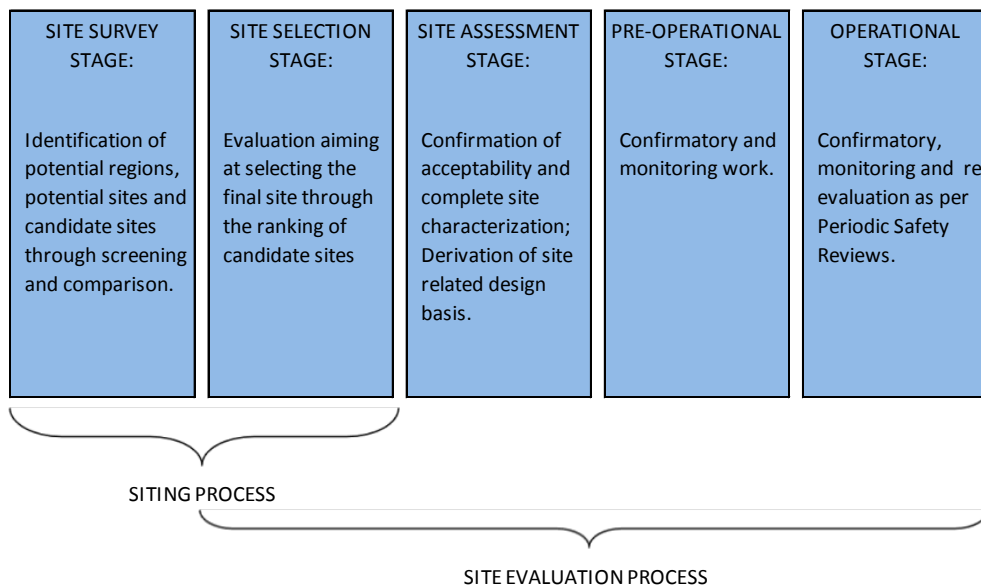


Figure 1: Siting and Site Evaluation Process in the Lifecycle of Nuclear Installation

2.4. Site evaluation is the process that extends from (a) the last stage of the siting process (i.e. the phase of evaluation of the candidate sites in order to arrive at the preferred candidate site(s)); to (b) the detailed assessment of the selected site to confirm its suitability, its characterization and derivation of the site related design bases for the installation; to (c) the confirmation and completion of the assessment during the pre-operational stage of 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 frame work of Periodic Safety Review (PSR)(see Para 1.8 and 1.14 of Ref. [1]).Thus, site evaluation continues throughout the entire operating lifetime of the installation with applicable components captured in the Final Safety Analysis Report (FSAR) to take into account the changes in site characteristics, availability of data and information, operational records, regulatory approaches, evaluation methodologies and safety standards [1,3,4,5,6,7,8].

2.5. The second stage of the siting process includes a part of the “site evaluation” and is the overlapping stage between the siting and site evaluation processes (see Figures 1 and 2). After the site selection stage, the confirmation of site suitability and a complete site characterization are performed along with finalizing the derivation of the design bases due to external events during the site assessment stage. This process eventually leads to the preparation of the Site Evaluation Report (SER) as a basis for the Site Chapter of the 3 Preliminary Safety Analysis Report (PSAR) of the nuclear installation. All the site related activities, involving confirmatory and monitoring work, are taken up in the pre-operational stage. With the approval of the Final Safety Analysis Report (FSAR) of the nuclear installation, the site evaluation during the operational stage starts. This includes all confirmatory, monitoring and re-evaluation work throughout operational stage and, especially, during periodic safety reviews of the installation. This portion of work is generally reported in Periodic Safety Review (PSR) reports. Outcomes vis-à-vis stages of siting and site evaluation processes are described in Fig.2.

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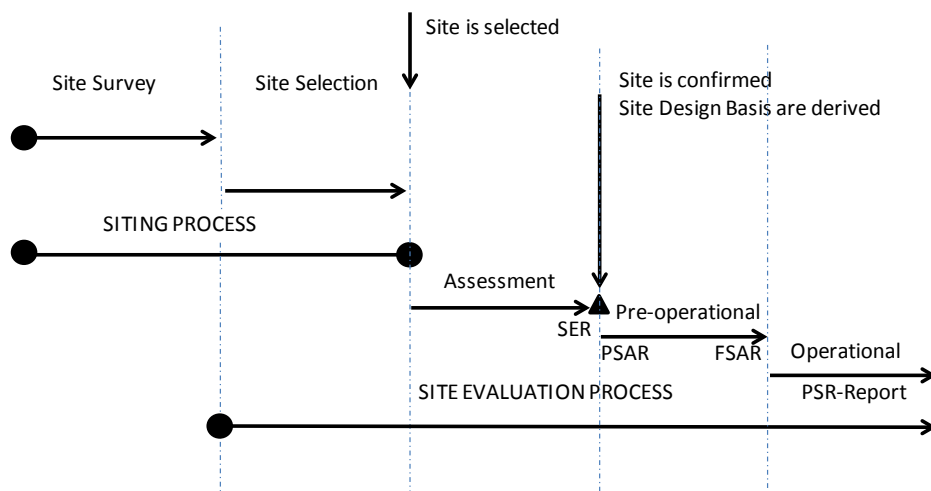


Figure 2: Outcome of Siting and Site Evaluation Process for Nuclear Installation

<sup>2</sup> Some member states use other terminologies, e.g. preliminary safety case

2.6. In most Member States ~~The~~ siting is a nonde-regulated activity and no license is required. Siting and site evaluation ~~evaluation~~ processes should be consistent ~~comply~~ with the licensing process defined by the Regulatory Body and be consistent with the applicable IAEA Safety Standards on this topic [9,10].

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

- (a) Decision regarding the 'suitability' of the preferred site, i.e. confirmation that the site has no characteristics that would preclude the safe operation of the nuclear installation.
- (b) The definition of the site related design basis parameters based on the Site Evaluation Report.
- (c) The review~~edition~~ of the PSAR or preliminary safety case which, inter alia, demonstrates that the site related design basis parameters have been appropriately accounted for, in particular through design features of the nuclear installation and measures for site protection.

### 3. GENERAL RECOMMENDATIONS FOR THE SITING PROCESS OF NUCLEAR INSTALLATIONS

#### SITING PROCESS

3.1. Siting ~~should be a~~ process is aimed to~~of~~ selecting suitable locations for a the envisaged nuclear installation such that its characteristics are compatible with available engineering protective measures for all natural and human induced hazards of external events so that an adequate level of safety can be reasonably achieved. Further, the surrounding demographic setting and dispersion characteristics should likely limit as low as reasonably achievable the radiological exposure of the population in any plant states, and allow the implementation of mitigation measures in the case of as accidental release of radionuclides over the live time of teh installation. ~~Further, the surrounding demographic setting and dispersion characteristics should likely allow the implementation of mitigation measures in the case of as accidental release of radionuclides.~~

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3.2. The siting process consists of a series of related activities with the objective of selecting the suitable site(s) for the new nuclear installation. The process should systematically apply a series of screening criteria to screen out those with attributes which contribute unfavourably to the safety of the installation ~~criteria to screen out those sites with~~



~~less favourable attributes that contribute to the safety of the site.~~ Details of a siting process for a nuclear installation are described in Fig.3.

