Milestone 61: Evaluation of RWM strategies for the disposal of waste bearing naturally occurring long-lived radionuclides

Work Package 3

Co-funded by the European Union under Grant Agreement n°101166718

Date of issue of this report: **17/12/2025**

Document information

Project Acronym	**EURAD-2**
Project Title	**European Partnership on Radioactive Waste Management-2**
EC grant agreement No.	**101166718**
Work Package Title	**ASTRA**
Milestone No.	**61**
Milestone Title	**Workshop on alternative RWM strategies for the disposal of waste bearing naturally occurring long-lived nuclides**
Lead Beneficiary	**NRG PALLAS**
Contractual Delivery Date	**31 December 2025**
Actual Delivery Date	**17/12/2025**
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Acknowledgement

This document is a milestone of the European Partnership on Radioactive Waste Management 2 (EURAD-2). EURAD-2 is co-funded by the European Union under Grant Agreement N° 101166718.

Executive Summary

This report summarises the work completed for EURAD-2, Work Package 3 (ASTRA), sub-task 5.3. The objectives of this work included a consolidation of learning internationally on the lifecycle management of challenging waste types such as: Radium, Thorium, Uranium (Ra/Th/U) and Depleted Uranium (DU) via a questionnaire developed and distribution to member states within this Work Package. There have been 19 submissions from 17 countries, from a range of different organisations, including consultancy groups, engineering companies, research and development organisations and those who are responsible for the management of these types of waste forms in their respective countries (such as TSOs, RE and WMOs).

The questionnaire itself had 29 questions across seven categories: General, Inventory and Management, Reuse/Treatment /Disposal, Safety Case and Long-Term Safety, Workshops and Follow-up, Research and Development (R&D) Needs, and Additional Information, which have been answered and summarised within this report.

This report includes the questionnaire results as well as the key findings from the workshops held during this work. This work package is apart of the wider research completed under EURAD-2. In this report, a summary of all the results within each questionnaire topic is provided; highlighting significant diversity in definitions, regulatory frameworks, and strategic approaches to the management, treatment, and disposal of the waste forms considered in this work.

The results emphasise varying degrees of maturity in national strategies, with countries such as the United Kingdom (UK), the Netherlands, Switzerland, and the Czech Republic demonstrating integrated lifecycle approaches that encompass waste minimisation, treatment, reuse/recycling, and conditional disposal options. Conversely, others remain in the early stages of strategy development, lacking safety cases or disposal programs, especially for DU, which is, in some countries regarded as a resource than a waste.

This report provides a concise summary of the collected data, as well as key conclusions and recommendations that can be made due to analysing all 19 submissions from the 17 analysed countries.

This report provides the detailed responses from each country within Appendix A, however, no personal information from the submitted parties has been included. Appendix B contains the questionnaire that was developed and presented within this Subtask 5.3. Appendix C provides the presentations presented by group members during the second Workshop, more details of the Workshop output are found within this report.

Keywords

Alternative RWM strategies, SIMS, LIMS, NORM, challenging waste types, reuse/treatment, disposal, safety case, and long-term safety.

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1. Introduction

ASTRA is a work package within EURAD-2, focusing on the analysis of readiness, feasibility, and challenges of alternative Radioactive Waste Management (RWM) solutions required by many countries, particularly Small Inventory Member States (SIMS), as well as larger programs due to new requests arising from National requirements to safely manage and dispose of their radioactive waste.

NRG PALLAS is part of ASTRA Task 5 and serves as the lead for Sub-Task 5.3, "Evaluation of RWM strategies for the disposal of waste bearing naturally occurring long-lived radionuclides". NRG PALLAS developed a questionnaire within ASTRA to assess how countries manage waste containing Radium, Thorium, Uranium and Depleted Uranium (Ra, Th, U & DU). The questionnaire (found in Appendix B) covered the following topics: Inventory definition and Management, Reuse and Recycling, Waste Treatment, Disposal Programs, Safety Case Procurement and Development, and R&D needs. Responses were received from 17 countries, including several within the European Union (i.e., EU member states), as well as South Korea, Ukraine, the United Kingdom (UK).

Waste management approaches are varied amongst the different countries, including reuse, recycling, DU re-enrichment, blending, conditioning, storage, and disposal. In looking at the different approaches for disposal solutions; it was seen that Near-Surface Disposal Facility (NSDF), dedicated landfills, and Deep Geological Disposal Facility (DGDF) are amongst some of the main options identified, for either NORM and/or DU waste types. Although, most final disposal solutions are still under development.

An initial workshop was held to present the results and allow for further discussion. The outline of the project has been captured in the Work Package 3 - ASTRA Green Paper (Deliverable 3.1: Green paper - Position paper on mutual understanding on alternative RWM strategies for tasks). The full collection and analysis of results from the developed questionnaire, is detailed within this report. The second workshop held under this task, allowed for different country members to present key information on their waste management processes, the presentations are found in Appendix C and more details are found within Section 3.

Sections 2.1 to 2.7 of this report include a review of each questionnaire topics results, highlighting the key findings, similarities and differences between the responses. Section 4 concludes the results collected from each section (2.1 to 2.7) and provides recommendations based off of the findings, for future work.

Each representation of results within this report (i.e., Summary Tables and Figures found in Sections 2.1 to 2.7 as well as the details provided in Appendix A) all come directly from the participating questionnaire responses. Conclusions and recommendations have been made from these results; however, it should be highlighted that any details presented regarding a countries waste management system (i.e., in Appendix A), has been taken directly from that country's response and no interpretation has been made (the results have been copied directly from questionnaire responses). Therefore, if there is a discrepancy or misalignment of information it comes directly from the questionnaire answers, not any form of interpretation of the results made during the production of the milestone report.

For those countries with double responses (i.e., France and the UK) confirmation of the reason between the differences within their responses has been obtained, and the results from both submissions are still presented within Appendix A – as these differences come from their different knowledge of the subject due to the company / organisation they are affiliated with, therefore, altering the level of detail provided in some cases. The information is, however, still valid for both responses.

1.1 Scope

This report will provide the results obtained from the developed questionnaire looking into waste management of U/Th/Ra and DU waste types; covering Waste Management, Reuse and Recycling, Waste Treatment Options, Disposal Programs, Key Challenges, Safety Case, R&D needs, as well as future Workshops and Follow up. It further provides all additional information collected from participating partners and the presentations given during the online workshop in September 2025.

1.2 Objective

The objective of Sub-Task 5.3 is to gain insight into the current inventory of waste bearing naturally occurring long-lived radionuclides in member states and the current state of their disposal program for dealing with such waste.

2. Questionnaire Results

2.1 Waste Management Options for NORM and/or DU

Looking at the waste inventory and management, summarised in Table 1, it was found that most countries have both NORM and DU wastes (13 countries) and only 2 countries had neither. Note, that one country (South Korea) states they have neither NORM and/or DU, however, their questionnaire response provided a detailed description of their waste management system. Therefore, South Korea has been counted to have both NORM and DU from their answers, within this report. 4 responses from different countries state they have only NORM wastes. Further details are provided in Appendix A.

Therefore, it is concluded that 13 countries have NORM and DU waste types, 1 country has neither NORM or DU and 3 countries have only NORM wastes

Each country has their own definition of NORM and DU wastes, which are provided in detail within the subsections for each country in Appendix A. However, in general, we have seen that 'NORM waste' is described as radioactive waste containing natural radionuclides, which exceed certain (specific) exemption limit criteria from each country. 'DU waste' generally has a more varied definition, where it is often not described as a 'waste' type, but as a material that can be reused, or defined as a resource. But most commonly it is described as a safeguard material.

Out of the 19 submissions, 10 of the countries operate with a centralised national registry system (i.e., Austria, Czech Republic, Estonia, France, Germany (NORM), Greece, Portugal, Slovenia, South Korea, the UK (NORM)). Denmark operates a decentralised system for its NORM wastes and Germany for its DU waste. The Netherlands registers and manages NORM and DU waste via COVRA, Norway manages their waste at repositories for NORM and DU is registered at DSA (Directorate for Radiation Protection and Nuclear Safety) and managed under safeguards. No specific information was gathered for Poland, and in Switzerland the PSI (Paul Scherrer Institute) is responsible for the inventory management of their waste. Ukraine currently has organised storage of their waste, but a draft strategy is being created to address such. The UK uses radioactive waste inventory and IGD (Inventory for Geological Disposal) for its DU waste.

The following tables (1-8) summarise the results from the key questions asked within the different topics of the questionnaire. Note that the results have been presented in table format, and some answers have been shortened for a suitable summary format; the full detailed responses can be found within Appendix A.

The following results for the different inventory management options currently used or considered, across the different countries, are summarised below for NORM and DU wastes in Table 1. These results are directly presented from the submissions received from the questionnaire.

Table 1: Management options currently used or considered for NORM/DU waste types for the participating countries within this questionnaire. Further details can be found in Appendix A.

Waste Management Options for NORM and/or DU								
Country	Waste minimization	Pre-treatment	Treatment	Blending with non-radioactive material	Reuse / recycling	Conditioning	Storage	Disposal
Austria						NORM	NORM	
Bulgaria								
Czech Republic	NORM DU	NORM	NORM	Prohibited	NORM	NORM DU	NORM	NORM
Denmark			NORM				NORM	NORM
Estonia	NORM					NORM		NORM
France	NORM				DU			NORM
					DU		DU	NORM
Germany	NORM				DU			NORM

Waste Management Options for NORM and/or DU								
Country	Waste minimization	Pre-treatment	Treatment	Blending with non-radioactive material	Reuse / recycling	Conditioning	Storage	Disposal
Greece					NORM DU		NORM DU	NORM DU
Netherlands		DU	NORM	NORM	NORM DU		NORM DU	NORM
Norway							DU	NORM
Poland							NORM DU	NORM
Portugal							NORM DU	
Slovenia	DU				DU			NORM
South Korea	NORM DU		NORM DU		NORM DU			NORM DU
Switzerland	NORM DU	NORM DU	NORM DU	NORM DU	NORM DU	NORM DU	NORM DU	NORM DU

Waste Management Options for NORM and/or DU								
Country	Waste minimization	Pre-treatment	Treatment	Blending with non-radioactive material	Reuse / recycling	Conditioning	Storage	Disposal
Ukraine							DU	
United Kingdom	NORM	DU		NORM	DU	DU	DU	NORM
	NORM		NORM	NORM	NORM	NORM	DU	NORM DU
Totals	**NORM (8)** **DU (4)**	**NORM (2)** **DU (3)**	**NORM (6)** **DU (2)**	**NORM (4)** **DU (1)**	**NORM (6)** **DU (9)**	**NORM (5)** **DU (3)**	**NORM (8)** **DU (10)**	**NORM (15)** **DU (4)**

From Table 1, looking at the management options used / considered there are some similarities in approaches, depending on where the country is currently positioned within their lifecycle management systems for NORM and/or DU wastes. Waste minimisation was selected 8 times for NORM and 4 for DU, Pre-treatment was selected 2 times for NORM and 3 times for DU, Treatment 6 for NORM and 2 for DU, blending with non-radioactive material 4 times for NORM and once for DU, Reuse and recycling 6 for NORM and 9 for DU, Conditioning 5 for NORM and 3 for DU, Storage 8 for NORM and 10 for DU and Disposal had 15 for NORM and 4 for DU.

For waste minimisation, it was not seen as a concern for those countries who selected it as a waste management process (i.e., Czech Republic, Estonia, France, Germany, Slovenia, South Korea, Switzerland, United Kingdom), for either NORM or DU waste types. Generally speaking, countries aim to reduce the amount of radioactive waste (or even, exempt waste) they produce and, therefore, have to dispose of. Therefore, this type of waste management option is not seen as a concern or challenge amongst the different countries that implement or consider it.

Pre-treatment was selected by four different countries (Czech Republic, the Netherlands, Switzerland and the United Kingdom), there is limited information regarding the type of pre-treatment processes completed by these countries, however, the same four countries are seen to complete treatment options, as well as Denmark and South Korea. Blending with non-radioactive materials was also selected by the same four countries. Further details and analysis of the waste treatment options selected or considered by the different countries are summarised in Section 2.3.

Reuse and Recycling option was selected by nine countries (Czech Republic, France, Germany, Greece, the Netherlands, Slovenia, South Korea, Switzerland and the United Kingdom). A detailed analysis of the challenges and solutions of this process for the different waste types can be found in Section 2.2.

Conditioning NORM and DU waste was selected by five different countries (Austria, Czech Republic, Estonia, Switzerland and the United Kingdom). No information has been provided about the type of conditioning completed for Austria (NORM), Czech Republic (NORM), however it is stated that some amounts of DU can be conditioned by the radioactive waste producer as radioactive waste. Estonia currently grouts their NORM waste before disposal. Whereas the UK mentions the potential possibility of encapsulation DU in cementitious grout for disposal – however, it is highlighted that this conditioning is not yet completed. From the results provided, it is seen that conditioning is not highly selected or considered, which could be due to lack of available processes or the current need due to DU often not being regarded as waste.

Austria, Portugal and Ukraine state that they currently only store their NORM and/or DU waste (if classifies as such), with no current or planned disposal route. However, Estonia, France, Germany and Slovenia state they only dispose or consider disposing of such waste without any storage requirements. The remaining 10 submissions have selected both storage and disposal management options.

