An integrated project for the surface disposal in Dessel of Belgian low-level and medium-level short-lived waste

Non-technical summary
Draft project-level EIA

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PROJECT DESCRIPTION **Construction and operation of a surface disposal facility in Dessel for Belgian low-level and medium-level short-lived waste** **Non-technical summary project-level EIA**	
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Glossary

Alpha rays	Alpha rays are high-energy particles emitted from unstable atomic nuclei. With alpha rays, the energy particles are relatively large and heavy – they are the nuclei of helium atoms consisting of two protons and two neutrons. This means that alpha rays are not highly penetrable and can be quickly contained. A piece of paper or an air layer of 3cm is enough to stop them. These particles are expelled from the atomic nucleus at a speed of 16,000km/second (source: ONDRAF/NIRAS website).
Beta rays	Beta rays are emitted from unstable atomic nuclei, just like alpha rays. Beta rays are lighter energy particles (electrons) than alpha rays. They are expelled from the atomic nucleus at a speed of 270,000km/second. They can be stopped by, for example, an aluminum plate several millimeters thick or by 3 meters of air (source: ONDRAF/NIRAS website).
Category A waste:	Low-level or medium-level and short-lived waste. The waste in category A is conditioned waste that contains radioelements in activity concentrations and with a half-life that is sufficiently small for the waste to be considered for surface disposal. This category contains short-lived low and intermediate level waste with a short half-life (30 years or less) but may also contain negligible quantities of radioactive elements with long half-lives.
Gamma rays	Gamma rays have a major penetrating power into surrounding material. They can only be contained by heavy substances such as iron, concrete or lead several centimeters to meters thick, depending on the intensity. Gamma radiation can pass through hundreds of meters of air without any noticeable loss of intensity (source: ONDRAF/NIRAS website).

1 Introduction

ONDRAF/NIRAS, the Belgian Agency for Radioactive Waste and Enriched Fissile Materials, is responsible for the management of radioactive waste in Belgium.

On 23 June 2006, the federal government decided that part of this waste, the low and intermediate level short-lived radioactive waste or category A waste, can be disposed of in a surface disposal facility on the territory of the Dessel municipality (province of Antwerp). The site is located close to the border with the municipality of Mol.

This government decision was the result of a long preliminary process in which ONDRAF/NIRAS linked the classical engineering approach to a participation and consultation process with the local communities of the municipalities where a repository could be located.

In Dessel, STOLA (now STORA), a partnership between ONDRAF/NIRAS and the Dessel municipality, was set up for this purpose. The municipality of Mol was also prepared to evaluate the possibility of a repository with associated conditions. In this municipality, the partnership MONA was established.

The STOLA partnership, along with ONDRAF/NIRAS, developed an integrated preliminary design for the disposal project: a repository linked to an aggregate of accompanying conditions that are inextricably linked with one another. The conditions relate to safety, the environment, human health, monitoring, measures concerning social added-value and a continuing participation by current and future generations. The disposal can only take place if the conditions of the partnership are sufficiently met.

The MONA partnership, also in cooperation with ONDRAF/NIRAS, drew up a preliminary draft for this project with accompanying conditions. The final choice for the location of the site was made for the municipality of Dessel, but since the disposal site is located close to the border with the municipality of Mol, the conditions of the partnership MONA are also considered in the elaboration of the project.

The preliminary drafts of the STORA and MONA partnerships contained a whole series of conditions that had to be met for the local communities in order to obtain acceptance of the surface disposal. Below, the conditions relevant to the project-level EIA are reiterated and the needed actions are formulated:

- The disposal concept must be technically and radiologically safe (during operation and afterwards) with safety as a priority condition, with the best guarantees in terms of safety, health and the environment: the radiological impact of disposal on people and the environment is described in detail for the various disciplines in Chapter 4. This description was taken from the license application file submitted to the FANC.
- Carrying out measurements: various air, surface water and groundwater measurements of radiological and non-radiological variables will be included in the monitoring programme that has already been activated to carry out baseline measurements and that will be continued during operation;
- Communication of results: the communication of the results of these measurements for citizens will be included in the communication programme of the repository that will be disseminated to the local community through the channels of TABLOO (visitor and community centre);
- Limit nuisance: in response to the request to minimise road transport nuisance a quay was built serving two functions: (1) a maximum of material is supplied through the quay for the construction of the various projects (caisson, salvage, IPM) and, (2) also a maximum of material is removed by using the quay such as the wood from deforestation;
- Location of the site: the site is not located in a valuable nature reserve and the environmental damage caused by deforestation will be compensated by carrying out a reforestation project of 10 ha on municipality of Dessel sites. A dedicated working group has been set up for this forest compensation project. The preparatory works for the reforestation started in May 2019 and are supervised by a working group with local actors.

- Mitigate the impact by installing infiltration basins: as part of the preparatory work (deforestation, removal of soil), sufficiently large basins were excavated on the site to allow all rainwater related to the repository to infiltrate locally.
- Integration of the disposal into the landscape: in the strip south of the caisson factory and north of the quay, the existing high-density green corridor will be made more compact by additional plantings aiming at limiting visual impact of the disposal and other installations (IPM, caisson factory) for residents of the future renovated residential area SCK-VITO just south of the Bocholt-Herentals canal. The visual impact of the disposal modules is very limited since they are located in a wooded area.

All these conditions were initially included in the master plan and will have to be included in the social contract to be approved by both partnerships in 2019.

1.1 Short description of the project

This project-level EIA is being made for evaluating the environmental impact of the construction and operation of a surface repository for category A waste at Dessel. This waste will be disposed of in concrete modules built on the Earth's surface and protected by a multi-layered cover.

The aim of surface disposal is to contain and isolate the radioactive waste so that there are no risks to humans or the environment. This will be achieved by applying successive barriers around the waste. In this way, safety does not depend on the operation of a single barrier. If one barrier does not function according to expectations, the other barriers must ensure that safety is still guaranteed.

In summary, the disposal proceeds as follows (see also Figure 1-1).

Radioactive waste from various sources is conditioned in 200 l drums or in 400 l drums. These drums are placed per 5 (200 l drums) or per 4 (400 l drums) in concrete boxes (caissons), in which they are encapsulated with mortar to form a monolith. Sometimes a single large 600 l barrel is placed in a caisson. Such a monolith stops the radioactive radiation and encapsulates the radioactive substances. Bulk waste is encapsulated directly with mortar in the caissons. The production of the monoliths will take place in the IPM, the Installation for the Production of Monoliths. The concrete crates or caissons will be produced in the caisson factory.

Both the IPM and the caisson factory are not subject of the present project-level EIA. However, any possible cumulative impacts (i.e. mobility and traffic-related impacts) are described and assessed. For the IPM an exemption was obtained therefore not requiring a project-level EIA. The caisson factory is not obliged to submit an EIA.

The monoliths are placed in storage modules, concrete bunkers with thick walls of reinforced concrete. Each module measures approximately 25 by 27 metres and can contain 780 or 936 monoliths depending on the type of monolith. The filling rate of the modules is determined by the rate of waste production and the time schedule required for dismantling the nuclear installations. After filling, the modules are sealed with a concrete cover plate. The first set of 20 modules will be covered by a fixed roof that provides shelter from the weather. The fixed roof over the modules will eventually be replaced by a permanent cover that is virtually impermeable to water. The cover will consist of a system of a fibre-reinforced concrete slab, natural materials and geotextiles. Among other things, it must provide protection against penetrating roots and burrowing animals and limit the seepage of water as much as possible. After covering, a so-called 'tumulus' is formed.

Figure 1-1: Diagram of disposal cycle

1.2 Why a project-level EIA?

The disposal is a nuclear facility that can have both a radiological and non-radiological impact.

According to European Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment, amended by Directive 2014/52/EU, which forms the basis of the Flemish and Belgian EIA legislation, projects likely to have significant effects on the environment must be made subject to an assessment of the environmental effects before development consent can be granted for such projects. The Directive requires that, where projects are subject to a prior environmental impact assessment, this must include an overall assessment of the project in relation to several factors and of the interaction between those factors. Such an overall environmental assessment presupposes that the objectives of the environment in general (including aspects of protection of the environment, including protection against ionising radiation) and the objectives on urban development and spatial planning are considered.

Protection against ionising radiation is a federal competence while the other aspects of environmental protection are a Flemish competence.

According to Flemish regulation, the repository is subject to an EIA because it falls within the following sections of the EIA Decree:

- "Installations designed only for the final disposal of radioactive waste (Annex I of the EIA Decision),
- Deforestation with a view to conversion to another land use where the area is 3 ha or more (and where exceptions as formulated in Article 90bis of the Forest Decree do not apply) (Annex II of the EIA Decree)'.

Works for the abstraction or artificial recharge of groundwater: abstraction of groundwater, including back-pumping of untreated and non-polluted groundwater in the same aquifer, if the net abstracted flow rate is

2500 m³ per day or more. The repository is designed for the final disposal of category A waste and more than 3 ha must be deforested.

Based on federal legislation, the disposal is a class I facility, which means that a project-level EIA must also be drawn up at federal level.

Both a Flemish and a federal EIA must therefore be made. It has been agreed with the competent authorities, the Flemish EIA Team and the Federal Agency for Nuclear Control (FANC) (for the federal EIA), that a single global project-level EIA will be made in which both the radiological and non-radiological impact of the disposal will be evaluated.

1.3 Purpose of the project-level EIA

In a project-level EIA the environmental impact of a planned project is evaluated. The "environment" must be understood very broadly and includes soil, (ground and surface) water, biodiversity, landscapes, monuments and archaeology, noise, climate, air quality and humans. For humans, mobility, spatial aspects, as well as health aspects are considered. If significant negative environmental impacts are expected, mitigating measures need to be proposed to prevent or reduce such impacts.

1.4 Procedure for making a project-level EIA

1.4.1 Flemish procedure

The Flemish procedure for making a project-level EIA starts with the preparation of a notification. The notification includes, as a minimum, a description of the project, including the alternatives that are considered, a description of the current state with respect to permits and an indication of the permits that are expected to be needed, a description of the likely project impacts, the proposed EIA team and division of tasks, a description of the process and a description of the environmental impacts that will be evaluated and how such impacts will be described and assessed.

The notification of the present project-level EIA also included a request for scoping advice and was developed into a draft project-level EIA. This means that the notification also included a proposal of the content of the project-level EIA and the methodology.

The notification was submitted to the Team MER on 5 April 2019. Following notification, the EIA Team shared the file with the competent advisory bodies (administrations, government agencies and public authorities). The consulted advisory bodies provided feedback to the EIA Team within 30 days. Feedback was received from the “Vlaamse Milieu Maatschappij”, “Landbouw & Visserij”, municipality of Mol, “Mobiliteit en Openbare werken” and the Province of Antwerp. In addition, 2 participatory reactions from citizens were received. The Department of Land and Soil Protection, Subsoil and Natural Resources, the FANC, Fluxys, the Flemish Waterway and the The Department of the Environment (“Departement Omgeving”) all gave their approval based on the notification. Next based on the advisory by the various competent authorities and the input by citizens the EIA Team took a decision on the notification. This scoping advice drafted by the Team EIA was received on 18 June 2019 and included comments on the impact assessment to be executed. The notification (including the decision by the EIA Team) was published on the website of the EIA Team and communicated to the consulted actors.

In the environmental permit procedure in Flanders, the project-level EIA is not yet approved prior to the permit application. When the permit application will be submitted it includes the draft project-level EIA. Following submission, the competent authority has 30 days to verify whether the submission is admissible and complete. As soon as the permit is found to be admissible and complete, a request for advice on the permit application and the project-level EIA is sent to the relevant advisory bodies. The deadline for advisory on the project-level EIA is 30 days after the advisory request has been sent to the relevant advisory bodies

(the deadline for advisory on the permit is 60 days). A public inquiry (O.R.) is also organised within 10 days. The public has 30 days to comment on the permit and the project-level EIA.

After reviewing the responses by the public and the relevant advisory bodies, the EIA Team decides on the approval or rejection of the project-level EIA within 60 days after the initial decision on the completeness and admissibility of the permit application. The EIA Team informs the initiator and the licensing authority and, where applicable, the environmental permit committee within a further 10 days.

If the project-level EIA is rejected, the permitting procedure stops by default as stated by regulation. If the project-level EIA is approved, the procedure can be continued.

After decision by the Team EIA, the approved project-level EIA and the project-level EIA report (drawn up by the administration) are available for inspection at the Team EIA offices and on its website.

1.4.2 Federal procedure

The federal procedure is different from the Flemish procedure.

Class I establishments, such as disposal, must have an establishment and operating license, which is granted and confirmed by the King. The permit application must be addressed to the FANC and must include, among other things, a project-level EIA.

The project-level EIA is therefore part of the permit application.

1.4.3 Two procedures, one global EIA

For the construction and operation of the surface repository at Dessel, an EIA must be made and approved with a first section relating to Flemish competences and a second section relating to federal competences. As has been explained in previous sections, the Flemish and federal procedures differ. To allow for making a single global EIA, this in the light of the protocol of 12 August 2010: "Protocol between the Federal State and the Flemish Region on the Environmental Impact Assessment of Nuclear Installations", agreements were made with Flemish and federal competent authorities (respectively the FANC and the EIA Team) on how both procedures will be coordinated. The following approach set out below was chosen.

The federal procedure starts with the submission to the FANC of the application for an establishment and operating license, with the EIA as part of it. This EIA is not officially assessed or approved beforehand and can therefore be considered as a draft EIA. Also, for the environmental permit procedure in Flanders it is not needed to have an approved project-level EIA prior to submission of the permit application. The Flemish EIA procedure starts with a notification.

This notification concerns the environmental assessment of the non-radiological impact of the disposal.

The draft EIA submitted to the Team EIA and the FANC contains both a radiological and non-radiological assessment. However, the authorities involved only give an opinion on the aspects within their area of competence.

The EIA Team assesses the content of the non-radiological impact assessment. The assessment of the radiological aspects is done by the FANC and the Scientific Council for Ionizing Radiations.

The Flemish EIA procedure ends when the project-level EIA being approved by the EIA Team.

This is done following submission of the permit application including both aspects on building and environment. This permit procedure includes a public enquiry.

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[1] The safety report from which the federal part of the EIA has been taken, was subject to a PEER review by an international review team led by the NEA (Nuclear Energy Agency).

2 An integrated project of surface disposal in Dessel for low and intermediate level short-lived waste

The integrated project of surface disposal in Dessel for low and intermediate level short-lived waste, in short, the cAt project, offers a solution to a sensitive societal challenge, namely the long-term management of category A waste in Belgium. The disposal project is called integrated because the repository for radioactive waste is inextricably linked to a set of accompanying measures aimed at delivering a sustainable added-value to the municipalities of Dessel and Mol and the wider region.

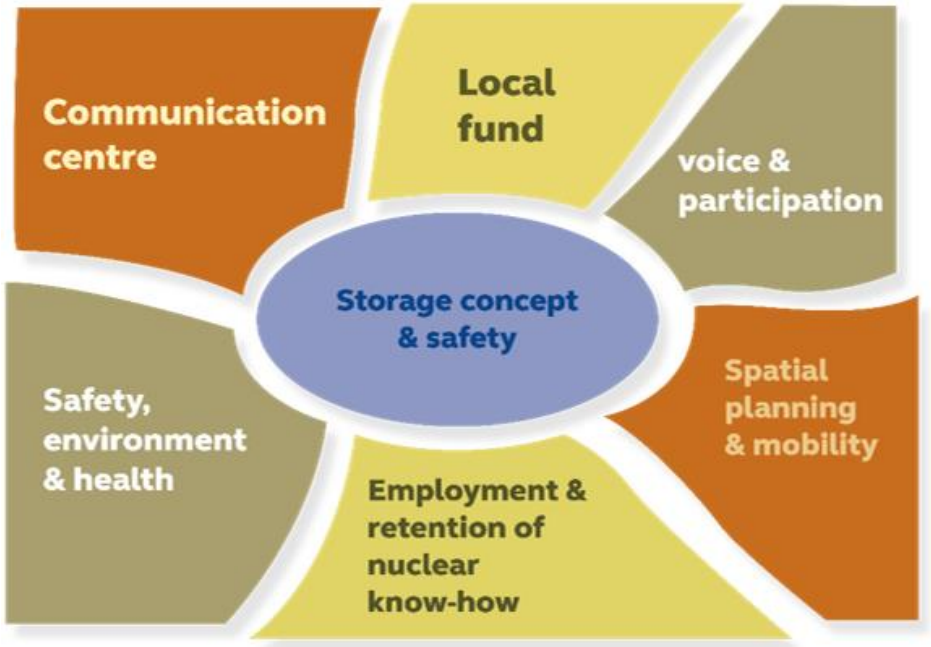
The realisation of such added value is motivated by the fact that by accepting the presence of a repository on their territory, these municipalities, and the population of Dessel, allow for a solution for the long-term management of category A waste. As such, these municipalities, which are currently but also in the future psychologically burdened by the presence of the repository, provide an important service to the Belgian population.

Allowing for the disposal of radioactive waste has little direct benefit to the local population and jeopardizes other uses of the assigned land. Indeed, due to the nature of the waste, land that could provide other uses and benefits to the municipalities will not be available for a very long period of time. In addition, surface disposal has a strong visual impact on the environment. Furthermore, multiple generations to come will carry the 'burden' that the site entails.

In order to achieve a sustainable solution, the aim is therefore to integrate the disposal project as much as possible with accompanying measures into the local community. Various project components of a socio-economic, socio-cultural, ecological and administrative nature balance the impact of the disposal project such that the integrated project results in a positive impact for present and future generations.

The aim of the integrated disposal project is therefore to develop a safe disposal solution for category A waste, this in combination with various aspects of providing added-value to the local community of Dessel and Mol and the wider region.

The cAt project can be schematized like consisting of several puzzle pieces that are inextricably linked to one another.



Storage concept and safety

This component includes the elaboration of the repository concept, the roof structure of the installation, the monoliths, the Installation for the Production of Monoliths (IPM), the cover, various extra buildings, etc. Safety is the absolute priority here.

Local fund

The Local Fund will respond to the changing needs of society. In the future, the fund must support or realize projects that improve the quality of the living and working environment.

Participation and participation

The partnerships STORA (Dessel) and MONA (Mol) are responsible for participation in the elaboration of the cAt project. Participation will also be guaranteed in the longer term.

Spatial planning and mobility

The objective of this component is to take the necessary initiatives with regard to the spatial planning of the different project components, the environmental impact assessment and to obtain the necessary permits for subsequent components of the integrated repository project. It also includes an extension of the SME zone Stenehei by approximately 10 ha.

Employment and retention of nuclear know-how

The preservation of nuclear knowledge in the region is central. Maximum local employment will be sourced for the construction and operation of the repository.

Control of safety, environment and health

A monitoring and surveillance programme for the repository will be set up. As an added value for the local population, i.e. separate from the monitoring of safety, etc., a pilot project on biomonitoring has been started.

Visitor and community centre TABLOO

NIRAS is planning the construction of an information centre near the future disposal site. The centre will be the reference for information on radioactive waste management. This will become a tourist attraction for the region providing additional benefits for the local communities.

2.1 Location of the project

The repository will be built on the territory of the municipality of Dessel. Dessel is approximately 60 km east of Antwerp and 15 km southeast of Turnhout. The neighbouring municipalities of Dessel are Retie (north and west) and Mol (south and east). The site has the following coordinates: 51°13'25"N 5°04'41"E.

The project area is in the south-west of the municipality of Dessel, in the nuclear zone north of the Bocholt-Herentals canal and east of the N118 Geel-Retie which forms the municipal boundary between Dessel and Retie. Within the nuclear zone, 2 more companies with nuclear activities are currently located: Belgoprocess (subsidiary ONDRAF/NIRAS) and Transnubel (nuclear transports). The company Belgonucleaire (engineering firm and manufacture of MOX) and the nuclear company FBFC have meanwhile been decommissioned. The soil of FBFC is being decontaminated. In the northwest, the nuclear zone borders on the SME zone Stenehei. Stenehei is a regional business park in which the intermunicipal container park of Dessel and Retie is also located.

Map 1: Topographic map

Map 2: Street plan

Map 3: Regional plan

Map 4: Aerial photo

The offices of the ONDRAF/NIRAS project team in Dessel are located just outside the Belgoprocess premises. Isotopolis is also located here. It is an information centre on radioactive waste set up by ONDRAF/NIRAS and Belgoprocess and receives approximately 13,000 visitors annually (mainly schools and associations). Isotopolis can only be visited by appointment.

To the west, the nuclear zone is bordered by the N118 and adjacent valuable landscape agricultural area and the Prinsenpark. The northern boundary of the nuclear zone is the Kastelsedijk, which is largely built-up (western part businesses, eastern part houses within a narrow strip of residential area with a rural character). The zone to the north of the Kastelsedijk is also occupied by agricultural land. To the east is a sand extraction area exploited by the company Sibelco. The south-eastern boundary of the project area is formed by the Bocholt-Herentals canal. To the south, the nuclear zone continues on the territory of Mol and Geel. Within this zone the Study Centre for Nuclear Energy (SCK) and the Flemish Institute for Technological Research (VITO) are located. On the southwest side, the Hooibeek forms the transition between the nuclear zone and valuable landscape agricultural area.

The choice for this site has receive broad public support and social consensus. Regarding the disposal and the long-term management of category A waste the Federal Council of Ministers decided, on 16 January 1998, to choose for a decision on a final solution or a decision that can become final based on a step-by-step, flexible and reversible approach. ONDRAF/NIRAS was instructed to limit its research to the existing nuclear zones and to zones in which the local authorities showed an interest. Also, NIRAS was to develop the necessary platforms for local consultation in order to integrate a disposal project at the local level.

