A multi-level geological disposal facility to dispose of radioactive waste according to their hazard potential

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Abstract

Apart from rock salt, Paleogene clay formations are considered in COVRA's long-term research programme for geological disposal of radioactive waste. Paleogene clays are poorly indurated clays. The construction of the geological disposal facility (GDF) in these poorly indurated clay formations is currently a major cost item with a large uncertainty. Construction of the GDF has therefore a high priority in this research programme. The presence of these clays in the Dutch subsurface has been used to optimize this GDF. Probabilistic estimates show that the costs to construct, operate and close the GDF are smaller for a multi-level GDF than a single level GDF.

Introduction

Netherlands is one of the few European countries that has successfully implemented the European INSPIRE Directive [1]. All public available underground data are compiled and accessible for any citizen and any company through the DINOLOKET website. Several Paleogene clay layers are available at almost any location in the Netherlands. This presence allows low and intermediate level waste (LILW) to be disposed of more near the surface than high-level waste (HLW). The available information about Paleogene clays in the Dutch subsurface has recently been explored to dispose of all different types of radioactive waste into a single GDF [2].

Paleogene clay formations

Fresh groundwater can be extracted from sandy formations that are overlain and underlain by clay formations. In many parts of the Netherlands, the hydrological base for groundwater extraction is the Maassluis formation, which of of early Pleistocene, c. 2.5 Ma [3]. A clay host rock confined by sandy formations containing no-potable saline waters is preferred for disposal of waste in order to minimize interactions with groundwater activities. The limited data available on the much older Oligocene aquifers shows these aquifers to be saline as seawater to brackish [4] so of no interest as sources of potable water supply. All Paleogene clay formations are therefore being considered [2]. Figure 1 is an example of the presence of Paleogene clay formations at a single site.

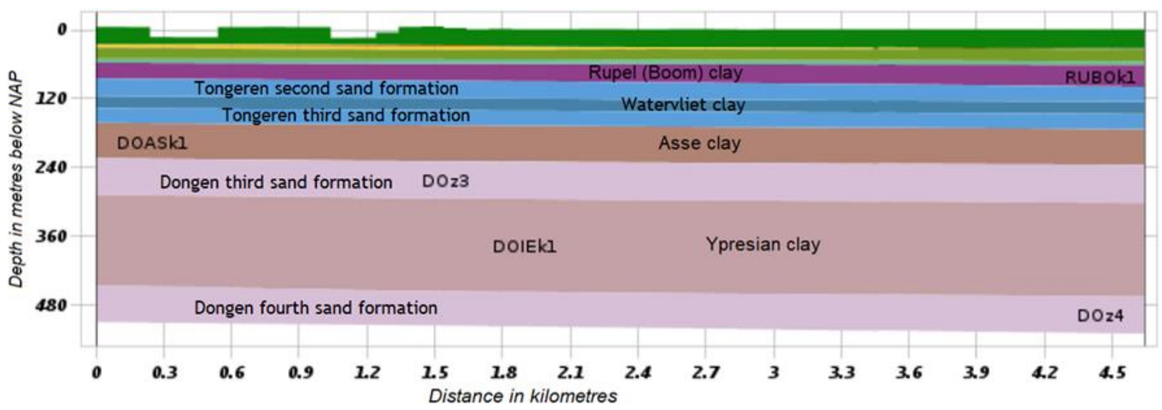

Figure 1. Example of a vertical section with Paleogene clay formations as presented at www.dinoloket.nl: Ypresian, Asse, Watervliet and Boom [2]

Single level GDF

In the third national programme OPERA, LILW and HLW was proposed to be disposed in one clay formation i.e. a single level GDF. The underground engineering structure consists of a transport tunnel that crosses all disposal tunnels and shafts. The fast convergence of clay requires a liner to be applied immediately after excavation. Figure 2 shows a feasible configuration of tunnels and shafts for waste scenario 1 i.e. no new nuclear power plants.

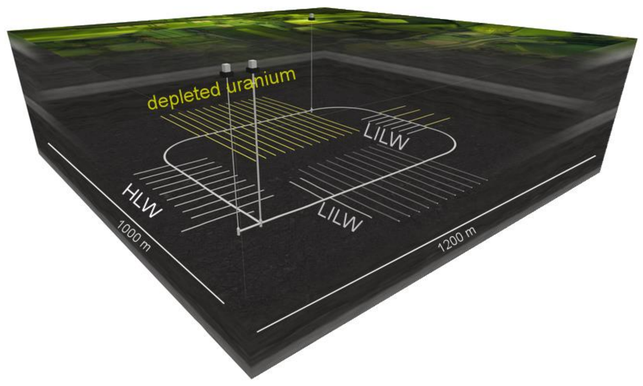

Figure 2. Single level GDF [2] for waste scenario 1 [5]. Footprint 1.2 km².

