Safety Assessment of El Cabril, the Spanish Surface Disposal facility for LILW and VLLW – 17233

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ABSTRACT

El Cabril project was launched in 1986, for Low and Intermediate Level Waste (LILW) disposal, based on concrete barriers and concrete disposal units. The operation of a Very Low Leve Waste (VLLW) complementary facility based on clay and High Density Polyethylene (HDPE) barriers and different types of disposal units started in 2008.

Two main objectives are considered in the design: Immediate and post-closure protection and no radiological restrictions, after institutional control period.

To fulfil these objectives several design criteria like waste isolation through a multi-barrier system, surveillance period no longer than 300 years and limitation of activity are applied.

The Safety Assessment process follows a methodology which, taking into account important facts like safety and design criteria, time frame, radiological protection criteria, waste characteristics, environment, FEPs (features, events and processes), etc., develops different scenarios, models and calculations to define the safety approach. This safety approach follows the current guides and recommendations of international organizations, it covers the potential impact of the facility for the operational and long-term periods and it includes normal evolution and less likely accidental and inadvertent human intrusion events.

All the studies and considerations done for the Safety Assessment have to be included in a safety Report, required for getting the Operation License for Nuclear Installations in Spain. The content of this Report is defined by the Spanish regulation and it has to be revised if there is a change in the facility that may affect the safety. It is also mandatory making a Safety Periodic Review (every 10 years in the case of El Cabril) that has to be presented to the Regulatory Council.

This paper outlines the principles, objectives and criteria of El Cabril's disposal installation and it explains the safety assessment performed, for both LILW and VLLW disposal, as part of the documentation produced to obtain the authorization to operate.

INTRODUCTION

El Cabril disposal facility, located in the province of Córdoba, is an essential part of the Spanish national management system for LILW and VLLW.

The project was launched in 1986 and the operation for LILW disposal started in 1992. This disposal facility is based on concrete barriers and concrete disposal units.

In October 2008, started the operation of a VLLW complementary facility based on clay and HDPE barriers and different types of disposal units.

The basic functions for LILW barrier system (see figure 1), according to the disposal concept shown in figure 2, are:

- First barrier: Confinement of the activity
- Second barrier: Limit the water entrance and control any possible leachate
- Third barrier: Limit the contaminant transport to the biosphere