3.3. The siting process has three distinct steps starting with 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 test: In the second step, the potential sites are screened to choose the candidate sites. The principal objective of this step is to exclude the unfavourable sites from safety as well as non-safety considerations.
- (3) Evaluation, comparison and ranking: The purpose of the third step is twofold: (i) to evaluate the site in order to assure there are no features (at the sites and in their surrounding area) that would preclude the construction and operation of the nuclear installation, and (ii) to compare the candidate sites and rank them in the order of their attractiveness as a nuclear installation site.

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

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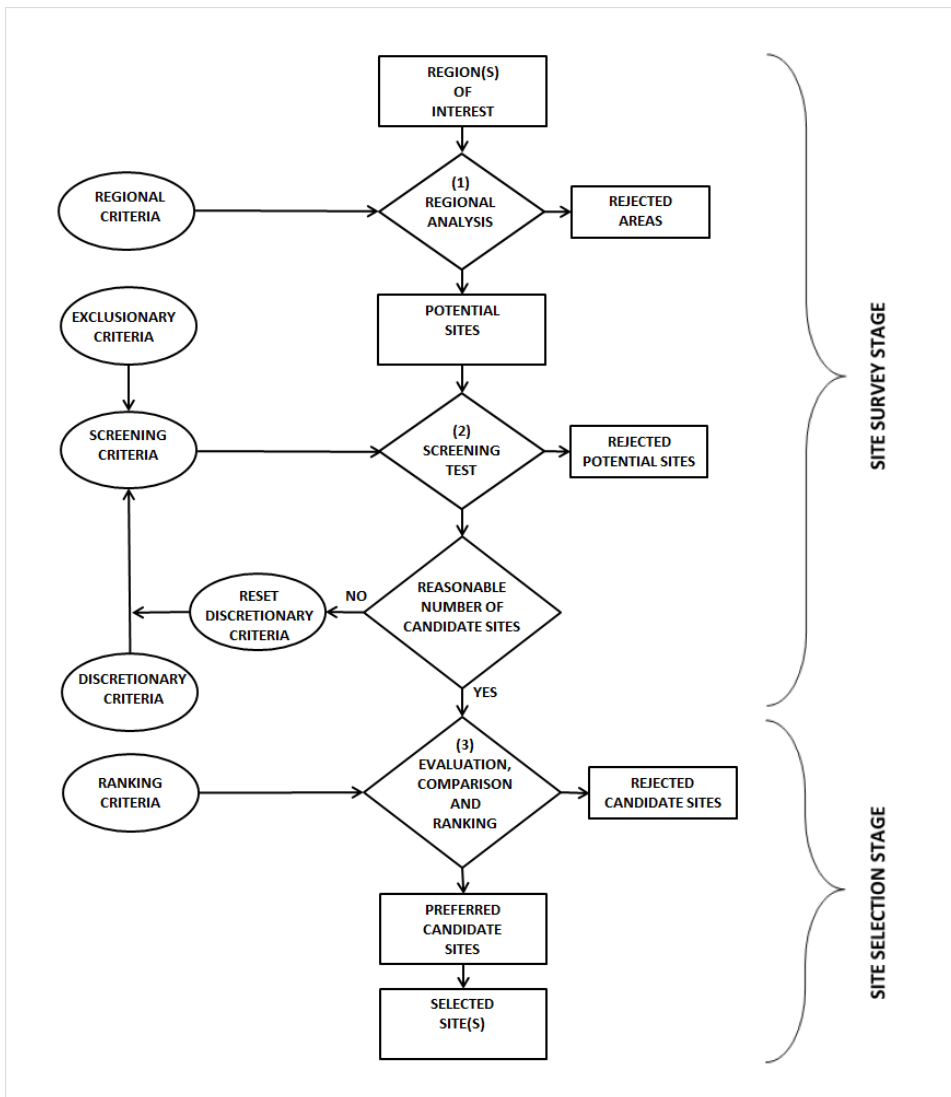


Figure 3: Flow Diagram for Siting Process for Nuclear Installations

3.5. The siting process is completed once the site on which the nuclear installation will be located is selected from the 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. ~~The final selection is generally done by the owner organization of the nuclear installation taking input from all the relevant stakeholders.~~

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SITING CRITERIA

3.6. Siting criteria are the bases (or the principles) by which decisions are made, on the site attributes during the different steps of the siting process. Siting criteria are used to evaluate site related specific 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 policy or other related policies of the Member State. Technical constraints and the availability of resources (e.g. water, infrastructure, etc.) on a regional basis are also important considerations for regional analysis. The important aspect of the regional criteria is that these criteria should identify all possible potential sites and not to discard any without appropriate justification.

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

- Exclusion criteria: the exclusion criteria are used to discard sites that are unacceptable from those attributes related to issues, ~~or~~ events ~~or~~ phenomena or hazards for which engineering solutions are not generally practicable.
- Discretionary criteria: the discretionary criteria are associated with those attributes related to issues, ~~or~~ events, ~~or~~ phenomena, ~~or~~ hazards, or considerations for which protective engineering solutions are available.
- These criteria, listed in Table I-1 of Annex eI, are used to facilitate the selection process through iterative screening to eliminate less favourable sites when a large number of possible candidate sites exist.

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 and ranking criteria consist of both safety related as well as non-safety related criteria. Screening and ranking criteria are further elaborated in Annex e I.

#### GENERAL BASIS FOR SCREENING CRITERIA

3.11. Exclusion criteria should be established and used as part of the screening in 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 any site related issue, event, phenomena and 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 these weaknesses either through design or 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 based on an arbitrary safety criterion may discard a site having otherwise favourable safety qualities and finally result in the choice of a site that may be less 'safe' than the one 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.
- increase the number of candidate sites if this number is too small or 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 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 dispersed to two or more regions with different attributes, this would prevent eventual elimination of all the candidate sites due to a common and regional shortcoming. e.g. for example, if two candidate sites are geographically widely separated then the seismic hazard may be widely different at each site, which reduces the risk of both being eliminated later in the siting process due to concerns over the seismic safety of proposed nuclear installations. ~~the eventual elimination of all the candidate sites due to a common and regional shortcoming. For e.g. If two candidate sites are geographically widely separated then the seismic hazard may be widely different at each site~~ Siting process of 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 sufficient amount of good quality data on which such a decision could be based with adequate certainty. In such case, additional data should be collected to confirm the site suitability in the subsequent site selection stage. Some preliminary field investigation, if required, should also be conducted in this stage.

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3.16. Data collection related to potential and candidate sites should focus in particular on attributes of the sites that are relevant to ~~the Exclusion~~the exclusion criteria.