NIRAS then revised its approach. A change was made from the traditional engineering approach followed up to that point it being replaced with a participatory approach. Concerns about safety, the environment and human health and desires and need by local communities were put up front.

In 1998, ONDRAF/NIRAS launched a call to all Belgian municipalities, and the 'nuclear municipalities', to examine together with ONDRAF/NIRAS whether disposal on their territory could be possible and whether this would require accompanying conditions or measures.

This new installed approach resulted in three local partnerships between ONDRAF/NIRAS and the municipalities that were willing to study the possibility of disposal provided possible accompanying conditions or measures:

- STOLA-Dessel (Study and Consultative Group on Low-level Waste): partnership between the municipality of Dessel and ONDRAF/NIRAS.
- MONA (Mols Consultation on Category A Nuclear Waste): partnership between the municipality of Mol and ONDRAF/NIRAS.
- PaLoFF (Partenariat Local Fleurus-Farciennes): partnership between the municipalities of Fleurus and Farciennes and ONDRAF/NIRAS.

Each partnership was requested to develop an integrated preliminary design for a repository project: a repository linked to a set of conditions that are inextricably linked. The conditions relate to safety, the environment, human health, monitoring, social added-value and lasting participation for current and future generations.

[2] Municipalities which have nuclear installations or nuclear zone on their territory according to the regional plan

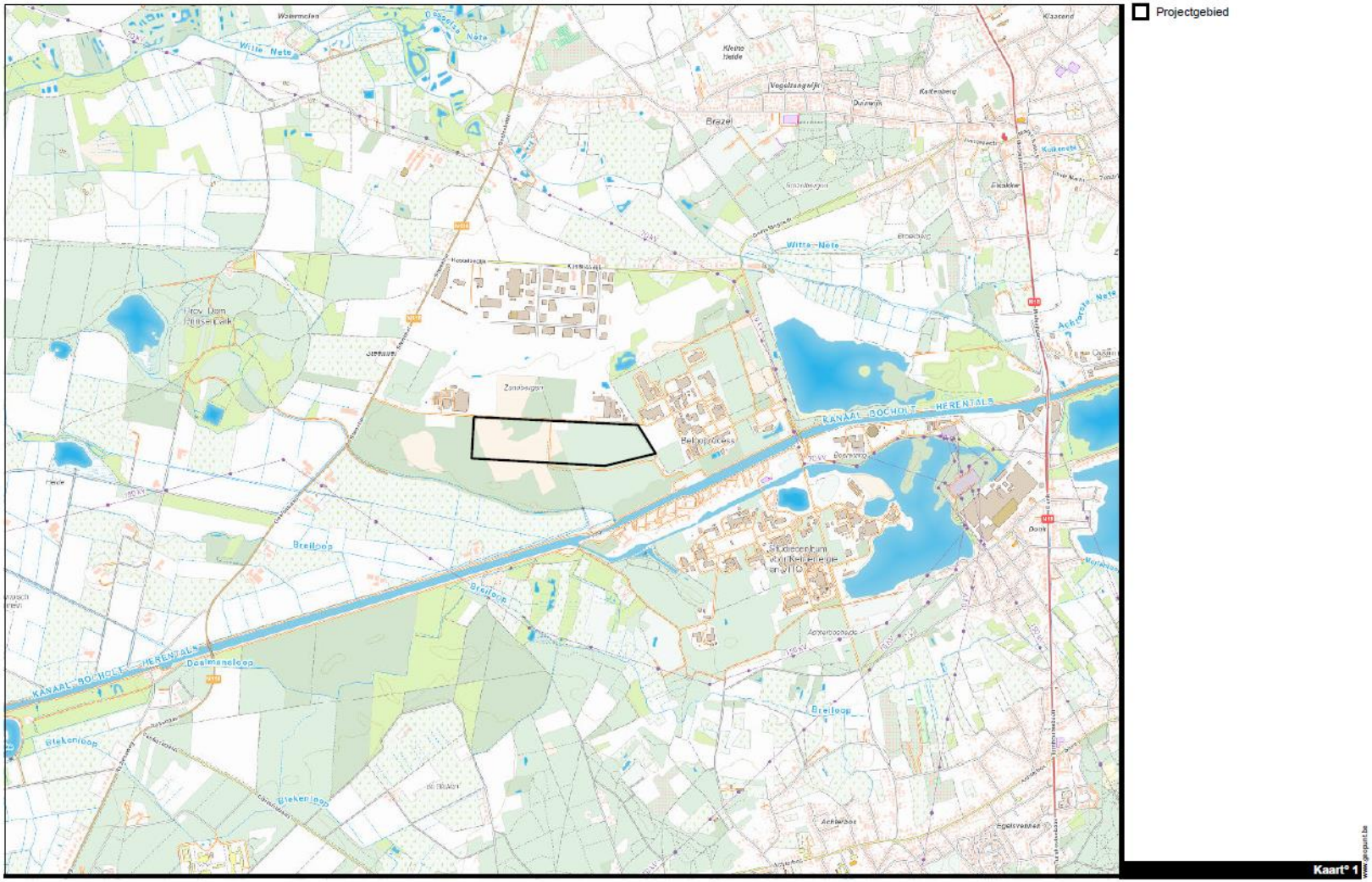
The final decision on whether to accept or reject the proposals lay with the municipal councils of the municipalities concerned. The municipal councils of Fleurus and Farciennes rejected PaLoFF's proposal and subsequently withdrew from the project. The municipalities of Dessel (January 2005) and Mol (April 2005) accepted the pre-proposals by their partnerships with the condition that the accompanying measures would be met.

The integrated preliminary designs for Dessel and Mol, both having a design for surface disposal as well as a preliminary design for deep disposal, were handed over to the federal government.

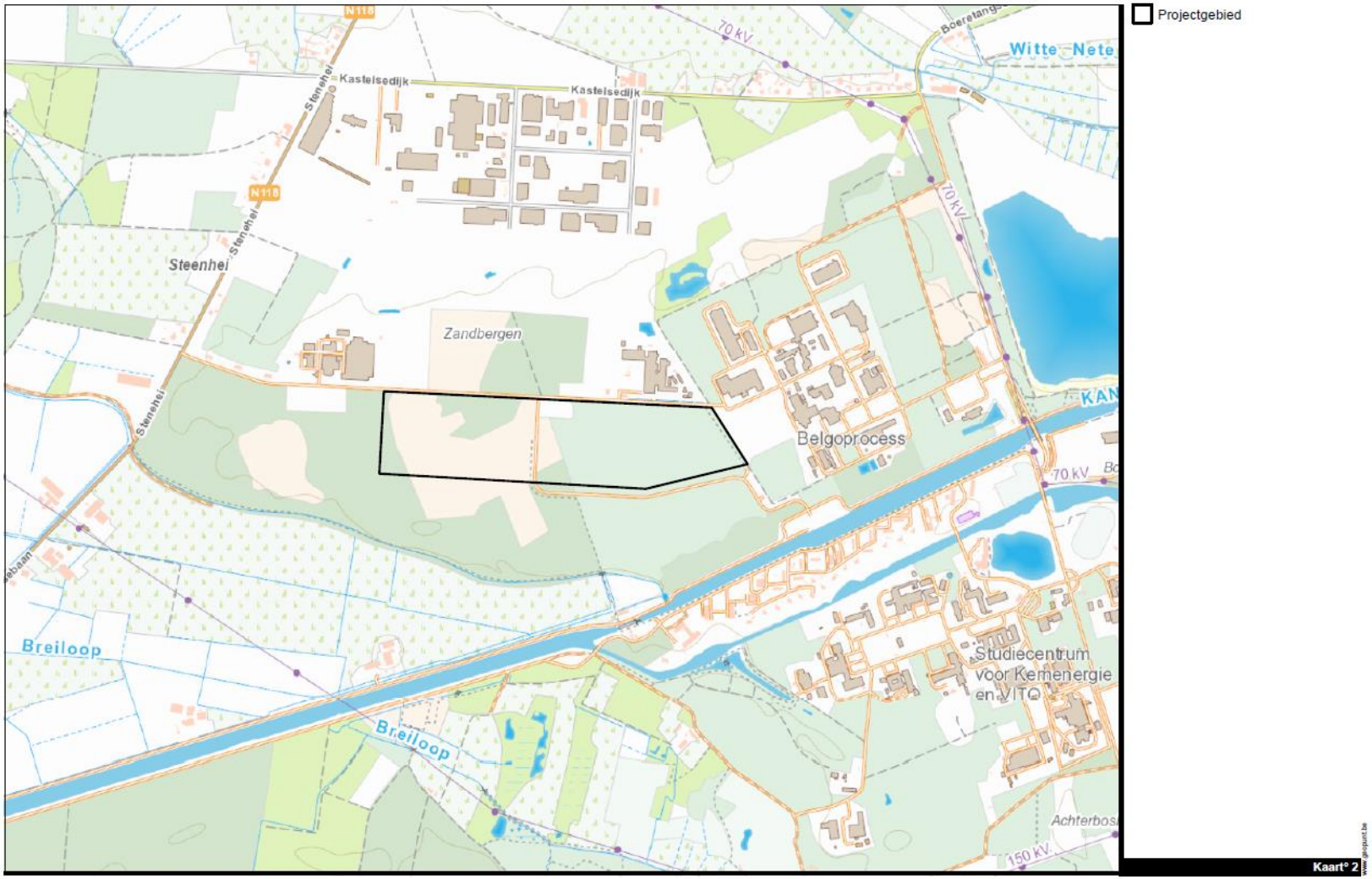
The Federal Council of Ministers decided on 23 June 2006 that low and intermediate level short-lived radioactive waste to be disposed in a surface repository on the territory of the Dessel municipality. As a consequence, the integrated preliminary design for disposal in Dessel forms the basis of the negotiations and discussions, with also the conditions for Mol having to be met.

The ONDRAF/NIRAS report "The disposal, on Belgian territory, of low- and intermediate-level short-lived radioactive waste - Final report of ONDRAF/NIRAS for the period 1985-2006, requesting the federal government to decide on the follow-up to be given to the disposal programme" (ONDRAF/NIROND 2006-02 N, May 2006) provides a historical overview of the studies carried out in the period 1985-2006. This study can be downloaded in Dutch or French from the ONDRAF/NIRAS website (www.niras.be) in the section “informatiecentrum” under publications (long-term low-level short-lived waste management section).

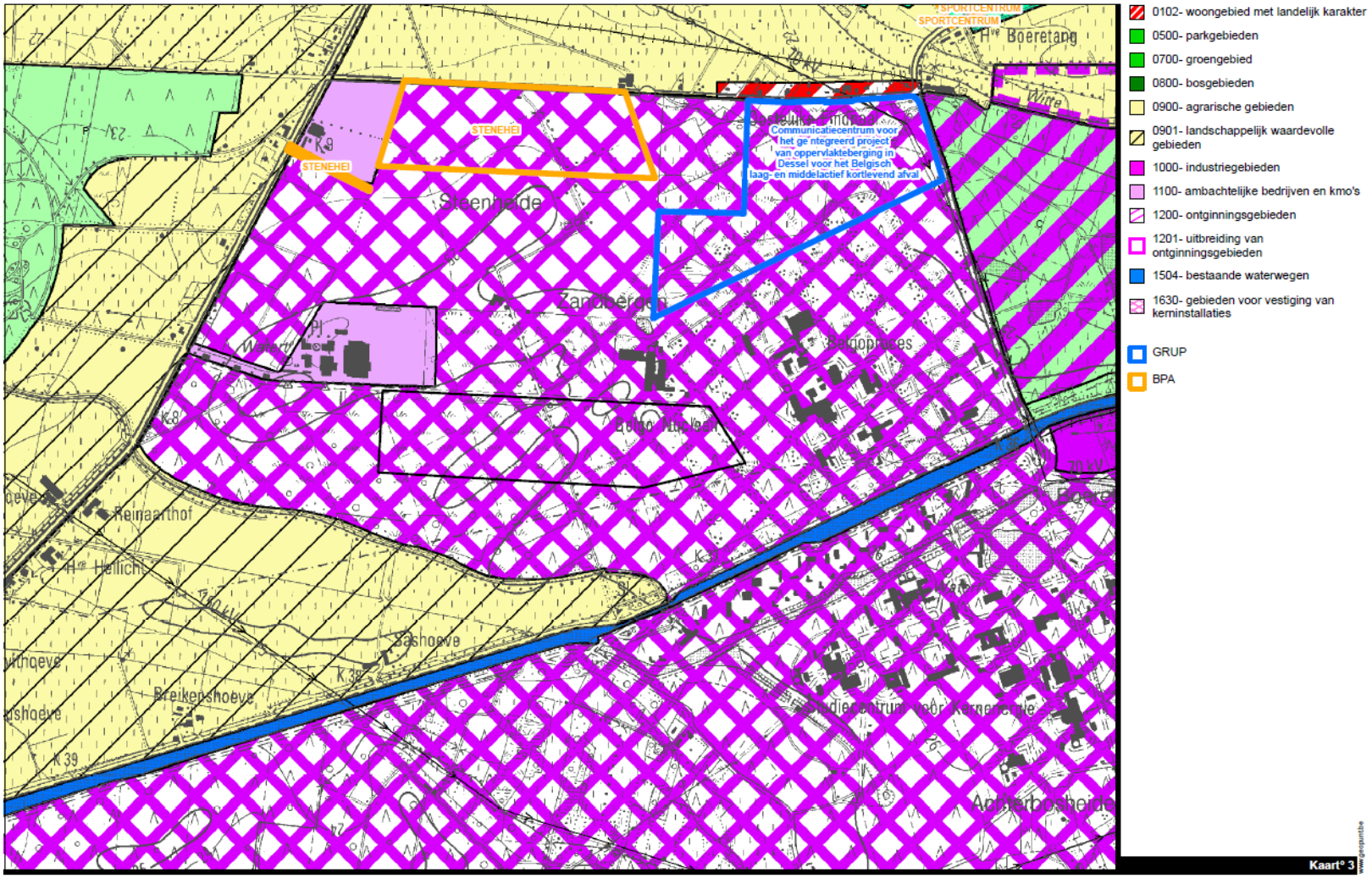
Map 1: Topographic map



Map 2: Street map



Map 3: Regional plan



Map 4: Aerial photo

2.2 Already issued permits/previous EIA

The following project components have already been licensed and/or built:

- the subsidence test;
- the demonstration test;
- the quay;
- the access road.

In addition, permits were issued for subsequent projects that are in the implementation phase:

- the IPM;
- the caisson factory;
- the TABLOO visitor and community centre;
- the access cluster (consisting of the administration and control building and the workshop/garage);
- the preparatory site works for the repository modules. The section "site preparation" includes the deforestation of 10 ha and the legally required forest compensation at the Diel, the sieving and separate storage of all topsoil and the excavation of the 2 infiltration basins.

At the start of the project, an **EIA plan** was made **as part of the realization of the accompanying preconditions of the integrated disposal project**. The reason for making this EIA plan was the construction of the visitor and community centre TABLOO. For the construction of this centre, ONDRAF/NIRAS and the partnership STORA selected a location at the corner of the Gravenstraat and the Kastelsedijk. On the regional plan this location is marked a zone for nuclear development and consequently not assigned for uses such as the visitor and community centre TABLOO. Therefore, a change was needed in the land-use plan. After the land-use plan was changed an EIA for the centre had to be completed. This EIA plan examined not only the impact of the TABLOO visitor and community centre, but also the impact of the other project components that would be built within the nuclear zone (disposal modules, IPM, caisson factory, quay) and the impact of the extension of the SME zone Stenehei. The EIA plan with reference PL105 was approved on 05/04/2012. Subsequently, the preparation of a change in land-use by means of a Regional Land-Use Plan (“gewestelijk ruimtelijk uitvoeringsplan or GRUP”) for the implantation of the centre on this site was started. The decision to approve the GRUP by the Flemish Government was taken on 21 November 2014. The GRUP was published in the Official Gazette (“Belgisch Staatsblad”) on 10/12/2014 and has been in force since 24/12/2014.

For the examination of impacts due to mobility (including derived impacts such as mainly air and noise), in the EIA plan 7 scenarios were compared, each including the traffic generation by the repository, the IPM and the caisson factory, and considering different possible scenarios of activities and events for the visitor and community centre TABLOO.

In April 2011, a motivated request for exemption of an EIA was submitted for the construction of the IPM. This, because the construction of the IPM needs to start before the construction of the disposal modules is started. The IPM is subject to Annex II section 3 g) 'installations for the treatment and storage of radioactive waste for more than three years (projects not covered by Annex I)' of the 2004 Decree. For Annex II projects, a motivated request for exemption may be submitted. This file was evaluated by Team MER (formerly called "Dienst Mer"), has reference number OHPR0427 and on 10/06/2011 the exemption was granted for the non-radiological part of the exemption. In a letter dated 10/06/2011, the federal Minister of the Interior also approved the exemption from the EIA obligation for the IPM.

In June 2014, a **motivated request for exemption was also submitted for deforestation as part of the preparatory works for the construction of the disposal modules**. ONDRAF/NIRAS wanted to have the possibility to start the preparatory works (of a non-nuclear nature) for the construction of the disposal modules. Deforestation falls under Annex II section 1d) 'Deforestation with a view to conversion to another land use insofar as the area is 3 ha or more and insofar as Article 90bis of the Forest Decree does not

apply' of the 2004 Decree. For Annex II projects, a motivated request for exemption may be submitted. This file was handled by the EIA Team under reference number PR2064 and the exemption was granted on 23/10/2014.

In April 2015, a **motivated request for exemption was also submitted for the construction of the TABLOO visitor and community centre**. The TABLOO visitor and community centre is subject to Annex II section 12a) 'holiday villages, hotel complexes outside urban areas, permanent camping caravan sites, theme parks, ski lifts and funicular railways, with associated facilities with a site area of 5 ha or more' of the 2004 Decree. For Annex II projects, a motivated request for exemption may be submitted. This dossier was dealt with by the EIA Team under reference number PR2199 and the exemption was granted on 29/06/2015.

2.3 Description of the project

The surface disposal project in Dessel comprises various components to be built:

- a quay, to allow for transport of resources and materials for the repository by waterway (canal);
- the caisson factory where the caissons are produced;
- the Installation for the Production of Monoliths (IPM), where the waste is encapsulated in the caissons to form monoliths;
- the disposal modules, the concrete structures in which the monoliths will be stored, and that, in the final stage, will be covered with earth layers and become tumuli in the landscape;
- the peripheral facilities or access cluster: these peripheral facilities on the repository itself do not have a safety function but are meant to operate the repository. This includes the administrative building, a material storage unit, the workshop/garage, the infiltration basins, the railway tracks from IPM to the modules...;
- a visitor and community centre called TABLOO.

For the present project-level EIA the scope is limited to the disposal modules and the peripheral facilities. The cumulative effects (i.e. mobility related impacts) of the caisson factory, IPM and the visitor and community centre TABLOO are described and assessed.

The constellation of the different project components is visualised in Figure 2-1.

Figure 2-1: Location of project components

2.3.1 Description of the surface disposal components

2.3.1.1 Quay

During the construction and operation of the repository, goods and raw materials must be supplied and removed. In order to minimise the impact of the disposal site on local road traffic, ONDRAF/NIRAS has chosen to build a quay on the nearby Bocholt-Herentals canal.

The expected transport volumes are not constant over the years. The first peaks are expected during the construction of the disposal site. Then, during a few years, important quantities of building materials such as sand, gravel, cement need to be supplied. A second activity that will cause a peak is the placement of the cover for which large quantities of materials will have to be supplied.

The quay not only provides access to the repository. It also fulfils a touristic function and can provide access for adjacent businesses via the canal.

It was built on the northern bank of the Bocholt-Herentals canal, between lock V and lock VI. At this location, the quay is closely connected to the caisson factory to be built, the IPM and the repository. The capacity of the canal is limited to vessels up to 600 tons. However, provided availability of the necessary ship types, the quay will result in reducing the number of road transports.

The quay consists of several parts:

- the quay wall itself, which is about 120 meters in length;
- facilities for unloading and loading the goods. This will be done with mobile cranes. These can be used more flexibly than fixed cranes, which is a plus given the variable supply via the quay;
- a zone for the transhipment and temporary storage of goods.

In order to make the quay easily accessible by road, ONDRAF/NIRAS constructed a new access road. This road also provides access to the caisson factory and runs from the Europalaan along the repository. The connecting road was constructed just outside the fence of the repository with a connection to the Europalaan. In addition, the existing busy canal towpath was also rerouted locally. This ensures that bicycle traffic is safely guided along the quay. The quay was built at ground level. The anchoring of coupled ships is possible. The total surface area is approx. 0.5 ha.

The quay was completed in 2013 and has been put to use from 2018 onwards.

Figure 2-2: Quay

2.3.1.2 Caisson factory

The purpose of the caisson factory is to make concrete products for the repository project. These include caissons, covers for the caissons and prefabricated shielding plates for shielding the monoliths in the modules.

Although the production of concrete elements is not part of the core activities of ONDRAF/NIRAS and Belgoprocess, ONDRAF/NIRAS will operate the caisson factory on its own account.

ONDRAF/NIRAS opted for a local production unit because of various advantages:

- the caissons are a barrier to stop the radioactive radiation and contain the radioactive substances. They are therefore an essential prerequisite for safe disposal. Careful monitoring of the composition and durability of the caissons is therefore extremely important. The proximity of the caisson factory facilitates quality control of the production and technical conditions of the caissons. The proximity also makes the supply of caissons to the IPM more secure;
- the proximity of all parts ensures that the process can be organized logically and efficiently. Transport chains are kept to a minimum and material flows are optimized;
- On-site production of the caissons contributes to local employment.