Figure 1 shows a graphical representation of the results discussed above and summarised in Table 1.

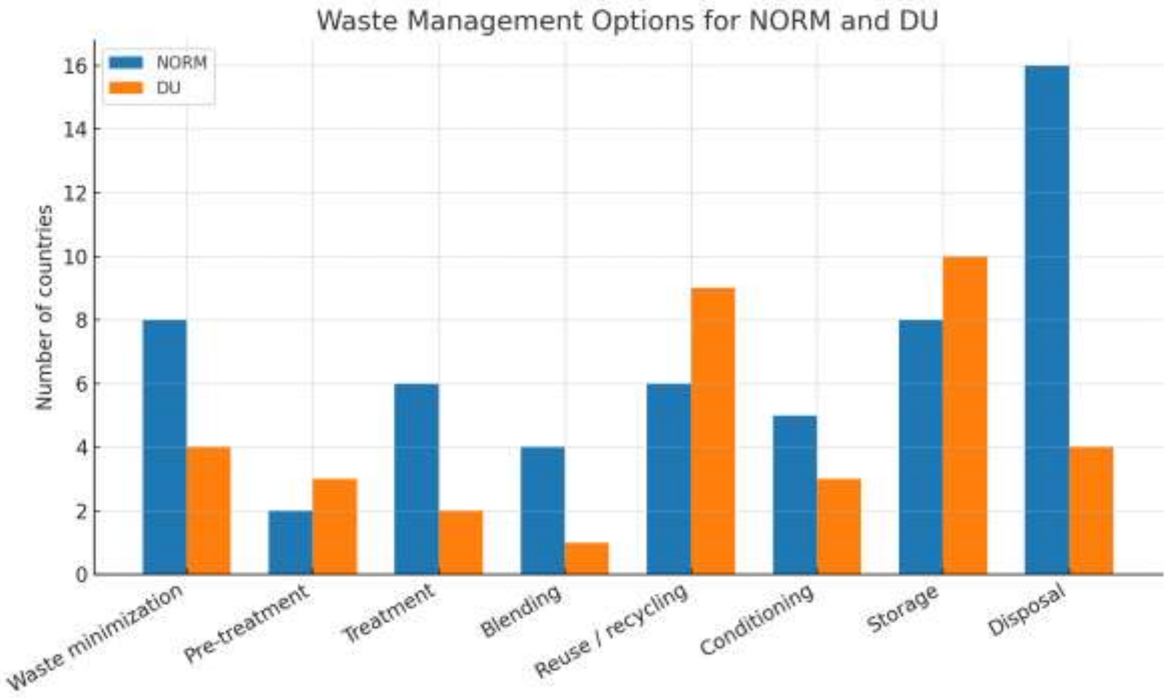

Figure 1: Visual representation of the results collected for waste management options of NORM and/or DU waste types.

As shown visually above, it is clear that either, currently used or considered waste management approaches are heavily focused on the storage and disposal of NORM and DU wastes (when DU is considered a waste form). As well as minimising the waste produced where applicable.

2.2 Reuse and Recycling of NORM and/or DU

A summary of the reuse and recycling question answers for NORM and DU is summarised in the Table 2. These results are directly presented from the submissions received from the questionnaire.

Table 2: Reuse and Recycling responses from the participating countries within this questionnaire. Further details can be found within Appendix A.

Reuse and Recycling of NORM and/or DU			
Country	Is NORM/DU currently reused or recycled in your country?	Will it be used / research be conducted into the reuse/recycling of NORM/DU for disposal?	How is safety demonstrated for this disposal technique for NORM/DU?
Austria	No reuse or recycling completed/ planned to be implemented.	NA	NA
Bulgaria	NA	NA	NA
Czech Republic	No solution is available for the removal of radioactive scales from scrap metal (pipes from water treatment, mining and spa industries). (Note on reuse/recycling - Radioactive waste is returned to the producer where possible, and NORM wastes are processed in the uranium industry.) Residues from production are returned to the producer where possible (e.g. cement production, iron production).	NORM waste is used as backfill material. Waste activity is measured, if its derived criteria are not exceeded (which means that E is less than 0.3 mSv/year), the waste may be used as a backfill material. No available practice for reuse within a disposal facility for DU.	No information provided

Reuse and Recycling of NORM and/or DU			
Country	Is NORM/DU currently reused or recycled in your country?	Will it be used / research be conducted into the reuse/recycling of NORM/DU for disposal?	How is safety demonstrated for this disposal technique for NORM/DU?
	This practice also applies to the production of depleted uranium shielding, thus minimising waste (RW). NORM waste of a mineral nature (mining waste, coal combustion product and other suitable waste) is used for reclamation purposes. Ionex cartridges used to remove uranium from drinking water are processed in the uranium industry.		
Denmark	No reuse or recycling data known for current or planned disposal	NA	NA
Estonia	No reuse or recycling is currently used	Could be used for shielding in high-level waste containers -Estonia holds depleted uranium (originating from DSRS containers), which is considered as radioactive waste. A container with this waste could be used for shielding	No safety information available yet, as it is in the early stages of the disposal solution

Reuse and Recycling of NORM and/or DU			
Country	Is NORM/DU currently reused or recycled in your country?	Will it be used / research be conducted into the reuse/recycling of NORM/DU for disposal?	How is safety demonstrated for this disposal technique for NORM/DU?
		of higher activity waste during disposal, if needed.	
France	Currently, for reuse/recycling, ANDRA - DU: Depleted uranium has been used regularly for several years as a support matrix for MOX fuel, produced in France at the Melox plant in Marcoule. DU Valorisation: Once re-enriched, the stock of depleted uranium currently present on French territory represents a deposit of around 65,000 tonnes of natural uranium, or around eight years of the requirements of France's current nuclear power plants. Re-enrichment can be used as a fuel based on enriched natural uranium (ENU).	Orano's R&D program is looking at ways of recovering value from uranium by exploiting its properties. Andra is conducting a feasibility study on a storage concept for depleted uranium in the event that all or part of the depleted uranium stock cannot be recovered under acceptable technical and economic conditions. Depleted uranium is used in non-electronuclear industries as radiological shielding or as a counterweight.	No additional safety information provided

Reuse and Recycling of NORM and/or DU			
Country	Is NORM/DU currently reused or recycled in your country?	Will it be used / research be conducted into the reuse/recycling of NORM/DU for disposal?	How is safety demonstrated for this disposal technique for NORM/DU?
	Producers are responsible for reuse/recycling and storage of DU. A part of the DU is used to manufacture MOX fuel.	In the future, use DU, for fuel for generation IV reactors. There is a reuse of NORM or DU / research being conducted for disposal.	No additional safety information provided
Germany	Management options for DU include reuse/recycling (e.g., re-enrichment of DU) For NORM and the re-use and recycling of DU is completed by URENCO. Re-enrichment of depleted uranium will in this case be done by URENCO to produce uranium for fuel production (3-5% enrichment).	No knowledge for reuse within a disposal facility for NORM or DU.	NA
Greece	Currently, the reuse/recycling of NORM is sometimes used to produce commodities, but no further information is provided.	NA	NA

Reuse and Recycling of NORM and/or DU			
Country	Is NORM/DU currently reused or recycled in your country?	Will it be used / research be conducted into the reuse/recycling of NORM/DU for disposal?	How is safety demonstrated for this disposal technique for NORM/DU?
Netherlands	Reuse/recycling of NORM is currently completed; Specifically released NORM material can possibly also be mixed with non-radioactive material under certain conditions, with a view to recycling and reuse. Reuse is preferred over disposal in NL. Melting down of contaminated or activated steel. Companies Begemann Milieutechniek, ATM and Reym specialise in processing various sludge streams and separating them into partly reusable components.	Currently, NORM and DU are not reused within the disposal process, and no specific research is being conducted for NORM wastes; however, some research is being performed into DU reuse.	NA
Norway	No reuse / recycling is currently used or planned.	NA	NA
Poland	They do not reuse/recycle the waste currently or planned.	NA	NA

Reuse and Recycling of NORM and/or DU			
Country	Is NORM/DU currently reused or recycled in your country?	Will it be used / research be conducted into the reuse/recycling of NORM/DU for disposal?	How is safety demonstrated for this disposal technique for NORM/DU?
Portugal	No recycling or reusing of radwaste or of DU (safeguards), is carried out at IST.	NA	NA
Slovenia	In line with national policy and strategies, RW and sources are primarily to be returned to suppliers or producers. If this is not possible, they are to be handed over to the ARAO for appropriate treatment, conditioning and storage in the centralised storage facility for institutional RW – continuously. NORM waste has been reused in the past, as backfilling material for the two existing disposal sites, Jazbec and Borst For DU, they try to avoid the reuse of it in disposal facilities; therefore, reuse/recycling is already supported by the holder before being taken over by the ARAO (WMO)	NA	NA

Reuse and Recycling of NORM and/or DU			
Country	Is NORM/DU currently reused or recycled in your country?	Will it be used / research be conducted into the reuse/recycling of NORM/DU for disposal?	How is safety demonstrated for this disposal technique for NORM/DU?
South Korea	NA	Reuse and recycling are used for research into shielding by using the waste type.	Safety is demonstrated based on national safety rules.
Switzerland	Waste management options include reuse / recycling for both NORM and DU, but no other information provided.	NA	NA

Reuse and Recycling of NORM and/or DU			
Country	Is NORM/DU currently reused or recycled in your country?	Will it be used / research be conducted into the reuse/recycling of NORM/DU for disposal?	How is safety demonstrated for this disposal technique for NORM/DU?
Ukraine	From 2013 to 2015, the State Specialised Enterprises for Radioactive Waste Management launched and successfully tested a project for the mechanical decontamination of pipes from oil and gas industry companies. Sludges received from oil and gas companies undergo conditioning through solidification by cementation at their places of origin, followed by placement of the cement matrix in certified IP-2 type packaging for transportation and temporary storage as low and intermediate level radioactive waste. Clean pipes that have undergone mechanical decontamination and meet the criteria for clearance based on dose rate and surface contamination levels	NA	NA

Reuse and Recycling of NORM and/or DU			
Country	Is NORM/DU currently reused or recycled in your country?	Will it be used / research be conducted into the reuse/recycling of NORM/DU for disposal?	How is safety demonstrated for this disposal technique for NORM/DU?
	are used as scrap metal. DU is not reused in Ukraine		

Reuse and Recycling of NORM and/or DU			
Country	Is NORM/DU currently reused or recycled in your country?	Will it be used / research be conducted into the reuse/recycling of NORM/DU for disposal?	How is safety demonstrated for this disposal technique for NORM/DU?
United Kingdom	Reuse / recycling of DU currently in the UK, is sometimes conducted, where re-enrichment of DU is sometimes conducted (as opposed to using fresh natural uranium from mining, milling and conversion), depending on market economics.	DU waste reused during its disposal process; Nuclear Waste Services (NWS's) Uranium Integrated Project Team (U-IPT) evaluated various ways in which to use the DU to realise some kind of benefit with a geological disposal facility. It concluded that there are several ways in which it would be feasible to use the UK inventory many times over, for example, as mass backfill or as part of structural components, avoiding the need for (or reducing the size of) dedicated disposal vaults for DU. These are referred to as 'GDF-use' options. The most credible of these is disposal of containerised DU in the service and transport tunnels for other waste types in place of some mass backfill. Source: Final report of the U-IPT, 2016, NDA	Considered at the conceptual design level – not currently implemented. However, the U-IPT also considered long-term safety implications of DU disposal

Reuse and Recycling of NORM and/or DU			
Country	Is NORM/DU currently reused or recycled in your country?	Will it be used / research be conducted into the reuse/recycling of NORM/DU for disposal?	How is safety demonstrated for this disposal technique for NORM/DU?
		Report no. NDA/RWM/142. Considered at the conceptual design level – not currently implemented. However, the U-IPT also considered long-term safety implications of DU disposal – refer to the report above for details.	
	NORM – re-use to extend life of resources, recovery through use in industrial resources, DU – Reuse options for DU are unspecified therefore continued designation as zero value asset.	For DU, used as backfill material is under consideration. U-loaded Backfill (if classed as waste) or DU- Co-disposal (If classified as waste) with Immobilized Pu waste forms.	Concept and detailed design development and safety case development for identified disposal option.

Looking at the results from the Reuse and Recycling questions summarised in Table 2, several countries either provided little to no information, or stated they have no implementation or planned implementation of such waste management processes (Austria, Bulgaria, Denmark, Estonia, Greece, Norway, Poland, Portugal, South Korea – some research is conducted, but currently not applicable to their processes. It is not clear whether the lack of reuse and recycling carried out by these countries is because they don't require it, or they lack the technology and methodologies to implement such practices.

Estonia noted that they currently do not carry out any processes; however, their waste could be used for shielding in high-level waste containers, as they do hold DU in DSRS containers, which is considered radioactive waste, and could be used for shielding of higher activity waste during disposal if needed.

The Czech Republic highlighted several issues within reuse and recycling. Firstly, they have no solution available for the removal of radioactive scales from scrap metal (for example, pipes from waste treatment). Ukraine, however, stated that they have methodologies for decontaminating pipes, which then met the clearance criteria and used as scrap metal. This solution was highlighted during one of the workshop presentations, to promote the sharing of solutions between the different member states. This highlighted the benefit of this EURAD-2 ASTRA Sub-Task 5.3, and the ability to enable sharing of information and practices between members.