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#### SPECIFIC SCREENING CRITERIA

3.17. The site safety requirements cited in Ref [1] are the primary source for establishing the screening criteria ~~to the siting process~~ and are reproduced below:

1 *In relation to the characteristics and distribution of the population, the combined effects of the site and the installation should be such that:*

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(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.*

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(b) *The radiological risk to the population associated with accident conditions, including those that could lead to emergency measures being taken, is acceptably low. 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 *Before a 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 *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.*

4 *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 should be deemed unsuitable.*

5 *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.*

6 *The hazards associated with an airplane crash to be considered shall include impact, fire and explosions. If the assessment indicates that the hazards are unacceptable and if no practicable solutions are available, then the site shall be deemed unsuitable.*

- 7 *The region should be investigated for installations (including installations within the site boundary) in which flammable, explosive, asphyxiate, 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. Hazards associated with chemical explosions should be expressed in terms of overpressure and toxicity (if applicable), with account taken of the effect of distance. 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.*
- 8 *Potential natural and human induced events<sup>4</sup> that could cause a loss of function of systems required for the long term removal of heat from the core should 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 hazards for the nuclear installation are unacceptable and no practicable solution is available, the site shall be deemed unsuitable.*

#### BASIS FOR RANKING CRITERIA

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

3.19. Ranking criteria are generally developed using the considerations related to discretionary criteria along with relevant non safety related issues and considerations.

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

3.21. The candidate sites are ranked in order to arrive at the preferred candidate site or several preferred candidate sites. Ranking involves cross comparison of sites with respect to

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<sup>4</sup> This term had been used in earlier safety standards [1,3], to which the draft safety guide 433 is referred to.

all their attributes, both safety related and non-safety related. This may involve weighting of various attributes in a matrix form. It is also possible to quantify the differences of each site with respect to a reference site/installation combination. ~~A reference site can be assumed to possess some average values for the different site parameters considered.~~ For many of the attributes, there exists more than one quantification parameter (e.g. the differential cost or cost and benefit estimation with respect to a reference site/plant combination) as the basis of comparison and ranking.

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One criterion for ranking candidate sites may be the likelihood that the specific site parameters are within the standard plant parameter envelope of potential nuclear installation suppliers. Suppliers of nuclear installation technologies typically offer non-site specific generic design information for consideration in bounding envelope cases being used for a siting exercise. This information identifies some of the design bases for site related load cases. Such information can be used to either screen out candidate sites or decide where design changes may need to be made to bring the design into the site bounding envelope.

#### SITING OF NEW NUCLEAR INSTALLATIONS AT EXISTING SITES

3.22. The siting process, as discussed above, is for construction and operation of a new nuclear installation at new sites. A similar process should be used for siting of a new installation at an existing site with certain special considerations, as discussed below. The existence of a nuclear installation should not lead to an automatic assumption that the site is suitable for a new nuclear installation. The site evaluation process should be conducted at the same level of rigor as that for a new site and depend on the safety implications of the new installation.

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3.23. There are several issues which need special attention, when sites:

- ~~was site was~~ Which have been selected in the context of an earlier nuclear installation project, are to be re-assessed to confirm up-to-date safety requirements
- ~~was site was~~ Which have been discarded are re-considered for a new nuclear installation project.

These include the completion of data, considerations for new regulations and standards, considerations for new methods of analyses and lessons learned from recent external events hazards, if relevant.

3.24. If the new site being considered is close to or adjacent to an existing nuclear installation site, the impact of existing site on the new site, and vice versa, should be considered. In certain cases, due to age, technology, design, etc., plants on the same

site could have different licensing requirements". The impact of a new installation ~~in~~ ~~onor near to an~~ existing site should be assessed by considering the following aspects:

- (a) Any design/~~construction~~/operational restrictions arising from the way the existing installation is operated. For example, the heat sink requirements of the operation of existing ~~installations~~ may have significant bearing on the design of heat sink system of the new one.
- (b) The radiological hazards arising from accidental events on the existing ~~installations or new installations~~ involving release of nuclear materials and/or radiation shine.
- (c) Conventional hazards arising from accidents on the existing ~~site~~ ~~installations or new installations~~ involving e.g. release of toxic chemicals, explosions, missiles, flooding, etc.
- (d) Interactions between the emergency arrangements for both new and existing sites.
- (e) ~~Relevant~~ ~~Some~~ hazardous events, e.g., loss of grid supplies, and most external hazards can initiate common cause ~~faults~~ ~~failures~~, on all the nuclear installations at the site and the effects of these should be accounted for,

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

(g) Compliance with dose and risk criteria from the combined sites under both normal operations and accident conditions ;

- i) Where the new ~~installation~~ ~~facility~~ forms part of an existing site, then the net effect of both ~~installations~~ ~~facilities~~ in terms of safety should be considered with regard to:

- *Normal operational doses to members of the public and environment:* It is to be expected that normal operations doses to members of the public may increase since the new facility will form an additional source term. Whether this new contribution requires additional protection over what would be expected if the new facility was on an isolated site should be established.
- *Accident condition doses and risks:* The new ~~installation~~ ~~facility~~ provides its own contribution to accident condition doses and risks to members of the public. Where the accidents from each ~~installation~~ ~~facility~~ are independent, then although the net combined contribution to risk should be established, the increase in risk is likely to be small. However, where the accident initiator is a common cause event (e.g. flood) then both risks and doses to members of the

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public should be assessed considering that all installations facilities at the site are simultaneously challenged. ~~as outside the site may be higher for the combined site.~~ This may warrant additional protection measures being applied to the new or both nuclear installations facilities to meet site dose and risk criteria, and in order to keep doses and risks as low as reasonably achievable.

ii) Where the new installation facility forms a separate site immediately adjacent, or very close to, an existing site, then it is to be expected that the physical effects to people outside the combined sites will be similar to those noted above. Additional protective measures may still be required from one or both sites to keep doses and risks as low as reasonably achievable.

~~iii) Doses and risks to workers on the site(s) should also be assessed in terms of the combined effects of the installations, and additional precautions taken if appropriate to keep doses and risks as low as reasonably achievable.~~

3.25. ~~Information exchange between site operators:~~ The developers of the new site should expect the operators of the existing site to seek information from them on the issues identified above. ~~Similarly, the developers of the new site will need information from the existing site for operators to make their own safety judgments.~~ It is therefore beneficial for both parties to establish a working relationship early on in the development of the new site, so that information on these issues can be made available to either party as and when needed.

#### 4. CLASSIFICATION OF SITING CRITERIA

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

- Safety related criteria,
- Criteria related to protection against malevolent acts nuclear security, and
- Non-safety related criteria.

Criteria falling under any of the above class may be screening (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 in IAEA NS-R-3 [1] and the associated Ssafety Gguides related to the site evaluation of nuclear installations. From a thematic perspective, these criteria are classified in 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 both high flood levels and recedes due to wave action, storm surges, seiches, tsunamis)
- ~~(e) Tsunamis in combinations with tides—sea water level variations and extremes,~~
- ~~(f)~~(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 flows, droughts
- ~~(g)~~(f) Blockage of intake channels (marine organisms, ice, debris, ship collisions, oil spills, fires, etc)
- ~~(h)~~(g) Combination of coastal and river flooding (~~in e.g. estuaries, e.g.~~), flash floods due to intense precipitation or downburst
- ~~(h)~~ High winds, both straight winds such as hurricanes, 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. extreme temperatures, including the temperature of the source of the cooling water ~~and lightning.~~
- (k) Geotechnical hazards such as slope instability, soil liquefaction, landslides, rock fall, avalanche, permafrost, erosion processes, subsidence, uplift and collapse
- (l) Forest fire
- (m) Credible combinations of events (both dependent and independent events that potentially may lead to more severe consequences as compared to a single hazard, e.g. seismic and flooding, wind and snow, etc.)

