ROLE OF SAFETY ASSESSMENTS AND SAFETY CASES IN THE REPOSITORY DEVELOPMENT PROGRAMME

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IAEA

Atoms for Peace: The First Half Century
1957–2007

CONTENTS

Safety case development

Safety assessments

Safety case content

Summary

IAEA DEFINITIONS 1

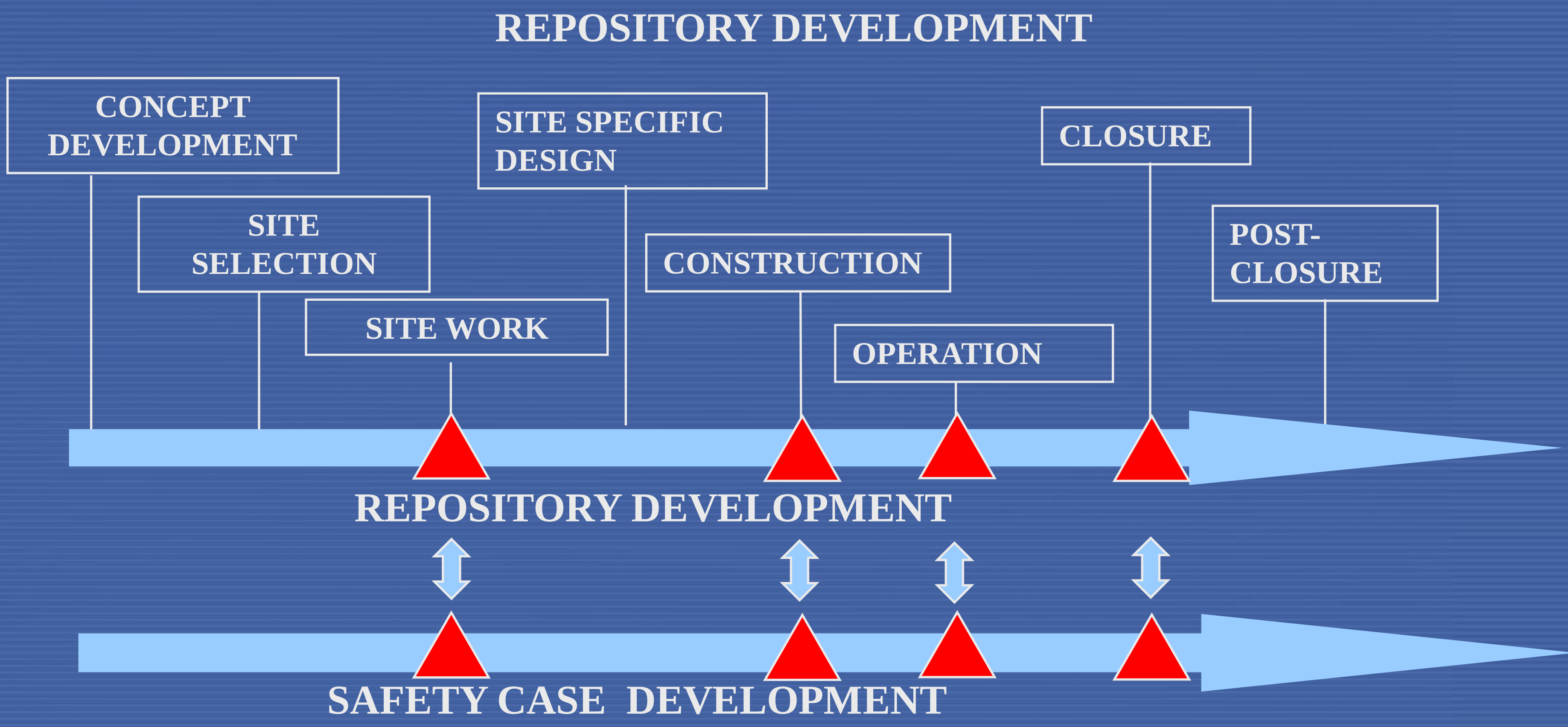
- Safety Case (IAEA Safety Glossary 2007)

  "A collection of arguments and evidence to demonstrate the safety of a facility or activity.

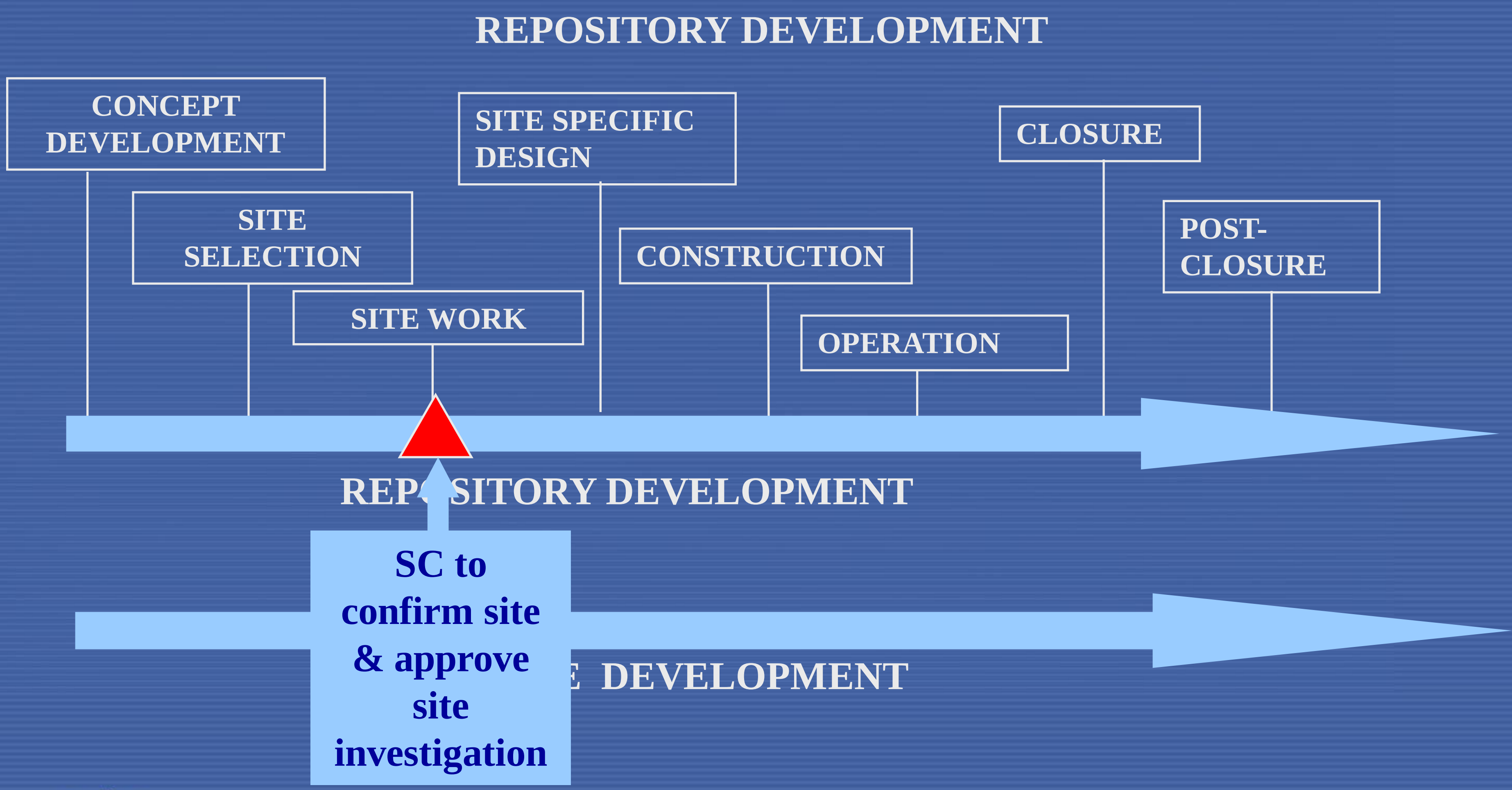
  For a repository, the safety case may relate to a given stage of development. In such cases, the safety case should acknowledge the existence of any unresolved issues and should provide guidance for work to resolve these issues in future development stages"