Secondly, the Czech Republic stated that they have no available practices for reuse within a disposal facility for DU. However, the Netherlands and the United Kingdom stated that some research was being conducted into the reuse of DU within its disposal process, including being used as backfill material. This emphasised a requirement for future Research and Development (R&D) to be conducted, as this could benefit other countries (outside the UK and the Netherlands) in economically dealing with DU waste, if a suitable methodology/ solution is found through R&D and can be shared amongst different countries.

Answers from Slovenia showed that NORM waste had been previously reused in the past, as backfill material for their two existing disposal sites, Jazbec and Boršt. Additional information was requested to summarise this process after the questionnaire was completed. Links to this information is provided in Appendix A – 'Slovenia 7 Additional Information', as well the presentation regarding the two disposal sites provided in Appendix C.

France presented some interesting information regarding their reuse and recycling strategies, where DU is used regularly as a support matrix for Mixed Oxide (MOX) fuel, as well as re-enrichment for a fuel based on enriched natural uranium. Several research programs are being conducted looking into ways of recovering value from uranium, as well as a feasibility study on the storage concept for DU if part or all of the stock cannot be recovered – this highlights that countries are concerned that if the DU stock cannot be reused or recycled effectively, it could cause storage issues within final disposal.

2.3 Waste Treatment Options of NORM and/or DU

Responses from each country regarding their waste treatment methods are summarised in Table 3. These results are directly presented from the submissions received from the questionnaire.

Table 3: Summary of waste treatment options for NORM and/or DU waste for each participating country, which are either applied or will be applied for disposal. Further details can be found in Appendix A.

Waste Treatment Options of NORM and/or DU					
Country	Encapsulation	Cementation	Specialised treatment (e.g., deconversion to U_3O_8)	No treatment, direct disposal	Other
Austria					
Bulgaria					
Czech Republic		NORM DU		NORM	Unusable DU residues are directly placed in approved packaging sets (double-layered barrels).
Denmark					For waste treatment, one company is licensed to physically clean the waste ("fysisk afrensningsmetode")
Estonia		NORM			
France					

Waste Treatment Options of NORM and/or DU					
Country	Encapsulation	Cementation	Specialised treatment (e.g., deconversion to U_3O_8)	No treatment, direct disposal	Other
					No waste treatment methods for NORM are specified yet.
Germany			DU		Waste treatment methods are dependent on the initial waste form; waste needs to be dry and inert for final disposal for NORM
Greece				NORM	No waste treatment currently for DU, just storage at the moment
Netherlands		DU (being evaluated for final disposal)	DU	NORM	Waste treatment methods for NORM are not carried out; direct disposal is used.
Norway				NORM	No waste treatment for NORM, just direct disposal. No waste treatment for DU, only storage until shipped back to producer.
Poland					No waste treatment methods for NORM, just direct disposal, storage in heaps. No waste treatment methods for DU, only temporary storage.

Waste Treatment Options of NORM and/or DU					
Country	Encapsulation	Cementation	Specialised treatment (e.g., deconversion to U_3O_8)	No treatment, direct disposal	Other
Portugal					For waste treatment methods, only storage without preparation for pre-disposal or disposal.
Slovenia	DU				No treatment of NORM carried out, just direct disposal.
South Korea	NORM DU	NORM DU			
Switzerland	NORM DU	NORM DU		NORM	Plasma burner, if this is looked at as different from vitrification (at ZWILAG) Research waste includes a wide spectrum of waste/radionuclides; therefore, PSI had/has to develop specific treatment options for the specific wastes and get confirmation for these options from the implementer (NAGRA) and regulator (ENSI).
Ukraine		NORM		DU	
	DU		DU	NORM	

Waste Treatment Options of NORM and/or DU					
Country	Encapsulation	Cementation	Specialised treatment (e.g., deconversion to U_3O_8)	No treatment, direct disposal	Other
United Kingdom		NORM	*NORM*		Specialised treatment for NORM (Phosphate mine tailings (contain uranium) → leaching → uranium purification → conversion to U_3O_8)
Totals	**NORM (2)** **DU (4)**	**NORM (6)** **DU (4)**	**NORM (2)** **DU (3)**	**NORM (7)** **DU (1)**	

In further analysis of the waste treatment options implemented by different countries, there were only four countries that implement or consider encapsulation for their NORM and/or DU waste (Slovenia, South Korea, Switzerland and the United Kingdom). Slovenia states that its DU waste is encapsulated and packaged in standard drums before being placed in concrete disposal containers for disposal. South Korea, interestingly, encapsulates both NORM and DU waste within metal drums and concrete reinforced containers and is currently disposing of both waste types in this way. Additional information has been requested from South Korea to understand this process further; however, none was provided in due course of this report being finalised.

No countries selected vitrification as a methodology type and hence it has been removed from the table summary.

Specialised treatment (e.g., deconversion to U_3O_8) was selected by four countries (Germany, the Netherlands, Ukraine and the United Kingdom). Germany states that specialised treatment will be used for long-term storage of DU, and the methodologies implemented will be dependent on the initial waste form. The Netherlands provided information on their current routes for DU, which include specialised treatment (e.g., deconversion to U_3O_8) for long-term storage at COVRA and possible cementation within a Konrad container for final disposal. The vast majority of NORM waste stored at COVRA originates from the uranium enrichment industry. This waste is stored in DV70 containers. In the OPERA (clay) and COPERA (rock salt) safety cases, it is assumed that the DU will be conditioned in a Konrad Type II container and disposed of. Based on the safety case, it is assumed that the calcinate does not go into the final storage facility but can be released.

Several countries do not treat their wastes and just directly dispose of them (either NORM and/or DU when classified as radwaste). As it stands, it is the case of Czech Republic, Greece, the Netherlands, Norway, Switzerland, Ukraine (DU), and the United Kingdom. The results from these questions look at the current disposal route of such waste types, with additional information provided from some countries regarding their future programs. The Czech Republic stated that its unusable DU residues are directly placed in approved packaging sets (double-layered barrels). Greece and Poland have no waste treatment methods currently for DU, just storage. Czech Republic, Greece, the Netherlands, Norway, Poland, Slovenia, and the United Kingdom do not complete waste treatment methods for NORM, just direct disposal. Interestingly, Norway returns their DU stocks to the producer for processing and disposaland Ukraine directly disposes of their DU waste, with no prior treatment. Portugal only has storage without preparation for pre-disposal or disposal. France stated that they have no waste treatment methods for NORM specified yet.

2.4 Disposal program for NORM and/or DU

A summary of whether the country has a disposal program or not, or if there is one in development, is summarised in Table 4. More information is found within Appendix A. These results are directly presented from the submissions received from the questionnaire.

Table 4: Summary of disposal program status for NORM and/or DU for each country, and the type of program is applicable. Further details can be found within Appendix A.

Disposal program for NORM and/or DU				
Country	Yes	No	In Development	Explanation and type if applicable
Austria		NORM		No current/planned disposal program or methods
Bulgaria		NORM DU		Legislative and regulatory aspects regarding NORM to be considered, and opportunities for their management in accordance with the National Strategy for RWM.
Czech Republic	NORM	DU		There is a current disposal program for NORM, NA for DU. There is no DU waste classified as available for disposal. Selected disposal methods for NORM; near surface and dedicated disposal sites Selected disposal methods for DU; near surface. There is no DU waste classified as available for disposal and not considered to change in the near future. No requirement for a disposal program yet.
Denmark		NORM	NORM	No current disposal program data known.

Disposal program for NORM and/or DU				
Country	Yes	No	In Development	Explanation and type if applicable
				According to the Ministry of Health (2020), the authorities are working on a solution for disposal methods (current/planned), but so far primarily sees it as the task of the operators.
Estonia			NORM	Disposal program is in development (silo and near surface facility). NORM waste is suitable for near surface according to WAC. If there will be free capacity in silo NORM waste will be disposed in silo. But it will require re-packaging of the waste as different type of containers will be accepted in silo.
France	NORM	DU		DU is considered recoverable and not a waste to dispose of. No selected methodologies for DU disposal. Selected methods for NORM disposal is near surface (4 disposals sites/ facilities are allowed to handle NORMs)
	NORM	DU		Selected methods for NORM disposal are engineered landfills, shallow depth disposal for the part of NORM classified as LL-LL waste. Landfills in operation, shallow depth is under study. No selected methodologies for DU disposal.
Germany			NORM DU	The current disposal program for NORM and DU is in development – the Konrad repository (DGR) for low and intermediate waste (including NORM) is expected to go into operation by 2029.

Disposal program for NORM and/or DU				
Country	Yes	No	In Development	Explanation and type if applicable
				The selected disposal method for NORM is a deep geological disposal / dedicated disposal site. Deep geological disposal for NORM classified as radioactive waste, dedicated disposal sites for NORM below an activity threshold and therefore, not classified as radioactive waste. No current disposal method for DU – all radioactive waste needs to be disposed of, in DGRs by law.
Greece		NORM DU		There is no current disposal program for NORM or DU. The selected disposal methods for NORM are near surface and dedicated disposal sites. The selected disposal method for DU is near surface, since the considered types of disposal methods in the country are: Near surface with and without engineered barriers, as well as borehole for DSRS, near surface with engineered barriers will be possibly used for DU wastes. The considered types of disposal methods for DU in the country are: 1) Near surface with and without engineered barriers; 2) borehole for DSRS. There was none for NORM as it is considered in the country.
Netherlands	NORM		DU	There is a disposal program for NORM wastes; The majority of NORM waste below the relevant exemption criteria is placed in designated landfill sites for final disposal. The other NORM waste is stored at COVRA and to be disposed of in the far future.

Disposal program for NORM and/or DU				
Country	Yes	No	In Development	Explanation and type if applicable
				There is a disposal program in development for DU; The DU will be placed in a Deep Geological Disposal facility in Clay or Rock Salt.
Norway	NORM	DU		The current disposal plan for NORM wastes is at dedicated disposal sites. No disposal plan for DU as returned to producer.
Poland		NORM DU		No current disposal program for DU or NORM, for NORM, there is no future plan, just storage for now. DU they will 'probably' transfer to the new build near-surface repository for temporary storage. The considered disposal method for DU would be a deep geological facility.
Portugal		NORM DU		Currently no disposal plan for NORM. (safeguards DU is stored) Info from IST (management) No disposal methods are planned for NORM or DU.
Slovenia	NORM		DU	There is a current disposal program for NORM, and one is being developed for DU. NORM is disposed of via dedicated disposal sites – two existing closed disposal sites for the disposal of mine and hydrometallurgical tailings. A near surface disposal site is planned for DU. With a concrete reinforced disposal container.
South Korea	NORM DU			NORM and DU are disposed of via near surface, currently encapsulating the waste. They are within metal drums and concrete reinforced containers.

Disposal program for NORM and/or DU				
Country	Yes	No	In Development	Explanation and type if applicable
Switzerland	NORM DU			There is a current disposal program selected for NORM and DU. NORM and DU waste is included in the wastes in CH, not specifically as NORM and DU. Deep geological disposal has been chosen for both legacy NORM waste—previously conditioned at PSI—and depleted uranium (DU). According to Swiss regulations, all radioactive waste must be disposed of in a deep geological repository (DGR). However, NORM waste not previously conditioned at PSI may be placed in surface disposal facilities under special authorisation, provided it contains no additional artificial isotopes. In such cases, it is exempt from DGR requirements.
Ukraine		DU	NORM	No current disposal plans for NORM or DU. For NORM, to be developed in the coming years as part of the Strategy for the Management of Materials, Equipment, and Waste from the Oil and Gas Industry Contaminated with Naturally Occurring Radionuclides, along with accompanying regulatory documents. For DU, currently DU waste is stored at State Specialised Enterprises for Radioactive Waste Management. Disposal methods for NORM or DU wastes have not been considered or selected in Ukraine.
United Kingdom	NORM		DU	Current disposal method for NORM is Engineered landfills, most NORM waste is disposed of as exempt radioactive waste in landfills that are permitted to accept controlled wastes Disposal program for DU is in development

Disposal program for NORM and/or DU				
Country	Yes	No	In Development	Explanation and type if applicable
			NORM DU	There is no current waste disposal program for NORM or DU Waste disposal methods for NORM, near surface and engineered landfills, either when applicable or when NORM is exempt. Waste disposal method concept for DU is deep geological disposal, which is currently a baseline concept (if classified as waste).

The information collected regarding each country's disposal program for NORM and/or DU highlighted the differences in the level of development across the member states' programs and which countries are already implementing successful solutions.

Austria (NORM), Bulgaria (NORM and DU), Czech Republic (DU), Denmark (DU), France (DU), Greece (NORM and DU), Norway (DU), Poland (NORM and DU), Portugal (NORM and DU) and Ukraine (NORM and DU) have all stated that they do not have disposal programs for these waste type(s). In some cases, there is no disposal program (for DU) nor a plan to develop one, as the material is not classified as waste that requires disposal (Czech Republic and France). Norway highlights that as DU is returned to its producer and therefore, there is no country-wide disposal program. In certain cases, there are suggestions of a disposal program (Poland and Portugal for NORM and DU); however, these have not been classed as 'in development' as there is no active program for developing such currently.