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

(a) Stationary sources

- (i) Oil and ~~g~~Gas operations, chemical plants, hazardous material processing e.g. commercial munitions plants or storage facilities, broadcasting and communication networks, mining or quarrying operations, other nuclear facilities, high energy rotating equipment, hydraulic engineering structures
- (ii) Military facilities (permanent or temporary) especially shooting ranges, arsenals

Electromagnetic interference

(b) Mobile sources

- (i) Railway trains and wagons, road vehicles, ships, barges, pipelines
- (ii) Airport and harbour zones ( both military and civilian)
- (iii) Air traffic corridors and flight zones (both military and civilian)

(c) Electromagnetic interference

(iii)

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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<sup>5</sup> 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 ground water
- (d) Population density and population distribution and distance to centres of population including projections for the 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 emergency plan implementation for the nuclear installation. In this context, the following phenomena should be considered:

- (a) Physical site characteristics that may hinder emergency plans (particular geographical features such as islands, mountains and rivers)
- (b) Infrastructure characteristics related to the implementation of emergency plans (especially local transport and communications network)
- (c) Population ~~land and water use considerations~~(e.g. special groups of the population who are difficult to evacuate or shelter)and land and water use considerations

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<sup>5</sup>This could also be of interest for the transfer of other hazardous substances

- (d) Specific considerations prescribed by the rRegulatory Bbody for special zones, such as the exclusionary area boundary, low population zone, etc.
- (e) Industrial facilities which may entail potentially hazardous activities.
- ~~(f) Agricultural activities that are sensitive to possible releases of radionuclides.~~
- ~~(g)~~(f) \_\_\_\_\_ Impact of concurrent external hazards on infrastructure.

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

#### CRITERIA RELATED TO NUCLEAR SECURITY PROTECTION AGAINST MALICIOUS ACTS

4.8. At the siting phase nuclear security aspects should be considered following IAEA Nuclear Security Series [18] to [20] and involving national competent agencies. The following criteria should be taken into account when considering ~~the protection of the installation from malicious acts~~nuclear security aspects:

- (a) The site is sufficient in size for the establishment of security boundaries (e.g. owner controlled area, protected area and vital areas) having enough spatial distance between each boundary to ensure adequate separation for the implementation of associated security measures. It should also accommodate the installation of security equipment and measures such as physical barriers, protected area perimeter isolation zones, protected area perimeter intrusion detection and assessment equipment, vehicle search areas (sally ports), and the implementation of a physical protection program and protective strategy.
- (b) The site characteristics that may require measures in order to control approaches to the facility.
- (c) The evaluation of site characteristics (location, size and proposed site layout) for potential negative impacts between safety and security, “(Safety/Security Interface).”
- (d) Terrorist threat environment for proposed site location.

4.9. The criteria related to ~~protection against malicious acts~~nuclear security 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 (cooling water, topography, access to grid, etc) ~~or protection against malevolent acts~~. They need to be considered together with the nuclear safety related aspects ~~and aspects related to protection against malevolent acts~~ in

an interactive manner especially in the ranking of the candidate sites ~~- -~~See [Ref.document](#) [11].

## 5. DATA NECESSARY AT DIFFERENT STAGES OF SITING PROCESS

5.1. Site selection should rely upon an increasingly detailed process of data collection and evaluation. In particular, the site survey phase should be based on information and data principally collected from existing sources such as available records, satellite imageries, topographic sheets, and information available from local authorities and other institutions. If a potential site could not satisfy all the screening criteria based on collected information during site survey stage but is likely to satisfy these criteria with the help of additional study/investigation, such investigation / study and the related screening test should be initiated as soon as possible so that their results are available in the next stage, i.e. site selection stage. The input information/data collected during site survey are important 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 focuses more and more on potential sites and candidate sites. The data acquisition and processing for these stages should be in line with the purpose and accordingly should generally start with regional data presented in large scales (coarser data; data of low resolution) to local data presented in small scales (finer data; data of higher resolution) .

5.3. For each topicsubject under consideration, the data should be collected in a coordinated manner, considering interfaces with other topicssubjects. The detail of different sets of data should be consistent with the aims of the specific steps of the siting process, ~~and should be similar across different topics.~~

5.4. The analyses performed based on the collected data should consider the total operating lifetime of the nuclear installation. 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 to site related hazards should be considered, as presented in [6], especially in terms of the possibility of increased rate 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 driven by 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 with the quality requirements, as recommended in Section 7.

5.7. All site data should be collected in a systematic, transparent, retrievable or traceable manner. The use of tools such as Geographical Information System (GIS) 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 data which are further elaborated in detail in Appendix-A:  
~~The following databases should be established for the siting process and are further~~

- (a) Geological ~~database~~
- (b) Hydrogeological ~~database.~~
- (c) Seismological ~~database~~
- (d) Fault displacement ~~database~~
- (e) Volcanological ~~database~~
- (f) Geotechnical ~~database~~
- (g) Coastal flooding including tsunamis~~database~~
- (h) River flooding ~~database~~
- (i) Meteorological ~~extreme events and rare events database~~information
- (j) Human induced events ~~database~~
- (k) Population, land and water use and environmental aspects~~database~~

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 Appendix A, and criteria associated with the data are listed in Table I-1.  
~~one or more of these databases will be needed to inform a judgment as to whether the site should be kept or screened in or out, and if kept, how it should be ranked with respect to other candidate sites. Not all databases need to be~~

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~~considered for every criterion. Each of the databases is described in Appendix A, and criteria associated with the databases are listed in Table I-1.~~

5.10. A two-stage process has been described for siting in Sections 2 and 3. It is intended that a graded approach to data collection is adopted for this process. The initial Site Survey Stage should collect readily available data<sup>6</sup> from relevant national and local authorities and other organizations, including contextual maps to undertake a qualitative desk-top study in order to establish relatively quickly whether the site can be screened in with respect to exclusionary criteria, and their likely impacts on the site for discretionary 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 of this stage is to provide sufficient information and analysis to enable confident judgments to be made using the ranking criteria. It is anticipated that at the end of this stage, a firm decision and reasoning on site selection should be made by the site owner/operator.

5.12. To enable activities of the second stage, it is anticipated that more data will need to be collected and analysis work would be undertaken. For example, comprehensive relevant literature surveys and in some cases, bespoke field-work will be required, e.g. to identify local sub-map scale topographical features of significance, and confirm geological features from local rock exposures, etc.

5.13. Although the data on some external hazards is likely to be limited and of variable quality, it is anticipated that some approximate analyses will be required, e.g. for:

- (a) Accidental aircraft crash hazard
- (b) Effects at the proposed site of nearby industrial facilities, for example impact of fires and chemical explosions, dispersion analysis for hazardous airborne releases that could affect the site.
- (c) More detailed analysis of local fault displacement capability
- (d) Estimate of seismically induced soil liquefaction potential at the site.
- (e) Generating a set of hazard curves for extreme meteorological and flooding events, e.g. wind, precipitation, temperature, sea and river flooding, etc., covering return periods applicable to the nuclear installation in question.

5.14. The judgments made at this stage should be sufficiently robust so that there is a high degree of confidence that they will not be undermined by further data collected or analysis during the site evaluation stage.

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<sup>6</sup>The extent of data collection and analysis cannot be defined explicitly in this guide since they are likely to be country and site specific.