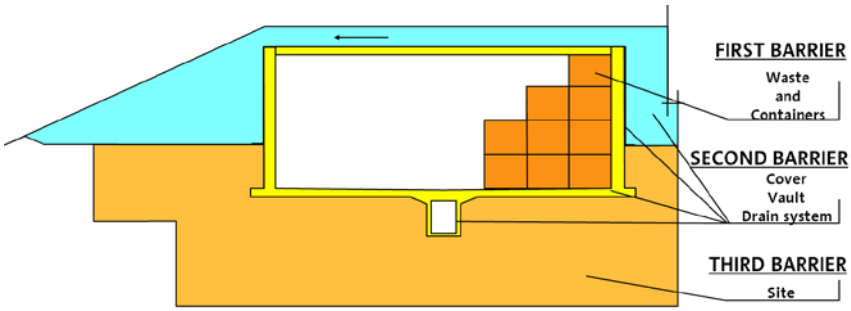

Fig. 1. LILW barrier system

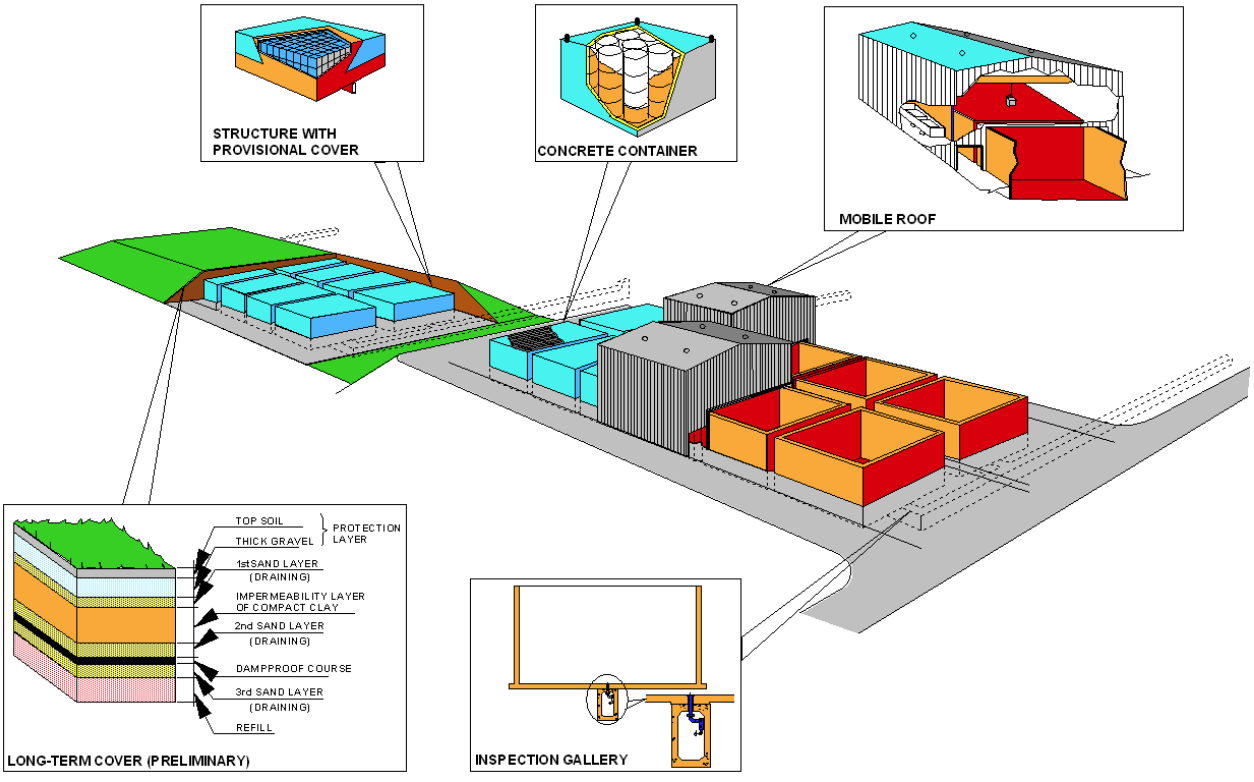

Fig. 2. LILW Disposal Concept

In the case of VLLW, the different barriers (shown in figures 3 and 4) have the following functions:

- Cover: Limit the water entrance (among others)
- Bottom barrier: Confinement of the activity and potential leachate control
- Natural terrain: Limit the contaminant transport into biosphere