Safety Case Development

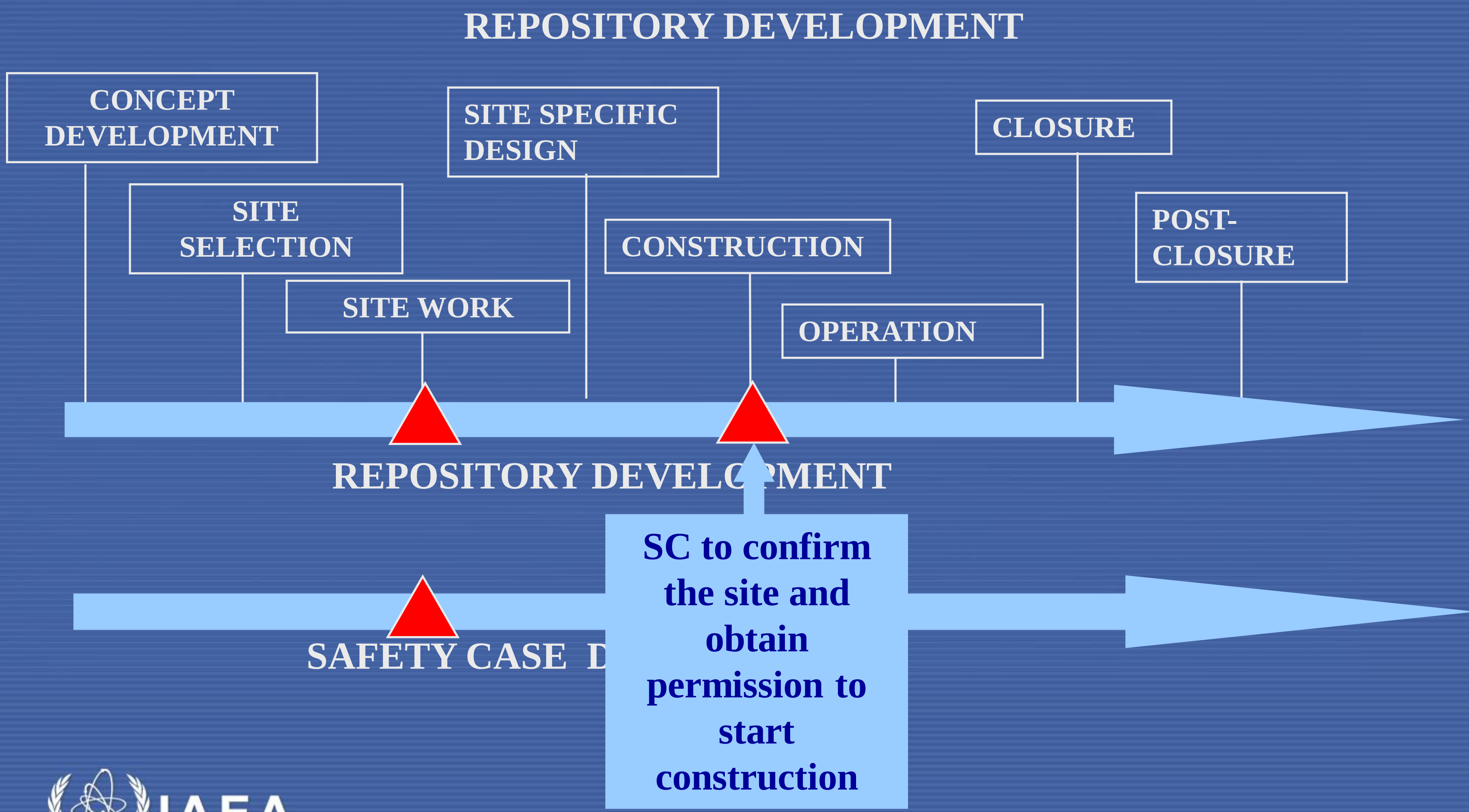
SAFETY CASE DEVELOPMENT



FIRST DECISION POINT



SAFETY CASE DEVELOPMENT