The caissons will be transferred to the IPM where they will be used to produce the monoliths.

The caisson factory will be constructed near the canal. Because of this location choice, maximum use can be made of the supply of goods over water. A safety perimeter of 100 meters between the caisson factory and the nuclear installations is taken into account. A fence will gate the nuclear zones from the non-nuclear zone where the caisson factory is located. The plant requires an area of approx. 0.3 ha.

Construction of the caisson factory started in 2018. The caisson factory will be completed at the beginning of 2021 and the start-up phase will then follow with prototyping and approval procedures. As such it will be possible to have the delivery of the necessary caissons at the start of operations of the IPM.

Figure 2-3: Caisson factory with an illustration of empty caissons

2.3.1.3 IPM

In the IPM, the Installation for the Production of Monoliths, the monoliths will be produced.

A monolith consists of a caisson (a concrete box with a wall approximately 12 cm thick and fitted with a lid) in which the waste is encapsulated using mortar. The monoliths are stored in the IPM until they can be transported to the disposal modules. Approximately 1,000 monoliths will be produced annually at the IPM.

The monoliths facilitate the exploitation of the repository because they:

- enable a profound standardization of the machines of the IPM and the repository (there only are three types of monoliths);

- limit the number of different waste receptacles, allowing efficient stacking in the modules;
- allow the waste to be recovered should it ever be necessary;
- allow the waste to be safely transported.

The monoliths increase the safety of the disposal operation because they:

- ensure mechanical durability during transport;
- ensure the necessary barrier during the entire disposal process, from storage in the IPM to placement in the disposal modules.

The monoliths guarantee long-term safety because:

- concrete and mortar have the chemical and physical properties to retain the radioactive substances;
- they ensure stable mechanical and chemical conditions for the waste and for the disposal;
- they limit the infiltration of water, which in turn prevents the leaching of radioactive substances into the environment;
- they protect the waste from environmental disturbance.

The IPM is comparable to the existing conditioning installations at Belgoprocess. The main components are:

- an input buffer to store the waste drums and the empty caissons awaiting their processing into monolith;
- a zone for the creation of the mortar;
- a filling and conditioning zone. In the filling zone a caisson is filled with waste. It is then filled with mortar in one of the two conditioning lines. Conditioning line 1 is equipped to treat caissons with waste drums. Conditioning line 2 can also treat caissons with bulk waste;
- a zone where the monoliths harden: the environmental parameters (temperature and humidity) are set so that the hardening of the mortar is optimal;
- an output buffer to store the monoliths awaiting storage in one of the modules. The monoliths are transported from the IPM by rail to the disposal modules;

The raw materials and production processes in the IPM must meet strict requirements. After all, the produced monoliths must meet the criteria for acceptance that are under development and that will apply to waste entering the repository. In addition to quality control, measures are in place to ensure safe operation of the IPM.

The positioning of the monoliths in the disposal modules is not random. Depending on their properties, the monoliths will be assigned to certain zones in the modules. For example, the monoliths with the highest radiation level are placed at the bottom of the modules.

To allow for the monoliths to be stored in the right zone in the modules, it is important to have them being created in a certain order in the IPM. The position of the existing waste drums in the Belgoprocess storage buildings is also important in this respect. In order to maintain the necessary flexibility when emptying the storage buildings, manufacturing the monoliths and selecting the monoliths to be transported to the repository, the IPM is equipped with a sufficiently large input and output buffer storage. All caissons and monoliths are provided with an unambiguous numbering system allowing for continued tracking of the waste.

ONDRAF/NIRAS developed the IPM concept together with Belgoprocess. Belgoprocess will also be responsible for operation of the IPM. After all, the company has many years of practical experience in the conditioning of radioactive waste.

The IPM (approx. 0.65 ha, approx. 14 m high) will be installed on the Belgoprocess site, where the temporary storage (in drums) of the category A waste that has already been produced takes place. The implantation is motivated for operational and logistical reasons. The IPM links up with the existing Belgoprocess processing facilities and storage buildings and the caisson factory.

Construction of the IPM started in 2018. Operation is scheduled to start in 2021.

Figure 2-4: IPM with illustration of vessels in a caisson which is then cemented into a monolith.

2.3.1.4 Disposal modules

The scope of the present project-level MER is the construction and exploitation of the disposal module: the concrete structures in which the monoliths will be stored, and which will be finished into two hills in the landscape.

The disposal modules are designed such that:

- the waste can be disposed in a robust and safe way;
- nuclear safety is ensured also in the long term.

The disposal modules are concrete constructions in which monoliths (concrete boxes filled with radioactive waste) are disposed. Each module measures approximately 25 by 27 meters and can contain 780 up to 936 monoliths depending on the type of monolith. The modules are constructed by means of reinforced concrete walls and floor slabs and are designed to withstand specific seismic stress, such as a high-intensity earthquake. The modules are equipped with an inspection gallery. Each module also has an inspection room at the bottom (over the entire surface) and a drainage system. These facilities enable early identification of any cracks or water seeping such that necessary measures can be taken in time. Provided the difficult access to the inspection area, inspections will be carried out using a robot.

To protect them from the weather, the modules are covered with a fixed steel roof during the entire period of operation (approx. 50 years). The roof is fixed to the side walls of the modules.

The modules are built on a package consisting of 3 layers:

- a 40 cm thick layer of sand into which non-swelling bentonite (4%) is milled;
- a 60 cm thick layer of gravel;
- finally, on top, a mixture of sand and cement (5%) 2 m thick.

The gravel layer prevents moisture from rising. The embankment ensures that the modules are always above the water level, even after, for example, extremely heavy rainfall. The sand-bentonite layer is an extra buffer with sorption capacity based on materials other than cement (defence in depth).

Figure 2-5: Illustration of disposal modules -being loaded under a steel roof structure

The monoliths produced in the IPM are transported to the repository by rail. They are placed on a specially designed trolley and transported to the modules.

Based on current forecasts, 34 modules are needed to dispose of the total amount of category A waste plus a reserve of 20% considering the uncertainties regarding estimates of future waste.

This reserve is used as a precautionary measure to which the following aspects are relevant:

- A possible extension of the lifespan of current nuclear power plants;
- Uncertainties on the exact volumes of waste resulting from decommissioning activities (46% of the waste consists of solid cemented decommissioning waste);
- Regulatory changes, such as adjustments to clearance levels;
- Incidents or accidents in existing nuclear installations;
- Reconditioning of existing conditioned waste;
- New nuclear installations (e.g. MYRRHA, RECUMO, new research reactors).

The modules are divided into two zones - one of 20 and one of 14 modules - each of which will eventually be covered to form a tumulus. The disposal modules will be built in different phases:

- In a first phase, the 20 modules closest to the IPM will be built. When enough modules have been built (e.g. 8) and all other necessary facilities and conditions have been met, operation can start. Subsequently, the remaining modules of the first set of 20 will be built. The operational zone and the site zone will be physically separated from each other. The modules will be filled 4 by 4, first those closest to the IPM.
- When a group of four modules is completely filled up, they will be fitted with a concrete structural top plate.
- When the first 20 modules are almost filled, the construction of the next set (14 modules) will start. The exact timing and duration of this phase will depend on future waste production and the scenario for decommissioning of the nuclear installations.

A temporarily lowering of the water table will be required for the construction of the basement of the Water Collecting Building (WCB). The groundwater level will have to be lowered to approximately 21.20 mTAW for a period of 6 months. The total area to be drained is 20 x 10 m, considering that the purpose of the drainage must be achieved for the basement area (10 x 10 m). Once the equilibrium is reached, the flow rate will be 4.2 m³/h per drain, resulting in a total flow rate of 100 m³/h for the 24 drains each 15 m deep. The pumped drainage water will entirely be infiltrated (50% in the already excavated southern infiltration basin + 50% via an overflow infiltration basin leading to a nearby forest called “rabattenbos” just south of the disposal modules). Before the drainage water is discharged, water treatment is applied. The proposed treatment technique for the pumped groundwater is the formation of an iron (III) hydroxide block and precipitation at pH approx. 8 and separation on a sand filter.

During the construction phase, the quay will be used to a maximal extent for the supply and removal of materials. In the tender stage, aspects off environment and mobility will be important award criteria for selection. Avoiding road transport in the village centres and supply by ship will be honoured.

For the construction of the disposal modules, a mobile concrete plant will be used. It will be on site for about 4 years, probably in the western part where the first series of modules are planned.

The supply of the granulates will take place via the canal. The remaining of the material will be transported by road. The granules will be stored partly on the quay and partly on the yard. The granules need to be stored dry (for the next landfill). Cement and limestone flour will be stored in silos.

The wastewater (rinse water) will not be recycled in the concrete products. The specifications of the tender will ask for the treatment of the rinse water. The treated wastewater will either be channelled into the sewerage system or will be discharged.

An emergency generator will need to be provided to continue working (at half capacity) in the event of a power failure.

The peripheral facilities of the disposal modules include:

- the administration and control building: this building will become the place of business of the disposal site. In addition to administrative and changing rooms, this building also includes the control and operating room of the repository, data storage rooms for surveillance, the security post and the archive room (already licensed under "access cluster");
- the workshop/garage (already authorised under "access cluster");
- tracks and roads for the transport of monoliths and materials (part of the "disposal" and not yet licensed);
- infiltration basins (already licensed under 'site preparation'): the modules and the fixed roof occupy a considerable surface area. Rainwater falling on this surface cannot penetrate into the ground. It is therefore diverted to 2 infiltration basins where it can infiltrate into the ground. Even after the cover has been applied, the basins will remain in service to allow for the precipitation falling on the tumuli to infiltrate.
    - The small, northern basin has a surface area of 530 m² at level inflow and a volume of 50 m³ between inflow and outflow. The level difference between inlet and outlet (at 24.8 mTAW) is 10 cm. However, the soil is at 24.3 mTAW, which coincides with the average groundwater level. Consequently, the infiltration area for this northern basin is approximately 145 m².
    - The large southern basin has a surface area of 4,330 m² at intake level and has a volume of 5,680 m³ between inlet and outlet. The outlet is located at 25.3 mTAW. The bottom of

the basin lies at 23 mTAW and is below the average groundwater level (24.3 mTAW). In order to realise enough infiltration surface, the basin has been designed as embankments, local puddles and gentle slopes. The sloping surface (surface of the flanks) between outlet (at 25.3 mTAW) and average groundwater level (24.3 mTAW) is approximately 4560 m².

- In addition, the horizontal pools can also be considered as infiltration bowls, if they are above the average spring groundwater level (24.7 to 24.8 mTAW). The horizontal zones at 25 mTAW (30 cm between these zones and the overflow at 25.3 mTAW) have a total surface area of about 760 m².
- This brings the total infiltration area of the southern basin to about 5320 m².
- The outlet of the southern infiltration basin brings the water via the canals underneath the access road to the forests lower area called “rabattenbos” further to the south and west of the disposal modules. However, calculations learn that the overflow will not be necessary, also considering the case of a 100-year return period and climate warming. The northern infiltration basin has an overflow opening into the southern basin.

The vegetation of the flanks of the infiltration basins, which is currently provided as grassy and herbaceous vegetation, will be maintained at regular intervals (at least once a year). Weeds and plants that are not suitable shoreline vegetation will be removed and shrubs will be trimmed.

The storage modules are an installation without offices. There is therefore no need to reuse recovered rainwater. All rainwater from the disposal modules will infiltrate again.

ONDRAF/NIRAS will operate the repository.

The repository modules will be located south of and parallel to the Europalaan. The associated peripheral installations (administrative buildings, control room, road, rail, infiltration basin(s)...) will be provided in the vicinity of the disposal modules (see Figure 4).

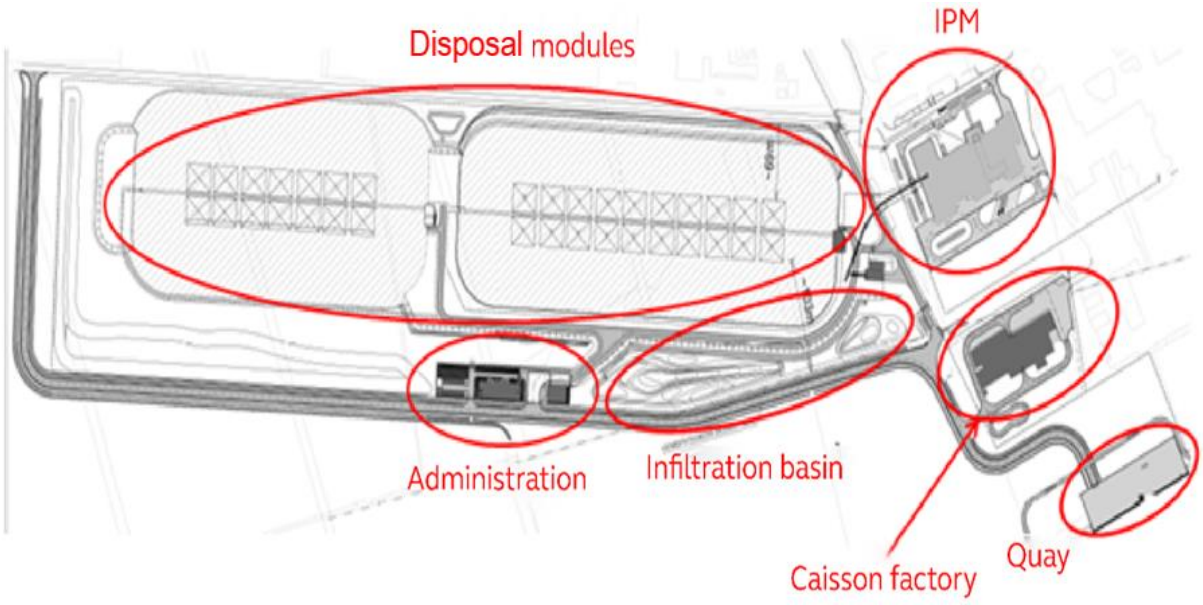


Figure 2-6: Design of the repository

The repository with associated peripheral infrastructure covers a total area of approximately 25 ha.

The total quantity of category A waste to be disposed of in the Dessel facility is estimated at 50,000 m^3 (without the 20% reserve), this assuming a lifetime of 40 years for the nuclear installations, with the exception of the Tihange 1 nuclear reactor, for which a lifetime of 50 years is assumed (law of 18 December 2013). This category A waste can take different forms:

- the conditioned waste, part of which is already stored in Belgoprocess' special buildings;
- bulk waste, which will be generated in the future by the decommissioning of the nuclear installations, and which will be conditioned directly in monoliths.

The disposable conditioned waste that is currently stored at Belgoprocess will be processed at a rate of approximately 1000 monoliths per year.

The total period of operation and covering of the installation is currently estimated at 50 years. Thereafter, further checks (monitoring, supervision and any after-care) will be carried out.

After installation of the cover and after a monitoring and control phase of several hundred years (approx. 250 years), monitoring can be lifted and safety for humans and the environment will continue to be guaranteed without the need for active measures (monitoring, aftercare).

Figure 2-7: Repository to be built

Figure 2-8: Impression after fitting the cover

Systems to mitigate the radiological impact of the repository

There are no discharges of radioactive substances.

External radiation is limited by various shields around the waste: the concrete caisson, the transport container, concrete shielding plates placed on top of the monoliths in the repository and through the modules. The module walls and the combination structural top plate + shielding plates have a thickness of approximately 70 cm. Exposure through external radiation is also restricted by limitations on the dose rate on contact with individual monoliths and on average per layer of monoliths within the modules. The population is protected by the 70m distance between the modules and the site perimeter, and by the limitation on the average dose rate per layer of monoliths within the modules.

During operation and closure, the radionuclides are mainly contained within the waste. The radionuclides are encapsulated by the mortar and the caisson. The strategy for containment after closure is to prevent the release of radionuclides as much as possible for about 1,000 years and then to spread any further release over time. The time frame for the containment strategy is based on the degree of reduction by natural decay of the radiological risk in the waste.

Containment is obtained as follows:

- Up to ~1,000 years, water infiltration into the modules is prevented as much as possible. The earth cover provides lateral drainage above the modules and imposes buried conditions on the fibre-reinforced impermeable top plate and underlying modules so that they are virtually not subject to degradation processes (freeze-thaw cycles and carbonatation). The module walls have a low hydraulic conductivity such that water infiltration into the modules from the side is also avoided. The repository is located above the groundwater table in a non-flood sensitive location and capillary rise is avoided by the design.
- Up to ~1,000 years the release of radionuclides from the repository is prevented. Through quality assurance in production and several independent conformity checks, it is expected that the primary packages will generally be in good condition with storage capability, providing that a high inclusion rate for radionuclides long buried conditions (anoxic, little available water) will prevail. Also, sorption on the hardened cement in the conditioning matrix, the waste and the concrete shields in the waste

packages contribute to limiting the release. The limited fraction of radionuclides that would nevertheless be released from the waste can only migrate very slowly due to the limited diffusion and sorption on cement in the monolith, module walls, impermeable top plate and support plate.

- After ~1,000 years, water infiltration up to the waste itself is still limited: after 1 000 years, due to erosion of the cover and possible earthquakes, the impermeable top plate, module walls and monoliths can be locally exposed to atmospheric conditions. This will initiate carbonatation and freeze-thaw cycles, which over time may cause an increasing occurrence of cracks in the concrete. The enormous mass of soil, sand and clay in the earth cover cannot easily disappear completely and vegetation on remnants of the cover will still contribute to evapotranspiration. Water that would seep into the modules will still be diverted away from the waste by provisions in the design (shielding plates covering the monolithic stacks, gutters in the monolithic walls, the conductive filling material in the gaps, the conductive grout in the inspection rooms and the measures against the bathtub effect) and vertical drainage along the monoliths will be promoted so that the fraction of water that can come into contact with waste is kept as low as possible.
- After ~1,000 years, the release of radionuclides from the repository will still be limited. On the one hand, in a degraded system, the migration of radionuclides using the various cracks will remain limited, mainly due to sorption on cement and limited diffusion in the concrete matrix and filling mortar. On the other hand, radionuclides, that do succeed to reach the cracks and from there migrate advective or dispersive, are intercepted as much as possible by having *conductive absorbent* materials in the module base, the inspection galleries and the foundations.

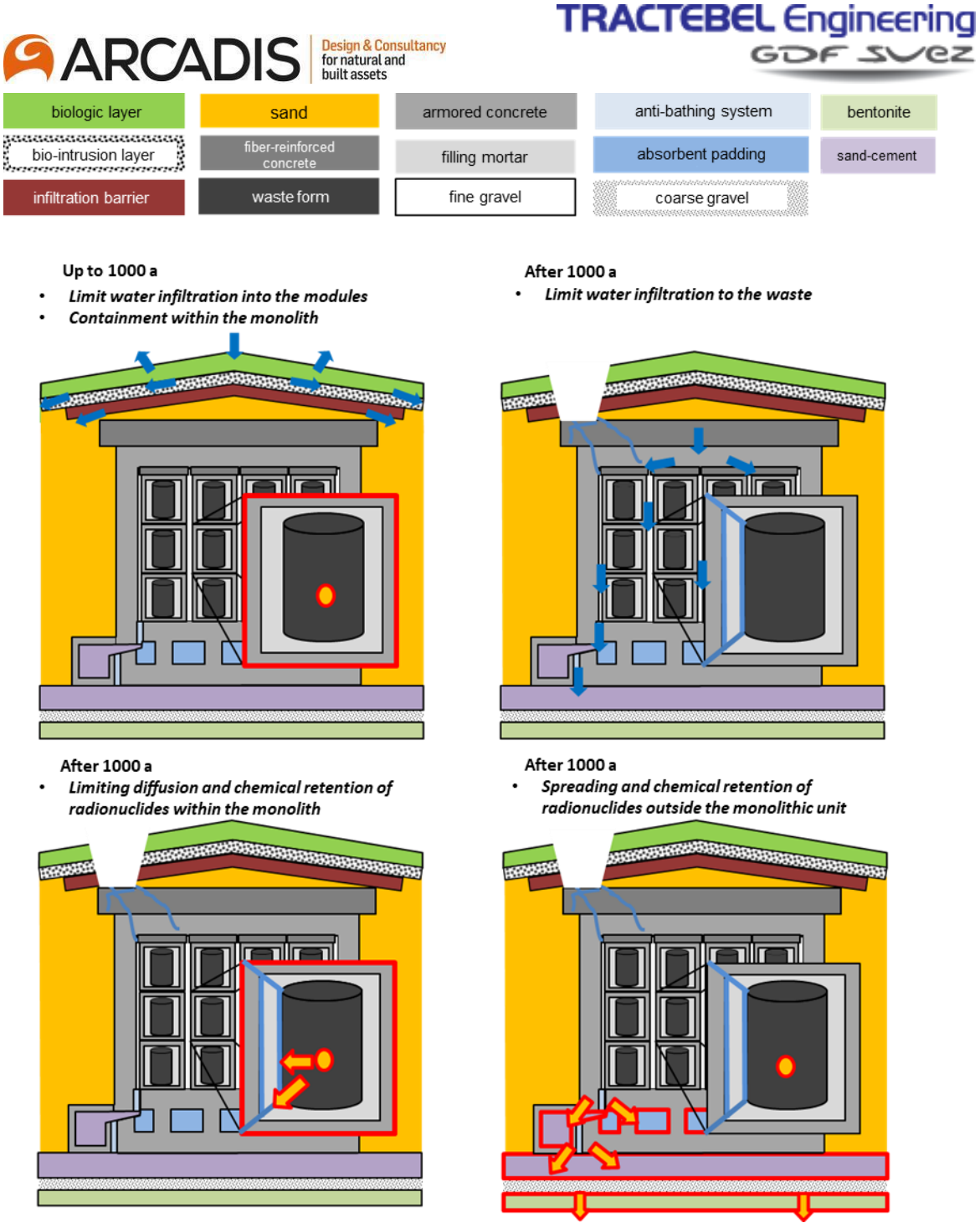


Figure 2-9: Containment by the disposal system

2.3.1.5 Visitor and community centre TABLOO

The visitor and community centre TABLOO will be the reference for all those who want to know more about radioactive waste and its broader context. From 2020, visitors will learn all about radioactive waste management. It will be a versatile visitor and community centre.