## 6. SITE SURVEY AND SITE SELECTION FOR NUCLEAR INSTALLATIONS OTHER THAN NUCLEAR POWER PLANTS

6.1. The graded approach as mentioned in Para. 1.16 provides guidance for the 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) Processing facilities for nuclear material in the nuclear fuel cycle, e.g. conversion facilities, uranium enrichment facilities, fuel fabrication facilities and reprocessing plants.
- (d) Facilities for the predisposal management of radioactive waste arising from nuclear fuel cycle facilities.<sup>22</sup>

6.2. For the purpose of site survey and site selection, 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) in which it is assumed that the entire radioactive inventory of incredible failure occur resulting in radiological release from the installation is released by an accident. The analysis should use the worst case radioactive inventory expected during the life 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.~~Prior to categorizing an installation if adopting a graded approach, a conservative process should be applied to estimate the consequences of a radiological release in which it is assumed that the entire radioactive inventory of the installation is released by an accident. The analysis should use the worst case radioactive~~



~~inventory expected during the life 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 event itself. Such characteristics should include the following factors:

- (a) ~~The amount, type, form (e.g. solid, liquid, or gas) and the status of the radioactive inventory at the site (e.g. whether solid or fluid, processed or only stored);~~  
~~The amount, type 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. 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~~~~sources~~ 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 and storage facilities it may be distributed throughout the installation);
- (f) The changing nature of the configuration and layout for installations designed for experiments (activities at which may be unpredictable);
- (g) Characteristics of engineered safety features for the prevention and for mitigation of the consequences of accidents ;
- (h) The characteristics of the process or of the safety features that might show a cliff edge effect<sup>7</sup> in the event of an accident;
- (i) The characteristics of the site relevant to the consequences of the dispersion of radioactive material to the atmosphere and the hydrosphere (e.g. size, demographics of the region);
- (j) The potential for on-site and off-site contamination~~:-~~;
- (k) Monitoring instruments, control and trip systems response time~~response~~.

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<sup>7</sup> 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.

6.5. Depending on the national requirements~~criteria of the regulatory body~~, some or all of the above factors should be considered. For example, fuel damage, radioactive releases or doses may be the conditions or metrics 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. 6.45.

~~(e)~~(d) National regulatory criteria, if any

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6.7. As a result of this process, three or more categories of installation may be defined on the basis of national practice 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 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~~the highest hazard category includes installations for which standards and codes for nuclear power plants should be applied.

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

6.8. The graded approach is generally applied to the extent and detail for the data to be collected and analysed at each step. ~~Furthermore, depending on the consequences of the external hazards considered as screening criteria, the protection feasibility and method for the installation may vary.~~ These aspects should be considered when setting up the screening criteria for nuclear installations other than NPPs.

6.9. Criteria not directly associated with safety (Paragraphs 4.101 and 4.12) may be very different for other nuclear installations. This should be taken into consideration.

## 7. APPLICATION OF MANAGEMENT SYSTEM

### GENERAL RECOMMENDATIONS

7.1. As a function of the management system, the quality assurance program should be established by the operating organization (future licensee), and the contractors that carry out the work for selection of the site of a nuclear installation organizations, and their contractors directly responsible for investigating and selecting the site of a nuclear installation.

7.2. The management system in compliance with [12] and [13] should cover the organization, planning, work control, personnel qualification and training, verification and documentation for the activities to ensure adequate performance of these tasks and for adequate reporting.

7.3. The ~~management system program for the~~ siting process should be addressed in is a part of the overall management system ~~program~~ 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 site survey and site selection stages of the nuclear installation – see [12, 13] for requirements, recommendations and guidance on management systems.

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 more generally safety related evaluations.

7.5. The studies and investigations should be documented in sufficient detail to permit an 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. When developing the part of the management system dealing with the siting process, the following should be considered:

- (a) The intended end use of the knowledge and data that result from the activities of the siting process, in particular, in terms of their consequences for safety;
- (b) The capability to demonstrate, test or repeat results;
- (c) The scale and technical complexity of the activities of 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 multiple disciplines, work units or internal or external organizations, with divided or contingent objectives and responsibilities;
- (e) The extent to which other site evaluation 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. project related to site survey and site selection. The work plan should convey the complete set of general requirements for the nuclear installation (such as total power generation of the nuclear power plant (NPP) project), 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 program should be established and implemented 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 site selection process traceable and transparent to the public, users and reviewers, the related documentation should provide the following:

- description of all elements of the process;
- identification of the study participants and their roles; and
- background material that comprises the analysis documentation, 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 appropriately 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 review.

7.15. Considering that a variety of investigations are carried out (in field, laboratory and office) technical procedures that are specific to the activity 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 implementing a management system program should be established by the responsible organizations to ensure appropriate process and input from their contractors. 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 [12, 13]. 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 for data collection and data processing, field and laboratory investigations, analyses and evaluations that are within the scope of this Safety Guide.

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## APPENDIX – A

### DATABASE FOR SITING PROCESS

1. The extent of work required to develop an appropriate database will depend on the nature of the site, how easy it is to meet the site selection criteria (especially the exclusion criteria) and the extent of effort for comparison and ranking among the candidate sites.
2. The database should be comprehensive, up-to-date and compiled to support the evaluation and judgment of relevant number of thematic sets given in Section .5.0.

### GEOLOGICAL AND HYDROGEOLOGICAL DATABASE

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

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

#### Site Survey Stage

5. Make use of existing data available from national and local archives, e.g.:
  - (a) Regional geological maps, including those which contain data on stratigraphy, i.e. with appropriate cross-sections
  - (b) Regional tectonic maps
  - (c) Hydrogeological maps
  - (d) Regional geophysical maps, indicating gravity and magnetic anomalies
  - (e) Satellite imagery
  - (f) Topographic and geographic maps

#### Site Selection Stage

6. At this stage the data indicated above should be augmented with more detailed information. This may require more detailed and site specific available information as well as



site studies to be undertaken to confirm geological and hydrogeological characteristics, such as existing bore-hole logs, geophysical surveys, and geological fieldwork.

#### SEISMOLOGICAL DATABASE

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

##### Site Survey Stage

8. Using available earthquake catalogues, major earthquakes which may have had significant impacts on the proposed site should be selected taking account of the characteristics of causative faults. This preliminary information will be used for identification of the seismic active zones and preliminary estimation of seismicity for the potential sites to be used in the screening process.

##### Site Selection Stage

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

#### DATABASE RELATED TO FAULT DISPLACEMENT

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 plant safety. This hazard is also referred to as capable fault hazard. A clear definition of capable faults is given in the Safety Guide [5] together with recommended site investigations in relation to potential capable faults.

##### Site Survey Stage

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

#### Site Selection Stage

12. An in-depth investigation should be made on the capable faults combining the survey of existing reference materials, tectonic geomorphologic investigation, the earth's surface geological feature investigation, and geophysical investigation, etc. depending on the distance from the proposed site. Especially the area near the proposed site (e.g. 8 km) should be investigated precisely and in detail.

#### VOLCANOLOGICAL DATABASE

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

#### Site Survey Stage

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

#### Site Selection Stage

15. An evaluation of the uncertainty in age determinations should be included in this assessment. For example, the stratigraphy of pyroclastic units commonly is complex and incomplete. Assessment of the completeness of the geologic record should be attempted, even if all volcanic deposits cannot 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 the Safety Guide [7].