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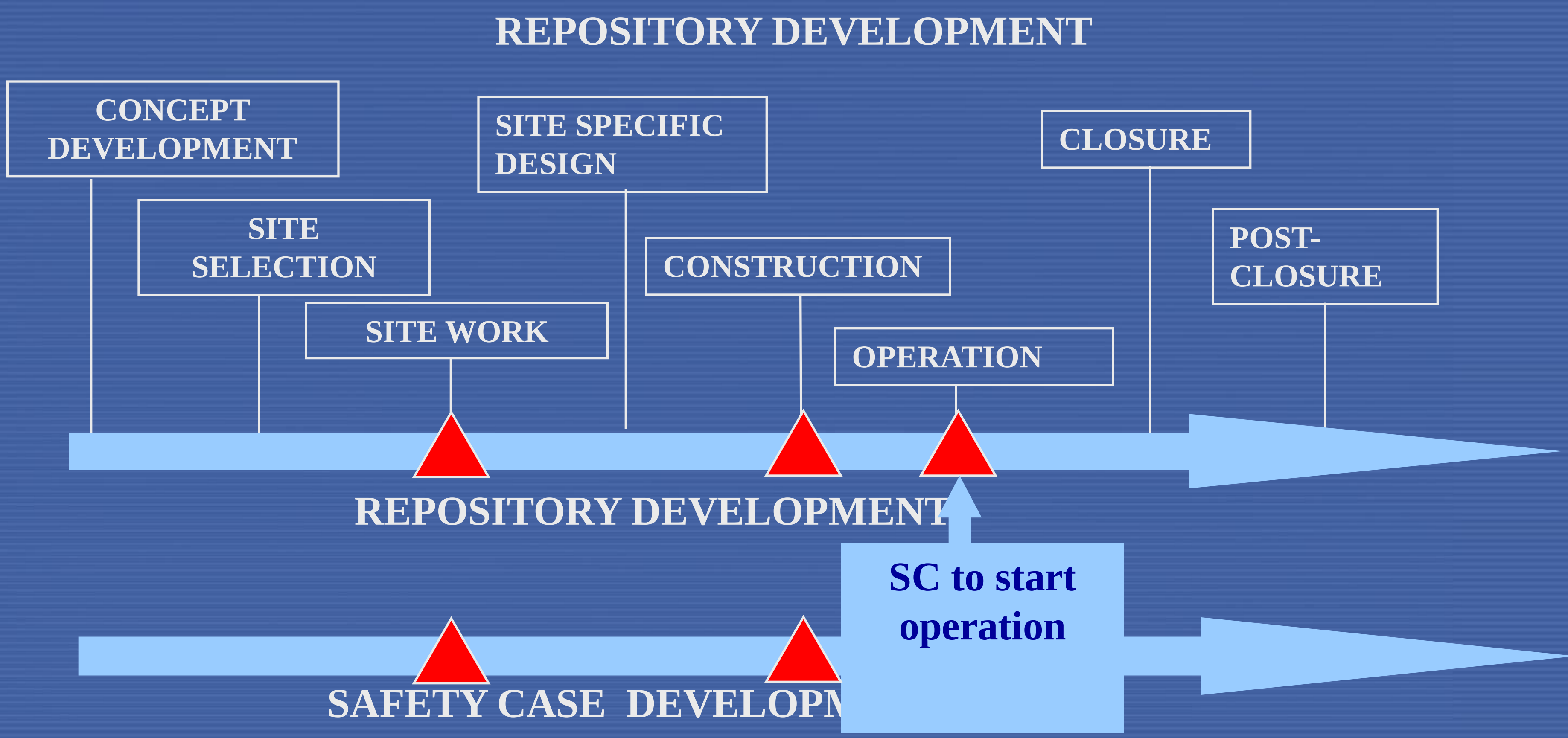
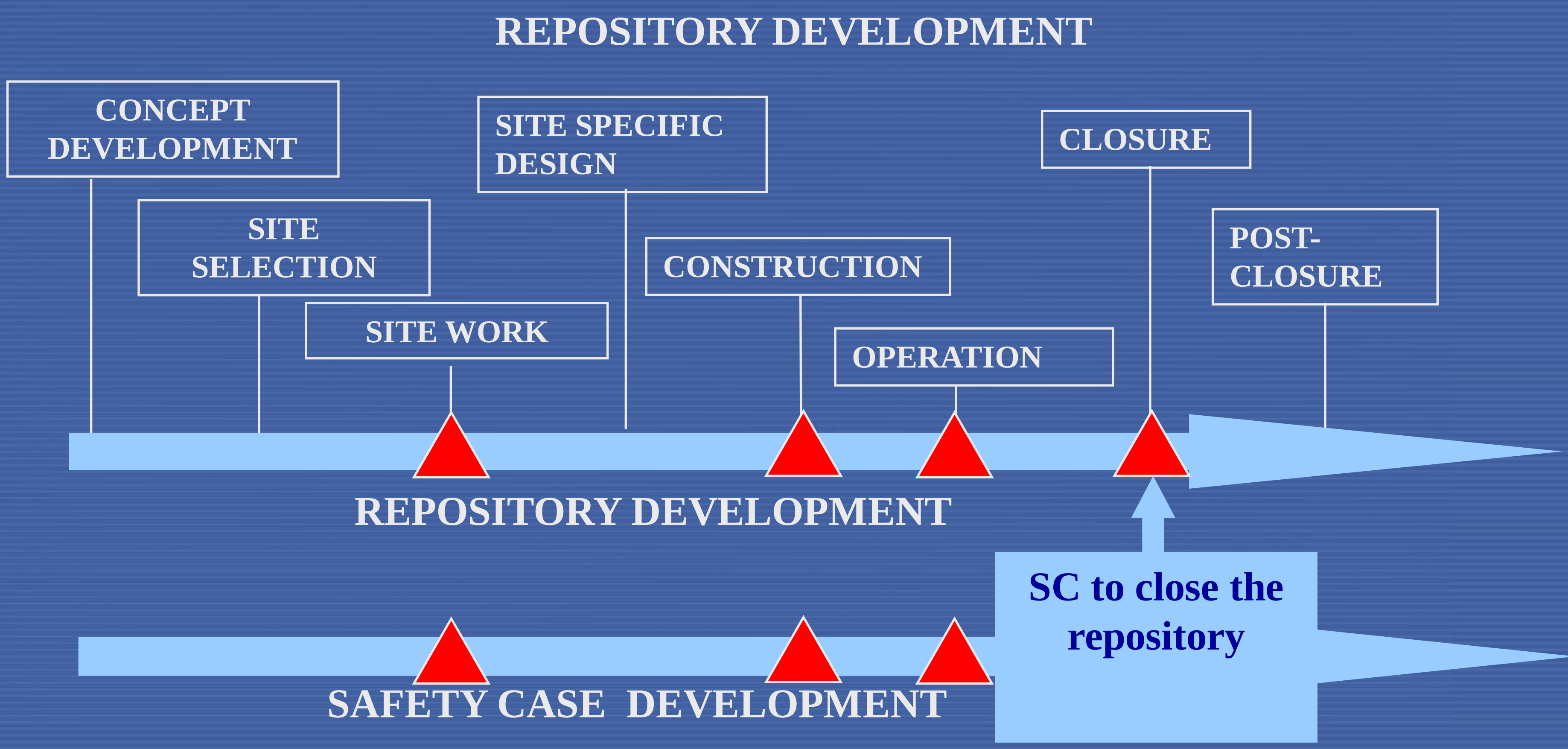
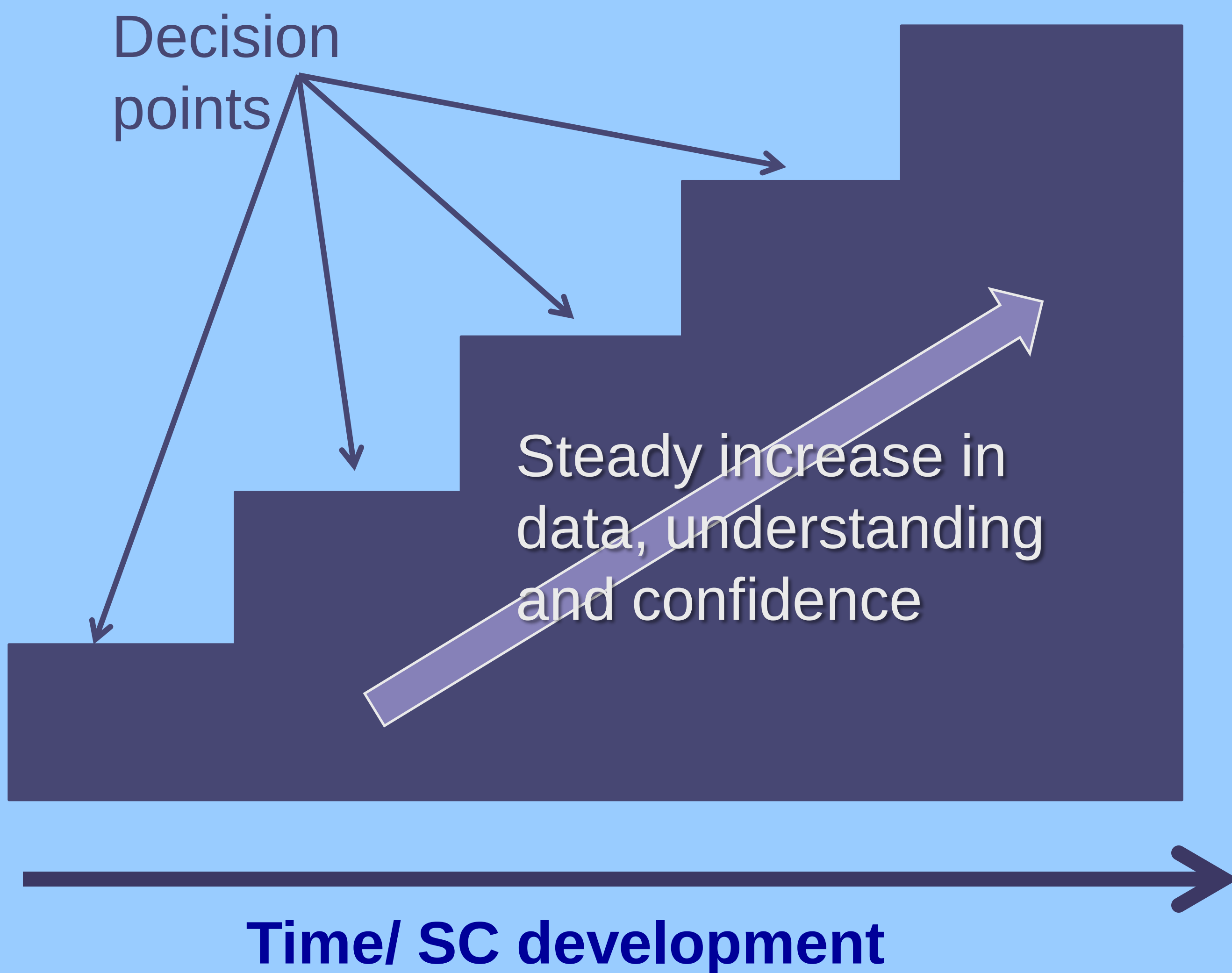