With TABLOO, ONDRAF/NIRAS meets the demand of the STORA and MONA partnerships for clear information on the disposal project and its wider context. This was one of the conditions the partnerships formulated in order to accept the building of the repository project in Dessel.

History

TABLOO will be built next to the repository, on the corner of the Gravenstraat and the Kastelsedijk. Because this area was still designated as a nuclear zone, the land-use plan had to be adjusted ("ruimtelijk uitvoeringsplan") allowing for the area to be used for non-nuclear activities. Before the GRUP ("gewestelijk ruimtelijk uitvoeringsplan") could be drawn up, the environmental impact of the plan first had to be carefully studied. This was done in an EIA plan.

In 2012, at the initiative of ONDRAF/NIRAS, the Flemish Government Architect launched a design competition for the Communication Centre. A consortium of the Antwerp architectural firms ONO architecture and Bovenbouw architecture won the competition in 2014.

Co-design

The winning preliminary design by the architects' consortium was the starting point for adapting it further to local wishes and expectations by those involved. This participatory approach is also maintained when developing the content of TABLOO. The visitor and community centre are a fine example of co-design between ONDRAF/NIRAS, the partnerships STORA and MONA and all other actors involved.

The design in a nutshell

The disposal project is characterized by a philosophy of openness and transparency. This idea has been continued in the design of TABLOO. The basic structure of the centre will be a table with legs 7.5 meters high. For 350 years, for the entire duration of the repository, that table will remain in place.

At the top of the table will be the exhibition spaces: a permanent experience exhibition on radioactive waste management and a space for temporary exhibitions. The space under the table will be for flexible use with smaller modules on two levels overlooking a central square. On the ground floor there will be a stage, multipurpose rooms, a catering facility and a tourist information point. The office and meeting rooms are on the first floor.

Experience expo

The main attraction of TABLOO will be an exhibition on radioactive waste and its broad context. 4D-experiences, interactive experiments and the latest multimedia techniques make the visit to the expo not only an educational experience but also an encompassing happening.

In the first part of the exhibition the visitor is immersed in the wonderful world of science. Where do galaxies come from? What is the structure of an atom? The visitor is introduced to concepts such as ionizing radiation and half-life. Armed with this luggage he will discover the rest of the exhibition. In it he gets acquainted with radioactive waste. Where does it come from, and what happens to it? However, it is not a purely technical-scientific story. Just as much focus is given to the accompanying conditions and measures of the integrated project approach. Which ethical questions do arise? How does our thinking evolve over time? How can we make the enormous period of time that goes with radioactive decay understandable? In what way is the community involved in this story?

In short, the exhibition tells an honest story where there is room for different perspectives. A mix of technical-scientific and ethical-societal themes. And all this in an interactive and animated way.

Community life

In the multipurpose rooms and with the stage there is room for scientific congresses, workshops and seminars. But these spaces are also available for local activities, as is the space for temporary exhibitions. In this way, the local communities and associations become the privileged co-users of the TABLOO visitor and community centre.

The TABLOO visitor and community centre will also bring together several services that were previously dispersed in the area. For example, the partnerships STORA and MONA and the Local Fund Foundation will have their offices there.

Landscape park with recreational assets

TABLOO is situated in the middle of a beautiful piece of nature. The total area of the disposal project is 88 hectares, of which 25 hectares will be transformed into a landscape park next to the visitor and community centre TABLOO. This park not only forms a magnificent backdrop for the building, it will also become a tourist asset. A network of comfortable paved paths and more natural footpaths will lead the visitor into the park. Cyclists will also be encouraged to enter the landscape park. The park forms a green bicycle connection between Dessel and the canal towpath and the Provincial Domain Prinsenpark. The paths in the park will connect to existing cycle network routes.

The landscape offers an alternation of heathland, woodland, a flower-rich grassland and a large pond. A nature trail will teach more about the vegetation and the applied ecological management. On a few spots in the landscape park, scientific test stands will be put to display telling the story of the research that preceded the construction of the repository.

The eye-catcher of the landscape park will be the 'strip'. On a strip of 300 meters long, alternating topographies encourage different forms of play. Children can run, climb, play hide-and-seek, on a landscape of slopes, mountains and natural play objects. The architecture is inspired by the theme 'radioactivity', which makes the whole setup location specific.

The scanty grassland can serve as an event meadow. For an activity or event part of the area can be mowed. This large event meadow is an asset for both the TABLOO visitor and community centre, as well as the local community.

A cosy café-restaurant will be integrated into the building. From the terrace there is a view over the landscape park. In the meantime, children can play in the adjacent playground or on the strip.

Figure 2-10: Atmospheric portrait of the visitor and community centre TABLOO

2.4 Existing installations Belgoprocess

Belgoprocess is a public limited company founded in 1984 in Dessel, where several nuclear companies were already present. It is a subsidiary of ONDRAF/NIRAS. ONDRAF/NIRAS, commissions Belgoprocess to process all radioactive waste produced in Belgium that is not processed by the producers themselves.

Belgoprocess' installations are spread over two sites:

- site 1, the former Eurochemic reprocessing plant, located in Dessel on the site where the IPM will also be built;
- site 2, the site of the former "Waste" department of the SCK, located on the territory of Mol.

Belgoprocess' operational activities can be divided into three groups:

- the processing and conditioning of radioactive waste;
- interim storage pending the disposal of radioactive waste;
- the dismantling of decommissioned nuclear installations and the decontamination of contaminated buildings and sites.

In addition, Belgoprocess provides services to other Belgian and foreign customers. Belgoprocess currently carries out these activities with the help of 280 employees.

2.5 Periods and phases in the lifespan and a repository

The figure below shows very briefly the different periods and phases in the lifespan of a repository.

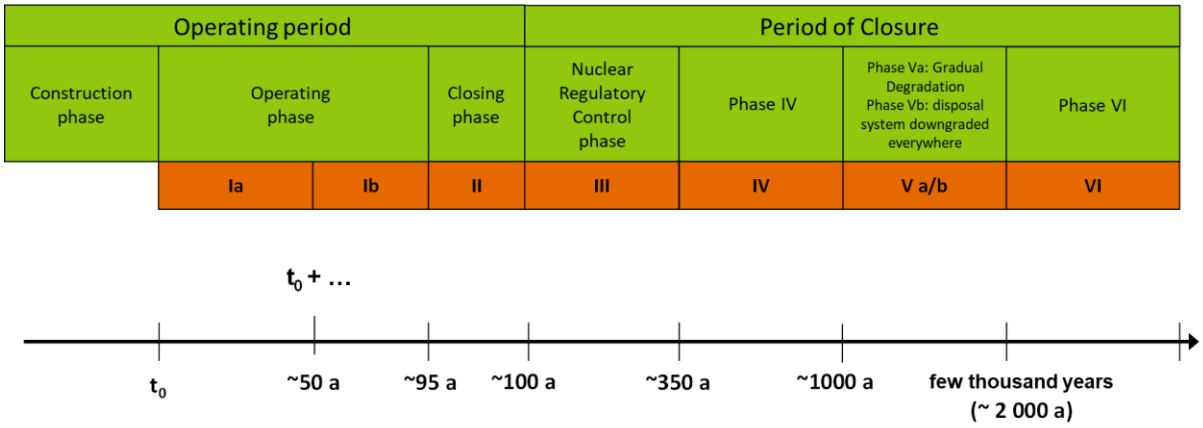


Figure 2-11: Overview of phases and time scales for surface disposal, as well as possible activities and the 2 types of safety evaluations. The time scales are indicative.

Two periods are distinguished:

- the **operational** period:
  - the construction phase: the phase during which the disposal modules and peripheral buildings are built. The modules will be built in series as follows:
    - In a first phase, the 20 modules closest to the IPM will be built. This will be done in two rows of 10.
    - When enough modules have been built (e.g. 8) and all other necessary provisions and conditions have been met, operation can start. Subsequently, the remaining modules of the first tumulus will be realized. The operational zone and the working area will be physically separated from each other. The modules will be filled 4 by 4, first those closest to the IPM;
    - When a group of four modules is fully filled, they are fitted with a concrete cover plate.
    - When the first 20 modules are almost filled, the construction of the next set (14 modules) will start. The exact timing and duration of this phase will depend on future waste production and the scenario for decommissioning the nuclear installations.
  - Phase I (exploitation) will be divided into two sub-phases:
    - in a first sub-phase (IA), the waste is placed in the disposal modules (estimated duration approximately 50 years). During this phase, the category A waste is conditioned in the IPM and then transported and stacked, in the form of monoliths, via the internal railway network to the disposal module.
    - the second sub-phase (IB) starts when the roof structure is removed, and the multilayer soil cover is applied (estimated duration approximately 45 years). The installation of the cover is estimated to start 50 years after the start of operation of the repository. For the first series of 20 modules, an estimated 650,000 m³ of natural materials would be needed, which can normally be supplied mainly by ship.

- In Phase II (closure), which will last about 5 years, all inspection rooms, galleries and drainage systems will be filled;

- the **period after closure** follows the operational period and consists of:
  - Phase III (nuclear regulatory control): nuclear regulatory control where monitoring and access control is ensured (approx. 250 years);
  - Phase IV: during this phase, water infiltration and contact of water with the waste is greatly reduced: leaching of radionuclides dominated by diffusion (up to about 1000 years and subject to local deviations on the expected performance of the disposal system);
  - Phase V: leaching of radionuclides dominated by diffusion (up to about 1000 years and subject to local deviations on the expected performance of the disposal system). From about 1,000 years usage, the limitation of water infiltration into the different barriers of the repository gradually disappears, and a transient occurs in which the artificial barriers slowly begin to degrade. During phase V, the disposal system is degraded, but can still be clearly defined;
  - Phase VI: post-conclusion phase. In this phase, the disposal system can no longer be aligned unequivocally, due to growing uncertainties about the evolution, geometry and configuration of the disposal system. The whole of waste, monoliths, modules and cover will eventually degenerate into a mixture of debris with an uncertain configuration and heterogeneous chemical state.

If, after the inspection period, the repository's license is lifted, the repository is no longer subject to the laws and regulations governing nuclear installations. This means that controls for radiation protection reasons can be stopped, but this does not mean that other controls (land use) and efforts to retain knowledge of the site should be continued. There is a strong intention to continue these controls for as long as possible, as well as to provide for mechanisms of preservation of the memory of the contents of the site, in interaction with local stakeholders and within a legal framework. ONDRAF/NIRAS as a public institution remains the owner of the repository and the land on which it is located and remains involved in the local fund and local integration (see MTF law) can contribute to this as an institutional element of continuity.

2.6 Timing of the project

Since it is not possible to determine exactly when the Royal Decree on the establishment and operating license will be published in the Official Gazette, relative start and lead times are indicated. T0 corresponds to the date of publication in the Royal Decree for the construction and operating permit for the surface repository in Dessel.

Phase		Description	Timing
Operational period	Construction phase	construction of modules 1 to 20	T0 ➔ T0+5
		construction of modules 21 to 34	T0+15 ➔ T0+18
	Phase I (operation)	the waste placed in the disposal modules	T0+4 ➔ T0 +50
		Remove roof structure and apply multilayer ground cover	T0+50
	Phase II (closure)	filling of all inspection rooms, galleries and drainage systems	T0+95 ➔ T0+100

Period after closure	Phase III (nuclear regulatory control)	ensuring monitoring and access control	T0+100 ➔ T0+350
	Phase IV	limiting water infiltration and water contact with the waste	T0+350 ➔ T0+1000
	Phase V	gradual degradation of the system; containment by residual sorption	T0+1000 ➔ T0+2000
	Phase VI	from this phase onwards, the disposal system can no longer be aligned unequivocally	T0+2000 ➔ …

The timing of the other components on the Niras site is shown in the table below.

	Start construction phase	Start of operations
Quay	Already implemented	2018
Caisson factory	2018	2020
IPM	2018	2021
Visitor and community centre TABLOO	2018	2021
Access cluster	2018	2020

2.7 Further decision-making and procedures

The present project-level EIA follows the single permit procedure prescribed by the decree of 25 April 2014 on the single permit, which came into force on 23 February 2017. This means that a notification will first be drawn up. Subsequently, the draft project-level EIA will be attached to the (regional) application for a single permit, which concerns both the Urban Development Act and the operation of a classified nuclear establishment or activity. The EIA procedure and the permit procedure are therefore integrated.

The authorization procedure requires a public enquiry. During this investigation, the design of the project-level EIA will also be made available to the public.

As part of the application for the federal establishment and operating permit for the repository, there is also a public inquiry. The intention is to have the two public inquiries simultaneously.

The procedure for applying for the federal establishment and operating permit started in 2013. At that time, the design of the project-level EIA was part of the application file.

After the first application in 2013, the FANC declared the dossier "incomplete" and a series of questions had to be answered. These answers were integrated in a revised version of the permit application that was submitted in 2019 together with the draft EIA (version according to single permit regulations). After the Scientific Council for Ionizing Radiation has given an initial opinion, the federal and regional permit application together with the draft EIA will be submitted to public inquiry. The regional single permit and the federal establishment and operating permit will then be issued.

2.8 Alternatives

2.8.1 Zero alternative

The zero-alternative defines the development that follows when neither the proposed project nor any alternative to it is carried out and the current policy is continued. The zero alternative is therefore the state and evolution of the study area if the project does not proceed.

2.8.2 Location and implementation alternatives

Location alternatives refer to alternative implantation sites for project components. Implementation alternatives are alternative implementation options or technical variants.

Considering the long history of the project and the government decision of June 2006, no location or implementation alternatives are studied in this EIA for the following reason: In its meeting of 23 June 2006, the Council of Ministers, after weighing up the above-mentioned criteria, opted for the realization of a surface disposal facility in the municipality of Dessel. After a policy-based assessment, the Council of Ministers thus argued that the realization of surface disposal in Dessel was the only reasonable, i.e. feasible and promising, alternative. This policy option of the Council of Ministers was subsequently confirmed by the start of the design phase (drawing up the safety study and drawing up the current project-level EIA).

This assessment is still valid today.

As far as the location alternatives are concerned, first of all, since 2006 no other municipality in Belgium has (indirectly or directly) expressed any interest in considering to have a disposal project on its territory. Hence, there are no indications of a (local) support for other municipalities than Mol and Dessel. Nor have there been any new nuclear zones in Belgium since 2006. Furthermore, the geographical situation of the possible site alternative at Mol has remained unchanged since 2006, underlying that the options and conditions on which the Council of Ministers made its decision for Dessel on 23 June 2006 remain valid.

The arguments considered by the Council of Ministers on 23 June 2006 are still up to date. For example, regarding the implementation alternatives (surface disposal vs. geological disposal) it remains valid that the recoverability of waste from geological disposal is more complex than is the case with surface disposal. Today, surface disposal of this type of waste still has a higher industrial maturity than geological disposal. Several modern and efficient surface disposal facilities are already in operation worldwide and can serve as a reference. Moreover, the cost price of geological disposal remains disproportionately high compared to the cost price of surface disposal.

In its guidelines of 15 July 2011, the EIA Team also confirmed that the choice for surface disposal to be regarded a final policy decision, implying that that the alternative of deep disposal is not in need for study for the current project-level EIA. Mutatis mutandis, the same applies to the location alternatives.

In view of the history of the project, which led to the decision by the Council of Ministers' of 23 June 2006 where a specific policy choice was made. This policy choice has not changed since then and is still relevant. In this project-level EIA, the Dessel location is therefore examined as the only reasonable location alternative and surface disposal as the only reasonable implementation alternative.

3 Reference situation, planned situation and development scenarios

The state of the environment of the study area in 2016-2017-2018 is taken as the reference situation. The description of the reference situation is based on map material, policy documents, measured data. The data used for describing the reference situation for the different disciplines remain up to date in 2019-2020.

The planned situation is the state of the study area during and after implementation and resulting from realization of the project, this as stipulated in the project description and thereby not considering the impact of any mitigating measures.

Development scenarios describe the evolution of the study area in the future, considering the autonomous evolution of the area and the evolution under the influence of plans and policy options. These scenarios should be described in addition to the reference situation, if there are reasons to assume that this situation could change significantly in the future. Within the framework of the disposal project, there are several relevant development scenarios that need to be considered. These mainly concern changes in in transport infrastructure in the vicinity of the project which will have a favourable impact provided the current, often problematic, traffic situation. The following projects are considered in this EIA:

- Upgrade N118 to secondary road II and selection of N18 as secondary road III (from provincial mobility study N118, already included in partially revised RSPA);
- Construction of connecting road N18 - N118 via Kastelsedijk, Gravenstraat and route north or south of the canal;
- Construction of connecting road N118 - R14 (ring Geel);
- Upgrading and finishing of ring road Retie;
- Refurbishment of the Retie centre in the interest of traffic liveability (after upgrading and completion of the Retie ring road);
- Refurbishment of the Dessel town centre in improving the traffic liveability (after construction of the N18/N118 link road);
- Refurbishment of Mol town centres and districts in order to make them roadworthy (after construction of connecting roads).
- Refurbishment in the centre of Geel-St. Dimpna (after construction of connecting road N118 - R14);
- Geel-Winkelomheide shopping centre in connection with traffic liveability (after construction of fly-over Geel-Punt).

In addition to changes in the transport infrastructure, the construction of the TABLOO visitor and community centre, the extension of the SME zone Stenehei and the redevelopment of the former military site Kievermont, which is also situated along the N118, must also be considered.

4 Environmental assessment

4.1 General information

This project-level EIA is made in order to obtain the necessary permits for the construction and operation of the disposal modules. Since the disposal modules are part of an environmental engineering unit formed by the quay, access road, caisson factory, IPM and the TABLOO communication centre, the cumulative effects will be described and assessed. Cumulative effects are only expected because of the traffic generated by the caisson factory, IPM and the TABLOO communication centre. The cumulative effects are therefore considered under the disciplines Human - Mobility, Air, Noise and Vibrations.

The environmental assessment of non-radiological effects is subdivided into various disciplines. These are the following disciplines:

- Human – mobility
- Soil
- Water
- Air
- Noise and Vibration
- Biodiversity
- Landscape, architectural heritage and archaeology
- Human - spatial aspects
- Human health
- Climate

Each discipline has the following structure:

- Description of the reference situation
- Impact description and assessment
- Mitigating measures

Description of the reference situation

For each discipline, a description of the reference or current situation is included. It is always indicated which elements will be studied and which sources of information have been used to this purpose.

Impact description and assessment

For each discipline it is indicated which possible impacts are to be expected as a result of the realization of the proposed project and the way in which these impacts will be studied. The impact description and assessment are carried out for the various phases/periods in the repository's lifespan:

- Operational period
  - construction phase;
  - Phase I (operation);
  - Phase II (closure);
- Period after closing.

Within each discipline, the impact assessment makes use of a system with 7 scoring possibilities in assessing significance:

- significant negative effect (permanent negative effect that is large in magnitude): ---
- negative effect (permanent negative effect that is small in magnitude or temporary negative effect that is large in magnitude): --
- limited negative effect (temporary negative effect that is small in magnitude): -
- negligible/ or no effect (neutral): 0
- limited positive effect (temporary positive effect that is small in magnitude): +
- positive effect (permanent positive effect that is small in magnitude or temporary positive effect that is large in magnitude) ++
- Significant positive effect (permanent positive effect that is large in magnitude): +++

Mitigating measures

The 'mitigating measures' section includes a statement of all relevant measures to be taken to prevent or reduce negative effects and to promote positive effects.

4.2 Human - mobility

4.2.1 Description of the reference situation

The traffic counts carried out in 2016 show that relative to the:

- Intersection N118 x Kastelsedijk: This intersection was rebuilt a few years ago. There are no structural problems with the traffic flow on this intersection controlled by traffic lights. The ratio between intensity and capacity at the intersection still shows a large margin to handle additional traffic flows. In the morning rush hour, the capacity is currently used for about 51%. In the evening rush hour this is 65%.
- Roundabout Kastelsedijk /Boeretangsedreef: Evaluation shows that in both the morning and evening rush hour a maximum of 26% of the available capacity is used.
- Intersection N118 x Europalaan: There are no structural capacity problems at this intersection, given the limited traffic volumes on Europalaan.

In the traffic accident data-GIS (period 2014-2016) several accidents can be noted at the intersections Boeretangsedreef x Kleine Boeretang and Boeretangsedreef x Gravenstraat and these accidents on the N118.

Based on the traffic intensities in the current situation, it appears that the traffic cross delay of the roads in the study area can be described as 'moderate' (without traffic islands) or 'good' (with traffic islands).

Several policy initiatives are underway covering the various development scenarios in the immediate vicinity of the project area. The basic objective remains to develop a sufficiently qualitative traffic structure that solves the current traffic situation and is in line with the desired spatial developments.