Multi-level GDF

Many European countries dispose of their LILW in surface or near-surface facilities. Only HLW needs to be disposed at hundreds of meters below the surface for isolation of the waste for several hundreds of thousands of years. The presence of Paleogene clays in the Dutch subsurface can be used to dispose of waste according to their hazard potential if a single facility is to be used to dispose of LILW and HLW. Figure 3 shows a multi-level GDF with the same waste scenario as Figure 2. There are still some 'empty' sections of the transport tunnels not crossing disposal tunnels. Consequently, more optimization is possible than currently visualized.

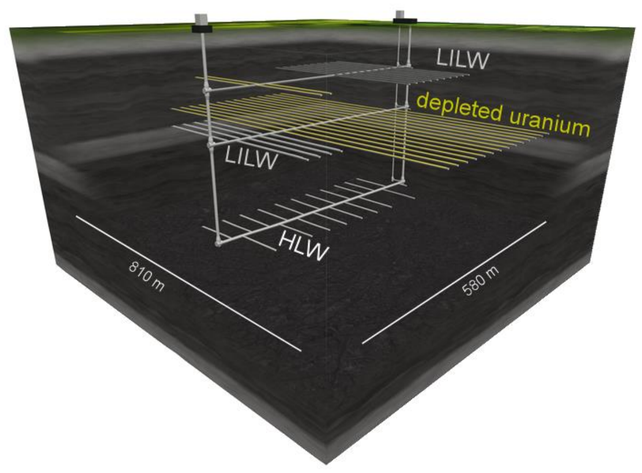

Figure 3. Multi-level GDF [2] for waste scenario 1 [5]. Footprint 0.5 km².

Optimization

The design of the facility and engineered components in a multibarrier system and their manufacturing and installation can be optimised. The change in design of the facility is currently limited in COVRA's hierarchical arrangement of requirements to the design specifications of the liner in the disposal tunnels. Figure 4 shows the hierarchical set of requirements that contribute to the emplacement of waste packages with proven techniques.

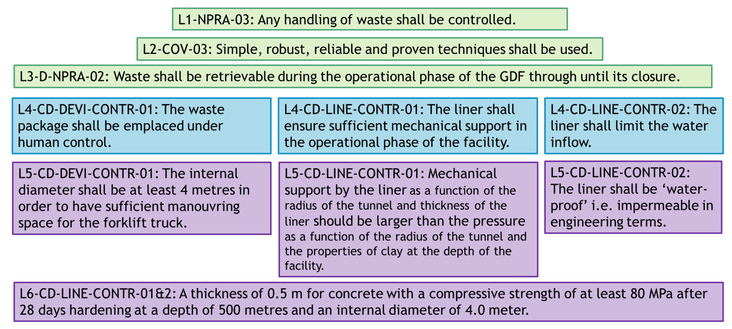

Figure 4. Set of requirements contributing to safe handling of waste, NPRA is the Dutch abbreviation for the national programme, CD=Clay Disposal, LINE=liner, DEVI=device[2].

Figure 5 shows the impact of this change in design specification: increasing the volume of waste that can be disposed of per meter tunnel length.

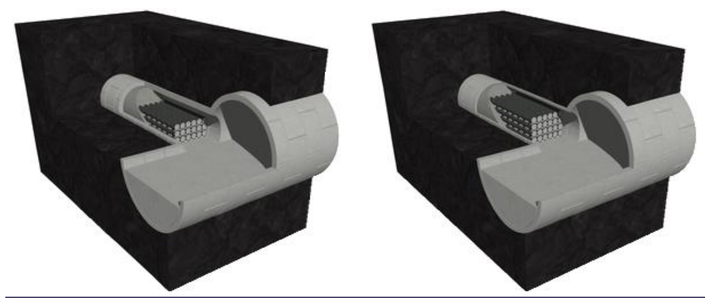

Figure 5. Disposed of LILW waste packages at 500 m depth (left) and 100 m depth (right) [2].

Design specifications are included in the cost estimate to construct, operate and close the GDF. For waste scenario 1 [5] and price level 2022, the best estimates for a single level and multi-level GDF are 3.0 and 2.7 billion euros, respectively. Discounted to 2130 (the starting year of emplacement of waste in COVRA's waste fees), the estimated costs are 2.8 and 2.0 billion euros, respectively [6].

Outlook

Activities have just recently started for investigating the building of new nuclear power plants in the Netherlands. The amount of waste arising from operating and dismantling these plants are expected to be much more than estimated in waste scenario 1 [7]. Modular extension of a multi-level GDF enhances the feasibility to dispose of waste, limits the associated costs and reduces the footprint.

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