#### DATABASE ON GEOTECHNICAL HAZARDS

16. Investigation of the subsurface conditions at a nuclear installation site is important at all stages of the site selection and evaluation process. 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 program should provide the data

necessary for an appropriate characterization of the subsurface. The specific requirements will vary greatly from stage to stage.

#### Site Survey Stage

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 all stages of the site evaluation process, but to varying extents.

#### Site Selection Stage

18. The purpose of an investigation at the site selection stage is to determine the suitability of sites and identify issues that may be used in comparing the site with other potential 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 and a limited amount of site specific field investigations in order to understand:

- (a) Unacceptable subsurface conditions
- (b) Classification of sites
- (c) Groundwater regime
- (d) Foundation conditions

Detailed data requirements are similar to those recommended in the relevant Safety Guide [8].

#### DATABASE ON COASTAL FLOODING

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 in the site survey and site selection process for which it is used, as discussed above. This section includes all forms of flooding, including tsunami hazard.

20. At both the site survey and site selection stages, the suitability of the site is not solely determined by whether the site is inundated or not at particular return frequency events.

Engineered solutions can be effected that can safeguard the site in many cases. ~~For example,~~ the installation grade could be built at a sufficiently elevated platform level to support the safety related structures and equipment for protection against these extreme events. ~~The site can also be protected from flooding by sea walls and dykes.~~ The practicality of employing these flood defensive measures should be considered along with the flood level

predictions when deciding whether the coastal flooding is acceptable according to the criteria noted above.

21. Similar investigation on shore line stability should be conducted.

#### Site Survey Stage

22. Flooding due to storm surges, seiches, tides and wind waves: To determine the flooding potential of the site in these cases, it is necessary to know the extreme sea levels from storm surges, seiches, tidal and wind waves and the topography of the land around the proposed site. At the site survey stage a good approximation to evaluate flood levels can be done using tidal data usually available at national or local authorities and/or institutions, although frequently this data is not sufficient by itself to assess the highest astronomical tides or the combined effects of storm surge, seiche and wind wave effects because only a few decades of data may be available.

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 possibility of coastal flooding is not clear, especially at longer return periods, then more detailed work is required and the judgment of site suitability should be carried to the next stage.

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

25. Flooding from Tsunami: Tsunami hazard arises because of the effects of earthquakes, volcanic activity or landslides on the ocean floor. Relevant data should be collected from national and international sources. There may also be historical records of large scale flooding in the region that can be associated with one of the initiators above. The Safety Guide [6] provides simple screening criteria that can be employed and that need only minimal data. If the proposed site does not satisfy the conditions for applying the screening criteria in [6], then a situation may exist where there is too little reliable data upon which a simple desk-top study can be made.

#### Site Selection Stage

26. Flooding from storm surges, seiches, tidal and wind waves: 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 for longer return periods and appropriate to the nuclear installation under consideration.

27. Flooding from Tsunami: A preliminary evaluation of tsunami hazard should be undertaken at this stage. A preliminary analytical technique may be used at this stage to determine the extreme sea levels for longer return periods and appropriate to the nuclear installation under consideration. Information provided in the Safety Guide [6] will be useful for further work on this area.

#### DATABASE ON RIVER FLOODING

28. This database provides information describing the river flooding and storm water flash floods characteristics of the proposed site including river course changes, river bank stability and upstream land use changes. The extent and quality of data collection can vary depending on the stage in the site selection process for which it is used. The flood level data by itself is not sufficient for screening a site from further consideration since it may be possible to provide flood defences to protect the site, and this aspect should be considered when making site selection judgments.

#### Site Survey Stage

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 failure of upstream dam. The following data should be obtained and is normally available from national or local authorities:

- (a) Regional and local maps of watercourses, rivers, lakes, streams, wadis etc. and local site topographic maps. All watercourses that could credibly flood the site should be identified. Topographic features such as flood plain characteristics and the location and size of existing flood protection systems should be established, e.g. dykes and levees.
- (b) For major rivers, statistical information on rate of water flow vs. river level should be obtained. The possibility of ice hazard, including frazil ice should be considered. Historical data on river levels, extent of flooding etc. should be obtained.
- (c) Information on water retaining structures especially upstream of the site should be collected.
- (d) Low river levels: The potentially detrimental effects of low river water levels should also be considered.

#### Site Selection Stage

30. For this stage it may be necessary to undertake preliminary flood hazard analysis to estimate flood water levels at the site and the potential for interfering 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 if not previously available. Information provided in the Safety Guide [6] will be useful for further work on this area.

#### METEOROLOGICAL DATABASE (on extreme and rare events)

31. This database provides information describing ~~extreme and rare~~ meteorological events that could affect the potential or candidate sites. The extent and quality of data collection can vary depending on the stage in the site selection process for which it is used. The meteorological data by itself is 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

32. Meteorological data is 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) Regional and local history of extreme values, both extreme highs and extreme lows of meteorological parameters like temperature, humidity, atmospheric pressure, wind speed, precipitation, icing, ice-storms, sandy/dust storms etc. Similar regional and local data on rare meteorological events, such as storms, tornado, cyclone, and lightning should be collected.
- (b) The site drainage characteristics should be ascertained, e.g. natural drainage routes for surface water, height of water table, ability of water to flow onto the site. Consideration should be given to the fact that in-ground works of the nuclear facility can have a significant effect on the site drainage characteristics.

#### Site Selection Stage

33. For this stage it may be necessary to undertake a preliminary analytical exercise to determine historical meteorological data to establish hazard/frequency curves for the various meteorological variables. The suitability of the site will also depend on the extent that protection measures can be put in place to protect safety related Structures, Systems and Components (SSCs). In particular the drainage requirements for the site should be evaluated in detail, and the geotechnical features of the site will need to be determined, at least approximately, and their sensitivity to extremes of precipitation, temperature and drought

established. Information provided in the Safety Guide [6] will be useful for further work on this area.

#### DATABASE ON HUMAN INDUCED EVENTS

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

##### Site Survey Stage

35. To determine the potential of human induced events that could affect the site, it is necessary to collect information about the human activities around the site and analyse how these activities may change over the life of the facility. There are a large number of potentially hazardous human activities that could affect a site. The following general categories should be considered for their hazardous potential:

- (a) Co-located nuclear facilities
- (b) Nearby industries, especially those using quantities of toxic/explosive chemicals, or involving exothermic reactions or high pressure/temperature processes. Also industries that provide strong sources of ionizing or electro-magnetic fields.
- (c) Nearby military facilities
- (d) Transport systems, including road, rail, air, shipping and pipeline transport.
- (e) Land use activities such as those that influence water courses or slope stability affecting the site, e.g. upstream dams, major users of river abstraction, industries that could deposit large amounts of debris into a river upstream of the site etc.

These sites can present a range of hazardous events including:

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

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

36. This data can be used with local and regional maps showing transport routes and industrial locations etc., and local topographical maps to make an initial assessment of whether the candidate site should be screened out or not on the basis of screening distance values for the sources of human induced events. It is anticipated that many of the hazards listed above can be eliminated on the basis that their effects are very local to the source and unlikely to affect the site directly, e.g. missiles from small scale pressurized systems, or can easily be protected against, such as impacts from road traffic/rail vehicles. Other hazards may require a more detailed analysis from the next stage before a judgment can be made in respect of site selection.