When, in principle, the operation of the disposal starts ('situation after 2020'), the following projects in the immediate vicinity of the study will have been realised:

- Upgrade N118 to secondary road II and selection of N18 as secondary road III (from provincial mobility study N118, already included in partially revised RSPA);
- Construction of connecting road N18 - N118 via Kastelsedijk, Gravenstraat and route north or south of the canal;
- Construction of junction road N118 - R14 (ring Geel);
- Upgrading and finishing ring road Retie;
- Refurbishment of the Retie centre in order to make it habitable for traffic (after upgrading and completion of the Retie ring road);
- Refurbishment of the Dessel town centre in improving the traffic liveability (after construction of the N18/N118 link road);
- Refurbishment of Mol town centres and districts in order to make them liveable (after construction of connecting roads N18 - N118 and N118 - R14);
- Refurbishment of the centre of Geel-St. Dimpna (after construction of connecting road N118 - R14);
- Geel-Winkelomheide shopping centre in connection with traffic liveability (after construction of fly-over Geel-Punt).

4.2.2 Impact description and assessment

The estimation of the traffic generation passenger transport shows that during the period 2018 - 2025 a maximum of 176 persons (full-time equivalents) will be employed. This is expected in 2021, when part of the construction (disposal, IPM, caisson factory, visitor and community centre TABLOO) coincides with the operation (IPM, caisson factory, visitor and community centre TABLOO).

In the planning and phasing, an estimate was made of the number of trucks that will drive to and from the project area during the various phases of the project, as well as the number of boats that will be responsible for transport by waterway.

Scenario A will include a minimum number of transports by boat. In this scenario an average of 2 trucks per day will be generated by the project during the period 2018 - 2071. The largest truck flows are expected during the construction phase: an average of 12 trucks per day in 2018, 11 trucks per day in 2019 and 9 trucks per day in 2020.

In Scenario B, all transports that can possibly be carried out by boat are also carried out by boat. In this scenario an average of 1 truck per day is generated by the project during the period 2018 - 2071. The largest truck flows are expected during the construction phase: an average of 8 trucks per day in 2018, also 8 in 2019 and 5 trucks per day in 2020.

The additional traffic generated by the disposal is limited and will be greatest during the construction phase. Even in the scenario where a minimum proportion of transport will be by waterway. The impact of the project on the degree of saturation of the surrounding intersections is negligible. After all, the intersections N118 - Kastelsedijk and Kastelsedijk - Boeretangsedreef - Gravenstraat have enough residual capacity to handle the additional traffic flows. The impact of the project during the construction phase on the traffic cross delay is limited. However, new conflict points will be created at the level of (1) the connection of the new access road for the quay, IPM, caisson factory and storage modules to the Europalaan and (2) the crossing of a recreational footpath (which will be realized as part of the implementation of an approved forest management plan) with the N118 in the direction of the Prinsenpark. During phase I (exploitation) the traffic flows coming from the visitor and community centre TABLOO must also be considered. The further development of Kievermont and Stenehei also create an additional traffic generation. However, this will only be realized after a connection between the N118 and the N19g/R14 ring road around Geel and the extension of the ring road around Retie to the N118. The effects on the degree of saturation of the intersections, the traffic cross delay and traffic safety are similar to the construction phase.

4.2.3 Mitigating measures

The impact on road safety is assessed as negative. This means that mitigating measures must be taken. In function of traffic safety, it is necessary to construct the connection of the new access road for the quay, IPM, caisson factory and disposal modules to the Europalaan in a traffic-safe manner. The crossing of the recreational footpath over the N118 should also be constructed in a traffic-safe manner (improving visibility by removing trees, installing road signs, organizing a crossing with a central island, ...). In consultation with the road manager, the most suitable measures should be determined.

The other measures are rather recommendations or accompanying measures (which can be taken by the competent authorities). These measures are therefore not necessary to mitigate a negative effect but can improve the traffic situation:

- Use the quay as much as possible for the supply and removal of materials during the construction phase (= Scenario B 'Maximum share of waterway' = is also ONDRAF/NIRAS' objective).
- Increasing the frequency of the bus lines calling at the stops in the vicinity of the project area, specifically the lines to and from the stations of Geel and Mol. This will be dealt with in the Kempen transport region;
- Providing bicycle paths (preferred) or bicycle suggestion lanes along the Europalaan. The verges along the Europalaan have a very valuable vegetation composition wherefore it is advised against to broaden the current road profile. If cycle paths are not possible (because of biodiversity), cycling suggestion lanes may be considered (ONDRAF/NIRAS will carry out this as this is a private road);

the construction of a secure crossing over the Europalaan. The N118 at the intersection with Europalaan, for cyclists and pedestrians (execution by the road authority);
- Ensuring road safety during the construction phase (adequate signage and shielding of construction sites). This will be included in the specifications as a requirement of the execution of works (execution by the contractor);
- Keeping pedestrian and cycle paths crossed by site traffic clean. This will be included in the specifications as a requirement of the execution of works (execution by the contractor);
- Evaluation of traffic handling. Where necessary - in consultation with the actors involved - infrastructural adjustments can be considered (execution by the road manager). This is done when problems are identified. Those actors to be involved will depend on the nature of the problem.

Finally, some accompanying measures are proposed in order to obtain a positive modal split for traffic to and from the visitor and community centre TABLOO:

- encouraging alternative modes of transport by:
  - providing information, including via websites, on accessibility by public transport and cycling.
  - providing sufficient bicycle parking facility in a clearly visible place, close to access.

4.3 Soil

In the soil discipline it is investigated whether the construction and operation of the disposal gives rise to soil movement, soil disturbance (due to changes in structure and profile) or soil pollution.

4.3.1 Description of the reference situation

The project area is part of the Antwerp Zuiderkempen. In the eastern part of the project area the soil on the soil map is referred to as land dune. In the western part there are sandy soils (podzols). There are no scientifically or culturally valuable soils within or in the vicinity of the project area.

The zone where the first series of 20 disposal modules will be implanted is currently occupied by coniferous forest. The zone where the second series of 14 modules will be implanted is a heathland area.

Within the project area, an exploratory soil survey was carried out in 2008 in the area where the disposal modules will be built, more specifically in the forest and heathland area. The results of this soil survey are still considered representative as no risk activities and no calamities or accidents that could influence the soil quality took place afterwards. No pollution that could be due to activities within the project area has been identified. However, historical pollution with heavy metals (e.g. zinc, lead, copper, nickel, cadmium, beryllium) was found in the groundwater due to the former zinc industry in the area. This contamination was also found on other plots of land in the vicinity. Elevated concentrations of chromium, zinc and nickel in the solid part of the soil and toluene and xylenes in groundwater were found at a former Eurochemic landfill site. To the northwest of the project area, a residual contamination with BTEX is still present after soil remediation. Increased concentrations of heavy metals were also found in the solid part of the soil and groundwater which are of a historical nature.

4.3.2 Impact description and assessment

4.3.2.1 Construction phase

Soil moving

For the construction of the repository the soil movement will be considerable. The most important soil moving will come from the levelling of the site and the installation of the embankment underneath the modules (40 cm thick layer of sand, then a 60 cm gravel layer with a 2 m mixture of sand and cement above it). In addition, solid moving will also occur for the construction of the infiltration basins.

An estimated 45,000 m³ of soil will be excavated to level the site. For the 2 infiltration basins of the first series of modules, approx. 13,920 m³ will be excavated and approx. 5,635 m³ of topsoil will be replenished.

Most of the excavated soil will be replaced and compacted after removal of roots and branches etc. or placed in stock for later use. Little soil will probably have to be removed.

For soil moving, all legal regulations will be followed.

Structural change

Compaction is the effect created using machinery and the application of important soil fillings or heavy structures above compressible or structure-sensitive soils. The disposal modules are heavy constructions under which compaction or subsidence will occur. However, this is not so much an important impact with respect to the receptor disciplines (nature, landscape, people) as it concerns the safety aspects of the disposal (e.g. subsidence may cause cracks in the modules). In order to gain a good understanding of the subsidence behaviour of the subsurface, this was measured directly by means of a soil embankment. A quantity of soil was raised (height 20 meters) and the subsidence of the subsurface was measured during several months. Relevant secondary effects (on receptor disciplines) are not expected.

When constructing the infiltration basins, it is important that the soils are not compacted. However, the basins are constructed in a moist sandy soil that is less sensitive to compaction.

Profile change

The original soil profile is disturbed when excavating soil and when foreign materials are introduced into the soil. The disposal modules will not contain large underground structures, except for foundations and underground pipes and drainage systems. The infiltration basins will also be excavated.

However, no scientifically or culturally-historically valuable soils are lost. Moreover, the profile disruption will not give rise to any significant secondary effects in view of future land use.

Change in land use

The disposal modules will be in the forest and heathland area south of the Europalaan. A total of approximately 25 ha of an area of approximately 80 ha will be effectively put into use for nuclear purposes. This use corresponds to the regional land-use planning map.

Damage to soil hygiene

During the construction phase, accidental soil contamination can occur as a result of e.g. leaks in fuel lines or spills of mainly oil and/or fuels during the use and maintenance of machinery. If such calamities occur, immediate measures must be taken to avoid soil contamination.

The discussion in the air discipline shows that the impact of the activities during the construction phase on air quality will be limited and therefore no relevant eutrophication (enrichment of the soil with nitrogen and/or phosphorus) or acidification is expected.

4.3.2.2 Phase I (operation)

Damage to soil hygiene

Due to the placement of the waste in the disposal modules, no relevant impact is expected within the soil discipline. These activities do not pose a risk of soil contamination. In addition, enough preventive measures are provided for in the legislation to prevent soil contamination and, where appropriate, to remediate it.

Approximately halfway through Phase I (operation), after the disposal modules have been filled with waste, the roof structure is removed and a multilayer soil cover (several natural soil layers and geomembranes) is applied (the so-called cover). It is assumed that in the future the regulations will be as strict or stricter than the current soil moving regulations and that it can therefore be assumed that no contaminated soil will be imported.

Also, during phase I (operation), the impact of the activities on air quality is limited and therefore no relevant eutrophication or acidification is expected during this phase either.

4.3.2.3 Phase II (closure)

Damage to soil hygiene

During phase II (closure), all inspection rooms, galleries and drainage systems are filled. Possible risks of soil contamination during this phase are similar to those of using the machinery during the construction phase.

4.3.2.4 Period after closure

Damage to soil hygiene

The only non-radiological effect that may occur during this phase is leaching of non-radiological components from the disposal. Since leaching to groundwater is particularly relevant here, this aspect is discussed in the 'water' discipline.

In the period after closure, no leaching of radionuclides is expected for the first 650 years and the radioactivity that may be released into the soil afterwards does not cause any significant increase in the radioactivity that is naturally present.

4.3.3 Mitigating measures

The effects described within the soil discipline are assessed as limited and do not give rise to any need for mitigation measures.

4.4 Water

In the water discipline it is investigated whether the construction and operation of the disposal can have an impact on groundwater or surface water through changes in infiltration and discharge characteristics, structural quality of watercourses, flood regime, groundwater flow and water quality.

4.4.1 Description of the reference situation

The project area is characterized by an average groundwater level of 24,3 mTAW. The project area is not situated in a water catchment area or in or on the edge of a protection zone for groundwater extraction. However, there are several aquifers in the vicinity of the project area.

There are no watercourses within the project area itself. There are two watercourses in the immediate vicinity of the project area: the Hooibeek and the Bocholt-Herentals canal. The Hooibeek forms the south-western boundary of the nuclear zone to the north of the canal. The Bocholt-Herentals canal runs south of the project area.

The Hooibeek is connected to the Bocholt-Herentals canal via an inlet construction and is used to feed the pond in the Prinsenpark.

The project area can be accessed via the Bocholt-Herentals canal. In order to limit road transport as much as possible, a quay has been provided along the canal. The Bocholt-Herentals Canal connects the Zuid-Willemsvaart in Bocholt with the Albert Canal in Herentals over more than 60 kilometres. The canal is managed by De Vlaamse Waterweg and is navigable for ships up to 600 tons. This relatively limited tonnage is due to the limited size of the locks.

The project area is not designated a flood plain.

4.4.2 Impact description and assessment

4.4.2.1 Construction phase

Change of infiltration and discharge characteristics

The construction of the repository involves a considerable surface area being paved. The first series of 20 modules will cover an area of 1.76 ha. The second series (14 modules) will cover an area of 1.2 ha. This paving will have an impact on infiltration and drainage characteristics.

The construction of the repository and the other structures are subject to the rules of the Regional Urban Development Ordinance on rainwater wells, infiltration facilities, buffer facilities and separate discharge of wastewater and rainwater. The purpose of this ordinance is to minimize the impact of pavements on infiltration and discharge characteristics. The regulation will be complied with.

Rainwater falling on the fixed roof above the modules will be diverted to 2 infiltration basins where it can infiltrate into the ground. Considering the complete "footprint" of the tumuli (i.e. 75,750 m²), the regional rainwater ordinance requires the following dimensions of the infiltration facilities:

- Infiltration volume : 75,750 m² x 25 l/m² = 1,893 750 l = 1,890 m³
- Infiltration area = 75.750 m² /25 = 3.030 m².

Together with the 2 infiltration basins, an infiltration volume of 5,730 m³ and an infiltration area of 5,465 m² are provided. This means that the imposed standards are more than met. For the installation of the cover, the roof surfaces and pavements must be considered. These amount to roughly 35,000 m² and therefore require an infiltration volume of 875 m³ and an infiltration area of 1400 m². This area is provided for in the current design.

Deterioration of watercourses and flood zones / alteration of watercourse structure quality

There are no watercourses or other surface waters within the project area. The construction of the repository therefore does not give rise to any direct interventions on watercourses.

The project area is also not designated as a flood zone, so no flood area will be inundated.

The northern infiltration basin has an overflow opening into the southern basin. The outlet of the southern infiltration basin brings the water to the wooded (lower) area south of the project area. Calculations show that the overflow will not be necessary, even when considering a 100-year return period and global warming. No impact on flood zones is therefore expected.

Influencing groundwater flow pattern

The groundwater flow can be influenced or disturbed by underground structures such as tunnels, shafts, cellars, etc. Disturbed groundwater flow can have an important effect on the environment. For example, the importance of local groundwater flow will be very high in places where there are natural values that depend on the level or flow of groundwater.

The disposal does not include any underground infrastructure. The disposal modules are even built on an embankment to ensure that the modules are always above the water level, even after, for example, extremely heavy rainfall.

During the construction phase it will be necessary to lower the groundwater level to a level of approximately 21.20 mTAW for a period of 6 months during the construction of the basement of the Water Collecting Building. The groundwater reduction is 3.86 m.

In the drainage memorandum drawn up by Tractebel, August 2019, a groundwater reduction of 0.2 m at 1050 m from the centre of the SCI is expected. It should be noted that this influence radius is maximal (= worst case) because no real precipitation was applied in the model. Therefore, the influence radius will be smaller.

The considered flow rate, after equilibrium is reached, is 4.2 m³/h per drain which leads to a total flow rate of 100 m³/h for the 24 drains of 15 m deep. The pumped drainage water will be infiltrated completely (50% in the already excavated southern infiltration basin + 50% via overflow infiltration basin which runs via infiltration ditch to the forest (“rabbatbos”) south of the disposal modules). The (passive) return drainage reduces the influence radius of the drainage. In addition, it can be assumed that the radius of influence in the south does not extend beyond the Bocholt-Herentals canal.

Derived effects of drainage are assessed in the disciplines soil, biodiversity and landscape, architectural heritage & archaeology.

Change in water quality

During the construction phase, accidental contamination may occur as a result of leaks in fuel lines or spills of mainly oil and/or fuels during the operation and maintenance of machinery. Pollutants that end up on or in the ground can leach out and migrate to groundwater under the influence of seeping rainwater. In the event of a disaster, immediate measures must be taken to avoid soil and groundwater contamination.

As there are no watercourses or other surface waters within the project area, there is no risk of contamination of surface water by calamities during the construction phase.

The drainage water released during the construction of the basement of the Water Collecting Building will be completely infiltrated. No effects on surface water quality are expected as the basin has no overflow to the surface water. In the studies carried out, the pollution parameters were determined in the groundwater. Therefore, the drainage water is first purified before it is infiltrated again. Consequently, there will be no effect on groundwater quality.

An impact study shows that the drainage will have no significant influence on the groundwater contaminants within the expected radius of influence of the drainage.

The rinse water from the concrete plant must be purified before it is either discharged into the sewer system or discharged. Effects on surface water quality are thus avoided.

4.4.2.2 Phase I (operation)

Change in water quality

The storeroom is an installation without offices. There is no need to reuse recovered rainwater. Therefore, no sanitary wastewater is discharged.

Also, the operation of the repository will not give rise to the generation of industrial wastewater. However, it cannot be ruled out that due to anomalies in the roof or through condensation, a limited amount of water will be collected in the drainage system. This water may be contaminated and will be collected in 2 tanks and transported by truck to Belgoprocess for further processing. The disposal modules therefore have no impact on surface water quality.

The only relevant form of wastewater is sanitary sewage from the 12 employees of the access cluster. This cluster is already licensed (and under construction) and is not part of the current permit application but is part of the disposal project. An individual treatment plant (IBA) is planned for the sanitary wastewater. Considering the limited number of employees and the IBA provided for wastewater treatment, no significant impact is expected on surface water via the discharge of sanitary wastewater.

Phase I (operation) also includes the removal of the roof structure and the application of a multilayer soil cover. Possible risks of water pollution during these works are similar to those of using the machinery during the construction phase.

Category A waste contains, in addition to the radioactive constituents, a large quantity of inorganic non-radioactive constituents. Containment and segregation are achieved by placing successive barriers around the waste. Monitoring and control are foreseen over a period of 350 years, but over time a gradual degradation of the modules and monoliths will start, which may leach out the non-radioactive elements present in the repository and affect the quality of the groundwater. Due to the use of different safety functions (specific to the disposal), there will be no leaching of nuclides. The same applies to chemotoxic elements present in the repository. There will be no leaching to groundwater in the first 650 years, including during phase I (operation).

No nuclear effects are expected during phase I (operation) of the disposal, as there are no discharges.

4.4.2.3 Phase II (closure)

Change in water quality

During phase II (closure), all inspection rooms, galleries and drainage systems are filled. Possible risks of soil contamination during this phase are similar to those of using the machinery during the construction phase.

There will be no leaching of non-radiological elements to groundwater during the first 650 years, including during phase II (closure).

During phase II (closure) of the repository, no nuclear effects are expected, as there are no discharges.

4.4.2.4 Period after closure

Change in water quality

The only non-radiological effect that could occur during this phase is leaching of non-radiological components from the disposal. This leaching can only occur provided the degradation of the disposal. This was modelled by a system of fissures. In the expected scenario, these will become "active" from 650 years, so no leaching is expected until that time. Moreover, a sorbent function is assigned to the cement within the waste barrel and bentonite is added to the embankment to ensure a delay of any leaching in the very long term (after 1000 years). A monitoring of Boron will be carried out to follow this up.

In the period after closure, no leaching of radionuclides is expected for the first 650 years. In addition, the water from a well near the repository meets the radiological quality conditions of water intended for human consumption, even after radionuclide leaching, and the radioactivity that may be released to groundwater after leaching does not significantly increase the radioactivity naturally present. Similarly, radioactivity that may be released to surface water and sediments after leaching does not cause a significant increase in radioactivity naturally present.

4.4.3 Mitigating measures

Within the discipline of water, no significant negative effects are expected. The project already foresees enough measures to limit impacts on ground or surface water. Therefore, no additional mitigating measures are proposed.

4.5 Air

Within the air section, it was investigated whether effects are to be expected as a result of additional road and ship traffic during the operational period of the disposal. The pollutants studied are NO2, PM10 and PM2.5. In addition, the risk of dust nuisance is also investigated.

4.5.1 Description of the reference situation

An investigation of the current situation reveals that the annual average NO_2 concentration within the study area is below the annual thresholds for the protection of human health and below the annual threshold for the protection of vegetation. The thresholds for PM_{10} are also being respected (both the daily and annual threshold). The annual average $PM_{2.5}$ concentration remains below the annual threshold of 25µg/m³, even if this is potentially tightened to 20µg/m³ in the future.

4.5.2 Impact description and assessment

4.5.2.1 Construction phase

Calculations are being made as to the effects of road and vessel traffic on air quality. The project's contribution to air pollution during the construction phase is considered negligible.

During the construction phase, relevant effects may arise as a result of dust generation from the soil works. However, the (calculated) deposits are only temporary. No relevant diffuse emissions are expected as a result of the storage and transfer of crushed limestone.

The works must be carried out in accordance with Vlarem (Section 4.4.7 - Control of non-guided dust emissions). This means, among other things, that a speed limit must be set on the site, that the sites must be sprayed wet in case of persistent dry weather, that procedures and instructions must be drawn up that must be followed when unloading lorries, using grabs and using wheel loaders in order to limit dust emissions and that, if necessary, temporary screens must be placed around the site zones. Additional mitigating measures are not required.

4.5.2.2 Phase I (operation)

The description of the impact on air quality arising from traffic takes account of the additional traffic resulting from phase I (operation) of the disposal site and from the TABLOO community and visitors' centre. The anticipated traffic intensities during phase I (operation) are based on the assumptions in the discipline of ‘mobility’. We are working with the figures for scenario A (worst case).

These calculations reveal that the impact of exhaust emissions from traffic are negligible.