SAFETY CASE DEVELOPMENT



Safety case development



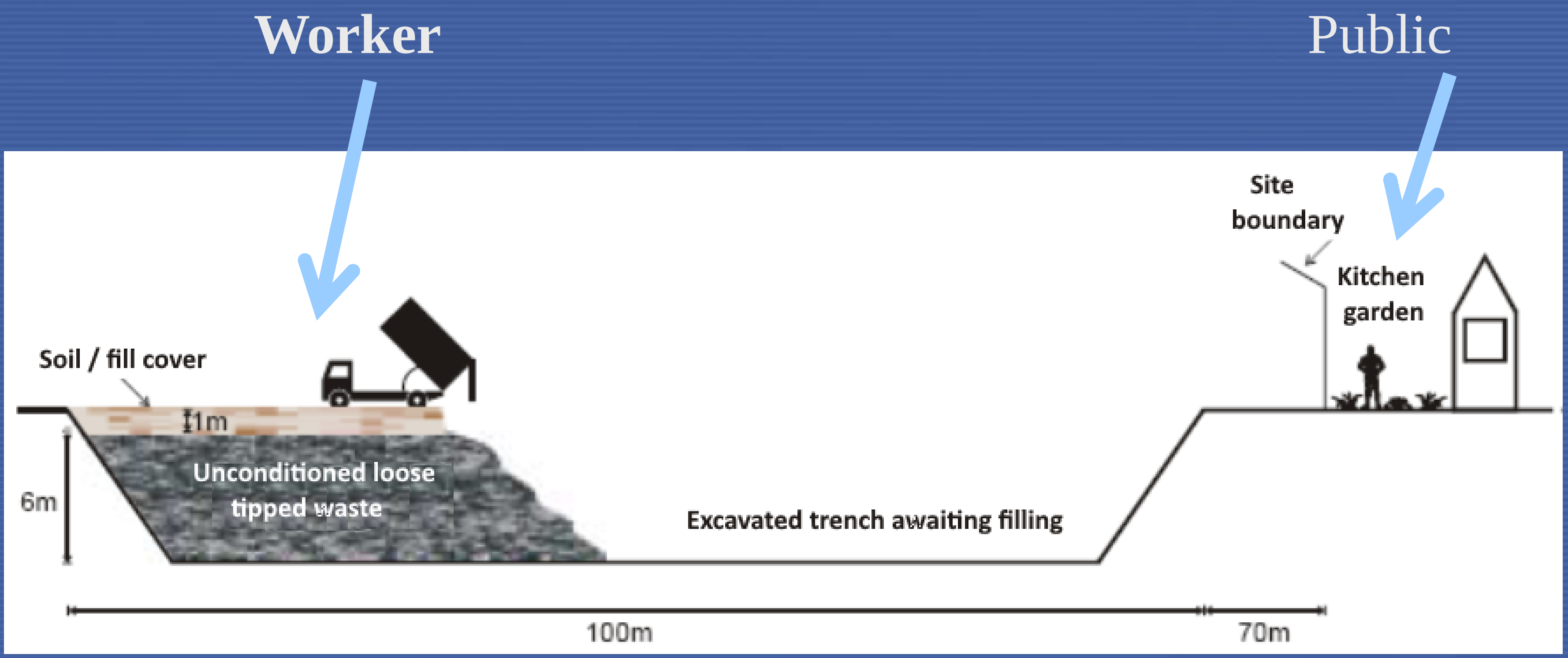
Safety assessment

Different types of SA in disposal

- Transport
- Conditioning?
- Operational
- Post-closure

} Focus on these here

Typical scenarios for operational safety



Typical exposure pathways for operational safety

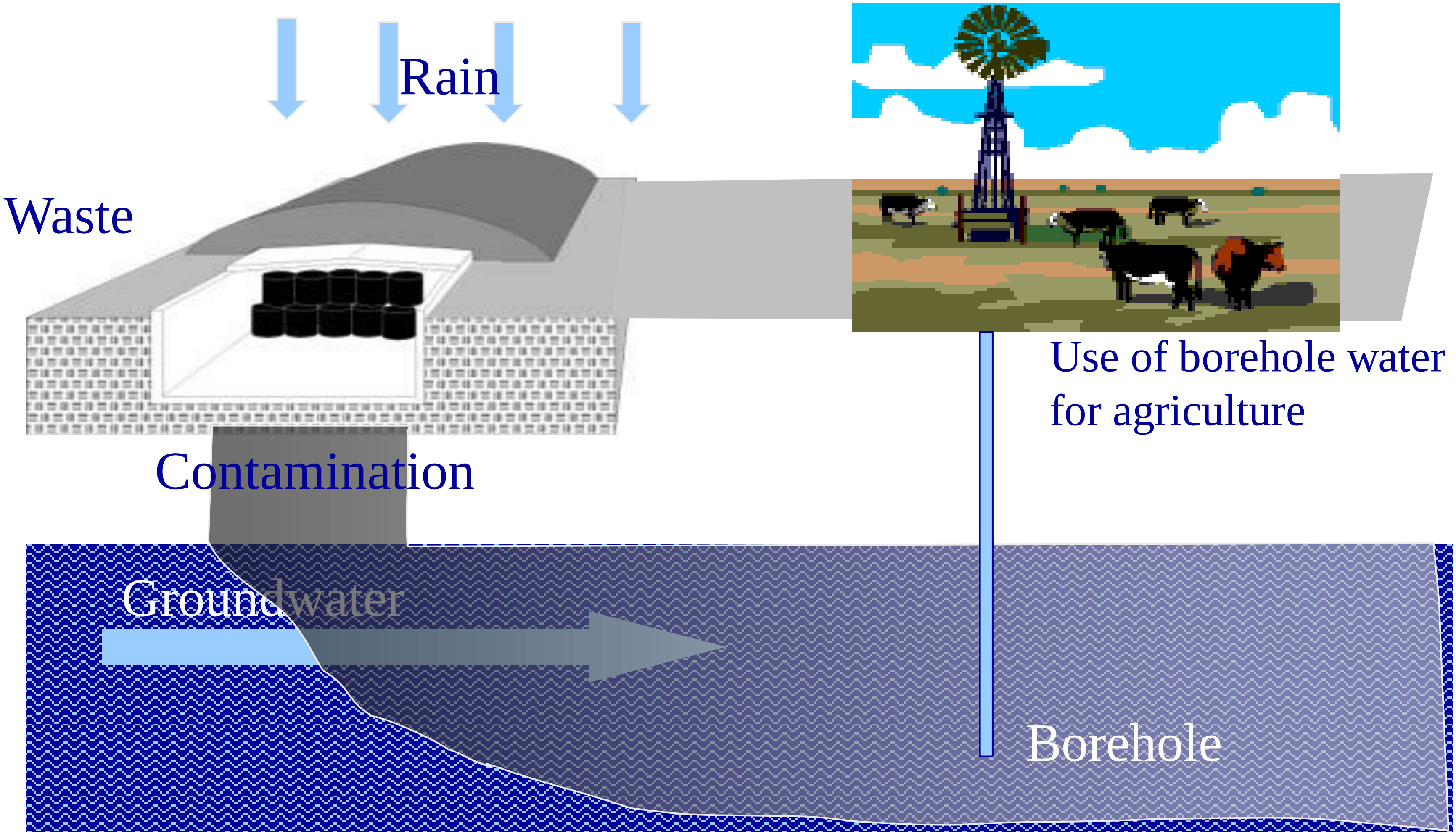
The repository worker is exposed to (for example)

- External radiation from the disposed waste and the waste in his truck
- Ingestion of contaminated dust from his hands and clothes
- Inhalation of dust produced by tipping

The member of the public is exposed to (for example)

- External radiation from the disposed waste
- Ingestion of food in his garden contaminated by dust and, perhaps, by a contaminated water course