Countries that are already disposing of their NORM and/or DU waste are as follows: the Czech Republic (NORM), using dedicated disposal sites or near surface facilities. France (NORM) already has four near surface disposal sites, whilst also utilising engineered landfills. The Netherlands (NORM), below the relevant exemption criteria, NORM waste is placed in designated landfill sites for final disposal, and other waste is stored at COVRA until it is to be disposed of in the far future. Norway (NORM) is currently disposing of their waste in dedicated disposal sites. Similarly, Slovenia (NORM) disposes of their waste in dedicated disposal sites, with two existing closed disposal sites for mine and hydrometallurgical tailings. South Korea (NORM and DU) interestingly already disposes of both waste types in a Near Surface facility, via encapsulation within metal drums and concrete reinforced containers. Switzerland (NORM and DU) both waste types are noted as having a disposal program, however, upon confirmation no waste has been disposed of until present in Switzerland, but they have selected their final disposal facility option (DGF), as all radioactive waste has to go into a deep geological disposal facility by law. And finally, the United Kingdom (NORM), which utilises engineered landfills, where most of the NORM waste is disposed of as exempt radioactive waste which are permitted to accept controlled wastes.

Several countries are, however, actively exploring disposal methods: Denmark (NORM), Estonia (NORM), Germany (NORM and DU), Slovenia (DU), Ukraine (NORM), the Netherlands (NORM [above exemption criteria] and DU), and the United Kingdom (NORM and DU). Estonia is exploring Silo and Near Surface facilities for their NORM waste, whereas countries like Germany, the Netherlands and the United Kingdom are exploring DGDF.

Out of all the submissions, seven countries are exploring Near Surface (or similar, such as Silo) for their final disposal solution, and there are five countries that have selected a DGDF for either their NORM and/or DU waste. Only 4 (Czech Republic, Greece, Slovenia, and South Korea) specified a Near Surface Disposal Facility for DU waste.

2.5 Key disposal challenges and WAC related issues for NORM and/or DU

The key disposal challenges and any WAC (Waste Acceptance Criteria) information / related issues for NORM and/or DU waste types of the individual countries are summarised in Table 5. These results are directly presented from the submissions received from the questionnaire.

Table 5: Summary of key disposal and WAC challenges for NORM and/or DU waste, including other relevant information regarding the WAC of such waste. Further details can be found in Appendix A.

Key disposal challenges and WAC related issues for NORM and/or DU	
Country	Key disposal challenges detailed
Austria	No information provided.
Bulgaria	No information provided. WAC for NORM and DU is not currently under consideration.
Czech Republic	No information provided. No WAC issues.
Denmark	No information provided
Estonia	Disposal challenges for NORM include: • Conditioning of the waste in a container and subsequent placement to the disposal facility. • If near-surface facility is selected, waste will be grouted inside near-surface facility due to possible crane overload issues. • If silo disposal is selected, the material has to be placed in different containers and will require additional cutting before grouting. No WAC issues: WAC are nuclide based; no other NORM related criteria used.
France	No information provided
	Disposal challenges for NORM; For the LL-LL waste part, a shallow depth disposal has been studied for several years in France. The main challenge is long-term safety for a shallow depth disposal, which is still under definition. WAC for NORM; Level of massic activity (under 100 Bq/g for engineered landfills), activity of Thorium, Radium, Uranium contained. There is no WAC defined for the shallow depth disposal project.
Germany	No specific disposal challenges for NORM, the WAC applied to those wastes as well. Nor challenges for DU.
Greece	No information provided
Netherlands	Disposal challenges for NORM; linked to the possible change of directives and, therefore, requirements for managing NORM waste.

Key disposal challenges and WAC related issues for NORM and/or DU	
Country	Key disposal challenges detailed
	Challenges for DU disposal; The Netherlands has a reasonably large quantity of DU in relation to other waste forms requiring disposal in a deep geological disposal facility. Due to the large volume and the fact that the radiotoxicity of DU does not decrease over time, it is important to demonstrate safety on a very long scale for this waste stream. Something that can be evaluated to help reduce costs is to reuse the DU more effectively during disposal, rather than requiring thousands of containers.
Norway	Challenge of disposal for NORM is Organic radioactive waste has no treatment and disposal options. Large inventory of NORM is costly to dispose of. WAC for NORM: According to Regulations on the application of the Pollution Control Act on radioactive pollution and radioactive waste based on the specific activity of material: Ra-226 (NORM-waste) specific activity conc < 1 Bq/g not radioactive waste Ra- 226(NORM-waste) specific activity conc > 1 Bq/g and < 10 Bq/g hazardous waste / radioactive waste may either be disposed-off at licensed repository or discharged on getting a license from DSA. NORM-waste specific activity conc > 10 Bq/g and total activity > 10.000 Bq radioactive waste to be disposed-off at licensed repository No WAC information for DU.
Poland	Disposal challenges for NORM, are difficult to comment on, ''but maybe full protection of existing mining waste heaps. Disposal challenges for DU, would be moving the DU from temporary storage and from existing repository which will be closed in the coming years, to the new facility. No WAC for NORM, and only safe packing required for DU.
Portugal	No planned route. No WAC is being applied.
Slovenia	NORM disposal challenges include long-term monitoring and maintenance of closed disposal sites. DU disposal challenges include final packaging in disposal containers. WAC for NORM, is site/ facility specific, regulated by rules on radioactive waste management and approved by the national regulator. WAC for DU, for interim storage there is WAC for storage facility and for disposal with WAC.
South Korea	No information provided

Key disposal challenges and WAC related issues for NORM and/or DU	
Country	Key disposal challenges detailed
Switzerland	Disposal challenges for NORM and DU are conditioning recipes for waste from industry and research. The WAC for NORM and DU are defined by ENSI (regulator) which should be in accordance with IAEA guidelines.
Ukraine	No detailed challenges WAC for NORM; TENORM-contaminated pipes are accepted as gamma-emitting radioactive waste with unknown specific activity, using classification as "low" or "medium" active based on the criterion of absorbed dose rate in air at a distance of 0.1 m from the surface where the radioactive waste is located. Sludges, after conditioning and solidification, are accepted as solid radioactive waste based on specific activity, which is the classification criterion for assigning these radioactive wastes to a particular category. To be developed in the coming years as part of the Strategy for the Management of Materials, Equipment, and Waste from the Oil and Gas Industry Contaminated with Naturally Occurring Radionuclides, along with accompanying regulatory documents.
United Kingdom	Key disposal challenges for DU; Identifying a suitable location for disposal of DU, as part of wider siting. WAC challenges for DU; Site / facility specific WAC and/or Conditions for Acceptance for pre-treatment (deconversion) of DU and for consolidation of DU at the Capenhurst site. Disposal is not yet implemented and a GDF is not yet available so there are no associated WAC at this time. The generic specification for waste packages containing DNLEU can be regarded as preliminary WAC for geological disposal of DU in the UK.
	NORM disposal challenges include the uncertainty in waste generation (volume and timing) from industrial activities and contaminated land and therefore volume/type of waste and treatment/disposal capability requirements. DU disposal challenges include – (If considered Waste) Volume of material contributing to GDF footprint, concept optimization for site specific considerations and efficiency, R&D on performance demonstration for safety case. WAC issues for NORM; for NORM waste to landfill an annual mass limit per consignor is applied based on specified dose criteria. For NORM waste at the Low-Level Waste Repository the radiological and non-radiological capacities are defined for the site.

There were several key disposal challenges highlighted by the different countries, which are provided in Table 5. The relevant challenges are summarised below, highlighting the issues per waste stream, NORM and DU.

NORM waste:

- Practical Logistics: such as, (i) no current waste treatment (or conditioning solutions, etc.) or disposal program being developed. (ii) Conditioning the waste within a container and subsequent placement within the disposal facility. (iii) The weight of the waste, once grouted, and possible crane overloading issues. (iv) Cutting and size reduction of waste, once put into a container.
- Assessments and Costs: such as, (i) long-term safety, monitoring and maintenance of disposal sites. (ii) Creation of a safety assessment within an acceptable economic methodology.
- Volume and Timeline: such as, (i) large inventory that is to be dealt with, difficult in planning for unknown volume and timings of such. (ii) Understanding the requirements for capability and capacity.

For DU waste:

- Practical Logistics: such as, (i) the movement of waste from temporary storage to a new facility. (ii) Final packaging in disposal containers. (iii) Conditioning recipes for the waste. (iv) Locating a suitable location for disposal (i.e., DGDF).
- Assessments and Costs: such as, (i) radiotoxicity does not decrease over time, therefore, requiring safety demonstrations on long timescales (i.e., costly). (ii) Assessment on how to reduce the cost required, so the number of containers required for final disposal can be reduced. (iii) Demonstrating safety within the volume of material contributing to the DGDF footprint.
- Volume and Timeline: such as, (i) large quantities of DU compared to other waste types.

From the summarised topics, it can be seen that generally the countries experience different challenges, for the different waste types; however, they all fit within three generalised topics.

- ‘Practical Logistics’ looks into how the waste will be dealt with practically, from its current storage location and chemical state to how it will be, for example, conditioned, re-packaged and moved into its final storage location.
- ‘Assessment and Costs’ looks at long-term safety and monitoring of the facilities, including obtaining safety assessments of such, as well as how to reduce costs within the selected final disposal solution.
- ‘Volume and Timeline’ looking at the volume of waste that some countries hold, and ensuring planning within capability and capacity is appropriately dealt with, ensuring timelines match with final disposal requirements.

2.6 Safety Case

A summary of each country's safety case, radiological impact assessment, and current stance is detailed in Table 6. These results are directly presented from the submissions received from the questionnaire

Table 6: Summary of information provided regarding safety case and radiological impact assessments for NORM and/or DU wastes. More information from each country can be found within Appendix A.

Safety Case	
Country	Safety case and radiological impact assessment details for NORM and/or DU
Austria	No information provided
Bulgaria	In general, the safety cases have been developed with respect to RAW from NPPs and the industrial sector, medicine, etc., but for now, these for NORM/DU are not being considered. Radiological impact assessment: It is not known whether this has been considered so far for NORM/DU. On the other hand, the uranium mining sites in Bulgaria have been subject to monitoring and radiological impact assessment after their closure about 35 years ago.
Czech Republic	The Czech Republic has a safety case for NORM; a safety case of the dedicated repository, and a safety evaluation for other licensed ways of management (treatment, storage, disposal ...). NA safety case for DU. Safety case of the dedicated facility is available for licensed ways of management (treatment, storage). Post-closure safety is evaluated as a part of the repository safety case (only for RW). At present, DU is not present in the repository, so it has not been evaluated, but NORM has. Timeframes are set up to 100 000 yrs. after closure. The answer is valid just for RW disposal.
Denmark	No information provided
Estonia	The safety case is in development, and NORM waste is covered. Preliminary post-closure safety assessment is done. Covered elements so far in safety case: safety policy and objectives, system/facility description, hazard and risk assessment, safety measures and controls, monitoring and continuous improvement. So far, radiological safety has been demonstrated through the safety assessment. Timeframes considered are, 100 000 years for silo and 15 000 years for near-surface facility.
France	No information provided
	There is a safety case for NORM (for the radioactive waste disposal).

Safety Case	
Country	Safety case and radiological impact assessment details for NORM and/or DU
	No information provided for DU – not considered waste in France Preliminary safety studies have been carried out for the NORM low-level long-lived waste in a shallow depth disposal project. For NORM studied for a shallow depth disposal: a “classical safety case” is implemented before 50 000 years (normal evolution scenarios, altered evolution scenarios and human intrusion scenarios). After this period due to the very long half-life of radionuclides, specific safety scenarios are studied with extreme degradation of safety functions according to a conventional approach.
Germany	Germany has a safety case for NORM and DU. Long-term safety assessment for both NORM and DU has been done for all waste approved to be disposed of in the Konrad repository (DGR). The assessment is checked and updated every 5 years. Timeframes for the safety case are 1 million years
Greece	No safety case for NORM or DU. There is a radiological impact assessment for phosphogysum sites.
Netherlands	The Netherlands has a safety case for NORM. The safety case for DU is in development; safety case for DU waste has been performed as part of the OPERA and COPERA research programs managed by COVRA. The radiological impact assessment for the period after closure for NORM; Mineralz Maasvlakte BV has obtained a license from the Dutch nuclear safety authority ANVS to dispose of low active NORM in a landfill (C3 deponie). DU will not be disposed of in a landfill. In the safety case for disposal in a clay formation, doses and radiotoxicity concentration in biosphere water have been calculated for the normal evolution scenario. Time frames for NORM safety case NA. Time frames for DU safety case are as follows: DU will not be disposed of in a landfill. In the safety case for disposal in a clay formation, the radiotoxicity concentration in biosphere water has been calculated over a billion years. It is indicated that, at these times, the calculation basis becomes highly stylised and is largely illustrative because considerable changes would be expected to occur in both the biosphere and the geosphere.
Norway	Norway has a safety case for NORM, but not DU.