#### Site Selection Stage

37. In this stage, it will be necessary to provide more detailed estimates of the severity/frequency of human induced events affecting the site or that may affect the site in the future. For several hazards listed above, a simple analysis based on site survey data alone may be insufficient to make a site selection judgment. For example, it is anticipated that this will apply to the following:

- (a) Aircraft crash (data collected for aircraft crash of accident origin can also be used to some extent for the evaluation of the site for aircraft crash of malevolent origin).
- (b) Toxic/explosive hazards from nearby industries using or storing very large quantities of these materials, e.g. oil and gas operations, large petrochemical factories, local quarrying or mining activities under the site.

For these situations it is likely that an expert analysis is required to determine the severity of the hazard, its likely impact at the site and the frequency with which the hazard is associated. ~~Such analyses should be undertaken at this stage by a competent person or organization.~~ Further guidance on undertaking these analyses is available in Safety Guide [3].

#### DATABASE ON POPULATION, LAND USE AND ENVIRONMENTAL ASPECTS

38. The criteria relate to the potential radiological and other impacts of the nuclear installation on the workers, population and the environment due to normal operation and

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accident conditions. Furthermore, the feasibility of the implementation of emergency plans is also addressed through this database over the life of the installation.

#### Site Survey Stage

39. One of the most common metrics considered at this stage is related to either population density in the site vicinity or distance of the potential or candidate sites to population centres (or both). This type of a metric is easy to use because most of the time such data is readily available. Care should be taken to use reasonable numbers for screening values.

It should also be noted that these values are country dependent. It is important however, to also consider population density projections for the life of the installation in the assessment of site suitability.

40. Bio-sensitive areas (protected species...), reserve forest, monuments, tourist spots should be identified.

#### Site Selection Stage

41. Depending on the regulatory requirements of the country this process may be more or less involved. In regulatory regimes where exclusionary area boundary (EAB) and low population zones (LPZ) are not required, attention should be paid mainly to the feasibility of emergency plan implementation in terms of effectively sheltering and evacuating the population in the external zone of the installation, i.e. emergency planning zone (EPZ). In countries where these additional measures (EAB and LPZ) are required more detailed work is needed to demonstrate compliance. This involves the collection of population data with more precision. Information provided in the Safety Guide [4] will be useful for further work on this area.

42. Preliminary evaluation of the compatibility of the nuclear installation with nearby bio-sensitive (protected species...), reserve forest, monuments, tourist spots should be performed

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## ANNEX I

### TABLES TO BE USED IN SITING PROCESS

I.1. Table I-1 provides an indication of the type of criteria that is generally associated with various issues related to siting process. It should be pointed out that there may be cases which are not consistent with Table I-1 due to the specific conditions of certain sites. Therefore, Table I-1 should be used only as a reference.

I.2. Table I-2 cross references applicable IAEA Safety Standards to the siting issues under consideration. Guidance provided in the Safety Standards is useful for issues related to evaluation of candidate sites. In some cases, explicit guidance may be provided for the site survey and site selection stages.

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

Criteria		Category		
Primary	Type	Screening		Ranking
		Exclusionary	Discretionary	
Earthquake	Ground Vibration		✓	✓
	Surface Rupture	✓		
Geotechnical	Slope Instability (Massive)	✓		
	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,		✓	✓
	Tsunami		✓	✓
Extreme Meteo Events	High Straight Winds		✓	✓
	Tornados		✓	✓
	Tropical Storms		✓	✓
	Precipitation		✓	✓

Criteria		Category		
Primary	Type	Screening		Ranking
	Sand/Dust Storms		✓	✓
Human Induced Events	Aircraft Crash		✓	✓
	Explosions		✓	✓
	Gas Releases		✓	✓
	External Fires		✓	✓
	Electromagnetic interference		✓	✓
<del>Malevolent acts</del> Nuclear			✓	✓
Unfavourable Dispersion Conditions	In air and water		✓	✓
Feasibility of emergency plan implementation		✓		
Implementation of emergency plan			✓	✓
Non-Safety	Topography		✓	✓
	Availability of Cooling Water	✓	✓	✓
	Accessibility to water		✓	✓
	Transport availability		✓	✓
	Access to <u>(national or regional)electric Grid</u>		✓	✓
	Non-radiological environmental	✓	✓	✓
	Socio-economic impact		✓	✓
	Land-use plan		✓	✓

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

Site Selection Issues		Safety Requirements	Site Evaluation Safety Guides						Design Safety Guides	
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	✓						✓		
	<u>Soil Liquefaction</u>	<u>✓</u>						<u>✓</u>		
	Extensive oil and gas extraction history	✓						✓		
Volcanism		✓					✓			
Flooding	River	✓				✓			✓	
	Dam Break	✓				✓			✓	
	Coastal	✓				✓			✓	
	Tsunami	✓				✓			✓	
Extreme meteorological events	High straight winds	✓				✓				
	Tornados	✓				✓			✓	
	Precipitation	✓				✓			✓	
Human Induced Events	Aircraft Crash	✓	✓						✓	
	Explosions	✓	✓						✓	
	Gas releases	✓	✓						✓	

Site Selection Issues		Safety Requirements	Site Evaluation Safety Guides						Design Safety Guides	
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
	External Fires	✓	✓						✓	
Population	Density	✓		✓						
	Distance from Centres	✓		✓						
Dispersion	In Air	✓		✓						
	In Water	✓		✓						
Feasibility of the Emergency Plan		✓		✓						

## ANNEX II

### EXAMPLE OF CRITERIA FOR SITING PROCESS OF NUCLEAR POWER PLANTS(NPPs)

#### GENERAL CONSIDERATIONS

II.1. The objective of this annex is to provide certain information that could serve as examples of attributes and related criteria to be considered in the siting process of NPPs. This annex is intended to be used by the stakeholders associated with the siting process of NPP. This annex is prepared by compiling information on the practices of different Member States and also from the new version of relevant IAEA safety standards. Examples are given in this Annex 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 sets are,

- External natural hazards.
- External human-induced events.
- Radiological impact on public and environment.
- Emergency planning.
- Aspects not directly related to nuclear safety.

The last set, though not directly related to nuclear safety, is considered to have important 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, hazard and considerations that are to be taken into account in siting process of an NPP. Screening values for some of these attributes serve as useful siting criteria. Examples on such screening values are provided. The candidate sites need to undergo preliminary evaluation which is useful for comparison and ranking in the second stage of siting process. Examples of discretionary criteria with respect to some of these issues, events, phenomena and hazards are also provided. Finally, the Annex provides example of content of emergency procedures, which would serve as useful information for examination of the feasibility of emergency planning.