- Inhalation of dust blown onto his property

Typical "natural discharge" scenario for post-closure safety 1



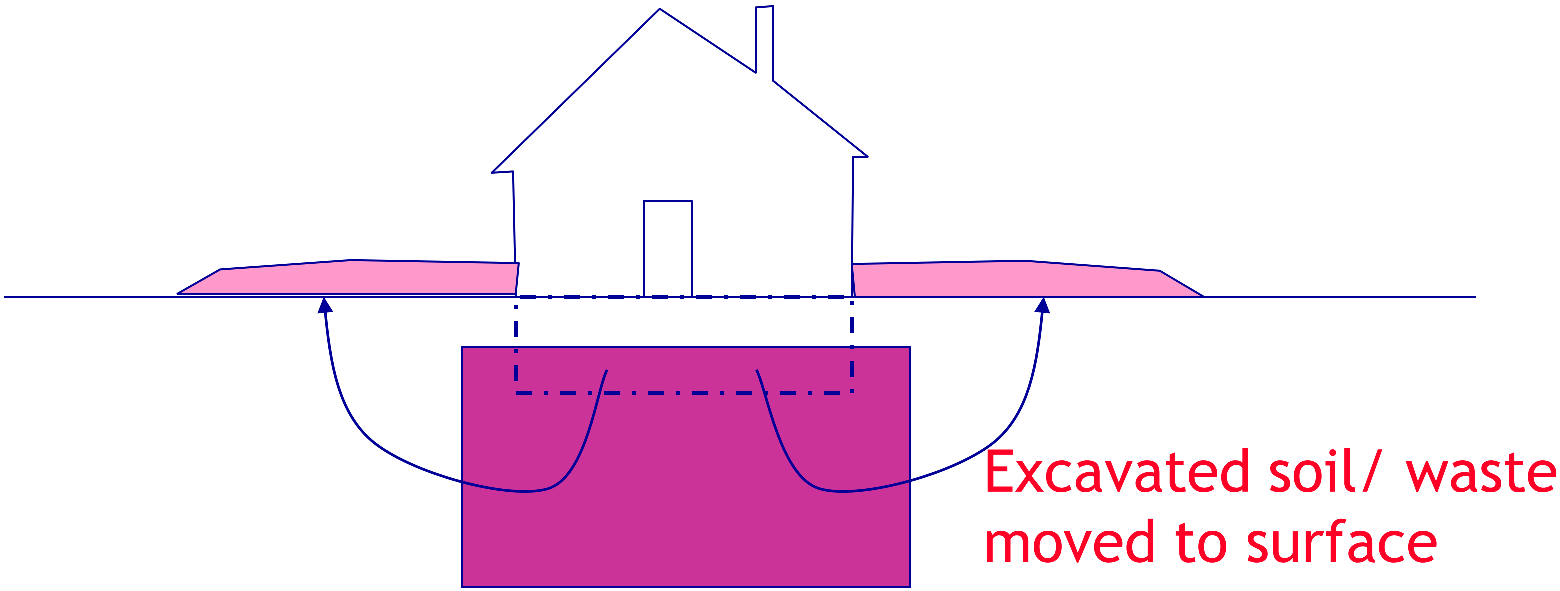
Typical exposure pathways for post-closure safety – natural discharge scenario

In the post-closure phase it is assumed that control and knowledge of the repository has been lost so that all exposures are to members of the public

In this case the member of the public is exposed through his extraction use of contaminated water from the aquifer. Typical sources of exposure are

- External radiation from soil contaminated through irrigation with water from the aquifer
- Ingestion of contaminated water and food grown on contaminated soil
- Inhalation of wind-blown contaminated soil