Safety Case	
Country	Safety case and radiological impact assessment details for NORM and/or DU
	The basic elements of long-term safety assessment for NORM are scientific assessments, engineering barriers, and regulatory oversight.
Poland	No safety case for DU or NORM, or radiological impact assessment.
Portugal	At present, there is no established safety case for the disposal of NORM or for using DU as a safeguard. This gap underscores the urgent need for comprehensive assessments to ensure that these materials are managed safely and responsibly.
Slovenia	Slovenia has a safety case for NORM; it was not directly a part of the safety case for LILW repository (in construction), but was/is part of the safety analysis report for closed disposal sites Jazbec and Boršt (mine and hydrometallurgical tailings). They have a safety case for DU. A post-closure radiological impact assessment has been completed for NORM and DU, as it was a condition to close both the disposal sites / the repository for the DU. No specific timeframes were defined for NORM, both sites are closed and long-term monitoring and maintenance is performed without time limitation. No specific DU timeframe, an overall timeframe based on other radioactive waste inventories is considered.
South Korea	South Korea has a safety case for NORM and DU. Radiological impact assessment has been performed looking at Engineered and Natural Barrier, Regulatory Compliance and Standards, Monitoring and Surveillance. Timeframe for NORM and DU; depending on national regulations, international guidelines, and the characteristics of the disposal site.
Switzerland	Safety case not applicable to NORM and DU, as they are included in the waste type inventory and for all wastes, there is a safety case defined (in CH). Radiological impact assessment is part of a general license application sent November 2024 from Nagra to ENSI. Timeframes for safety case is 100 000 years.
Ukraine	No safety case for NORM or DU. Ukraine does not have a post-closure radiological impact assessment for NORM or DU wastes.

Safety Case	
Country	Safety case and radiological impact assessment details for NORM and/or DU
	Due to the absence of relevant legislation, time intervals have not been defined
United Kingdom	The UK has a safety case for NORM; for NORM disposal at the LLW Repository, an environmental safety case has been produced. N/A safety case for DU. A generic disposal system safety case has been published (in 2016). DU is included. However, as no disposal facility has been identified for DU there is not a site-specific safety case (as pertains to definition in footnote 1). For NORM wastes, a radiological impact assessment has been performed for the LLW Repository. Timeframe for NORM waste - 'Long-term' means at all times after the completion of disposal and the end of active institutional control of the site (currently anticipated to be 2230 AD for the EDA).
	The UK has a safety case for NORM – environmental safety case. Safety case for DU; If classed as waste a Generic disposal System Safety Case for GDF will require inclusion for DU and Operational and Post Closure Safety Cases. Radiological impact assessment for NORM; for wastes sent to Low Level Waste Repository impacts are considered in the Environmental Safety Case. Radiological impact assessment for DU; - assumptions for the potential inventory of DNLEU for disposal was modelled within the generic Disposal System Safety Case, Total System Model. Timeframe for NORM; Low Level Waste Repository Environmental Safety Case considered active control of the site for 100 years. Timeframe for DU; the Generic Disposal System Safety Case assumes geological stability for 300,000 years post GDF closure where there is increasing levels of uncertainty in environmental changes beyond this time scale.

In summarising the safety case results from each country, there are several countries who have either provided no information or there is no safety case in place for final disposal as of yet (Austria, Bulgaria, Denmark, France (one submission), Greece, Poland and Portugal).

Countries that provided information on their current techniques for disposing of NORM and/or DU waste have provided information on their safety case and/or radiological impact assessment; Czech Republic, France, Germany, Greece (radiological impact assessment for phosphogysum sites, no safety case), the Netherlands, Norway, Slovenia, South Korea, Switzerland (not an individual safety case, but within safety case for all wastes) and the United Kingdom.

For DU, it is seen that most countries are in development phase of such a safety case, as this is dependent on their final disposal site selection (Germany, the Netherlands and the United Kingdom). Slovenia and South Korea, however, state that they do have a safety case for DU. Slovenia also states that a post-closure radiological impact assessment has been completed for NORM and DU, as it was a requirement in order to close both the disposal sites / the repository for the DU. The disposal sites in Slovenia are Near Surface Disposal facilities.

2.7 Workshops and follow up

A summary of each country's willingness to be a part of future collaboration and workshops is summarised in Table 7, including the general topics they would benefit from being a part of. Further details regarding their exact workshop and follow up, research priorities and international collaboration interests can be found in their individual subsections contained within Appendix A.

From the table below 'Inventory Management Techniques' include those detailed in Section 2.1, such as reuse and recycling, as well as waste characterisation techniques.

Table 7: Summary of countries that would like to be involved in additional workshops and future discussions, within pre-selected generalised topics. Future details can be found in Appendix A.

Generalised Topics of Interest					
Country	Inventory Management Techniques	Waste Treatment & Disposal Technologies	Safety Case Development	Long-term Monitoring and Surveillance	Other
Bulgaria	NORM, DU	NORM, DU	NORM, DU		
Czech Republic	NORM, DU	NORM, DU	NORM, DU	NORM, DU	
Denmark	NORM	NORM	NORM	NORM	
Estonia		NORM	NORM		Gas emissions solutions for disposal of Ra-226
France 2		NORM	NORM		Chemical toxicity of uranium Long term uncertainties Impact of climate change
Germany	NORM, DU				
Greece	NORM	NORM, DU	NORM, DU	NORM	
Netherlands	NORM, DU	NORM, DU	NORM, DU	NORM, DU	
Norway	NORM	NORM, DU	DU	NORM	Strategies for management of radioactive waste with TOC (total organic

Generalised Topics of Interest					
Country	Inventory Management Techniques	Waste Treatment & Disposal Technologies	Safety Case Development	Long-term Monitoring and Surveillance	Other
					carbon) > 10 % (NORM)
Poland	NORM, DU	NORM, DU	NORM, DU		
Portugal	NORM, DU	NORM, DU	NORM, DU	NORM, DU	
Slovenia	NORM, DU	DU	NORM, DU	NORM, DU	
South Korea	NORM, DU	NORM, DU			
Ukraine	NORM	NORM	NORM	NORM	
United Kingdom 1	DU	NORM, DU	NORM, DU	NORM, DU	Identifying opportunities for enhanced application of the waste hierarchy with respect to DU
United Kingdom 2	DU	NORM, DU	NORM, DU		
Totals	**NORM (12) DU (10)**	**NORM (14) DU (11)**	**NORM (13) DU (10)**	**NORM (9) DU (5)**	

From the information collected in Table 7 the following can be concluded:

- NORM dominance: Higher coverage in all categories, suggesting it remains the bigger operational and regulatory concern, even amongst those countries with both waste types.
- DU relevance: Strong presence in Waste Treatment & Disposal Technologies, as well as Safety Case development.
- Special interests: Climate change, chemical toxicity, gas emissions, high TOC (high total organic carbon) waste management, and international DU practices were highlighted as side topics.

The results from the workshop participation interest, is summarised further in Table 8 below. Highlighting any additional notes provided by the participants.

Table 8: Summary of results related to follow-up workshops and topics requiring further attention

Topic	NORM Mentions	DU Mentions	Notes
Inventory Management Techniques	13	10	Similar relevance across both waste types. Interesting in reuse and recycling techniques mentioned frequently throughout questionnaire results.
Waste Treatment & Disposal Technologies	15	11	Selected most for both waste types. Key discussion points for future workshops and collaboration.
Safety Case Development	14	10	Key topic across both waste categories.
Long-term Monitoring and Surveillance	10	5	Least prevalent. Highlighting a potential knowledge gap
Other	Various	Various	Topics included gas emissions from Ra-226, uranium toxicity, TOC > 10% disposal strategies, regulatory requirements for DU, and climate change impacts.

3. Workshop Result

In September 2025, the Second Workshop for this EURAD- 2 ASTRA work package was held.

Upon analysis of results obtained from the Questionnaire (see details above), four country representatives within this group were contacted and requested to participate in the Workshop.

The presentations included the following.

- The United Kingdom: An overview of DU management within the UK and research and development opportunities
- France: Management of NORM waste in France
- Czech Republic: Czech Safety Case
- Slovenia: Overview of remediation and closing program for disposal sites Jazbec and Boršt at the closed uranium mine Žirovski vrh.

These presentations from the four different countries, covered varied topics found within this work package's questionnaire. Sharing their own countries approach to waste management of these waste forms (i.e., NORM and DU), as well as providing information on safety case processes and ultimate site remediation.

This sharing of information was successful in showcasing the varied approaches, technologies and methodologies carried out by different countries.

The presentations can be found in Appendix C.

4. Conclusions and Recommendations

From the collected results across the 17 different countries, it can be seen that there are variations between their approaches to dealing with NORM and/or DU waste types. This is dependent on the waste type definition (i.e., the exemption limits for radioactive waste or if it is seen as a resource (DU)), the amount of waste the country holds, the stage of development of their disposal route (i.e., in draft or operational), the amount of R&D completed within the country for the waste type and if it is linked to the final disposal of said waste type, and finally the legislation of the country which determines how the waste should be handled.

From the individual Sections 2.1 to 2.7, a summary of the results for the different topics has been presented, and the following key conclusions and recommendations are shown below:

1. **Waste Management Options for NORM and/or DU:** from the different waste management options, it was seen that waste minimisation was not seen as a particularly challenging and those who selected it are currently carrying out processes which indeed reduce their waste volume. There was limited information on pre-treatment completed by the different countries, as well as treatment methodologies. A common theme across the different countries (and through other topics of questions) highlighted that conditioning of waste (i.e., grouting or cementation) is being carried out, or planned to be completed for final disposal. However, more information could be collected on this process, to encourage sharing between those countries with suitable cementation mixtures, processes and technologies for conditioning their waste compared to those countries that have not yet completed this waste management option.
2. **Reuse and Recycling of NORM and/or DU:** This topic highlighted a range of challenges across different countries - from those lacking any processes for DU reuse or recycling, to those facing difficulties in applying specific solutions. The collected results highlighted two key issues: effective approaches already exist in other countries, underscoring the need for stronger international collaboration, and in order to reduce waste volumes and implement economically viable strategies, further research into the reuse and recycling potential of these waste forms is warranted. Such efforts could help integrate reuse and recycling options into final disposal plans, ensuring that materials are recovered and utilised where possible before being consigned to permanent storage.
3. **Waste Treatment Options for NORM and/or DU**: These answers showcased the variation in approach between the different countries, with many stating that no treatment is completed and only storage is currently carried out until final disposal. There were a few countries implementing different waste treatment options; however, compared to the majority, there should be more research/sharing of research that is being completed into different waste treatment options between the different member states. As well as the details of the methodologies implemented. This topic highlighted some information gaps on the specific details regarding the waste treatment options implemented and through further discussions and knowledge sharing a deeper understanding of the processes being carried out effectively could be obtained.
4. **Disposal Program for NORM and/or DU:** The results showed that there are 8 countries which currently have a disposal methodology for NORM waste. Either a near-surface, dedicated disposal site or engineered landfills seem to be most commonly used currently. Due to the exempt nature of NORM waste, the majority of countries that can already dispose of NORM do

so due to available waste acceptance criteria. However, an expectation that once a long-term final disposal site decision is made, and subsequently built, the NORM waste that cannot be disposed of via these exempt criteria, will be deposited in these sites. The longer term / in development sites include a DGDF, Near Surface, engineered landfills or a shallow depth disposal facility. More information should be collected on how the different options were assessed and the decision was made as to which disposal site type was selected. For DU waste, there is only one country currently disposing of its DU waste, South Korea. However, confirmation of methodology from a request for additional information was never received. Switzerland has already selected its disposal program for NORM and DU (DGDF for all radioactive waste is required by law) and four other countries are in the process of developing their solution for final disposal of DU. Exploration of understanding their selection processes as well as their research into developing a solution should be explored further through knowledge sharing, to try and understand the key factors that enabled them to make their decision in-line with inventory, safety, and economical requirements.

5. **Key Disposal Challenges:** This section highlighted the key disposal challenges from each country, highlighting that three general topics need further investigation: 'Practical Logistics', 'Assessment and Costs' as well as 'Volume and Timelines'. Additional collaboration between the member states should be continued to share and explore solutions to these problems.
6. **Safety Case:** The results from the safety case and radiological impact assessment section showed that many countries have a safety case for their NORM waste – if they are disposing of the waste currently, some form of safety case / radiological impact assessment has been completed in order to perform the appropriate disposal methodology. Many countries who hold DU, are still in the process of developing a safety case, alongside their final disposal solutions. However, Slovenia and South Korea have stated that they already hold a safety case for DU. Additional information should be collected from these countries about the development of such. This section was seen to highlight the key information regarding having (or not) having a safety case, however, it is suggested that further information gathering is completed within this topic to understand how countries have obtained their safety cases for disposing of these wastes (i.e., NORM and DU) and how they plan to approach this task for their final disposal sites.

5. List of Tables

6. References

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Appendix A - Country responses

Austria

Organisation – NTW.

Role – CSO.

EURAD college - TSO

1 Waste Inventory and Management

Austria has NORM waste with the following definition 'The Austrian legislation defines the conditions under which naturally occurring radioactive material falls under the provisions of the radiation protection legislation. If such material is declared as radioactive waste, it is subject to the same requirements as other radioactive waste and is considered to be radioactive waste for the purpose of the Convention.'

Type of NORM waste:

- Extraction of rare earth elements
- Oil and gas production (only in a few cases radiologically relevant)
- Production of phosphate fertilizers
- Ground water filtration facilities (industrial or commercial use of materials having high contents of Uranium or Thorium e.g. use of abrasives for sandblasting)
- Deep geothermal energy production
- Radon spas
- Quantity: More than 14g of Radium were conditioned and are in interim storage (as of 2019). NORM: "no large amounts" according to latest Joint Convention Report, no further data publicly available.