The only relevant effects during phase I (operation) result from dust formation when applying the cover. The calculated depositions are only temporary. The works should also be carried out with reference to Vlarem (the Flemish Environmental Legislation, in particular Section 4.4.7 discussing control of fugitive dust emissions). Among other things, this means that a speed limit will need to be applied on the site, that the grounds will need to be sprayed with water during protracted dry weather and that temporary screens may need to be placed around the site zones. No further mitigation measures will be necessary.

During phase I (operation), no nuclear effects are anticipated, as there will be no discharges.

4.5.2.3 Phase II (closure)

No relevant impact on air quality is expected during Stage II (closure). The only emissions during this phase will come from the equipment used to fill all inspection rooms, galleries and drainage systems and these will normally have no appreciable impact on air quality.

During phase II (closure) no nuclear effects are expected as there are no discharges.

4.5.2.4 Period after closure

No relevant impact on air quality is expected in the period after closure. No activities likely to have a relevant impact on air quality will take place during this phase.

In the post-closure period, no leaching of radionuclides is expected for the first 650 years and the radioactivity that may subsequently be released into the air does not cause any significant increase in radioactivity naturally present.

4.5.3 Mitigating measures

The effects described within the air discipline are assessed as negligible and do not give rise to prescribing mitigation measures.

4.6 Noise

4.6.1 Description of the reference situation

For the description of the quality of the current ambient noise, long-term environmental measurements were used from around the entire plan area (autumn 2008/ spring 2009 and December 2010) and recent measurements carried out in the spring of 2017 at 2 fixed measurement points.

These are the following measuring points:

- MP1: house Lock VI, no. 6
- MP2: house Lock VI, no 12
- MP3: house Lock VI, no. 14
- MP4: house Stenehei, no. 58
- MP5: house Geelsebaan, no. 176
- MP6: house Kastelsedijk, no. 27
- MP7: house Boeretang, no 230

Figure 19: Noise measurement points

The measurement points are in rural locations. This means the noise climate is largely determined by agrarian activities and road traffic from the Geelsebaan/Stenehei (N118) and the Kastelsedijk. There is also the activity on the business park. Around the study area, however, it is very peaceful, particularly during the evening and night period.

If one interprets the area for nuclear facilities as being the industrial area (shaded in purple on the regional plan), then no infringements of the environmental quality standards are identified at the measurement points.

If one does not take the area for nuclear facilities into consideration, the infringements remain limited to 0.2dB(A) and 0.7dB(A) at measurement point MP3 and measurement point MP4 respectively during the evening period in the week. The environmental quality standards at these measurement points are those for agrarian areas.

It follows from the comparison of the L_{den} and L_{night} values for the present ambient noise with the differentiated reference values that the L_{den} and L_{night} values are only higher than at the other locations in the area of MP5, located along the busy N118 (Geelsebaan) and MP6, located along the Kastelsedijk, but that the differentiated L_{den} en L_{night} values continue to be respected for existing secondary or local roads. The ambient noise around these 2 measurement points is chiefly determined by the road traffic

4.6.2 Impact description and assessment

The noise effects of the construction work, of the additional traffic and of the planned activities are investigated.

4.6.2.1 Construction phase

Noise will be produced during the construction phase of the disposal modules. During construction, equipment will be used such as for example sawing machines, rollers, dumpers, excavators for the ground and harvesting work and for example cranes, pumps, concrete mixer wagon and a concrete plant for the construction of the modules/roof. In addition, material will be delivered by truck and/or possibly by ship (effects of yard traffic).

Given the fact that for the project the machinery to be used and the timing of the different construction phases are not yet fully known, it is impossible to calculate a correct noise contribution during the construction phase. A minimum and maximum noise contribution was determined at several representative distances and at the measurement points. The noise contribution at the measurement points was also compared with the ambient noise during day and night at these measurement points. Based on this comparison, we may assume that the constructions, which take place during the day, will not cause any nuisance. At the level of the closest occupants of Lock VI (MP1 and MP2) and Boeretang (MP7), the maximum noise contribution of the structures is higher than the continuously present original ambient noise during the day. This means that the noise of the buildings can be perceived. Whether this level of noise can be considered an annoyance is rather unlikely given the relatively low noise contribution of the structures compared to the ambient noise.

If construction works were to take place at night, the maximum noise contribution of the buildings at Lock VI and Boeretang would appear to be more than 10 dB(A) above the original ambient noise, so that noise nuisance can no longer be discarded. For this reason, it is not advisable to allow construction works to continue during the night period.

The mobile concrete plant is located at least 500 m from the nearest house, which means that no noise nuisance is expected for residents. Nevertheless, it is advisable to observe a few "guidelines" in order to limit the noise nuisance as much as possible: refill the beacon of the granules regularly so as not to pour into empty bins and cover the bins with a sound-absorbing material (plastic or rubber).

There will be a negligible effect on the environmental noise caused by site traffic. After all, the increase is not such that road traffic noise will increase by more than 1 dB(A).

4.6.2.2 Phase I (operation)

Since the disposal modules are completely closed and consist of reinforced concrete, we expect little noise emission from the modules to the surroundings. There is also a workshop/garage for maintenance etc. but this will not be a relevant noise source. There is also an emergency group (diesel) present, but since this will only come into effect in case of power cuts, the noise contribution of this emergency group is not considered relevant in a representative situation. As a result, no exceedance of the limit values is expected at the most nearby dwellings and no relevant increases in ambient noise are expected. The noise impact of the repository activities can be assumed to be negligible.

Phase I (operation) also includes the removal of the roof structure and the application of a multilayer soil cover. Depending on the distance to the dwellings, the noise effect of these works is assessed as negligible to limited negative if only daytime work is carried out.

As no effect is expected from the industrial noise during the operational phase, no cumulative effects are expected as a result of the joint presence and operation of the disposal modules, IPM, caisson factory and quay.

All traffic to and from the entire company site (and not just the repository) has been considered for evaluating the road traffic noise impact. Based on traffic intensities, the speed of the cars, the distribution of cars/trucks and the road surface, a noise map has been made that shows the noise contours due to traffic noise. This shows that for Lden, the increase in traffic has a negligible effect (< 1 dB(A)).

4.6.2.3 Phase II (closure)

The noise impact during phase II (closure) is comparable to that during the construction phase.

4.6.2.4 Period after closure

In the period after closure, there will no longer be any activities that may have an impact on the ambient noise and therefore no noise nuisance will occur.

4.6.3 Mitigating measures

Currently, the ambient noise at the houses along the canal (Lock and Boeretang) can still be called very quiet. For the houses along the N118 and the Kastelsedijk, road traffic, especially during the day, determines the ambient noise. $L_{Aeq,1h}$ during rush hours of more than 60 dB(A) are used for this. Evenings and nights can be particularly quiet throughout the study area.

If construction work were to take place at night during the construction phase, the maximum noise contribution of the structures at Lock VI and Boeretang would be more than 10 dB(A) above the original ambient noise, making that noise nuisance can no longer be discarded. For this reason, it is not recommended to allow construction works to continue during the night period.

4.7 Biodiversity

4.7.1 Description of the reference situation

The current state of the natural values in the project area has been described in detail based on an extensive ecological inventory spread over a full year (2008) (Lambrechts et al., 2009). This inventory was characterised by a great deal of depth and detail and included a wide variety of species groups. It may be argued that this inventory went much beyond what is customary for assessing a project that is not located in Natura 2000 (Special Protection Area) or part of the Flemish Ecological Network (VEN), as is the case for the ONDRAF/NIRAS project. For several of the species groups the knowledge about their occurrence is therefore more detailed and complete than for similar areas elsewhere in Flanders. As an illustration, this encompassing and detailed inventory resulted in the updating of the Biological Scoring Map of Flanders (BWK). Based on a more recent update of the 2008 inventory carried out in 2016 (Jacobs et al. 2017), it was concluded that the descriptions of 2008 still represent of the current situation. For the entire study area inventory in 2016 based on indicative species from the selected taxonomic groups of species (butterflies, grasshoppers & crickets, dragonflies and ladybirds), confirmed and occasionally supplemented the valuable results from 2008. The 2016 update has thus led to an increase in recorded fauna observations in the area. At the same time, the biological values within the Belgoprocess site were completed and the initial effects of design and management measures included in the approved management plan (2014) were monitored. For the impact assessment of the project for the discipline biodiversity, the area-wide inventory results of 2008 are therefore used, this supplemented by the information gathered in 2016.

The present ecotopes/habitats/species as well as faunistic and floristic values of the wider environment of the project area are described on the basis of available data from the BWK, vulnerability maps, information at the Institute for Nature and Forest (INBO), data on VEN, Habitat and Birds Directive areas and ecosystem visions (e.g. brook valleys).

Areas within the study area that immediately catch the eye because of their very high nature value are the open 'dune vegetations' just west of Belgonucleaire, just north of Belgoprocess and in the eastern zone of Belgoprocess, as well as the very valuable roadside embankment along the Europalaan. The high nature value zones, in particular the heathland vegetations, cover considerable areas.

The good populations of many characteristic heather species underline unambiguously that this is a very valuable heather area. The numbers of Tree Pipit, Viviparous Lizard, Grayling, various species of grasshopper (*Metrioptera brachyptera*, *Omocestus rufipes*, *Gryllus campestris*, *Chorthippus mollis*) and numerous characteristic and special ground beetles and spiders are very high. All mentioned species are listed in the respective Species Red Lists. In addition, 3 European protected bird species (Birds Directive) occur in the area (Kingfisher, Black Woodpecker and Honey Buzzard), which are currently not seriously threatened in Flanders.

The complete list of special plant species is also impressive, however, with many species only being found in relict populations.

In ecology one also speaks of the 'heather paradox'. Heather is a very rich ecosystem for fauna, but its botanical diversity is generally low. In other words, a rather limited number of plant species grow there. In the study area, this does not fully apply because there are also species-rich, very valuable heather vegetations, which in fact are lacking in many other heathland areas in Flanders.

The *Molinia caerulea* grazed heathland in the central part of the study area is botanically poorer (due to the grazing) than well-developed heathland and is therefore from a botanical point of view only moderately valuable. However, the fauna study showed that there are still a considerable number of characteristic and rare heather species, and that it can be considered 'valuable' from a faunistic point of view.

Specifically, for fauna, the value of the ecotopes has been determined as follows:

- Very valuable ecotopes: the land dune relicts (adjacent to the Belgonucleaire and Belgoprocess sites, as well as within the latter), the mowed vegetation (Europalaan roadside, FBFC car park, mowed paths through the heath) and the Hooibeek;
- Valuable ecotopes: all the open ecotopes within the 'heathland', i.e. the Calluno-Genistetum heather vegetation sometimes covered with grasses, the *Molinia caerulea* vegetation and the open light-rich deciduous forest;
- Moderately valuable locations: the various densely wooded locations;
- (Very) Limited value: fields and (seeded) *Lolium g*rasslands;

In view of the relatively large contiguous area of Querco-Betuletum forest and, in particular, the dry heathland vegetation, the project area plays a role in the ecological coherence between the natural high value spots within the area, particularly the 'De Ronde Put' and 'De Zegge' Birds Directive areas, The Habitat Directive area 'Valleigebied van de Kleine Nete with source areas, marshes and heathers' (with heather-covered Koemook and 's Gravendel), the VEN area 'De vallei van de Kleine Nete benedenstrooms', the nature reserves De Maat and Den Diel and the provincial nature reserve 'het Prinsenpark'.

4.7.2 Impact description and assessment

4.7.2.1 Construction phase

Direct space utilization

As a result of the project, a total of more than 28 ha of biologically less valuable to very valuable vegetation will be occupied and/or modified. This ecotope land use is almost completely permanent and irreversible.

The construction of the eastern series of modules (modules 1 to 20) involve the loss of biologically less valuable, monotonous coniferous plantations of predominantly Corsican pine. At the same time, the hunting and breeding areas of the Honey Buzzard, Black Woodpecker and Willow tit, among others, and the foraging area for Roe deer will be taken over. Biologically valuable Plant Basal Communities of dry heathland will be lost near the western disposal modules (modules 21 to 34), including the loss of 7 breeding areas of Tree Pipit.

Disturbance due to construction site

The noise discipline shows that the total noise impact of the structures for the disposal modules can vary between 93 dB(A) and approx. 109.9 dB(A), depending on the number and type of machines in operation at the same time. As the noise increase during the construction phase is temporary in nature, it is argued that this temporary effect outweighs the permanent effects. However, the area is vulnerable to nature disturbance and some sensitive bird species occur.

Disturbance caused by site traffic

The discussion of the noise discipline shows that the effects of site traffic during the construction phase will not differ from those during phase I (operation). For the discussion of road traffic, reference is therefore made to the next section.

Impacts due to change in the water balance (desiccation/rewetting)

During the construction phase it will be necessary to lower the groundwater level for a period of 6 months during the construction of the basement of the Water Collecting Building. The water discipline shows that a groundwater reduction of up to 0.2 m can still take place at approx. 1050 m around the building site. It should be noted that this influence radius is maximal (= worst case) because no effective precipitation has been applied in the model. The influence radius will be smaller.

According to the ecosystem vulnerability map for desiccation, the ecotopes within this distance are not or not very vulnerable to desiccation. Nevertheless, during the vegetation mapping in 2008, a limited amount of *Erica tetralix*, a typical species for humid heather, was observed at 2 locations. As a vegetation type, however, humid heather did not occur anywhere in the study area in well-developed form. In addition, the groundwater dependence of 2 sites will be very limited as drainage ditches of approx. 0.8 m deep are present. In addition, the desiccation impact of the drainage is mitigated by allowing the drainage water to infiltrate again.

The effect on the ecotopes and species present as a result of changed water management is limited due to the temporary nature and the specific locations where a limited amount of groundwater dependent vegetation occurs.

4.7.2.2 Phase I (operation)

Noise disturbance

During phase I (operation) there will be a disturbance on avifauna due to the additional road traffic and the various activities on the site. As the current ambient noise within the project area is low to very low, the entire project area is very vulnerable to additional noise disturbance. Based on the comparison of the noise contour maps with the territory map for breeding birds, it is considered that both the species richness of the avifauna in the area and the numbers of breeding birds can be negatively impacted by the implementation of the project. These noise impacts may be further amplified by other disturbance effects (see below).

Light and visual disturbance of species

The disposal modules will have artificial lighting at night. As far as light disturbance is concerned, it cannot be ruled out that foraging bats (including *Myotis daubentonii and M. dasycneme*) along the Bocholt-Herentals canal may suffer from the lighting in the business park. The principles of "good ecological lighting" must be complied with for the lighting of the disposal modules. The most important characteristics are the following:

- only illuminate where necessary;
- only downward lighting;
- no unnecessarily strong light sources;
- do not use blinding directions.

Dynamic (visual) disturbance to fauna is less relevant at the level of the disposal modules. Several breeding birds occurring in the study area are particularly sensitive to disturbance, such as Tawny Pipit and Skylark (both ground breeding species), Curlew and Lapwing. Provided appropriate mitigation measures are taken, this effect can be kept to a minimum.

Impacts due to change in the water balance (desiccation/rewetting)

There are no relevant changes in water management. No underground structures will be constructed and 2 infiltration basins will be constructed to allow rainwater from the disposal modules to infiltrate. The effect on the ecotopes and species present as a result of a change in water management is therefore negligible.

Air pollution

The air discipline shows that only a very limited impact on air quality is expected. There is therefore no relevant impact on fauna and flora through air pollution.

Network effects

The dry east-west connection between the dry (moorland) ecotopes to the east and west of the project area will be seriously affected as a result of the planned project implementation. The following project components contribute to this negative impact:

- the western disposal modules
- the internal access road from the caisson factory to the Europalaan.

In order to make a correct assessment of the impact on the existing dry-east-west connection, the following development scenarios should be considered:

- Possible establishment of a TABLOO visitor and community centre with event meadow in the northeast corner of the nuclear zone, at the junction of the Gravenstraat with the Kastelsedijk.
- An eastern expansion of the SME zone Stenehei. This extension is relevant because it fits in with the project area of the disposal project.
- A test set-up in which a pilot cover will be built to simulate the planned large-scale cover on the tumuli. The test set-up may be built adjacent to the visitor and community centre TABLOO.

With the construction of the disposal modules and the internal access road, a continuous relict of dry heathland (partially forested) will disappear. In addition to this immediate loss of space, the location is also a bottleneck. The most westerly series of disposal modules are located centrally in the heathland and this causes considerable network effects. As a result, the ecological east-west connection is weakened.

This dry east-west connection could be further affected by the planned development scenarios in the study area, the pilot plant, the TABLOO visitor and community centre and the extension of the SME zone Stenehei. This (planned) infrastructure is located at the level of the only remaining corridor and crossing to the east of the study area. By realizing the expansion of the SME Stenehei on the one hand and the visitor and community centre TABLOO and the demonstration test set-up between the Kastelsedijk and Gravenstraat on the other hand, the width of the corridor will be too limited to keep, among other things, the existing roe deer tracks functional.

Nuclear effects

During phase I (operation) of the disposal, there are no discharges of radioactive substances. Also, because the external radiation from the disposal is very limited no nuclear effect on biodiversity is expected.

4.7.2.3 Phase II (closure)

The filling of inspection rooms, galleries and drainage systems can lead to disturbance, but to a lesser extent than during the construction phase.

During this phase, new vegetation will normally also develop on the soil cover that was applied over the disposal modules at the end of phase I (exploitation). A vegetation development of a type that maximally reduces wind erosion will be allowed. The exact vegetation that will develop depends on the composition of the cover and as this is not yet known, therefore no statement can be made about this.

Nuclear effects

During phase II (closure) of the repository, there are no discharges of radioactive materials. Also, because the external radiation from the disposal is very limited no nuclear effect on biodiversity is expected.

4.7.2.4 Period after closure

In the period after closure, the vegetation on the covering layer will continue to develop and the disturbance by Phase I (exploitation) and Phase II (closure) will disappear. More concrete statements about this period are not possible.

In the period after closure, no leaching of radionuclides is expected for the first 650 years and the radioactivity that may subsequently be released into the environment will cause radiological impacts for non-human biota below a reference value conservatively set at 10 µGy/h for all types of non-human biota. Therefore, no nuclear impacts on biodiversity are expected.

4.7.3 Mitigating measures

In what follows, a clear overview of all mitigation measures, which must be taken during the different phases of the project is provided. Many of the mitigating measures described about the qualitative recovery and quantitative compensation have already been realized prior to the construction phase of the disposal thanks to the management plan. For the remaining mitigating measures, it is necessary to follow up during the works whether the measures are effectively respected, such as briefing the site personnel on site traffic and routes, respecting the noise requirements, applying accessibility regulations and banning the use of roadside barriers as a construction strip.

The upgrading of the fauna and flora will take place in the uncultivated areas (75 ha). These measures are included in the management plan. ONDRAF/NIRAS has opted to compensate or restore the valuable heather areas present on its own land, and to maximize the ecological value of these heathland areas by means of specific, targeted management. The coniferous wood that has recently been deforested as part of preparatory works for the construction of a repository will be compensated on several plots of land in the Special Protection Area (SPA) Den Diel in Dessel.

Finally, in order to avoid negative impacts on biodiversity, the following mitigating measures must be taken:

- Keep the roadside of the Europalaan outside the area of construction and completely free of buildings/roads.
    - Restrict construction site routes to areas under construction and do not pass through sensitive/valuable ecotopes (that are to be retained for the time being).
    - Managing the Europalaan roadside embankment and the access road with the same mowing intensity and at the same mowing dates and with the removal of clippings.

- Ecological management of the coniferous and oak birch forest and heathland Z(W) of the disposal modules
- Start construction phase between the beginning of September and the end of March
- Monitor the evolution of the breeding bird stock
- Comply with the principles of "good ecological lighting":
    - only illuminate where necessary;
    - only downward lighting;
    - no unnecessarily strong light sources;
    - do not use blinding directions
    - keep luminaires as low as possible
    - luminaires shall comply with class 6 according to CEN
- Installation of a fully-fledged green buffer at least 100 m wide, partly to the north and partly to the south of the Belgoprocess shielding fence. This green buffer should be designed with a combination of dry heathland and summer oak birch forest in which the noise, light and visual disturbance from the adjacent project components must be kept to a minimum.
- Monitoring the evolution of nature values within the project area
- It is advisable to carry out the most noise-disturbing operations outside the breeding season or to start before the breeding season, such that the breeding birds can find a suitable nesting place at enough distance away from constructions.

4.8 Landscape, architectural heritage and archaeology

4.8.1 Description of the reference situation

The study area is situated on a western edge of the Kempen plateau. In the past, the landscape there was largely formed by a specific nature management i.e. deep litter animal housing system based on the repeated spreading of straw or sawdust material in indoor booths. Near the project area there was mainly heathland. Since the 19th century the reclamation of the wild land started. In the Kempen mainly pine forests were planted. Due to the presence of quartz-rich white sands, large artificial mining lakes appeared in Mol and Dessel during the 20th century. These lakes gave the region a new identity and specific character to the landscape.

There is no protected heritage within the project area. The Boeretang farmhouse (with ramparts and surroundings) is a protected cultural-historical landscape and protected monument. The farmhouse is also included in the architectural heritage inventory, as are several other farms in the area (Hoeven Reinaerthof and Heilicht, Braselhoeve, ...) and the study centre for Nuclear Energy and associated residential area and Kasseiweg Heide. On the other side of the N118 the Kasseiweg Heide is protected as a monument.

4.8.2 Impact description and assessment

4.8.2.1 Construction phase

There are no protected or architectural heritage values within the study area that will be disturbed by the realization of the project.

The excavation of topsoil and upper soil layers can impact archaeological heritage. In addition, the temporary drainage may affect the archaeological material and its state of conservation. An archaeological preliminary study that has already been carried out for the first series of modules showing that there are no prehistoric sites and that there will therefore be no impact on archaeological heritage. For the second set of modules, this preliminary research has yet to be carried out and it is not yet possible to make an evaluation.