"Human intrusion" scenario for post-closure safety



After a period of time (typically assumed to be 300 years) someone inadvertently digs into the repository, perhaps to build a house. Waste is brought to the surface causing the occupiers of the house to be exposed. Radioactive gas may also seep into the house

Typical exposure pathways for post-closure safety – human intrusion

Again we are not concerned with worker exposures

A member of the public is exposed to (for example)

- External radiation from the waste brought to the surface
- Ingestion of food grown in contaminated soil and irrigated with contaminated water in his garden
- Inhalation of wind-blown contaminated soil
- Inhalation of radioactive gas seeping into the house

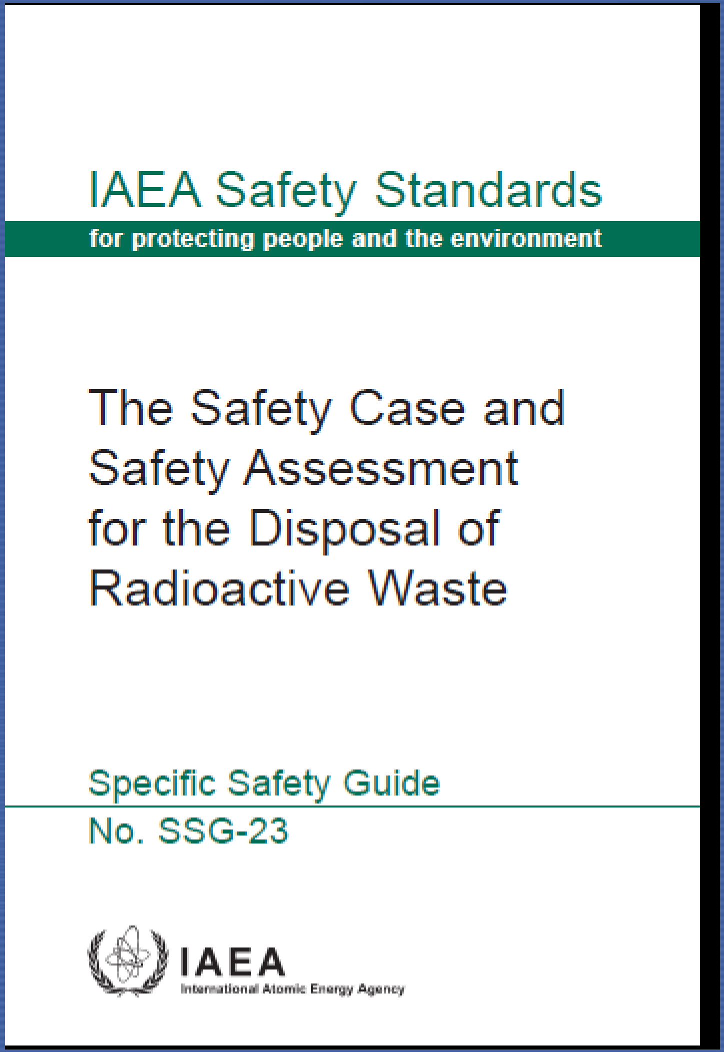
Key differences (for near-surface disposal)

	Operational safety	Post-closure safety
Time scales	The period of operation – probably a few decades	Starts at the end of the institutional control period (eg 300y) and lasts for many thousands of years
Exposed persons	Workers and public	Public
Dose limits	20 mSv/y workers, 1 mSv/y public	1 mSv/y public
Scenarios	Mostly defined by operational procedures for workers and proximity of disposals to points where the public have access	The extremely wide range of possibilities makes it necessary to make many conservative assumptions eg the representative person eats only locally grown food
Control of radiation exposures	Relatively easily controlled through the conventional method of combining "time, distance and shielding" and other measures such dust suppression, control of liquid effluents etc	Important method of control is use of an "institutional control period" during which public access to the site is prevented. Engineered and natural barriers can provide more long-lived protection
Significant Radionuclides	Exposures are usually dominated by relatively short-lived gamma emitters (eg Co-60, Sr-90, Cs-137) which represent the major sources of radioactivity in the waste	Exposures are always dominated by long-lived radionuclides that represent a small fraction of the radioactivity initially present in the waste eg Ra-226, Ni-59

Safety Case content

Reference

- This section on the content of the safety case comes from IAEA Safety Standard SSG-23