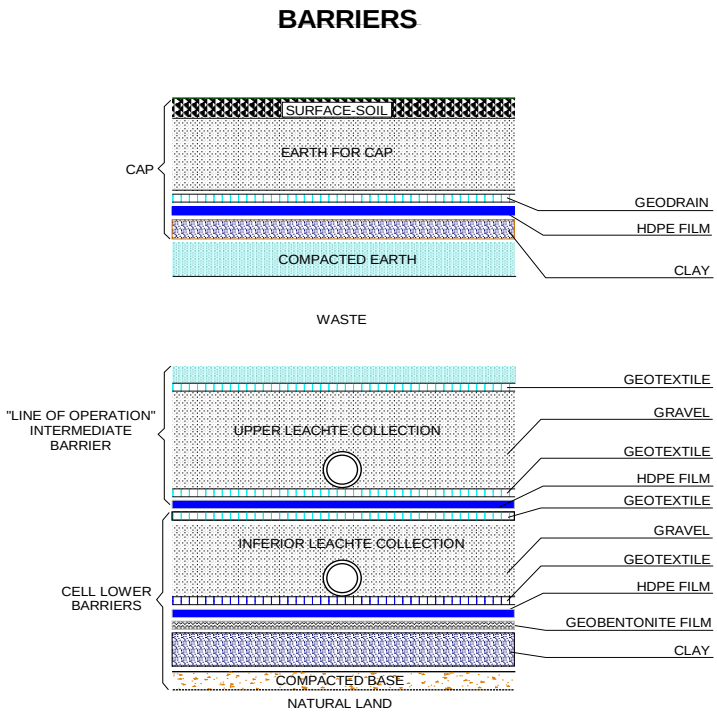

Fig. 3. VLLW barrier system

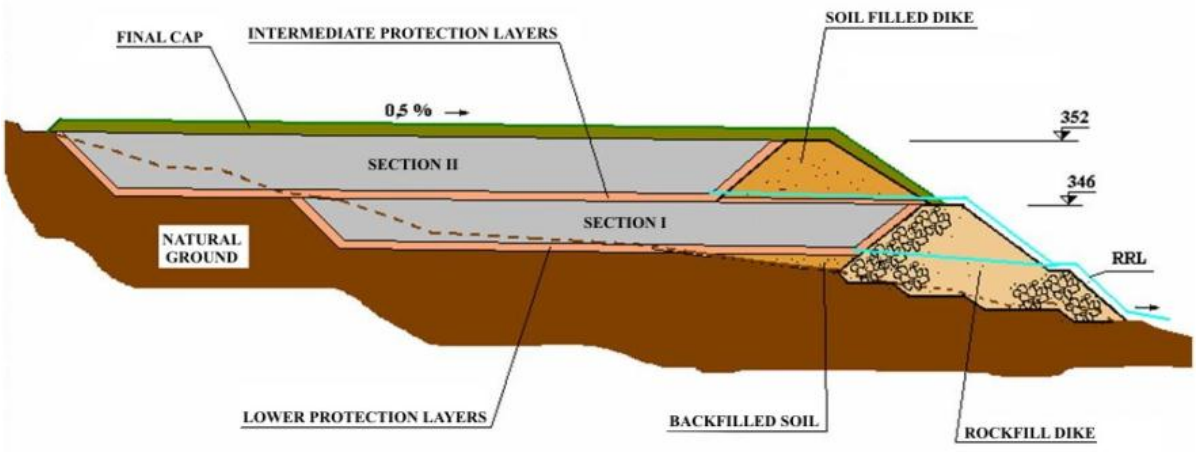

Fig. 4. Longitudinal section of VLLW cell

The facility has a total surface of 35 Ha, where 20 Ha are occupied by buildings and the LILW disposal. The rest are occupied by the VLLW disposal area.

It has an internal capacity for LILW of 100,000m^3 (28 vaults) and, for VLLW, 130,000m^3. As an average, there is an annual reception of 1700m^3.

Nowadays, El Cabril has the following facilities (see figure 5): disposal areas for LILW and VLLW, treatment and conditioning systems, concrete containers manufacturing plant, active & non-active characterization laboratories, ancillary installations and interim storages.

The authorization for this facility, as shown in the operation license [1], will be valid until the available disposal capacity is completed.