The discussion of the visual disturbance during the construction phase takes place under the discipline human.

4.8.2.2 Phase I (Operation)

As soon as the disposal modules are filled (after a period of at least a few decades), they will be covered, increasing the area that is occupied. There is no protected or architectural heritage within this area. Archaeological heritage is not affected by the cover.

From the north, the modules cause less landscape disturbance as the landscape is already disturbed here. However, it is advised to preserve and further develop the forest edge along the Europalaan. From the south, the disturbance effect is larger because the landscape there is less disturbed and more open. The forest remnants to the south of the modules provide a first visual shield. In addition, the greenery along the Hooibeek and the row of trees along the canal provide partial shielding for the modules. In order to mitigate the visual disturbance effects, the adjacent forest and the greenery along the Hooibeek must be preserved. In addition, the row of trees along the canal should be completed up to the bridge thereby creating an additional screen.

With regard to the visual disturbance from the surrounding heritage (protected or included in the architectural heritage inventory), it can be stated that only the views from the farms along the N118 can be disturbed as the shielding by the surrounding forest is not complete (certainly not in winter). In most cases, the roof of the disposal modules will still be visible.

The visibility of the peripheral facilities (administrative buildings, control room, roads, railways, infiltration basins, etc.) is considered negligible compared to that of the disposal modules and is therefore not further considered.

At the end of phase I (operation), a cover layer is applied over the modules. From then on, the disposal will have a less 'industrial' and more natural look. The tumuli will then form green hills in the landscape, which will reduce landscape visual disturbance. The tumuli are also lower compared to the modules with roof structure, 20 m instead of 26 m. Vegetation development should be allowed on the tumuli of a type that reduces wind erosion as much as possible but still forms a landscape connection with the surrounding terrain.

4.8.2.3 Phase II (closure) and period after closure

After the covering, during phase II (closure) and the period after closure, the tumuli form an almost permanent relief structure in the landscape. This impact is judged to be limited, provided a vegetation development is allowed of a type that reduces wind erosion as much as possible but still forms a landscape connection with the surrounding terrain.

4.8.3 Mitigating measures

In order to avoid negative effects on the landscape, the following mitigating measures should be taken:

- In order to compensate for the direct use of space, vegetation development on the tumuli can be allowed of a type that reduces wind erosion as much as possible but still forms a landscape connection with the surrounding terrain as much as possible.
- In order to limit the visibility of the modules, the surrounding woodland and greenery along the Hooibeek must be preserved and the row of trees along the canal up to the bridge completed.

A further measure is only a recommendation and is therefore not necessary to mitigate a negative effect, but may additionally reduce visual disturbance:

- preserve and develop the edge of the forest along Europalaan.

Before the second series of modules can be built, a preliminary archaeological survey must be carried out. This has already been carried out for the first series of modules.

4.9 Human - spatial aspects

4.9.1 Description of the reference situation

The project area is located approximately 1 km southwest of the Dessel residential area. Within the study area several houses/agricultural businesses are present. South of the canal is the residential area of the VITO/SCK. A renovation project design has been made for this district. After the renovation and conversion works, the district will accommodate various kinds of housing with a total of 307 residential units.

Most of the plots within the study area are in agricultural use (fields or grassland) or are forested. In recent years, a few grasslands/pastures have been used as festival grounds for the Graspop Metal Meeting.

In addition, a large part of the study area includes a nuclear zone, the SME zone in which the business premises of the former FBFC International and Belgonucleaire are located and the SME zone Stenehei with about 50 companies. The Isotopolis information centre of ONDRAF/NIRAS is also located here. South of the canal Bocholt - Herentals is the site of VITO/SCK.

To the south of the project area lies the service road of De Vlaamse Waterweg, which is part of the bicycle junction network and is a busy bicycle connection. The Bocholt - Herentals canal is an important tourist-recreational waterway.

4.9.2 Impact description and assessment

4.9.2.1 Construction phase

The construction of the modules does not lead to a loss of user functions as they are realized in areas that currently have a direct human function.

The visual disturbance caused by the work is of a temporary nature and can be nuanced given the location of the project area in 'area for the establishment of nuclear installations'.

4.9.2.2 Phase I (operation)

In phase I (operation) the disposal modules are visible. Only at the end of this phase the roof structure will be removed, and a ground cover will be applied. The tumuli will be lower than the modules with a roof structure, 20m instead of 26m.

It can be stated that there will be no visual disturbance for the human habitation in the Kastelsedijk because the modules are located at sufficient distance from the habitation and are largely shielded by intermediate forest fragments. Visual disturbance by the disposal modules for the employees in the Stenehei business park is not considered relevant.

The visual disturbance extends further south as the landscape is more open and currently has a more 'natural' or less disturbed character. Views from the scattered buildings and farms in the south (west) along the N118 and along the canal can be disturbed as the shielding by the surrounding forest and the row of trees along the canal are not complete. The roof structure of the modules will be visible. Provided that the surrounding forest and the greenery accompanying the stream along the Hooibeek are preserved and the row of trees along the canal is completed, the negative impacts can be limited.

No visual disturbance effects are expected from tavern Lock VI and the residential area of SCK/VITO.

At the end of phase I (operation), a cover layer will be applied over the modules. From then on, the disposal site will have a less 'industrial' and more natural look. The tumuli will then form green hills in the landscape, which will reduce the perception of visual impact. In addition, the tumuli will be lower than the roof structure of the modules, 20m instead of 26m.

4.9.2.3 Phase II (closure) and period after closure

After the cover, during phase II (closure) and the period after closure, the disposal modules will be visible as tumuli. The covered modules or tumuli will be about 20 m high. The visual disturbance of these tumuli is limited to negligible depending on the view angle. The tumuli are in an 'area for the establishment of nuclear installations' but are also partly visible from the surrounding area.

4.9.3 Mitigating measures

In order to avoid negative effects on human-spatial aspects, the following mitigating measure must be taken:

- In order to limit the visibility of the modules, the surrounding forest and the greenery accompanying the stream along the Hooibeek must be preserved and the row of trees along the canal up to the bridge completed.

4.10 Human health

4.10.1 Description of the reference situation

Within the study area, human habitation is present along the Kastelsedijk, N118-Stenehei-Geelsebaan-Retiebaan and Lock VI. Based on the average family size for the Flemish Region of 2.35 persons per family, an estimate can be made of the number of inhabitants. As a result, approximately 92 people live along the streets mentioned above.

South of the canal Bocholt - Herentals lies the residential area of SCK/VITO. A renovation project has been designed for this district. After the renovation and conversion works, the district will accommodate various residential forms with a total of 307 residential units.

The edge of Dessel's residential area is approximately 1 km northeast of the study area. The population density in this municipality amounts to 353 inhabitants per km² (anno 01/01/2018). The residential areas of Retie and Mol are located at a greater distance, respectively approx. 2 km north and approx. 2 km south/southeast (Mol-Achterbos). The population density in these municipalities amounts to 232 inhabitants per km² and 319 inhabitants per km² respectively. The hamlet of Mol-Donk is 1.2 km southeast.

There are no vulnerable functions (schools, retirement homes) within the study area.

Data on the population's risk perception of ONDRAF/NIRAS are limited. The PISA research group of SCK-CEN periodically carries out a national survey (SCK-CEN Barometer). This is not only about SCK-CEN, but is a general survey about the risk perception of the nuclear sector (http://science.sckcen.be/en/Institutes/EHS/SPS/STS/Risk_perception/Barometer).

4.10.2 Impact description and assessment

In the table below a list is made with the stressors, as well as a motivation as to why they are included or not.

Table 4-1: List of stressors and related health impacts for the project

Stressors	Specific description stressor and/or source, health impact (1)	Motivation as to why stressor was not included
Chemical stressors		
Via atmospheric emissions	Emissions from road and ship traffic during the construction phase, phase I (operation) and phase II (closure)	The emissions are limited in size and time and completely negligible compared to the emissions from existing sources in the

Stressors	Specific description stressor and/or source, health impact (1)	Motivation as to why stressor was not included
		environment (industry, road traffic) (see Air discipline).
Via emissions to soil and groundwater	Accidental emissions during construction phase, phase I (operation) and phase II (closure)	In the event of any accidental emission (cf. Soil Decree), immediate action must be taken.
	Over time, a gradual degradation of the modules and monoliths will begin, which may leach out the non-radioactive elements present in the repository and affect the quality of the groundwater.	Using different safety functions (specific to the disposal) there will be no leaching of nuclides. The same applies to chemotoxic elements present in the repository. There will be no leaching to groundwater during the first 650 years, including phase I (operation) and phase II (closure). In addition, the cement within the waste drum has a sorbent function and bentonite is added to the embankment to ensure a delay of any leaching in the very long term (after 1000 years).
Via discharge to surface water	Discharges during the construction phase, phase I (operation) and phase II (closure)	The operation of the repository will not give rise to the generation of industrial wastewater. The only relevant form of wastewater is sanitary wastewater from the employees of the access cluster. An individual treatment plant (IBA) will be provided for this wastewater. Water that may be collected from the modules via the drainage system may be contaminated and will be collected in 2 tanks and transported by truck to Belgoprocess for further processing.
Physical stressors		
Noise	Noise emissions from various noise sources during the construction phase, phase I (operation) and phase II (closure)	The calculations in the noise discipline show that construction work that takes place during the day will not cause any disturbance at the measuring points MP3 (house Lock VI no. 14), MP4 (house Stenehei no. 58), MP5 (house Geelsebaan no. 176) and MP6 (house Kastelsedijk no. 27). At the closest houses of Lock VI (nos. 6 and 12, MP1 and MP2) and Boeretang no. 230 (MP7) disturbance caused by the works cannot be excluded, although the probability of significant disturbance is assessed by the noise expert as rather unlikely due to the relatively low noise contribution of

Stressors	Specific description stressor and/or source, health impact (1)	Motivation as to why stressor was not included
		construction works compared to the ambient noise. Construction works during the night should then be avoided. The increase in the noise impact of road traffic is negligible for humans.
Wind	Tall structures in an open and undeveloped environment	Although the disposal modules are tall structures, they are in a little built-up area, so there is no relevant wind disturbance or risk of wind danger.
Light, shadow	Lighting of the terrain and constructions	Although the disposal modules are tall constructions, they are in a little built-up area, so there is no relevant shade disturbance for residents.
Biological stressors		
Dust pollution	Disturbance due to dust deposits during construction and phase I (operation)	The works take place in a little built-up area and the modelled dust emission values remain below the Vlarem limit values. The works must be carried out cf. Vlarem in order to limit dust deposition as much as possible.
Others:		
Proximity green space	Green space use by the disposal modules and peripheral infrastructure during the operational phase and period after closure	The disposal modules are planned in an area intended for the establishment of nuclear installations. Once the disposal modules have been covered, the tumuli will see development of vegetation of a type that reduces wind erosion as much as possible but still forms a landscape connection with the surrounding terrain as much as possible.
Psychosomatic aspects	Concern on the part of residents about the storage of low- and intermediate-level short-lived waste in a surface repository.	The disposal project is planned on a site where similar activities (nuclear research reactors, treatment of radioactive materials, nuclear transport) are already taking place. The site is part of a larger cluster of institutions and companies in Mol-Dessel related to nuclear activities. At the start of the disposal project, ONDRAF/NIRAS followed a participatory approach. In view of the involvement of the population and the operation of the partnerships, it is not expected that the realization of the repository project will cause a significant increase in possible psychosomatic effects among residents.

Table 4-1 shows that for none of the stressors a further inventory is required.

The non-radiological human health impacts, under the condition that construction works do not take place at night, can be assessed as limited negative to negligible. No human health effects are expected for the residents of Residentiewijk SCK (Atoomwijk), where there will be room for a total of 307 residential units after the renovation project.

The impacts on human health via groundwater extraction due to possible leaching of non-radioactive elements remains a knowledge gap. However, this effect is not expected over the next 1000 years. Furthermore, the leaching of non-radioactive elements will be monitored.

Nuclear effects on human health are expected to be very limited. The assessed nuclear impacts of the disposal during Phase I in normal operation and during Phase II (closure) are in line with the dose limit of 0.1 mSv/a for the disposal. The cumulative impact by the environmental disposal unit - IPM - caisson factory - quay was evaluated as lower than approximately 0.2 mSv/a. This is lower than the dose limit of 1 mSv/a for the population. It is also lower than the average exposure in Flanders of 2.1 mSv/a from natural sources.

The evaluated nuclear impacts of the disposal for the expected evolution over time are also in line with the dose constraint of 0.1 mSv/a for the disposal. Nuclear impacts on human health are therefore expected to be very limited.

The listing as an environmental unit no longer applies after closure as the MPP operation is assumed to no longer exist.

In the expected evolution after closure, there is no leaching from the disposal up to 650 years, and the impact due to leaching thereafter is lower than 0.1 mSv/a for the reference scenario. The reference scenario accounts for the expected evolution and uncertainties within the expected evolution. The leaching plume from the disposal always remains strongly localized (order of magnitude of a few km²) between the disposal and the Witte Nete.

4.10.3 Mitigating measures

The measures to be taken to mitigate human health effects have already been formulated in the noise discipline where it has been indicated works may not continue during the night.

4.11 Climate

1.1.1 Description of the reference situation

The present climate in Belgium is a moderate maritime climate.

Based on climate modelling, a global temperature rise in the range from 1.8°C to 4°C is anticipated by 2100. Temperatures in Europe are expected to rise higher than the global average, with a particular rise of the winter temperatures in Northern Europe.

The annual amount of precipitation is also very likely to increase (0-16%) throughout most of Northern Europe. The greatest increase in the amount of precipitation is expected to occur in winter. In summer not all models systematically simulate an increase or decrease, although most models south of 55° N do expect a decrease in precipitation.

There are also indications of changes in wind circulation, which will have an impact on precipitation amounts: in winter an increase in precipitation is expected (influenced by increasing westerly winds), and in summer generally a decrease (more easterly winds).

Because of the temperature rise, part of the ice caps will melt, the summer sea ice at the polar caps will probably disappear during the 2nd half of this century. Higher temperatures will lead to thermal expansion of the oceans, with a rise in sea levels as a result. This rise is estimated at 0.18 to 0.59m by 2090.

1.1.2 Impact description and assessment

No significant effects are anticipated as a result of extreme rain showers or flooding from climate change. The project will provide 2 very wide infiltration basins to catch the rainwater running off from the roof of the disposal modules and, in a later phase, from the tumuli. The conclusions included in the current regional rainwater regulations will be amply met, meaning it can be assumed that the water discharge downstream will be limited in the future as well (in the event of extreme rain showers resulting from climate change and once the disposal modules are fully covered). Regarding the risk of the project area itself flooding, it was shown that there is no historical proof of floods at the disposal site and that the local topography itself will mitigate a possible flooding of the site. Even if sea levels were to rise by 20-25m, no risk of flooding is anticipated bearing in mind the elevation of the disposal modules. Finally, the limited incline of the earth cover, the presence of vegetation and the deliberate granulometry of the bio-intrusion layer will help to avoid wind and water erosion.

1.1.3 Mitigating measures

No additional measures relating to climate effects are deemed necessary in this EIA.

5 Accidents and unexpected evolutions in the long term

For the above-ground surface disposal facility in Dessel, most of the processes involved in the lifetime of the facility will be simple and would not normally involve extreme conditions such as high temperatures and pressures. This means that the normal operating conditions are safe and that probably no radioactivity shall be released as a consequence of possible accidents during the lifetime of the facility. The risks relating to such incidents were limited by adequate design measures (e.g. electromagnetic compatibility of I&C equipment). Moreover, specific operating procedures when necessary (i.e. when an incident happens) allow for safely stopping all operations (operations are stopped in strong wind or when functionality/services are disrupted). The possible radiological consequences for employees, the population and the environment are therefore acceptable.

The facility's design must be able to guarantee safety for various events of external and internal origin: earthquakes, floods, snow, wind and tornadoes and certain temperatures.

The risk analysis in which incidental and accidental situations of internal and external origin were evaluated consistently shows limited radiological consequences for the public, should these occur. An aeroplane crash is the accident that has the most far-reaching radiological consequences. The radiological impact for this accident is lower than 1 mSv.

In the period after closure, besides the expected evolution, there are also unexpected but possible evolutions that would disrupt the expected evolution. To this end, human intrusion scenarios and alternative evolution scenarios (AES) have been considered.

Human intrusion could lead to a disruption of the Systems Structures and Components or SSCs and give rise to a sudden loss of isolation and containment capacity. For a surface disposal site, the possible dose impacts resulting from human intrusion should be assessed. In this assessment, it is assumed that the radioactive nature of the material at the disposal site is not discovered; in other words, that the human intrusion is inadvertent.

Given the inherent uncertainty with respect to future human actions and behaviour, a limited number of stylised intrusion scenarios are being developed, which are representative of the various conceivable types and scales

of human intrusion. The encompassing nature of the 'human intrusion scenarios' has been systematically substantiated.

The radiological impacts for the inadvertent human intrusion scenarios respect the reference value of 3 mSv/a as prescribed for these scenarios by the FANC.

Based on an analysis of possible events or processes at the root of a change in circumstance for the disposal system, or the routes by which radionuclides could be released and thus have an adverse influence on the disposal system's containment performance, the significant and plausible effects that are not covered by the encompassing nature of the reference scenario or the inadvertent human intrusion scenarios have been determined. These effects are included in the AES.

The conceptualisation of an AES in one or more calculation cases considers uncertainties that are linked to the intensity and probability of the disruption, as well as possible different radionuclide pathways which could occur as a result of the disruption. To limit the number of calculation cases and guarantee the conservative nature of the chosen calculation case, the conceptualisation is always based on the earliest possible time of occurrence of the disruption and the greatest possible damage to the SSCs as a result of the disruption.

The estimated probabilities and doses for the AESes should be combined to form the radiological risk. For exposures due to the whole set of AESes, the overall risk is smaller than the risk reduction of 10^{-5}/a for the radiological risk (risk of death from cancer). The radiological impacts for the alternative evolution scenarios are comparable with exposure from natural sources.

6 Conclusion

The general conclusion is that the overall impact of the disposal project remains limited to extremely limited. There are only a few areas where significant negative impacts are anticipated, and these impacts can be mitigated or compensated for in the short or somewhat longer term.

The **additional traffic generated** by the disposal site is limited and will be peak during the construction phase. Even in the scenario where a minimum proportion of transport will be done by waterway. The impact of the project on the degree of traffic saturation of the surrounding intersections is negligible. The intersections N118 - Kastelsedijk and Kastelsedijk - Boeretangsedreef - Gravenstraat have enough residual traffic capacity to handle the additional traffic flows. The impact of the project during the construction phase on the traffic cross delay is limited. However, a new conflict traffic point will be created at the junction of the new access road for the quay, IPM, caisson factory and storage modules on Europalaan and at the crossing of the recreational footpath with the N118. These intersections must be constructed in a traffic-safe manner. During phase I (operation) the traffic flows coming from the visitor and community centre TABLOO must also be considered. The further development of Kievermont and Stenehei also create an additional traffic generation. However, this will only be realized after the realization of a connection between the N118 and the N19g/R14 ring road around Geel and the extension of the ring road around Retie to the N118. The effects on the degree of saturation of the intersections, the traffic cross delay and traffic safety are similar to the construction phase.

The most relevant impacts indicated in the **soil discipline** is a relatively large soil movement and subsidence of the subsurface due to the weight of the disposal modules. The soil movement will be executed in compliance with current legislation. Not much soil will probably have to be removed. In function of the safety aspects of the disposal, the subsidence behaviour was studied by means of a subsidence test. The results were integrated in the design of the disposal. Subsidence as a result of the groundwater reduction will be less than 10 mm. The effect of profile disturbance is limited due to the limited excavations and the absence of scientifically or culture-historically valuable soils. Deterioration of soil hygiene will be avoided on the one hand by adhering to the Soil Decree regulations and on the other hand by the safety measures already provided for by the project. No relevant contamination of the soil by eutrophication and acidification is expected. No nuclear effects are expected during the operation and closure of the repository, as there are no discharges. In the period after closure, no leaching of radionuclides is expected for the first 650 years and no significant increase in radioactivity naturally present in the soil is expected.

No significant effects are expected for the **water discipline** either. During the construction phase, drainage is temporarily necessary. At 1050 m, in the worst-case situation (without effective precipitation) a groundwater reduction of 0.2 m can be expected. The drained water will be completely infiltrated again after water treatment has been carried out. Impacts on the structural quality of watercourses, the flooding regime and the groundwater flow will not occur. Due to the construction of the repository, a large surface area will be paved, but this effect will be compensated for by the construction of 2 infiltration basins into which the rainwater can infiltrate. The basins will be dimensioned in such a way that they have capacity not only for the rainwater from the roof of the disposal modules but also for the rainwater runoff from the tumuli. The overflow is not expected to be needed. Hence, there is no impact on flood zones and no additional load on downstream watercourses. Groundwater pollution is avoided on the one hand by the regulations included in the Soil Decree and on the other hand by the safety measures already provided for in the project. Rinse water from the concrete plant must be purified before it is discharged into the sewer system or drained. Effects on surface water quality are thus avoided. The operation of the repository will not give rise to the discharge of process wastewater. In addition to radiological elements, non-radiological elements are also present in the repository. These non-radiological elements may start leaching into the groundwater over time - as a result of the gradual degradation of the concrete structure of the disposal facility - and affect the quality of the groundwater. The modelling of the degradation of the disposal shows that no leaching of chemotoxic elements or nuclides is expected for the first 650 years. In addition, the cement within the waste vessel has a sorbent function and bentonite is added

to the embankment to ensure a delay of any leaching in the very long term (after 1000 years). Monitoring of boron will be carried out. No nuclear effects are expected during operation and closure of the repository, as there are no discharges. Moreover, the water from a well near the repository meets the radiological quality conditions of water intended for human consumption, even after leaching radionuclides, and the radioactivity that may be released into the groundwater after leaching does not significantly increase the radioactivity that is naturally present. Similarly, radioactivity that may be released to surface water and sediments after leaching does not cause a significant increase in radioactivity naturally present.