IAEA Safety Standards

for protecting people and the environment

The Safety Case and Safety Assessment for the Disposal of Radioactive Waste

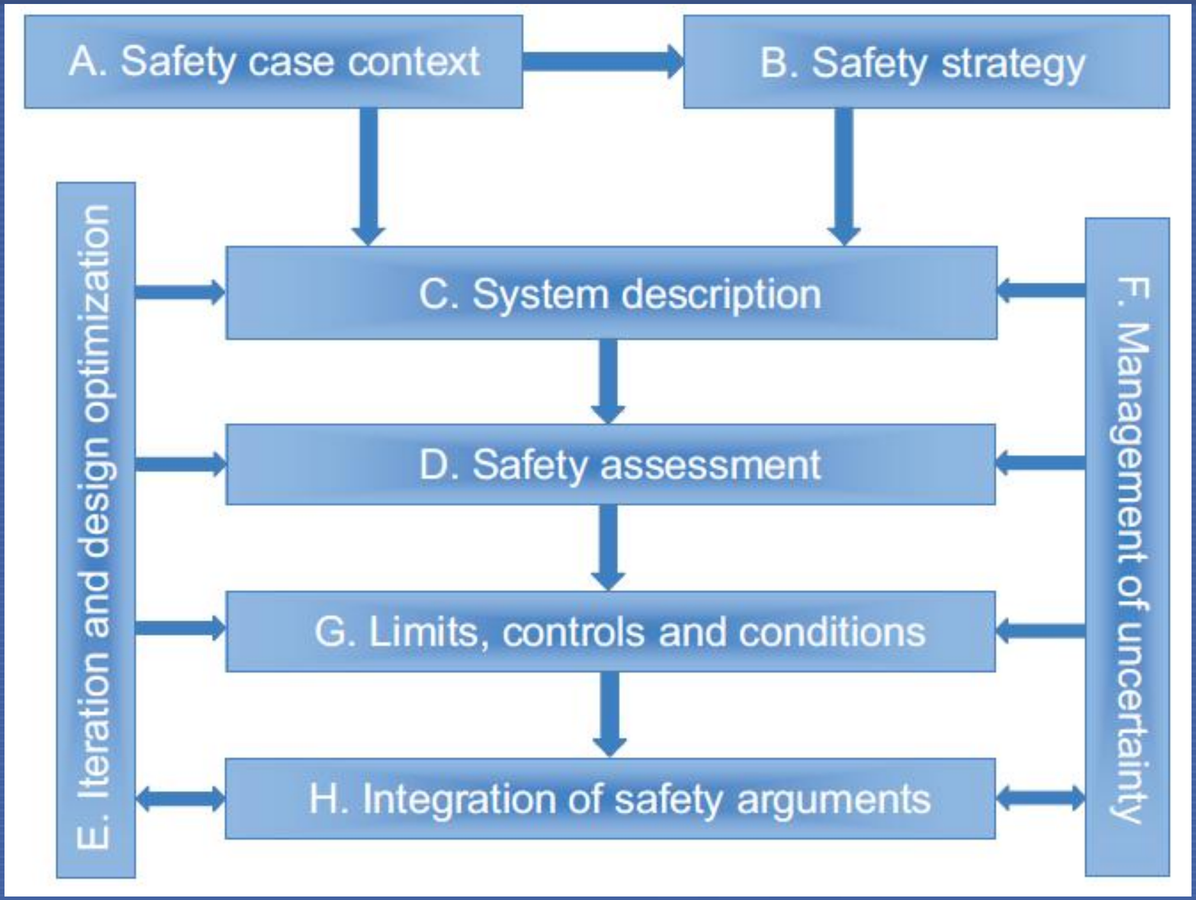
Specific Safety Guide

No. SSG-23

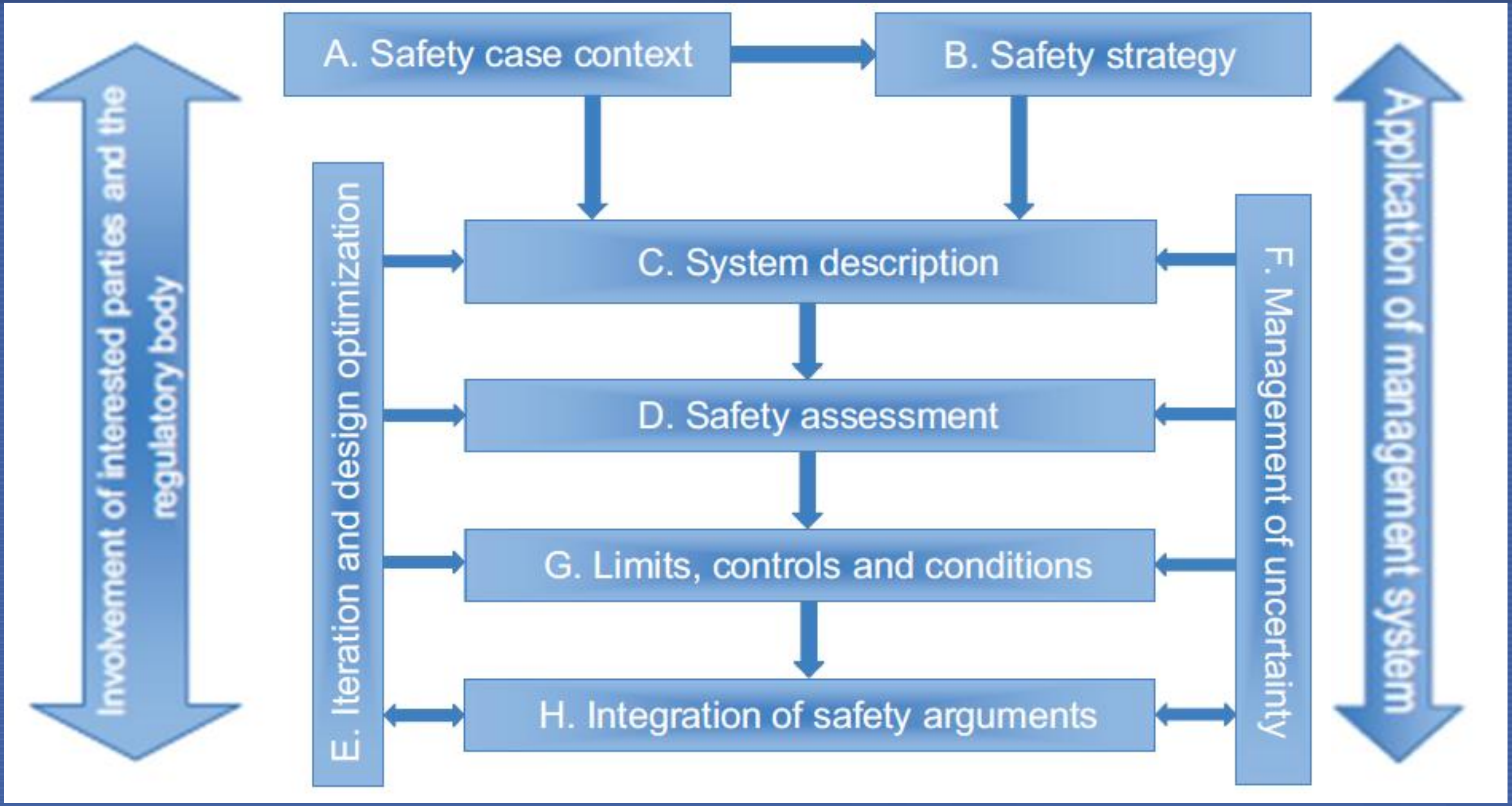
IAEA

International Atomic Energy Agency

Safety Case Components



Safety Case Components



All aspects will involve the regulatory body and (perhaps) other interested parties; all aspects are subject to the application of a quality management system.
We shall examine each of these components in turn

Safety Case Context

Safety case context describes the **purpose** of the safety case, the approach to the **demonstration of safety** and how the **graded approach** has been (or is to be) applied.

We expect the **purpose** to change as the repository development programme moves forward. Some examples of are

- testing of initial ideas for safety concepts,
- site selection,
- demonstration of the safety of the disposal facility,
- design optimization etc

Demonstration of safety refers to the safety objectives and safety principles that must be applied and the regulatory requirements that must be met. This aspect should also explain how uncertainties are to be identified, characterised and managed

Graded Approach is applied to ensure that the scope, extent and level of detail of the safety case and supporting assessment are commensurate with the level of risk and the stage of facility development. This part of the safety case context aims to explain and justify the adopted approach

Safety Case Strategy

Safety strategy describes, at high level, the means of demonstrating compliance with safety requirements and good engineering practice. It is usually developed early in the repository development programme.

In terms of meeting safety requirements, for example, we might expect to see

- the provision of multiple safety functions and defence in depth,
- containment and isolation of the waste,
- passive safety features,
- robustness of the disposal system to external perturbations,
- demonstrability of safety related features and aspects,
- interdependences with predisposal waste management and
- the overall approach to the management of uncertainties.

With respect to demonstrating good engineering practice, the safety case strategy could require (for example)

- a comparison of the adopted approach with solutions used elsewhere in the world
- peer reviews to verify the use of good engineering practice

System Description

System description is a detailed description of the proposed facility & its surroundings, the repository components and their safety functions, how the facility will be operated and how the overall system is expected to evolve over time. A key issue is data provenance.