Management of NORM is carried out via a centralised national registry, however, there is no information regarding NORM waste that is not classified as radioactive waste.

If classified as radioactive waste, NORM is managed via storage options, where it is conditioned and stored in interim storage, no information on the type of conditioning completed. NES is responsible for this storage.

2 Reuse and Recycling

No reuse or recycling completed/ planned to be implemented.

3 Waste Treatment

No waste treatment information collected.

4 Disposal Options

No current / planned disposal program or methods. No information on containers / disposal challenges or WAC issues.

5 Safety Case

No information provided on the safety case-related questions for the disposal of NORM.

6 Workshops and follow up

No information provided on workshops or follow up questions.

7 Additional information

No additional information provided.

Bulgaria

Company – Technical University of Sofia (TUS).

Role – TUS is not involved in this area and considered general public information only.

1. Waste Inventory and Management

Bulgaria has neither NORM nor DU.

Type of NORM may arise from past mining.

There is no such public information on the quantity, management of inventory, management options, or systems of these types of waste.

2. Reuse and Recylcing

There is no such public information on the quantity, management of inventory, management options, or systems of these types of waste.

3. Waste Treatment

There is no such public information on the quantity, management of inventory, management options, or systems of these types of waste.

4. Disposal Options

WAC for NORM and DU is not currently under consideration.

Legislative and regulatory aspects regarding NORM to be considered, and opportunities for their management in accordance with the National Strategy for RWM.

5. Safety Case

In general, the safety cases have been developed with respect to RAW from NPPs and the industrial sector, medicine, etc., but for now, these for NORM/DU are not being considered.

Radiological impact assessment: It is not known whether this has been considered so far for NORM/DU. On the other hand, the uranium mining sites in Bulgaria have been subject to monitoring and radiological impact assessment after their closure about 35 years ago.

6. Workshops and follow up

Bulgaria would like to be involved in workshops and follow up, for the following topics.

- Safety case methodologies (NORM and DU)
- Inventory management (NORM and DU)

Research priorities:

- Waste characterisation and inventory management (NORM and DU)
- Development of safety case methodologies (NORM)

International collaboration topics:

- Development of safety case methodologies (NORM and DU)
- Waste treatment and disposal technologies (NORM and DU)

7. Additional information

Not known if future projects are occurring.

Czech Republic

Company – SURO.

Role – TSO/ Technical support.

1. Waste Inventory and Management

The Czech Republic have both NORM and DU wastes, with the following definitions 'Radioactive waste containing only natural radionuclides (i.e. sealed radionuclide sources with Ra-226 - radioactive needles and Ra-Be neutron sources, possibly Ra-226 contaminated materials from research, Ra-226 labelled instrument dials, DU processing waste, some NORM waste) is conditioned and disposed of in RW repository. In fact, the waste is not classified as NORM waste, but simply as radioactive waste containing natural radionuclides. NORM waste, the radionuclide content of which allows release from the workplace (to the environment, e.g. to conventional waste disposal sites or its combustion), is not considered as RW. NORM waste whose radionuclide content does not allow release from the workplace (into the environment, e.g. conventional waste landfills), but must be permanently isolated, is considered RW)

Type of NORM wastes:

- Coal combustion products
- Products of mining activities (mining waste)
- Oil and gas industry
- Waste from groundwater treatment
- Production of titanium white
- Primary iron production and from the use of zirconium
- Waste from oil and gas industry
- Uranium mining is not considered as a NORM industry

Quantity of NORM; at present, the total volume of this waste is up to 600 m^3, actual production is very low, lower units of cubic meters per year.

Quantity of DU; DU waste is not actually considered as a special category of waste, but DU waste represents the largest volume of currently disposed of RW containing natural radionuclides. WAC assess the activity limit of 238U nuclide. The limit of the U-235 nuclide is determined within the alpha-bearing nuclides category. This category is not a part of the RW inventory. The RW producer can condition some amount of DU as a RW. It is declared as RW containing nuclear material (conditioned or retained waste) with declared activity of U-238. This amount of DU/U-238 is calculated as part of the RW inventory.

Inventory management of NORM is carried out via a centralised national registry, which contains all RW containing natural radionuclides. A complete inventory of NORM waste not considered as RW is not kept.

Waste management options for NORM include waste minimisation at source, pre-treatment, treatment, reuse/recycling, conditioning, storage and disposal. Blending of radioactive waste with non-radioactive material is prohibited. Many residues from the NORM industry, if they cannot be recovered, are disposed of as waste in conventional landfills, including hazardous waste landfills (i.e. the process of release from NORM workplaces) or in tailing ponds. No solution is available for the removal of radioactive scales from scrap metal (pipes from water treatment, mining and spa industries). (Note on reuse/recycling - Radioactive waste is returned to production where possible, and NORM wastes are processed in the uranium industry.)

Waste management of DU includes waste minimisation at source and then conditioning. DU is still declared as a raw material by its producer. The declaration of DU as a waste is unlikely in the near future. DU is the category of nuclear material, and it is stored separately from RW (mainly shielding, metal scraps, etc.). This category is not a part of the RW inventory. The RW producer can condition some amount of DU as an RW. It is declared as RW containing nuclear material (conditioned or retained waste) with declared activity of U-238.

The waste management system responsible persons for NORM are as follows: Waste producer - waste minimisation at source, pre-treatment, treatment, reuse/recycling, conditioning, storage; (Private) landfill operator - operation of the landfill, placement of NORM waste in the landfill; State-owned organisation (SURAO) – disposal.

The waste management system responsible persons for DU are as follows: Waste producer - waste minimisation at source, treatment, conditioning, storage; State-owned organisation – disposal (no DU is declared by disposal), DU storage in the repository.

2. Reuse and Recycling

Reuse/recycling of the waste currently; Residues from production are returned to production where possible (e.g. cement production, iron production). This practice also applies to the production of depleted uranium shielding, thus minimising waste (RW). NORM waste of a mineral nature (mining waste, coal combustion product and other suitable waste) is used for reclamation purposes. Ionex cartridges used to remove uranium from drinking water are processed in the uranium industry.

Reuse within a disposal facility for NORM; NORM waste is used as backfill material. Waste activity is measured; if its derived criteria are not exceeded (which means that E is less than 0.3 mSv/year), the waste may be used as follows.

No available practice for reuse within a disposal facility for DU

3. Waste Treatment

Waste treatment methods for NORM include cementation, no treatment, and direct disposal; regulatory body approves limits and conditions of the solidification process of radioactive waste, with respect to the facility (storage, disposal).

Waste treatment methods for DU include cementation; unusable DU residues are directly placed in approved packaging sets (double-layered barrels). DU is a category of nuclear material. The RW producer can condition some amount of DU as an RW. It is declared as RW containing nuclear material (conditioned or retained waste) with declared activity of U-238

4. Disposal Options

There is a current disposal program for NORM, but not for DU. There is no DU waste classified as available for disposal. DU is the category of nuclear material, and it is stored separately from RW (mainly shielding, metal scraps, etc.). This category is not a part of the RW inventory. The RW producer can condition some amount of DU residues as an RW. It is declared as RW containing nuclear material (conditioned or retained waste) with declared activity of U-238. This amount of DU/U-238 is calculated as part of the RW inventory. DU residues are placed directly in approved packaging sets (216-litre drums or double drums with an inactive layer) and stored in a radioactive waste repository (Richard repository for institutional RW).

Selected disposal methods for NORM; near surface and dedicated disposal sites. Near surface disposal and/or dedicated disposal sites – currently used near surface disposal – The Bratrství radioactive waste repository was constructed in a part of the abandoned uranium mine Bratrství. Only low- and intermediate-level waste containing exclusively natural radionuclides is disposed of in the repository. Disposal in the Bratrství repository is considered only for small quantities of high-activity NORM.

Selected disposal methods for DU: near surface. There is no DU waste classified as available for disposal. For the near future, there is no indication of a change of this state. Possibly DU waste could be disposed of in Bratrství near the surface repository. There is no DU waste classified as available for disposal. For the near future, there is no indication of a change in this state. The DU residues are directly placed in approved packaging sets (Drum 216 l, or double drum with an inactive layer) and stored in a Richard radioactive waste repository (underground complex of the former Richard II limestone mine - repository for institutional waste, which is produced in the healthcare, industry, agriculture and research sectors).

Drum 216 l, or double drum with an inactive layer, both for radioactive waste containing natural radionuclides.

WAC for NORM; WAC approved for the dedicated repository (e.g., total activity, volume activity, mass, surface contamination, dose rates, leachability, stress resistance, and other).

WAC for DU; WAC approved for the dedicated repository (e.g., total activity, volume activity, mass, surface contamination, dose rates, leachability, stress resistance, and other). WAC assess the activity limit of the U-238 nuclide. The limit of the U-235 nuclide is determined within the alpha-bearing nuclides category.

5. Safety Case

The Czech Republic has a safety case for NORM, including a Safety case for the dedicated repository, and a safety evaluation for other licensed ways of management (treatment, storage, disposal).

NA safety case for DU. Safety case of the dedicated facility is available for licensed ways of management (treatment, storage).

Post-closure safety is evaluated as a part of the repository safety case (only for RW). At present, DU is not present in the repository, so it has not been evaluated, but NORM has.

Timeframes are set up to 100,000 years after closure. The answer is valid just for RW disposal.

6. Workshops and follow up

They would like to be involved with workshops and follow up, for the following topics;

- Safety case methodologies (NORM and DU)
- Long-term disposal strategies (NORM and DU)
- Reuse and recycling options (NORM)

Research priorities;

- Waste characterisation and inventory management (NORM and DU)
- Development of safety case methodologies (NORM and DU)
- Reuse and recycling technologies (NORM)
- Long-term safety assessment and modelling (NORM)
- Communication and transparency with the public (NORM)

International collaboration topics;

- Development of safety case methodologies (NORM and DU)
- Waste treatment and disposal technologies (NORM and DU)
- Long-term monitoring and surveillance (NORM)
- Reuse and recycling strategies (NORM)

7. Additional information

No additional information was provided within the initial survey. Information was provided in a Word document following additional questions asked of the Czech Republic. The information is summarised below.

References provided:

[1] Act No. 263/2016 Coll., Atomic Act, available here.
[2] Decree No. 422/2016 Coll., on radiation protection and security of a radionuclide source.
[3] National report of the Czech Republic under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management issued by: State Office for Nuclear Safety, Prague, 2024, available here.
[4] ACT No. 44/1988 Coll., on the protection and utilisation of mineral resources, available here.
[5] Act No. 541/2020 Coll., Waste Act, available here.
[6] Act No. 157/2009 Coll., on the Management of Mining Waste and on Amendments to Certain Acts, available here.

Conditions for the release of materials contaminated with natural radionuclides into the environment

The main legislative requirements are listed in the Atomic Act No. 263/2016 Coll.[1] and Decree on radiation protection No. 422/2016 Coll.[2]

Licensees operating facilities with probable higher exposure to natural radionuclides are obliged to:

- prevent the aggregation of radioactive substances intended to be released,
- assure measurement and determination of radionuclide activity released from the facility, including the cases bound to reuse and recycling, the extent, method and way of evaluation are set by the Dec. no. 422/2016 Coll.[2],
- provide evidence of measurement, and to provide the results of measurement to the regulator, the extent and frequency are set by Dec. no. 422/2016 Coll. [2],
- have ready and follow the internal document concerning the management of released radioactive substances, the content is set by Dec. no. 422/2016 Coll.[2],
- using the released radioactive substance as a building material must be announced to the building material producer, with the specification of the released material and its activity,
- respect values of release activities from the facility and conditions which are declared as exceeding the limits set by Dec. no. 422/2016 Coll.[2].

Release from facilities showing probable higher exposure to natural radionuclides, radioactive substances can be released **without regulator authorisation** in the case that clearance levels are not exceeded.

Radioactive substances can be released from the facility with natural radionuclides **without regulatory body authorisation,** also in the case that the effective dose of each affected person caused by radioactive substance release during a calendar year is lower than 0,3 mSv. This rule is valid for building material as well, but it is necessary to be announced to the regulator 60 days before the action, with specification of:

- type of released substance,
- activity of released radionuclides,
- time and extent of release,
- identification of building material producer,
- submit to the regulator an annual report on outlets monitoring

Release levels for facilities showing the possibility of probable higher exposure to natural radionuclides are:

For solid materials (landfill, reuse, recycle, incineration):

- mass activity of natural radionuclides from the row U-238 – 1 kBq/kg.
- mass activity of natural radionuclides from the row Th-232 – 1 kBq/kg.
- mass activity of K-40 – 10 kBq/kg.

Release level is not exceeded if the average mass activity of a single radionuclide is not exceeded.

Release levels for outlet drainage to surface waters are:

- average volume activity alpha in all substances 0,5 Bq/l, total volume activity beta without activity K-40 in all substances 1 Bq/l.

Release level is not exceeded if the average volume activity alpha or average volume activity beta without K-40 activity is not higher than the release level.

Release levels for outlet public drainage to the canal are:

- average volume activity alpha in all substances 50 Bq/l, total volume activity beta without activity K-40 in all substances 100 Bq/l.

Release level is not exceeded if the average volume activity alpha or average volume activity beta without K-40 activity is not higher than the release level.

Average values mentioned above are related to released masses or volumes, which can be considered homogeneous. The condition of homogeneity is defined by Dec. no. 422/2016 Coll.[2].