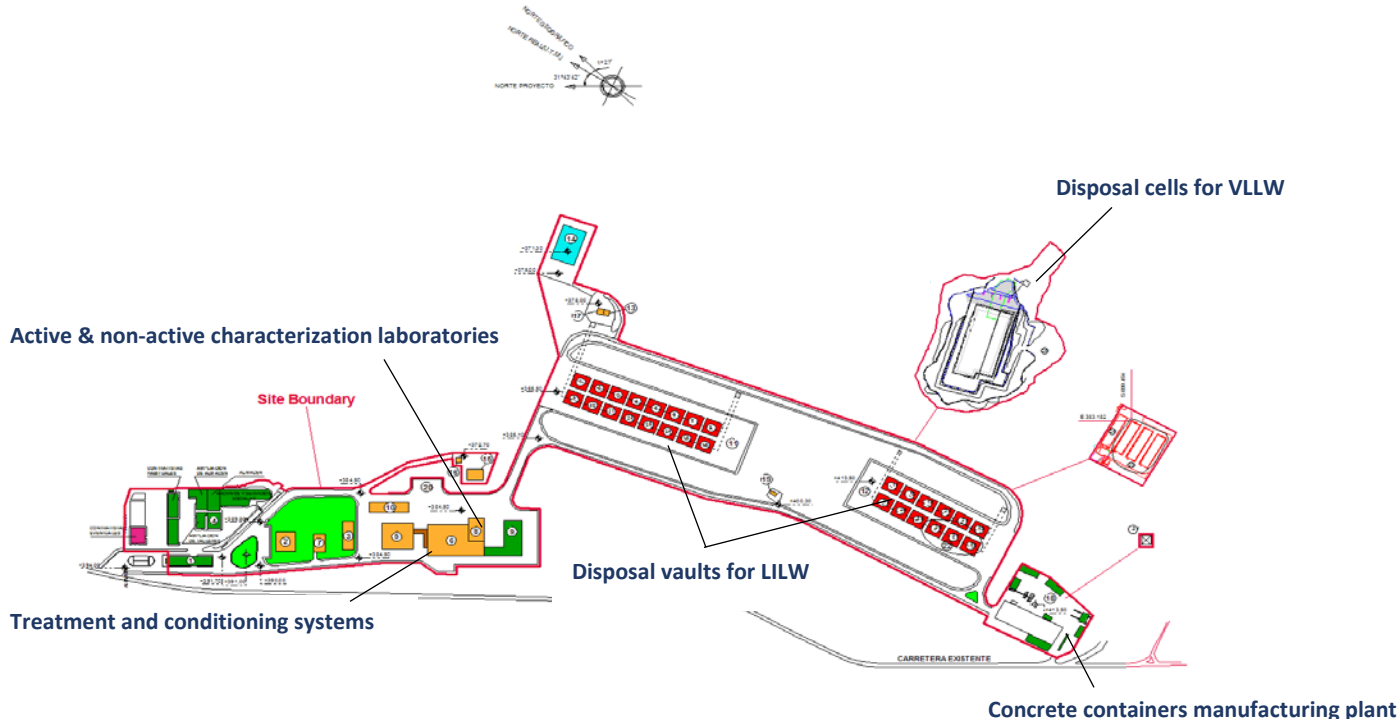

Fig. 5. El Cabril disposal site location

SAFETY OBJECTIVES AND CRITERIA

The disposal must fulfil some basic safety objectives and criteria, according to the Spanish regulation [2-4]. For VLLW disposal, the technical design was based on the regulations governing disposal facilities for non-radioactive hazardous waste in Europe, more in keeping with the type of waste and risk associated with its very low activity content.

Two main fundamental objectives are considered in the design:

- Ensure the immediate and deferred protection of the public, the workers and the environment, during operation and after closure.

- Having no radiological restrictions at the end of the surveillance phase (related to a possible inadvertent human intrusion).

The criteria applied that lead to the fulfilment of the objectives are:

- The use of isolation barriers to prevent radionuclide migration.
- The limitation of the activity by waste package and by cell.
- The requirement of a surveillance period no longer than 300 years.

Some other technical options have been considered in the design, such as:

- In order to ensure the protection of the public and the environment during the operational phase:
  - There are no liquid radioactive effluents discharges
  - The annual effective dose due to gaseous effluents has to be below 10^{-2} mSv
  - The average dose in case of hypothetical accidents over 5 consecutive years will be below 5 mSv
- To ensure the protection of the workers:
  - The occupational dose will be below the maximum limit authorized
  - 5 mSv/y is the reference value used during the design phase
  - ALARA (as low as reasonably achievable) criteria for the exposure will be applied
- In the case of members of the public and the environment during the post-closure phase, water pathway scenarios and inadvertent human intrusions scenarios will be considered.

SAFETY APPROACH

The safety assessment approach and safety requirements adopted follow the current guides and recommendations of international organizations such as the International Atomic Energy Agency (IAEA), and the International Commission on Radiological Protection (ICRP), along with the national regulatory requirements [5-9]. It covers the potential impact of the facility with regard to both the operational and long-term periods. The radiological criteria adopted as a maximum value for the exposure of workers under normal conditions is 5 mSv/y, and the dose constraint for the public is 0.1 mSv/y in normal evolution scenarios, according to the national recommendation stated by the Spanish safety authority, Consejo de Seguridad Nuclear (CSN).

The safety analysis examines situations relating to anticipated conditions, both now and in the future, including events associated with the normal evolution of the disposal facility and, less probable, accidental and intrusion events.

The safety assessment performed has a dual objective:

a) The derivation of waste activity acceptance criteria for disposal

b) The demonstration that an acceptable level of protection of human health and the environment will be achieved both now and in the future.