## EXAMPLE OF ATTRIBUTES CONSIDERED IN SITING

### II.4 General Site information

#### 1. Maps of site area at suitable scale

- i) Site boundary and emergency zones; typically these are zones demarcating 5km, 16km, (>) 25 km, and 80km from centre of reactors [II-1, II-2, II-3], although these vary from country to country.
- ii) Population distribution and location of existing industrial, commercial, institutional, recreational and residential facilities including projections for the operating lifetime of the nuclear power plant

### II.5 External natural hazards

#### 1. Geology

- i) Properties of sub-surface strata, depth of bed rock and type
- ii) Characteristics of sub-surface material
- iii) Ground water

#### 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 cyclone, tornado and water spout
  - b. Precipitation
  - c. Storm
  - d. Snow
  - e. Lightning
  - f. Dust storm and sand storm
  - 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 – sea water level variations and extremes

~~f.g.~~ 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 river and other drainage channel

~~c.d.~~ d. Combination of flooding with relevant meteorological events

vi) Combination of coastal and inland flooding for sites on 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. Avalanche
- 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 and water use.

## II.6 External human induced hazard

1 Stationary sources



- i) Oil and Gas Operation (e.g. refineries)
- ii) Industrial plants and operations and other hazardous substances processing facilities
- iii) Hazardous substances storage facilities
- iv) Broadcasting and communication networks (for electromagnetic interfering hazard)
- v) Mining or quarrying operations
- vi) Other nuclear facilities
- vii) High energy rotating equipment
- viii) Military facilities (permanent or temporary) especially shooting ranges, arsenals
- ix) Co-located facilities (like fuel reprocessing unit, storage of fresh and 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 military and civilian)
- vi) Transportation of fresh and spent fuel and other nuclear material or 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/Dust storms

### 2 Use of land and water

### 3 Population consideration

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- 4 Dispersion of radioactive material through
  - i) Atmosphere
  - ii) Sub-surface water
  - iii) Surface water
- 5 Management of radioactive waste during operational states
  - i) Radioactive solid waste
    - a. Characteristics of waste
    - b. Quantity
    - c. Level of activity
    - d. Management Strategy
  - ii) Radioactive liquid waste
    - a. Characteristics of waste
    - b. Quantity
    - c. Level of activity
    - d. Management strategy
  - iii) Management of gaseous radionuclides
    - a. Characteristics gaseous radionuclides
    - b. Quantity
    - c. Level of activity
    - d. Management strategy
- 6 Management of the Radioactive releases during accident conditions
- 7 Co-located facilities like fuel reprocessing facility, storage of fresh and spent fuel
- 8 Ambient radiation
- 9 Monitoring
- II.8 Emergency management
  - 1 Physical and site characteristics that may hinder emergency plans
  - 2 Emergency management procedures
  - 3 Infrastructure characteristics related to the implementation of emergency plans
    - i) Evacuation routes/ accessibility routes
    - ii) Shelter
    - iii) Transportation

- 4 Special considerations prescribed by the regulatory authority for special zones, if any such as exclusion ~~ary zone~~ boundary, low population zone etc.
- 5 Population considerations within emergency zones outside the nuclear installation boundary
- 6 Additional statutory requirements by the
  - i) Federal government
  - ii) State, provincial or territorial government
  - iii) Local government

## II.9 Aspects not directly related to radiological safety

1. Topography
  - i) Salient feature
  - ii) Contour maps for the region up to 30 km
2. Accessibility
  - i) Nearest railway lines
  - ii) Nearest national highway and major road
  - iii) Nearest sea port
3. Available industrial infrastructure and construction facilities
  - i) Construction materials
  - ii) Construction power
  - iii) Construction water
  - iv) Infrastructural facilities
4. ~~Availability of power supply sources and transmission lines p~~ Proximity to load centres
  - ~~i) Start up power~~
  - ~~ii) Power evacuation scheme~~
5. Availability and access conditions to cooling water
  - i) Condenser cooling
  - ii) Fresh water for consumptive use
6. Township
  - i) Location
  - ii) Distance from NPP site
  - iii) Expected population
7. Proximity to load centres
  - i) Power distribution grid lines

- ii) Location of major power consuming units/facilities/population
8. Non-radiological environmental impact including ecological considerations
- i) Heat sinks – water bodies/atmosphere
  - ii) Presence of bio-sensitive areas adjacent to site
  - iii) Reserve forest or monuments or tourist spots
  - iv) Statutory bodies restriction on
    - a. Thermal pollution
      - Differential temperature between the intake and outfall points of the condenser cooling water.
      - Effect of condenser water discharge on aquatic life.
    - b. Chemical pollutant discharge
9. Socio-economic aspects including public acceptance
- i) Type of adjacent area – urban or rural
  - ii) General source of income for local population – large scale industry, small scale industry, agriculture and agro industries
  - iii) General economic condition of the surrounding population with respect to national averages (e.g. per-capita-income)
  - iv) Acceptance level of the plant by general 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 during site survey stage. Examples of such screening values are given in Table II-1, these values are typical and may vary from country to country. If a site does not satisfy any one or a combination of screening values, it can still be acceptable provided engineering solutions are available, i.e. design features, measures for site protection or administrative procedures exist.

Table II-1 Example of the screening values

No.	Characteristics	Screening Values	Remarks
1.	Distance from capable fault	8.0 km[II-3]	Exclusion criterion
2.	Distance from flight path approaching airport	4.0 km [II-4]	Discretionary criterion
3.	Distance from airport with attributes of Type-2 event*	7.5 Km [II-4]	Discretionary criterion
4.	Distance from small airports	10.0 km [II-4]	Discretionary criterion

No.	Characteristics	Screening Values	Remarks
5.	Distance from large airport for yearly flight operations > 500d <sup>2</sup> for yearly flight operations > 1000d <sup>2</sup>	< (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 fire ranges	30.0 km [II-4]	Discretionary criterion
7.	Distance from military installations storing ammunitions etc.	8.0km [II-4]	Discretionary criterion
8.	Distance from facilities of storing handling 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.	Reserved bio sensitive region and forest	Exclusion zone	Exclusion criterion
11.	Tsunami	10 km from sea or ocean shore line or 1 km from lake or fjord shoreline, or 50 m above mean water level [II-5]	Discretionary criteria

\*Accidental aircraft crash at the site as due to take-off or landing operation at nearby airport.

## REFERENCE

### TO ANNEX\_II

- II-1 INTERNATIONAL ATOMIC ENERGY AGENCY, Seismic Hazards in Site Evaluation for Nuclear Installations, Safety Standard Series No. SSG-9, IAEA (2010).
- II-2 INTERNATIONAL ATOMIC ENERGY AGENCY, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, Safety Series No. NS-G-3.2, IAEA (2002).
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- II-4 INTERNATIONAL ATOMIC ENERGY AGENCY, External Human Induced Events in Site Evaluation for Nuclear Power Plants, Safety Standard Series No. NS-G-3.1, IAEA (2001).
- II-5 INTERNATIONAL ATOMIC ENERGY AGENCY, Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations, Safety Standard Series, No. SSG-18, IAEA (2011).

## ABBREVIATIONS

~~ALARA~~ — ~~As low as reasonably achievable~~

~~DBA~~ — ~~Design basis accident~~

~~DBGM~~ — ~~Design basis ground motion~~

EPZ            Emergency planning zone

~~EZ~~ — ~~Exclusion zone~~

EAB            Exclusionary area boundary

FSAR          Final safety analysis report

GIS            Geographical information system

LPZ            Low population zone

~~MS~~ — ~~Member States~~

PSR            Periodic safety review

PSAR          Preliminary safety analysis report

SER            Site evaluation report

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