Figure 2 shows the usual scheme used to assess materials and facilities/workplaces with a potential risk of NORM occurrence and probable higher exposure to natural radionuclides.

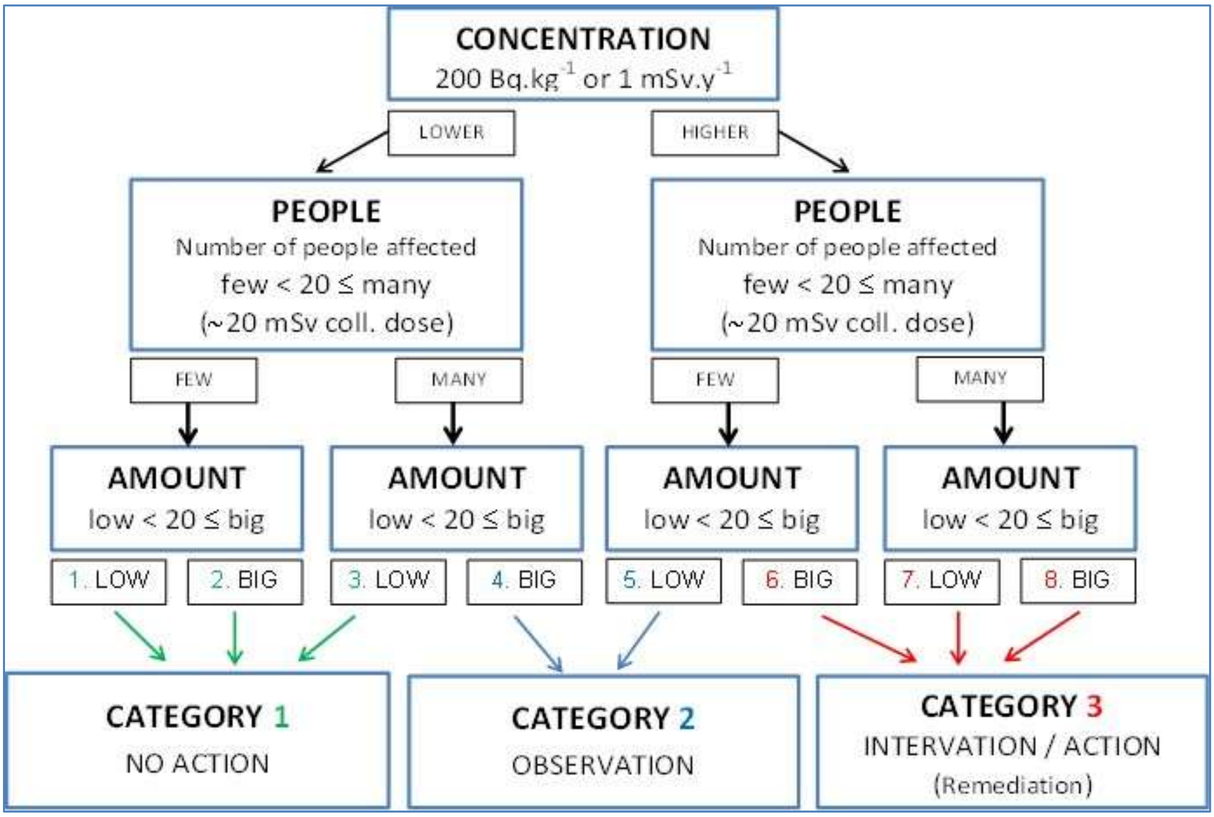


Figure 2: Classification of NORM/TENORM Activities and Materials

NORM Recycling/reuse

Examples of utilisation/recycling of waste and by-products from industrial sectors with a risk of NORM materials:

- **Coal mining and combustion**
  Energy by-products: ash, slag and gypsum
  At present, more than 90% of combustion products are reprocessed:
    - construction purposes,
    - mine reclamation,
    - water treatment (gypsum).

- **Phosphate fertilisers production**
  Generally, less radioactive raw materials are used.
  The current, non wase technologies are used in phosphate fertiliser production, and all by-products are recycled and reused before the introduction of non-waste technology by-product CaSO4.xH2O (known as "phosphogypsum") created during the production of fertilisers. This material also contains negligible amounts of radioactive elements and can be reused for the production of construction materials and agricultural purposes.
- **Production of titanium dioxide pigments**
  At the present time, ilmenite from Ukraine is used for the production of TiO_2 pigments. The raw material contains ca 200 Bq of Ra-226 per kg and ca 80 Bq of Th-228 per kg of basic material.
  By-products:
    - green copperas as a basis for iron pigments, ferric coagulants and two forms of ferrous sulphate (MONOSAL – for production of mineral feeding additives and the cement industry, HEPTASAL – in the water treatment),

- gypsum, white form called PREGIPS, brown form called PRESTAB – products are used for construction materials production and reclamation.

As these materials are not very active, they are handled in accordance with the Waste Act *(on protection of the environment and human health through effective waste management, promoting the circular economy, and ensuring sustainable use of natural resources)* [5] or the Mining Waste Act *(a Czech law that implements European Community directives on the management of waste from extractive industries*)[6], provided the relevant requirements are met. The activity of NORM waste does not prevent this use, as the doses are low. However, only construction materials are checked for activity in accordance with §105 of the Atomic Act [1]; this obligation is not directly stipulated for other products. This issue (a gap in the legislation) is being addressed in the Czech Republic and internationally (within the EU). This issue (a gap in the legislation) is being addressed in the Czech Republic and internationally (within the EU).

Other NORM waste is not yet widely used.

NORM – Radioactive waste repositories and their designation

Three radioactive waste disposal facilities are operated in the Czech Republic; each is designed for a different RAO stream. The URAO Dukovany disposes of low-level waste from nuclear energy activities, while the URAO Richard disposes of waste from non-nuclear energy activities, so-called "institutional" radioactive waste (industry, research, education, medical radiation applications) containing artificial radionuclides or an inseparable mixture of artificial and natural radionuclides. Institutional waste containing only natural radionuclides is disposed of at the URAO Bratrství in Jáchymov. These are mainly Ra-226 Sealed radioactive sources - radioactive needles and Ra-Be neutron sources, or Ra-226 contaminated materials from research, etc. A significant amount of the disposed waste consists of the waste from the depleted uranium processing, primarily from the manufacture of transport containers and shielding covers/equipment for working with ionising radiation sources and respective associated workplaces. Occasionally, items containing natural radionuclides are also disposed of as radioactive waste, such as various parts of the device marked with radium dyes, uranium glass, porcelain, thorium stockings for lamps, etc.

Several years ago, filter cloths from the production of titanium white were pressed into barrels, filled with concrete and disposed of as radioactive waste. If it were no longer possible to process the ion exchange resins saturated with uranium generated during the treatment of drinking water in the uranium industry, there would probably be a requirement for their disposal.

The chemical inventory is mostly RaSO4 in platinum cases (medical sources), Ra-Be neutron sources, laboratory waste containing natural radionuclides, disused sealed sources, depleted uranium and natural thorium (mostly as Th(NO3)4.5H2O and ThO2).

The overall inventory of selected radionuclides disposed in the Bratrství repository shall not exceed 1E+13 Bq of natural radionuclides. Radionuclides U-238, Th-232 and Ra-226 have their limits as specific WAC in the Richard repository. WAC are derived on a case-by-case basis according to the conditions in the repository and the type and form of waste deposited. The documentation on WAC identification is usually internal in relevant organisations and not publicly available—the majority of it is in the Czech language.

URAO Bratrstvi

Design and construction of facilities

URAO Bratrstvi in Jachymov is designed to dispose RAW consisting of or contaminated with natural radionuclides of the radium and thorium series. The disposal facility was developed particularly to dispose of leaking and disused radioactive sources from healthcare facilities. The Bratrstvi in Jachymov disposal facility has been developed from a part of the abandoned underground premises in the former uranium mine Bratrstvi.

Two factors are specific for the disposal facility operation:

- high humidity in the underground premises and a substantial flow rate of mine water near the disposal chambers,
- high concentration of radon decay products (not generated by the disposed RAW but by natural activity of the host environment), which makes it necessary to maintain a special regime.

The mine work is stable from the geotechnical viewpoint. Based on earlier performed extensive prospecting works, regular hydrological and geotechnical monitoring was introduced in 1992 at the location and it focuses on the disposal facility safety from the viewpoint of its stability.

A concept has been approved for the disposal facility's decommissioning and closure.

The disposal facility was developed by adapting a gallery in a former uranium mine, while five chambers were adapted for waste disposal with a total volume of nearly 1200 m^3. The disposal facility started operating in 1974. The mine is situated in a water-bearing crystalline complex. Therefore, a drainage system has been built in the surroundings of the disposal facility area with a central retaining tank and flow-through retaining tanks. The removed water is monitored.

Figure 3: View into a disposal chamber of RAW Disposal Facility Bratrstvi [3]

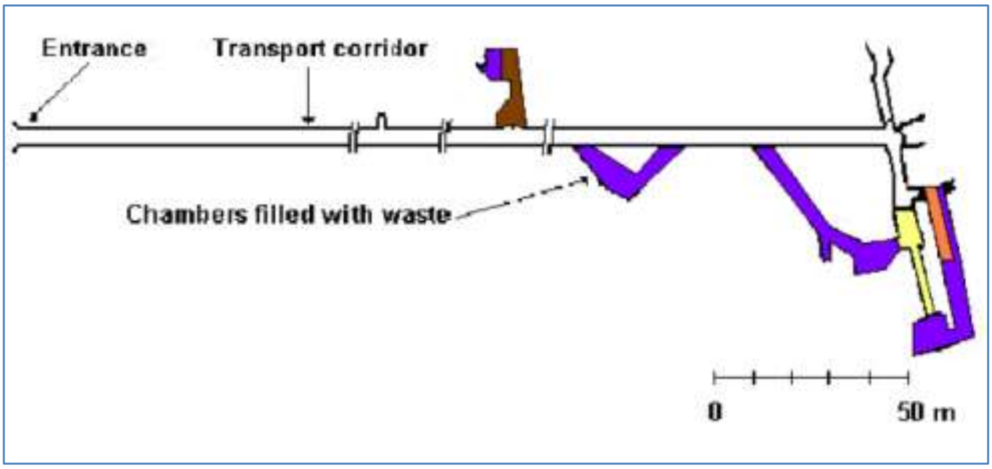


Figure 4: RAW disposal facility BRATRSTVÍ – layout [3]

Assessment of safety

The safety analyses performed in 2003-2013 were supposed to verify the disposal facility capacity and to propose limits and conditions for its operation. The efforts included safety evaluations for options with and without a backfilling material in the disposal facility premises, taking into account the updated information on the source term, including RAW inventory and employment of different types of filling materials, particularly bentonites and materials on a cement basis.

The safety analyses evaluate individual personal doses in the following scenarios: transport of radionuclides in the disposal facility and underground water in the case of barrier damage, a scenario in which persons enter the disposal facility and a scenario in which persons stay in the location. The transport of radionuclides was considered in two variants - with and without a backfilling material. The scenarios were anticipated to take place after termination of institutional control, ie, 120 years after the operation of the facility is finished. Individual doses calculated for the real disposal facility system (inventory, construction design, and host rock environment) were compared with applicable limits, and the acceptance criteria for RAW in the Bratrství disposal facility have been proposed based on the comparison [3].

A project to assess the long-term safety of the RAW Disposal Facility Bratrství is currently underway, with an assessment of the geological and hydrogeological model, the current and future RAW inventory, and revisions to the disposal facility development scenarios. As part of the project, samples of backfill concrete were collected and experiments were conducted to obtain migration parameters for selected radionuclides in the disposal facility environment. The results of the project will be used for the periodic safety assessment of the RAW Disposal Facility Bratrství [3].

There is an Ageing Management Programme developed to support the safe operation of the disposal facility.

In 2019, a revision of safety analyses was prepared, including a revision of the hydrogeological model.

The disposal facility's safety has been assessed using the requirements of the Atomic Act No. 263/2016 Coll.[1] and its implementing regulations.

The utilisation of underground premises for RAW disposal is classified as a special interference in the Earth's crust according to mining regulations, and therefore, the safety evaluation process also takes into account the requirements of Section (§) 34(1) of Act No. 44/1988 Coll. [4].

The disposal facility is operating in accordance with the standard operating regulations, in particular the “Limits and Conditions of the RAW Disposal Facility Bratrství“ and WAC. Routine maintenance is carried out on the underground parts of the mine and the surface area.

In accordance with the document “Monitoring Programme of the RAW Disposal Facility Bratrství“, the volumetric activity of selected radionuclides in groundwater and surface water is monitored. In addition, the volumetric activities of Rn and its decay products in the air of the repository are monitored. According to the Monitoring Programme of the RAW Disposal Facility Bratrství“, personal and site monitoring is carried out. The monitoring results confirm that the disposal facility has no effect on its surrounding environment.

According to the document “Limits and Conditions of the RAW Disposal Facility Bratrství“is regularly verified:

- the operability of electrical equipment,
- the operability of forklifts,
- the permeability of the drainage system,
- the operability of the instrumentation.

The standard package for RAW disposal is a 216 L drum with anticorrosive treatment. Packages are placed flat in layers up to a height of approximately 2 m.