To generate scenarios for both phases, systematic methods purporting to be transparent, justified and documented have been applied. The scenario generation process results in the identification of important scenarios to accomplish the safety assessment objectives. The scenarios are classified in two groups: those relevant to the assessment of specific activity waste limits and those that are relevant to demonstrate an acceptable level of protection of human health and the environment. This does not mean that the scenarios are different for each group; one or more scenarios may be relevant for both groups. The main scenarios considered are the following:

1. Scenarios related to the operational phase are developed (operational safety analysis-scenarios), using a methodology based on the preparation of an operational activities list and on the identification of the possible events associated with each activity during the progress of the radioactive wastes from reception to final disposal, taking into account the design of the facility and its operating methods and instructions. The scenarios studied in this case are the following:
    a. In normal operation
        - Water pathway scenarios, with no radiological impact and zero release imposed by the authorisation.
        - Atmospheric pathway scenarios, where controlled ventilation system and incineration stack are required.
        - External exposure scenarios that take into account the external exposure due to operational activities (like treatment, maintenance, etc.) and the external exposure occurred in the disposal areas.
    b. In accidental situations
        - Atmospheric pathway scenarios
            - Handling incident that may cause activity dispersion
            - Waste fire outside the incinerator
            - Operational failure in the ventilation system
            - Operational failure in the incineration system
2. Scenarios related to the post-institutional phase are developed (Long Term safety analysis-scenarios) applying an approach based on the preparation of a list of FEP's, identifying the relevant factors for disposal performance.
    a. Water pathway scenarios
        - Normal evolution
        - Cover failure
        - Rise of water table (in LILW vaults)
        - Bathtubing (in VLLW cells)
    b. Human intrusion scenarios
        - Road construction
        - Residence construction
        - Residence use
        - Residence and playground use
        - Residence and agricultural use
3. Inadvertent human intrusion scenarios take into account the following aspects:
        - Deterministic evaluation done with occurrence after 300 years
        - There is no physical barrier to prevent intrusion
        - Historical memory concerning disposal facility is not conserved
        - The wastes are unrecognisable and homogeneously mixed

- There is no activity loss due to leaching and only radioactive decay is considered
- Human activities in 300 years are assumed to be similar to the present ones

The analysis carried out to support the proposed activity limit is based on calculations for each single radionuclide. The scenario development methodology and subsequent formulation and implementation of model processes ensure that the analysis is coherent.

The long-term safety performance of the disposal facility is evaluated taking into account the analysis of the normal evolution scenario and intrusion events. There is a reference inventory established for the vaults in operation for LILW. The inventory for VLLW is limited to be no higher than 1% of the reference inventory of El Cabril, shown in table I.

TABLE I. Reference inventory of El Cabril

Radionuclide	Activity (TBq)
H-3	2,00E+02
C-14	2,00E+01
Ni-59	2,00E+02
Ni-63	2,00E+03
Co-60	2,00E+04
Sr-90	2,00E+03
Nb-94	1,00E+00
Tc-99	3,20E+00
I-129	1,50E-01
Cs-137	3,70E+03
Pu-241	1,50E+02
Total alpha (at 300 years)	2,70E+01

Conclusions of the safety analysis

The evaluation of the radiological impact on the population and the environment in the influence area of the facility has been done according to the scenarios already mentioned.

The artificial barriers introduced between the wastes and the environment provide adequate isolating conditions for the required period minimizing the dispersion of the radioactive materials. The activity limits are also acceptable according to the possible effects on the humans and the environment in case of degradation of the isolating conditions.

The system has also some limits referring to the distribution of the activity within a cell, consistent with the limits established for the disposal units.

From the different analysis performed for water pathway scenarios, we conclude that the impact for all the facility is below the criteria of 0.1 mSv/y.

In reference to the inadvertent human intrusion scenarios, the analysis of the impact is done after 300 years from the closure of the facility (according to the operation license). The estimated consequences in this period are below the reference dose value (1 mSv).

As result of all these evaluations, the following data are obtained for public exposure (see tables II-V):

TABLE II. Maximum doses arising from operational safety analysis (LILW disposal)

SCENARIO	Maximum Dose
External exposure in non-restricted areas	4.04 E-04 mSv/h
Emissions from the incineration	9.18 E-04 mSv/y
Emissions from the controlled ventilation system	6.34 E-04 mSv/y
Fall of bulks	2.27 E-02 mSv
Burnt of bulks	2.27 E-01 mSv
Failure of the controlled ventilation system	1.82 E-03 mSv
Loss of power supply in the controlled ventilation system	≤1.82 E-03 mSv
Failure of the incineration system	3.35 E-03 mSv
Contaminants release through water pathway from the disposal vaults/cells	1.40 E-12 mSv/y

TABLE III. Maximum doses arising from operational safety analysis (VLLW disposal)

