# Retrieving legacy waste from the Swedish geological repository for short-lived waste

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**Abstract**

At the geological repository for short-lived waste (SFR) at the Forsmark NPP, radioactive operational waste from NPPs and similar waste from other Swedish nuclear facilities is disposed. This includes short-lived waste from e.g. research and industry that has been treated at the facilities in Studsvik. SFR is operated by the Swedish Nuclear Fuel and Waste Management Co (SKB) and has been in operation since 1988. In 2012, SKB reported that it was suspected that some waste packages disposed at the SFR, following conditioning at the Studsvik facility, might contain waste not in accordance with the waste acceptance criteria. SKB planned to retrieve the waste containers in the 2030s. The Swedish Radiation Safety Authority (SSM) has since 2012 asked for complementary information regarding the suspected content of radioactive substances in the waste, as well as an analysis of the risks involved in retrieving the containers and the radiological risk if the containers were not to be retrieved. In 2020, based on the review of the presented studies, SSM supported SKB’s intention to retrieve the waste. SSM judged that SKB had presented a credible plan for handling containers with questionable structural integrity due to corrosion. Furthermore, according to SSM the need for retrieval is mainly due to the potential for very high doses in the event of inadvertent intrusion into repository, combined with an assessed non-negligible probability that a drinking water well could be drilled into the repository, at a depth of only 50 meters below the surface. The paper describes the background to the identified problem and the relevant regulatory requirements leading to the position taken by SSM. The paper also describes the ambiguity that recently has arisen when one of the waste consignors at Studsvik has disclaimed both nuclear and financial responsibility for large quantities of Swedish legacy waste, including a significant proportion of the waste intended for retrieval.

## INTRODUCTION

At the geological final repository for short-lived low- and intermediate-level waste (SFR) at the Forsmark NPP, operational waste from nuclear power plants as well as similar radioactive waste from other nuclear facilities is disposed of. This includes short-lived waste from e.g. industry and research that has been sent to the facilities in Studsvik for conditioning and packaging. SFR is owned by SKB and was taken into operation in 1988.

SFR is located in crystalline rock at a depth of about 50 metres under the Baltic seabed and consists of different repository sections with different designs of barrier system. The most active waste is deposited in a 50 m deep cylindrical concrete silo with a surrounding bentonite barrier in addition to the geological barrier. Waste with the lowest content of long-lived radionuclides as well as a low external dose rate is placed in standard ISO containers that are deposited in a rock vault without any credible technical barriers. The protective capacity of this repository section is thus determined entirely by the barrier functions provided by the bedrock and the repository's surroundings.

Since the repository is located under the seabed, on the coastline of an extensive region of low topography, the local groundwater flow is low. The probability of inadvertent human intrusion through, for example, a drinking water well can be expected to be negligible during the period of time the repository is covered by the sea. However, land uplift is occurring in the area at such a rate that the repository can be expected to be located below dry land after approximately 1000 years. After this time period, the hydraulic gradient is expected to increase somewhat, which leads to an increased groundwater flow through the repository. The probability of intrusion into the repository as a result of wells being established in the vicinity can also be expected to increase.

## Regulatory requirements

In addition to the overall requirements set in relevant primary legislation, operations at SFR are regulated by the issued Government licence with associated radiological conditions, applicable regulations with associated general advice, as well as other approvals and decisions from SSM. Licence conditions and regulations have been issued with the support of both the Radiation Protection Act and the Act on Nuclear Activities.

In addition to requirements related to the repository’s location and design, SSM’s regulations establish a risk criterion that ultimately regulates the undisturbed repository’s protective function. This risk criterion has been established to ensure that the annual dose limit of 1 mSv is met by a significant margin [1].

The potential consequences of unintentional intrusion are regulated separately from the risk criterion. The regulation regarding unintentional intrusion focuses primarily on the need to take measures aimed at limiting the probability of unintentional intrusion. SSM has not established any specific regulatory requirements as to which doses would be considered unacceptable in the event of intrusion, but in the permit examination for SFR accepted estimated annual doses up to 10 mSv in the event of a drinking water well intercepting the repository [2].

SSM’s general regulations regarding safety in nuclear facilities [3] were updated in 2012, which led SKB to establish waste acceptance criteria (WAC) for deposal at SFR. The WAC differ between the different sections of the SFR. Prior to 2012, waste acceptance was regulated by licence conditions that were issued in 1988 that required a waste producer to present a so-called waste type description (WTD) as a basis for approving the disposal of that particular waste in SFR [4] [5]. In the WTD, the properties of the waste were reported, demonstrating how these meet the WAC. The WTD was handed in by SKB to the regulator together with SKB’s own assessment. The regulator’s approval to dispose of a certain type of waste was based on the information given in the WTD, according to documentation provided by SKB and the waste producer.

## Identified uncertainties

In 1994, the regulator approved the disposal of certain wastes that had been treated at the Studsvik facilities since the 1960s [6]. On the basis of the information provided, approval was limited to waste drums produced after 1980. Uncertainties regarding the older wastes’ content of long-lived radionuclides were an important reason for this limitation. A total of approximately 2,800 waste drums have been deposited in accordance with the approval. This waste, like other wastes with low external dose rate and considered to have a low content of long-lived radionuclides, was placed in a simple rock vault in ISO containers. To date, a total of about 500 such containers have been placed in this section of the repository, of which just over 70 contain waste that has been treated at the facilities in Studsvik.