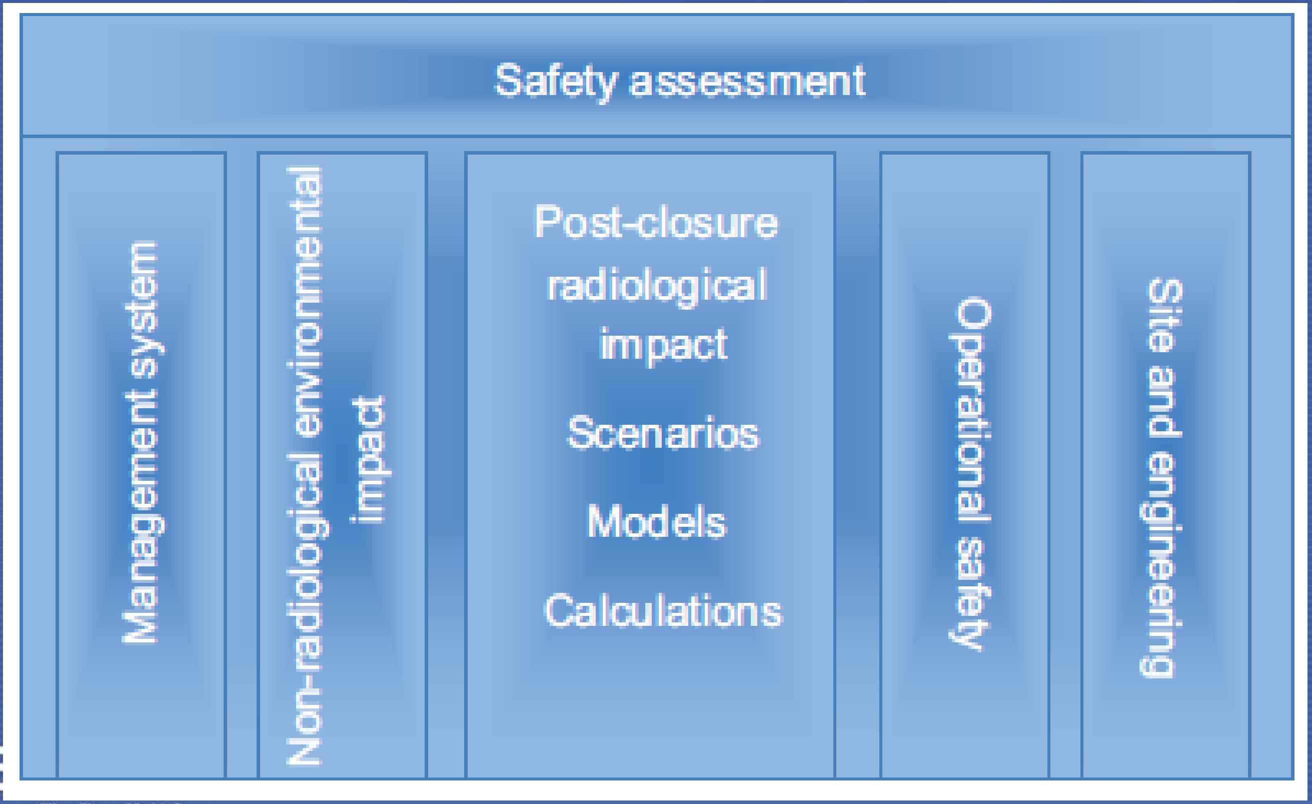
Conventionally, it is usual to divide this description into

- the near field, including: (i) the types of waste (e.g. the origin, nature, quantities and properties of the waste and the radionuclide inventory); (ii) system engineering, e.g. waste conditioning and packaging, disposal units, engineered barriers, cap or cover of the disposal facility, drainage features); and (iii) the extent and properties of the zone disturbed by any excavation or construction work;
- the far field, e.g. geology, hydrogeology, hydrology, geochemistry, tectonic and seismic conditions, erosion rates;
- the biosphere, e.g. climate and atmosphere, water bodies, the local population, human activities, biota, soils, topography

These separate parts need to be described as they exist in their current state and as they are expected to evolve through the timescale of the operational and post-closure safety assessments.

Safety Assessment

Safety assessment should be understood to include all the safety assessments contained within the safety case. This diagram, taken from SSG-23 shows three supporting safety assessments for non-radiological environmental impact; post-closure radiological impact and operational safety. Others that could have been included are transport safety, conventional safety during construction and operation and post-closure non-radiological safety. Safety assessment is covered in detail in other modules. The safety assessment is also supported by the Management System and the properties of the site and the engineered design.



Management of uncertainties

Management of uncertainties refers to the need to explicitly address uncertainties within the safety case and, especially, the safety assessment

- Overall aim is to understand the significance of uncertainties and then to reduce or bound them. Where uncertainties remain, a conservative approach is needed.
- Recognize three main sources of uncertainty: scenario, modelling and data/ parameter. Methods for quantifying these include
  - Scenario uncertainty: use of alternative scenarios to demonstrate potential impact of changed assumptions e.g. alternative future climate states
  - Modelling uncertainty: use of alternative conceptual models to demonstrate impact of different approaches e.g. groundwater flows in fractures as opposed to a continuous porous medium model
  - Data/ parameter uncertainty: use of probabilistic techniques or, where a deterministic approach is adopted, sensitivity analysis to identify key parameters and their impact. Again, data provenance is a key issue

Iteration and design optimization

Iteration and design optimization reflects the fact that a safety case and the repository design will be developed over a period of years. During this time many aspects will be revised and improved with the expectation that the final proposal for implementation will be a mature product

One might expect that iteration may be necessary when, for example,

- revising the safety case context or strategy
- optimizing the facility design
- new site data become available
- suggestions or recommendations arise from peer review

Limits, controls and conditions

Limits, controls and conditions refer to the standards, derived from the safety case, that will be applied during the construction, operation and closure of the repository to ensure that it corresponds to the facility described in the safety case.

The safety of a disposal facility will depend on a combination of site features and administrative arrangements, which in turn will depend on the availability of suitably qualified staff.

Examples of limits, controls and conditions include

- waste acceptance criteria and
- controls on
  - construction processes,
  - emplacement operations
  - backfilling materials and techniques,
  - requirements on monitoring and on staff training
  - etc.

Integration of safety arguments

Integration of safety arguments is a synthesis of the safety case that brings together the arguments, analyses and evidence to demonstrate that adequate levels of safety will be achieved and, therefore, that development of the repository should continue.

The treatment should include

- **Comparison with safety criteria** ie with the relevant dose and/or risk constraints and limits
- **Complementary safety indicators and performance indicators** eg comparisons between calculated concentrations and fluxes of radionuclides with naturally occurring values or with alternative regulatory guidelines eg drinking water standards
- **Multiple lines of reasoning** eg the use of natural and anthropogenic analogues to support models used in the safety assessment
- **Plans for addressing unresolved issues**. It is recognized that, especially when a programme is in the early stages, there may be many unresolved issues. These need to be acknowledged, their significance explained, and a plan for their resolution put in place

Summary

Safety case development

Progressive approach to support the major decision points in the repository development

Safety assessments

Various types of SA will be found in the safety case eg operational, post-closure

Safety case content

Structured approach that starts with the SC context (what is the purpose of the SC?) and includes the management system, peer reviews, uncertainties, limits, controls and conditions etc