SCENARIO	Maximum Dose
External exposure in non-restricted areas	N/A
Emissions from the ventilation system in the Technological building	3.54 E-06 mSv/y
Fall of bulks	4.32 E-02 mSv
Burnt of bulks	7.88 E-01 mSv
Failure of the controlled ventilation system	1.06 E-02 mSv

TABLE IV. Maximum doses arising from the long-term safety analysis (LILW disposal)

SCENARIO	Maximum Dose
Reference scenario	8.82E-04 mSv/y, in 756 years
Cover failure scenario	8.84E-04 mSv/y, in 756 years
Plane crash scenario	3.34E-02 mSv, in 300 years
Rise of water table scenario	1.08E-03 mSv/y, in 375 years
Road construction scenario	4.56E-01 mSv, in 300 years
Residence construction scenario	2.24E-02 mSv, in 300 years
Residence use scenario	1.06E-01 mSv/y, in 300 years
Residence and agricultural use scenario	1.43E-01 mSv/y, in 500 years
Residence and playground use scenario	5.32E-02 mSv/y, in 300 years

TABLE V. Maximum doses arising from the long-term safety analysis (VLLW disposal)

SCENARIO	Maximum Dose
Reference scenario	1.32E-02 mSv/y, in 2.02 E+05 years
Cover failure scenario (bathtubing)	2.73E-02 mSv/y, in 2.07 E+05 years
Road construction scenario	4.98E-02 mSv, in 60 years
Residence use scenario	9.61E-01 mSv/y, in 60 years

SAFETY ASSESSMENT REPORT

All the studies and considerations done for the Safety Assessment have to be included in a safety Report. This document is required for getting the Operation License for Nuclear Installations in Spain. The content of this Report is defined by the Spanish regulation and it has to be revised if there is a change in the facility that may affect the safety.

According to the Spanish regulation, this report should include all the information needed to perform an analysis of the installation from the point of view of nuclear safety and radiological protection. It also has to include a risk evaluation, for both normal operation and accidental situations. There must be a description of the different safety

functions for all the systems, structures and components related with the safety and, finally, it has to identify all the applicable regulations, requirements and standards.

El Cabril's Safety Report comprises the following aspects:

- Site characteristic and data acquired during construction
- Description of the installation such as it has been constructed
- Description of the radioactive waste disposal
- Description of the processes that take place in the installation
- Description of the systems, structures and components relating to the safety
- Description of the design criteria and the implemented technical measures regarding radiological protection, control and surveillance
- Description of the environmental radiological surveillance program
- Safety analysis during the operation
- Long term safety analysis

The Safety Report has to be revised in case there is any actualization or improvement in the long-term safety of the facility. It also has to be revised if there is any change in the design. According to this, several revisions of the Safety Repot have been performed from the beginning of the operation. In 2016, revision number 14 was edited in order to include the new cell that had been built in 2015 for VLLW disposal.

Additionally to the safety assessment report, it is also mandatory making a Safety Periodic Review (every 10 years in the case of El Cabril) that has to be presented to the Regulatory Council. The objective of this review is making a follow-up of the established process and evaluate its results and the improvements introduced in the facility.

CONCLUSIONS

From the site and construction license application until the current operation phase, full implementation of the disposal system concept and safety assessment, has been carried out at El Cabril Disposal Facility.

The evaluation of the radiological effects in the facility for all the scenarios considered show that the design criteria and the safety technical options guarantee that all the safety objectives are fulfil. It also indicates that the facility does not generate any inacceptable risk for the populations, at any moment of its life.

In order to fulfil the requirements of the Spanish Regulation, a Safety Assessment Report has been edited for El Cabril LILW and VLLW disposal. All the safety analysis executed for the operational phase and the long-term phase are included in this safety assessment report; the safety analysis is based on the safety objectives and criteria and on the safety approach, in which different scenarios, models and calculations are developed.

One of the main objectives of the safety approach, and of the methodology applied, has been to demonstrate an acceptable level of protection for human health and environment.

The content of the Safety Assessment Report has to be revised if there is any change in the facility that may affect the safety. Before carrying out any design modification in the disposal facility, ENRESA must study if compliance with the criteria, requirements and conditions (on which the authorization is based) are guaranteed. In case they are, the Safety Assessment Report will be updated and sent to the competent authorities. Otherwise, ENRESA shall apply for specific authorization of the design modification.

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