The project will not have a relevant **impact on air quality**. The operation of the disposal does not give rise to any relevant air emissions. Emissions from (yard) traffic will also only have a limited impact on air quality. Certain activities (e.g. the application of the top layer and the covering and storage of broken limestone for the concrete plant) will give rise to the formation of dust, however, works need to be done in compliance with Vlarem. This means, among other things, that a speed limit must be set on the site, that the sites must be sprayed wet in case of persistent dry weather, that specific procedures and instructions apply when unloading lorries, using grabs and wheel loaders in order to limit dust emissions and that, if necessary, temporary screens must be placed around the zones with activities. In this way possible disturbance caused by dust formation can be avoided. No nuclear effects are expected during the operation and closure of the disposal, as there are no discharges. In the period after closure, no leaching of radionuclides is expected for the first 650 years, and the radioactivity that may subsequently be released into the air does not cause any significant increase in the radioactivity that is naturally present.

In terms of **noise**, no major effects on humans are anticipated. Given that it is relatively quiet in the vicinity of the project area in the current situation, certainly in the evening and at night, it would not be appropriate for (construction) works to continue into the night period. This may cause a nuisance for the local residents. No problems will present themselves during the day. For the mobile concrete plant, it would be appropriate to take several “guidelines” into consideration to limit noise pollution as far as possible: regularly re-filling the granule containers to avoid pouring into empty containers, and lining the containers with a noise-dampening material (plastic or rubber). The operation of the disposal site itself (including the additional traffic flows) will not give rise to a relevant increase in ambient noise.

The direct occupation of space is a major effect for the discipline **biodiversity**. The western set of storage modules coincides for the most part with a biologically valuable Plant Basal Community of dry heathland. The eastern modules will be in a monotonous coniferous plantation. In particular, the loss of very valuable heathland is assessed as considerably negative. This effect will be mitigated by qualitative recovery and quantitative compensation. There will be an improvement of the fauna and flora in the uncultivated areas (75 ha). These measures are included in the forest management plan that will be changed into a nature management plan in compliance with new regulations. Several measures have already been realized prior to the construction phase of the disposal. The remaining mitigating measures will need to be followed up during the works. In order to avoid noise disturbance for breeding birds, works should start between the beginning of September and the end of March and the evolution of the breeding bird stock should be monitored. Desiccation impacts due to temporary drainage are limited. Concerning the lighting of the project area, the principles of "good ecological lighting” to avoid light disturbance must be complied with. If no mitigating measures are applied, the construction and operation of the repository, in combination with the construction of the other project components and the TABLOO visitor and community centre to the north-east of the project, will have a limited to potentially significant negative impact (mainly due to the implantation of the western series of repository modules) on the preservation of the dry east-west ecological connection. This impact can be partly mitigated by the improvement or development of dry arid ecotopes within the preserved parts of the study area. In this way, the potentially significant negative impact on the dry east-west corridor is turned into a neutral or even rather limited positive impact. During the operation and closure of the repository, there will be no discharges of radioactive substances.

Also due to external radiation, no nuclear impact on biodiversity is expected during operation and closure, because the external radiation from the disposal is very limited. In the period after closure, no leaching of

radionuclides is expected for the first 650 years and the radioactivity that may subsequently be released into the environment will cause impacts for non-human biota below a reference value conservatively set at 10 µGy/h for all types of non-human biota. Therefore, no nuclear impacts on biodiversity are expected.

The construction of the first series of disposal modules will have no impact on archaeological heritage. The second series of modules will be preceded by a preliminary archaeological survey. However, the disposal modules may have a **landscape-disturbing effect**. The visual impact of the peripheral facilities (administrative buildings, control room, roads, railways, infiltration basins...) is considered negligible compared to that of the disposal modules. The visual disturbance of the disposal modules from the surrounding area or from the surrounding architectural heritage mainly occurs in the south and southwest of the study area. The impact can be mitigated by preserving the surrounding forest and the greenery accompanying the stream along the Hooibeek and completing the row of trees along the canal. When the covering layer is applied over the modules, the disposal will have a less 'industrial' and more natural look. The vegetation on the tumuli is aimed to reduce wind erosion as much as possible and still forms a landscape connection with the surrounding terrain.

The construction and operation of the repository does not lead to the loss of **human functions** as the site currently has no direct human function. The disturbance of the visual experience during construction is limited. The disposal modules themselves have a greater impact, especially from the south and southwest of the study area. In order to mitigate this effect, the surrounding forest and the greenery along the Hooibeek should be preserved and the row of trees along the canal should be completed. After the covering the visual disturbance is more limited. The tumuli are in 'area for the establishment of nuclear installations' but are also partly visible from the surroundings.

The non-radiological impacts on **human health** resulting from air and noise emissions can be assessed as limited negative to negligible, this if work is not carried out at night. No significant increase in potential psychosomatic effects for local residents is anticipated from the implementation of the disposal project, given the involvement of the population and the functioning of the partnerships. The impact on human health through groundwater extraction due to possible leaching of non-radioactive elements remains a knowledge gap. However, this impact is not expected over the next 1000 years and will be monitored. Nuclear effects on human health are expected to be very limited. The evaluated nuclear impacts of the disposal during normal operation and with the expected evolution after closure are in line with the dose constraint of 0.1 mSv/a for the disposal. The cumulative impact by the environmental disposal unit - IPM - caisson factory - quay was evaluated as lower than about 0.2 mSv/a. This is lower than the dose limit of 1 mSv/a for the population. It is also lower than the average exposure in Flanders of 2.1 mSv/a from natural sources. The listing as an environmental unit no longer applies after closure as the IPM operation is assumed to no longer exist. With the expected evolution after closure, there is no leaching from the repository up to 650 years, and the impact due to leaching thereafter is lower than 0.1 mSv/a for the reference scenario. The reference scenario encompasses the anticipated evolution and uncertainties within the anticipated evolution. The leaching plume from the disposal site will remain highly localised (on the order of several km²) between the disposal site and the Witte Nete at all times.

No significant effects are expected as a result of extreme rainfall and flooding due to **climate change**. The project will provide large infiltration basins in which rainwater will be collected from the roof of the disposal modules and at a later stage of the tumuli. In this way the water discharge towards the watercourses downstream will be limited. Regarding the flood risk of the project area itself, it appears that there is no historical evidence of flooding at the disposal site and that the local topography will mitigate a possible flooding of the site. Finally, wind and water erosion will be limited by the limited slope of the soil cover, the presence of vegetation and the selected granulometry of the bio-intrusion layer.

The table on the next page gives an overview of the impact assessment by discipline. The resulting impact after the mitigating measure is also assessed.

Table 6-1: Synthesis table of non-nuclear and nuclear effects

Phase	Non-nuclear / nuclear	Impact group	Assessment without mitigating measure	Mitigation measure	Assessment with mitigating measure
Construction phase					
Man - mobility	Non-nuclear impact	Impact on saturation level intersections	Negligible	None	Negligible
		Impact on traffic cross delay	Limited negative	None	Limited negative
		Impact on road safety	Negative to limited negative	Construction of the intersection of the new access road for the quay, IPM, caisson factory and storage modules on Europalaan in a traffic-safe manner. Construction of the crossing of the recreational footpath on the N118 in a traffic-safe manner	Negative to limited negative
Soil	Non-nuclear impact	Soil moving	No rating	None	No rating
		Structural change	Negligible	None	Negligible
		Profile change	Limited negative	None	Limited negative
		Change in soil use and soil suitability	No rating	None	No rating
		Damage to soil hygiene	Limited negative to negligible	None	Limited negative to negligible
Water	Non-nuclear impact	Change of infiltration and discharge characteristics	Limited negative	None	Limited negative
		Deterioration of watercourses and flood zones Change in structure quality of watercourses	Negligible	None	Negligible

Phase	Non-nuclear / nuclear	Impact group	Assessment without mitigating measure	Mitigation measure	Assessment with mitigating measure
		Influencing groundwater flow pattern	Negligible	None	Negligible
		Change in water quality	Negative to negligible	None	Negative to negligible
Air	Non-nuclear impact	Impacts of road traffic	Negligible	None	Negligible
		Impacts of vessel traffic	Negligible	None	Negligible
		Impacts of the disposal modules	Negligible	None	Negligible
Noise and vibrations	Non-nuclear impact	Impacts of the construction site	Significantly negative to negligible	No work at night - refill the bins of the granules regularly so avoid any pouring into empty bins - cover the bins with a sound-absorbing material (plastic or rubber)	Limited negative to negligible
		Impacts on site traffic	Negligible	None	Negligible
Biodiversity	Non-nuclear impact	Land use: First series of storage modules Second set of salvage modules	Negative to negligible Significantly negative	- Keep the roadside of the Europalaan outside the construction site and completely free of buildings/roads. - Restrict construction site routes to areas under construction and do not pass through sensitive/valuable ecotopes (to be retained for the time being). - Managing the Europalaan roadside embankment and the access road with the same mowing intensity and at the same	Limited negative

Phase	Non-nuclear / nuclear	Impact group	Assessment without mitigating measure	Mitigation measure	Assessment with mitigating measure
				mowing dates and with the removal of clippings. - Ecological management of the coniferous and oak birch forest and heathland S(W) of the disposal modules - Monitoring that the measures are effectively respected during the works, such as briefing the site personnel on site traffic and routes, respecting the noise requirements, applying accessibility regulations, banning the use of roadside barriers as a construction strip, etc.	
		Noise Disturbance	Negative to limited negative	- Construction phase starts between the beginning of September and the end of March - Monitor the evolution of the breeding bird stock	Negative to negligible
		Impacts of changes in water management	Limited negative	None	Limited negative
Landscape, architectural heritage and archaeology	Non-nuclear impact	Direct land use	Limited negative to negligible	None	Limited negative to negligible
		Disruption impacts	Limited negative to negligible	None	Limited negative to negligible
Human - spatial aspects	Non-nuclear impact	Direct land use	Negligible	None	Negligible
		Visual experience	Limited negative	None	Limited negative

Phase	Non-nuclear / nuclear	Impact group	Assessment without mitigating measure	Mitigation measure	Assessment with mitigating measure
Human health	Non-nuclear impact	Non-radiological health impacts	Limited negative to negligible	None	Limited negative to negligible
	Nuclear impact	Radiation impacts (dose)	Limited negative	No additional	Limited negative
Phase I (operation)					
Human - mobility	Non-nuclear impact	Impact on saturation level intersections	Negligible	None	Negligible
		Impact on traffic cross delay	Limited negative	None	Limited negative
		Impact on road safety	Negative to limited negative	Construction of the intersection of the new access road for the quay, IPM, caisson factory and storage modules on Europalaan in a traffic-safe manner. Construction of the crossing of the recreational footpath on the N118 in a traffic-safe manner.	Negative to limited negative
Soil	Non-nuclear impact	Damage to soil hygiene	Negligible	None	Negligible
	Nuclear impact	Radioactive contamination	None	No additional	None
Water	Non-nuclear impact	Changing water quality	Limited negative to negligible	None	Limited negative to negligible
	Nuclear impact	Radioactive contamination	None	No additional	None
Air		Impacts of road traffic	Negligible	None	Negligible

Phase	Non-nuclear / nuclear	Impact group	Assessment without mitigating measure	Mitigation measure	Assessment with mitigating measure
	Non-nuclear impact	Impacts of vessel traffic	Negligible	None	Negligible
		Impacts of the disposal modules	Negligible	None	Negligible
	Nuclear impact	Radioactive contamination	None	No additional	None
Noise and vibrations	Non-nuclear impact	Impacts on industrial noise	Significantly negative to negligible	No work at night	Limited negative to negligible
		Impacts of traffic noise	Negligible	None	Negligible
Biodiversity	Non-nuclear impact	Sound disturbance	Negative to limited negative	- Construction phase starts between the beginning of September and the end of March - Monitor the evolution of the breeding bird stock	Limited negative to negligible
		Light and visual disturbance of species	Negative	Comply with the principles of "good ecological lighting": - only illuminate where necessary; - only downward lighting; - no unnecessarily strong light sources; - do not use blinding directions - keep luminaires as low as possible - luminaires shall comply with class 6 according to CEN	Limited negative
		Impacts of changes in water management	Negligible	None	Negligible
		Air pollution	Negligible	None	Negligible

Phase	Non-nuclear / nuclear	Impact group	Assessment without mitigating measure	Mitigation measure	Assessment with mitigating measure
		Network impacts: Dry east-west connection Wet east-west connection	 Potential substantial negative to Limited negative Negligible	- Installation of a fully-fledged green buffer at least 100 m wide, partly to the north and partly to the south of the Belgoprocess shielding fence. This green buffer should be constructed from a combination of dry heathland and summer oak birch forest in which the noise, light and visual disturbance from the adjacent project components must be kept to a minimum. - Monitoring the evolution of nature values within the project area	Negligible to limited positive
	Nuclear impact	Reducing biodiversity through radiation	None	No additional	None
Landscape, architectural heritage and archaeology	Non-nuclear impact	Direct land use	Negligible	None	Negligible
		Disruption impacts	Negative to negligible	Preserve the surrounding forest and the greenery accompanying the stream along the Hooibeek and complete the row of trees along the canal.	Limited negative to negligible
		Network impacts	Negative	Allowing vegetation development of a type that reduces wind erosion as much as possible but still forms a landscape connection with the surrounding terrain.	Limited negative

Phase	Non-nuclear / nuclear	Impact group	Assessment without mitigating measure	Mitigation measure	Assessment with mitigating measure
Human - spatial aspects	Non-nuclear impact	Visual experience	Negative to negligible	Preserve the surrounding forest and the greenery accompanying the stream along the Hooibeek and complete the row of trees along the canal.	Limited negative to negligible
Human health	Non-nuclear impact	Non-radiological health Impacts	Limited negative to negligible	None	Limited negative to negligible
	Nuclear impact	Radiation impacts (dose)	Limited negative	No additional	Limited negative
Phase II (closure)					
Human - mobility	Non-nuclear impact	Not relevant	-	-	-
Soil	Non-nuclear impact	Damage to soil hygiene	Limited negative to negligible	None	Limited negative to negligible
	Nuclear impact	Radioactive contamination	None	No additional	None
Water	Non-nuclear impact	Change in water quality	Limited negative to negligible	None	Limited negative to negligible
	Nuclear impact	Radioactive contamination	None	No additional	None
Air	Non-nuclear impact	Impacts of the disposal modules	Negligible	None	Negligible
	Nuclear impact	Radioactive contamination	None	No additional	None

Phase	Non-nuclear / nuclear	Impact group	Assessment without mitigating measure	Mitigation measure	Assessment with mitigating measure
Noise and vibrations	Non-nuclear impact	Impacts on industrial noise	Significantly negative to negligible	No work at night	Limited negative to negligible
Biodiversity	Non-nuclear impact	Noise disturbance	Negative	- It is advisable to carry out the most noise-disturbing operations outside the breeding season or to start before the breeding season, such that the breeding birds can find a suitable breeding place at a sufficient distance from the constructions.	Limited negative to negligible
	Nuclear impact	Reducing biodiversity through radiation	None	No additional	None
Landscape, architectural heritage and archaeology	Non-nuclear impact	Network impacts	Negative	Allowing vegetation development of a type that reduces wind erosion as much as possible but still forms a landscape connection with the surrounding terrain.	Limited negative
Human - spatial aspects	Non-nuclear impact	Visual experience	Limited negative to negligible	None	Limited negative to negligible
Human health	Non-nuclear impact	Non-radiological health impacts	Limited negative to negligible	None	Limited negative to negligible
	Nuclear impact	Radiation impacts	Limited negative	No additional	Limited negative

Phase	Non-nuclear / nuclear	Impact group	Assessment without mitigating measure	Mitigation measure	Assessment with mitigating measure
Period after closure					
Human - mobility	Non-nuclear impact	Not relevant	-	-	-
Soil	Non-nuclear impact	Damage to soil hygiene	No rating	None	No rating
	Nuclear impact	Radioactive contamination	Limited negative	No additional	Limited negative
Water	Non-nuclear impact	Change in water quality	Limited negative	None	Limited negative
	Nuclear impact	Radioactive contamination	Limited negative	No additional	Limited negative
Air	Non-nuclear impact	Impacts of the disposal modules	Negligible	None	Negligible
	Nuclear impact	Radioactive contamination	Limited negative	No additional	Limited negative
Noise and vibrations	Non-nuclear impact	Impacts on industrial noise	Negligible	None	Negligible
Biodiversity	Non-nuclear impact	Noise disturbance	No rating	None	No rating
	Nuclear impact	Reducing biodiversity through radiation	Negligible	No additional	Negligible
Landscape, architectural	Non-nuclear impact	Network impacts	Negative	Allowing vegetation development of a type that reduces wind erosion as much as possible but	Limited negative

Phase	Non-nuclear / nuclear	Impact group	Assessment without mitigating measure	Mitigation measure	Assessment with mitigating measure
heritage and archaeology				still forms a landscape connection with the surrounding terrain.	
Human - spatial aspects	Non-nuclear impact	Visual experience	Limited negative	None	Limited negative
Human health	Non-nuclear impact	Non-radiological health impacts	Limited negative to negligible	None	Limited negative to negligible
	Nuclear impact	Radiation impacts (dose)	Limited negative	No additional	Limited negative

The processes that occur during the lifetime of the surface repository in Dessel are mostly simple and do not normally take place under extreme conditions such as high temperatures or pressure loads. This means that the normal operating conditions are safe and potential incidents during the repository's lifetime are unlikely to result in the release of radioactivity. Correct design measures (such as the electromagnetic compatibility of I&C equipment) ensure that such incidents pose little risk. In addition, specific operating procedures, when necessary, i.e. in the event of an incident, allow safe cessation of operations (e.g. operations are shut down when strong winds occur or when functions/services have ceased). The possible radiological consequences for workers, the nearby human population and the environment therefore remain acceptable.

For various events of external and internal origin, the design of the installation must be able to guarantee safety: earthquakes, floods, snow, wind and tornadoes and certain temperatures.

The risk analysis in which incidental and accidental situations of internal and external origin were evaluated consistently shows limited radiological consequences for the public, should these occur.

An aeroplane crash is the accident that has the most far-reaching radiological consequences. The radiological impact for this accident is lower than 1 mSv.

In the period after closure, in addition to the expected evolution, there are also unanticipated but possible evolutions in which the expected evolution is disturbed. To this end, human intrusion scenarios and alternative evolution scenarios have been considered.

Human intrusion can lead to a disruption of the Systems Structures and Components or SSCs, leading to a sudden loss of isolation and containment capacity. For surface disposal, the possible dose impacts due to human intrusion should be evaluated. In this assessment, it is assumed that the radioactive nature of the material at the disposal site is not discovered; in other words, that the *human intrusion is inadvertent*.

Given the inherent uncertainty regarding future human actions and human behaviour, a limited number of stylized intrusion scenarios will be developed, representative of the different conceivable types and scales of human intrusion. The encompassing nature of the 'human intrusion scenarios' has been systematically substantiated.

The radiological impacts for the inadvertent human intrusion scenarios respect the reference value of 3 mSv/a as prescribed for these scenarios by the FANC.

On the basis of an analysis of possible events or processes underlying a change in the state of the disposal system or the routes along which radionuclides may be released and thus adversely affect the containment performance of the disposal system, it was determined which effects are significant and plausible and not covered by the enveloping nature of the reference scenario or the unintentional human intrusion scenarios. These effects are included in the alternative evolution scenarios (AES).

The conceptualisation of an AES in one or more calculation cases takes into account uncertainties that are linked to the intensity and probability of the disruption, as well as possible different radionuclide pathways which could appear as a result of the disruption. To limit the number of calculation cases and guarantee the conservative nature of the chosen calculation case, the conceptualisation is always based on the earliest possible time of occurrence of the disruption and the greatest possible damage to the SSCs as a result of the disruption.

The estimated probabilities and doses for the AESes should be combined to form the radiological risk. For exposures due to the whole set of AESes, the overall risk is smaller than the risk reduction of 10^{-5}/a for the radiological risk (risk of death from cancer). The radiological impacts for the alternative evolution scenarios are comparable with exposure from natural sources.

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7 Signatures

Name	Disciplines	Signature
Recognised EIA experts - non-nuclear environmental assessment		
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Hilde De Lembre	Water	
Guy Putzeys	Noise and vibrations	
Frank Van Daele	Air	
Mieke Deconinck	Biodiversity Landscape, architectural heritage and archaeology	
Adel Lannau	Man - mobility	
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Technical Expert - Tractebel Engie	
Katleen Remeysen	

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Radiological expert - nuclear environment assessment - ONDRAF/NIRAS	
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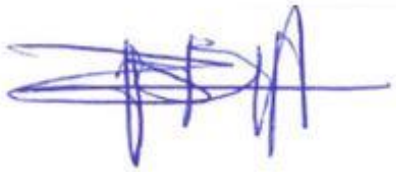
Internal expert ONDRAF/NIRAS - Coordination	
Arne Berckmans	

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