At the end of the 1990s, the regulator rejected on three occasions the disposal of different fractions of the remaining waste drums produced before 1980. After these refusals, more advanced characterization of the remaining, non-deposited 7,500 waste drums was carried out by the company AB Svafo. This company was established following a Government decision in 1993 as the organisation responsible for legacy waste produced at the Studsvik site before June 30th 1991 [7] [8]. The characterization activities, conducted between 2009 and 2011, included X-ray examination and extended gamma spectrometric measurements. The results, reported to SSM in 2012 [9], showed deviations in relation to the WAC presented in the WTD for the previously disposed wastes, for instance with regard to their content of liquids, hazardous material and the presence of fissile material. It had already been clarified that a fraction of the legacy waste drums contained fissile material from research work during the 1960s and 70s, but the investigations carried out showed that a significantly larger number of the drums contained uranium and plutonium than was apparent from the documentation. These deviations were also present in the few remaining waste drums produced after 1980 that were examined.

In 2015, SSM requested an assessment of the conclusions that could be drawn from these investigations regarding the presence of radioactive substances in the deposited waste drums. Furthermore, SSM requested an assessment of the implications for long-term safety if the waste was not retrieved from SFR [10]. SSM requested this because a retrieval can entail risks for the personnel since some of the earliest deposited containers in SFR have substantial corrosion damage. The retrieval involves extensive work as a large number of other containers need to be moved to enable access to the containers that contain the waste from the facilities in Studsvik.

A thorough review of the documentation linked to the disposed waste drums showed that they contained a very large number of Ra-226 radiation sources. Based on the documentation, it is estimated that the drums contain about 400,000 low-activity Ra-sources (disused aiming devises from the Swedish military). Furthermore, there were indications that the waste could contain larger amounts of Pu than is allowed by the licence for SFR [11]. The presence of these radioactive substances is of significance for the long term radiation safety [12].

SKB and the waste producers at Studsvik have stated that they plan to retrieve the waste. However, SKB and the waste producers have argued that the retrieval does not need to be undertaken for all of the waste drums. Furthermore, it was argued that the retrieval would take place in the 2030s [13].

## SSm’s assessment on the need for retrieval

According to the results presented by SKB, the presence of Ra-226 and other long-lived alpha-emitters increases the estimated maximum risk to the critical group due to releases from the SFR by around a factor of 5. Even if this meant that the estimated risk did not comply with the regulatory criterion, this might not according to SSM necessarily have justified the retrieval of the waste. However, the reported results also showed that the annual doses from a hypothetical drinking water well drilled into the rock vault where the waste is placed would be significant, in the order of 0.1 – 1 Sv. This is partly due to the lack of credible technical barriers surrounding the waste packages in this rock vault in SFR. According to the International Commission on Radiological Protection Publication 81, doses of this magnitude are sufficiently high that intervention would almost always be justified and that, in the context of solid waste disposal, reasonable efforts should be made to reduce the probability of human intrusion or to limit its consequences [14].

As already described, SSM’s regulations are primarily concerned with measures to limit the probability of inadvertent intrusion rather than the level of exposure to the intruder. However, the probability of inadvertent intrusion into a repository at a depth of 50 m cannot be judged to be negligible. Given this, and the scale of the very high doses estimated for the drinking water well intrusion scenario, SSM supported SKB's intention for retrieval [15]. SSM also took into account that SKB had presented a credible plan for limiting the risks associated with the handling of the potentially damaged containers during the retrieval.

In its review, SSM questioned the basis for limiting the retrieval to a subset of the deposited waste. Given the errors in documentation revealed by Svafo’s original investigations, as reported to SSM in 2012, SSM considered that all waste drums need to be retrieved for further characterization. The additional work required to undertake complete retrieval was assessed by SSM to be comparatively limited. SKB has subsequently changed its plans on this point, and is now planning for a complete retrieval [16].

Furthermore, SSM questioned the arguments put forward for delaying retrieval until the 2030s. SKB has changed its planning assumptions on this matter also, and now intends to carry out the retrieval in the next few years. A prerequisite for this, however, is that necessary storage capacity for the retrieved waste is established at the Studsvik site [16].

## Present status

In a letter to the government in December 2020, AB Svafo disclaims responsibility for substantial components of the legacy waste inventory [17]. This applies to radioactive waste that does not originate from nuclear activities, such as waste from the Armed Forces or other national institutions. AB Svafo also disclaims responsibility for nuclear waste that is insufficiently characterized to be sent to a final repository without further measures. AB Svafo states that the company can ensure safe continued interim storage of the retrieved waste, provided that the state assumes responsibility for the financial cost. According to Svafo, the clarification of financial responsibility is a prerequisite for carrying out the retrieval.

In April 2021 SSM received an assignment from the Government to investigate the issue of responsibility for the legacy waste as well as its financing and to submit proposals for measures to be taken by the Government. SSM will present its conclusions to the government by the end of the year [18].

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