When disposing of the waste, the operator checks for:

- damages of the packages,
- surface contamination of the packages,
- dose rate equivalent on the package's surface,
- content of radionuclides (gamma-spectrometry).

The individual packages are disposed of in disposal chambers. In addition to the monitoring of parameters important for radiation protection, basic climatic and hydrological data and geotechnical parameters are measured at the site. [3]

Inventory of RAW at the URAO Bratrstvi

Radionuclide	Total activity [Bq]
^{226}Ra	1.36×10^{12}
U	6.38×10^{11}
^{232}Th	3.20×10^{9}

Figure 5: Inventory of RAW disposal facility Bratrstvi in Dec 31, 2023 [3]

The disposed capacity of the Bratrství repository is almost exhausted (only about 5 standard packaging sets, i.e., double packaging set (115 L drum embedded in a 216.5 L outer steel drum), can be disposed – info from 5/2024). SÚRAO has complete project documentation for the construction of new disposal facilities. The necessary modifications would provide a new disposal capacity of approximately 480 m^3, i.e. up to 1500 standard RAO packages. This could be sufficient for several decades of operation with the current production of RAO with an exclusive content of natural radionuclides (lower tens of waste packages/year, nominally 35 waste packages/year is mentioned in the concept documents).

The closure of the repository, which was originally planned for 2020, requires extensive work, particularly the stabilisation of the disposal chambers by filling them with a special concrete mixture. The work is so extensive that extending the project to include the construction of new disposal chambers would not significantly increase the costs or time required to complete the work. Due to the technical and administrative complexity of the project, radioactive waste disposal at the Bratrství repository is not expected to resume for another 2 to 5 years.

Waste form for disposal in the URAO Bratrstvi

Homogeneous and uniform solidified waste containing natural radionuclides has been disposed of at the disposal facility Bratrství.

Waste is usually solidified in drums of 210 litres using cement as solidification media or in a sandwich container (100 l drum in 200 l drum) with a non-active cemented interlayer) or in the MOZAIK steel container. WAC are approved by SÚJB in the frame of licensing process.

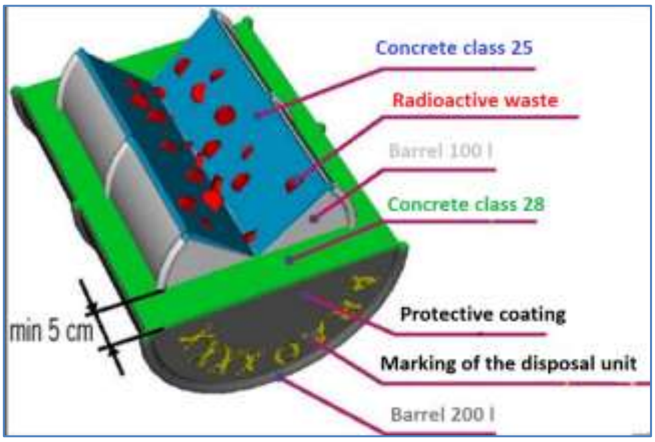


Figure 6: Radioactive waste disposal container – “sandwich” disposal unit (author: SÚRAO)

Richard Repository

Design and construction of facilities

The Richard Disposal facility is a near surface underground facility for LILW of institutional origin.

Radioactive Waste Disposal Facility Richard is designed to dispose institutional radioactive waste containing artificial radionuclides or an inseparable mixture of artificial and natural radionuclides. The disposal facility is situated on the north-western edge of the Litoměřice cadaster area under the Bidnice hill. In the past, there were three limestone quarries in the location (now called Richard I - III), and there was an underground factory constructed during World War II. In the early 1960s the mine work Richard II was identified as a potential disposal facility for LLW.

The disposal facility is situated in a carbonate bank, with overlying and underlying clayey rocks. URAO Richard has been developed in a complex of the former limestone mine Richard II (inside the Bidnice hill - 70 m under the ground level). Its communication corridor is 6 – 8 m wide and 4 – 5 m tall. Individual disposal chambers are accessible from the corridor. Since 1964, the disposal facility has been used to dispose of institutional waste (radioactive waste from utilisation of radioisotopes in medical care, industry and research). The mine premises and disposal rooms are dry. The only leakage of underground water in the disposal facility premises occurs in the entrance portal and from the ventilation chutes. Additional water gets into the disposal facility through condensation from forced ventilation. The seeping and condensing water in the disposal facility is drained into the mine drainage system. The mine water from the Richard disposal facility (in orders of tenths of litres per second) is drained through a system of retaining tanks into a public sewerage system. The mine water is monitored before it is discharged into the sewerage system. Moreover, 13 drills have been made in the Disposal Facility Richard to monitor hydrogeological conditions in the concerned area, 9 of which for monitoring purposes and the remaining ones for prospecting purposes. From the geotechnical viewpoint, the mine can be considered as stable.

Based on the earlier performed prospecting works, regular geotechnical monitoring was introduced in 1992 at the location to focus on the disposal facility's safety in terms of stability.

A concept has been approved for the disposal facility’s closure and decommissioning.

The total volume of adapted underground premises exceeds 17,000 m^3, while the capacity for waste disposal is about half of the volume, and the rest are service galleries.

Figure 7: RAW disposal facility RICHARD (source: SURAO)

Beginning of operation	1964
Scheduled end of operation	Not before 2025
Repository depth under the surface	70 - 90 m
Total volume adapted for the disposal facility	18 900 m^3
Filled volume of disposal chambers	8 201 m^3
Free volume	2 047 m^3
Access tunnel and other corridors (including that to Richard I)	8 652 m^3

Figure 8: Summary data on Radioactive Waste Disposal Facility Richard (as on December 31, 2019) [3]

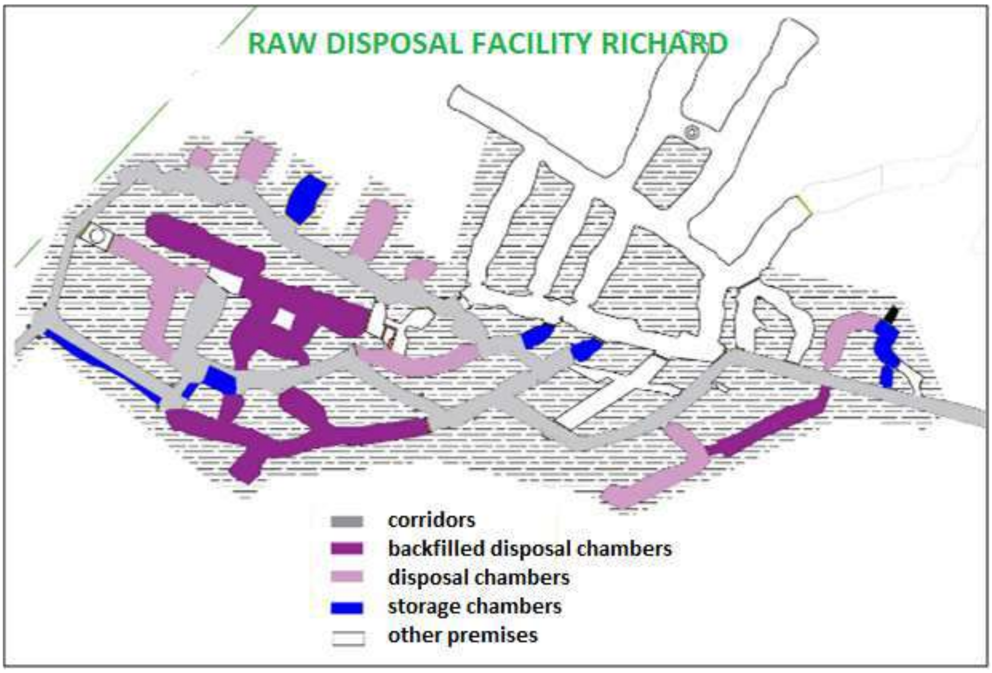


Figure 9: RAW Disposal Facility Richard – layout [3]

Safety assessment of the radioactive waste disposal facility Richard

A revision of safety analyses for the Radioactive Waste Disposal Facility Richard was prepared in 2016, which is a continuation of safety analyses, and their revisions performed in 1995 - 2013, and it has been used as a supporting document for the application for a license to operate the disposal facility.

The safety analyses performed in 2003-2016 were supposed to verify the disposal facility capacity and to reassess the already proposed closure and decommissioning method. The efforts included safety evaluations for options with and without a backfilling material in the disposal facility premises, taking into account the updated information on the source term, including radioactive waste inventory and employment of different types of filling materials, particularly bentonites and materials on a cement basis. The transport model has been updated using data from the newly made drill holes to further specify hydrogeological data in the location.

Safety analyses evaluate the individual doses received by persons in the following scenarios: transport of radionuclides in the disposal facility and underground water in the case of barrier damage, scenarios in which persons enter the disposal facility and scenarios in which persons stay in the location.

The transport of radionuclides was considered in two variants - with and without a backfilling material. The scenarios were anticipated to take place after termination of institutional control, i.e. 300 years after the operation of the facility is finished. Individual doses calculated for the real disposal facility system (inventory, construction design, host rock environment) were compared with applicable limits and the acceptance criteria for radioactive waste in the disposal facility Richard Litoměřice have been proposed based on the comparison.

In 2019, a revision of safety analyses was prepared, including a revision of the hydrogeological model. Furthermore, the new safety analysis will consider the optional extension of disposal capacity to previously unused premises in the northern part of the disposal facility.

Storage of waste containing natural radionuclides at the URAO Richard

Although the safety analyses conducted for the Richard repository permit the disposal of waste containing natural radionuclides, the disposal of RAW containing only natural radionuclides has not yet been implemented for conceptual reasons. This possibility is being re-evaluated as part of the ongoing "Project of Preparation of Safety analyses for Regular Safety Assessments of Radioactive Waste Repositories in Operation".

The current situation in the area of disposal of RAW containing only natural radionuclides is solved by storing them in the Richard repository. **For the storage of these RAW there is a dedicated chamber No. 28** at the Richard repository, which is specially adapted for this purpose. Its capacity will allow it to cover about ten years or more at current production. This period appears to be sufficient for a decision on the future management of RAW containing only natural radionuclides.

Storage of RAW in the Richard repository is theoretically possible for the entire period until the Richard repository is decommissioned (decommissioning and closure are expected to take place in 2050 at the earliest, but there is also a theoretical prospect of operation beyond 2100).

For the final disposal, SURAO can then decide between several options:

- disposal directly at the Richard repository, based on a positive assessment in the framework of the safety analyses;
- disposal at the Bratrstvi repository, after the construction of the new storage capacity;
- disposal in a deep repository after its construction and operation.

Details of the treatment of RAW into a form suitable for storage

The standard packaging for disposal or storage of conditioned RAW is a steel drum with an internal volume of 115 litres, encased in an external steel drum with a volume of 216.5 litres. The intermediate concrete layer must be at least 50 mm thick at all points and have the defined properties of the concrete (class A) and cement used, compressive strength, aggregate size and consistency, etc.

In the case of RAW storage, which is currently the only practical option for transferring RAW containing natural radionuclides from producers to SÚRAO (WMO), due to the Bratrství repository's capacity being exhausted, the outer container/drum must be made of high-grade, corrosion-resistant steel. A higher fee must also be charged for transferring one container of RAW than for disposal (in accordance with Government Regulation No. 35/2017 Coll., or the annual decision of the SÚRAO director).

When deciding on the method of treatment or filling of RAW into drums, it is important to take into account all specified limits and conditions of acceptability (as well as any other relevant factors). The main limits are the activity of radionuclides in the packaging set, the maximum value of absorbed equivalent dose on the packaging set's surface, and its weight.

In order to make the process as economically efficient as possible, the Technologist responsible for RAW management must take into account the specified conditions and waste acceptance criteria, considering the properties of the treated and subsequently conditioned waste, with the aim of minimising the number of packaging sets for a given volume of waste while meeting the acceptance criteria.

Specific problems in the transfer of RAW containing only natural radionuclides

If the radioactive material (RAW) contains uranium or thorium, SURAO (WMO) requires proof of its proper removal from the nuclear material register as a condition of acceptance for storage or disposal. In these cases, the original owner/producer must now make the appropriate changes to the nuclear material inventory and list SÚRAO as the receiver. In some cases, removal from the register may be carried out by the Nuclear Material Accounting Manager at SÚRAO (head of the nuclear material register at SURAO). Alternatively, the nuclear material may be classified as retained waste and treated as radioactive waste and disposed of.

This is a requirement in terms of international guarantees and trilateral agreements relating to nuclear non-proliferation. Radioactive substances released from NORM workplaces are not included in this register. At least the holder of a RAW management licence, who will ensure the treatment and transport of RAW for storage or disposal for the primary originator, must hold a licence for handling nuclear materials to the relevant extent (nuclide, form and quantity). Furthermore, the holder of the aforementioned licence must ensure, at the expense of the originator/original owner, the administrative tasks related to the introduction and subsequent removal from the register or transfer of nuclear materials.

Currently, RAW containing natural radionuclides can only be stored (not disposed of). This requires the use of an external container/drum made of high-alloy corrosion-resistant steel instead of a standard carbon steel container/drum, resulting in increased costs. Furthermore, a higher fee for the transfer of one unit/package for storage must be taken into account.

For the RAW package containing only natural radionuclides intended for storage in the Richard URAO, the overall limit applies to the total activity of the radionuclides in a single package. This limit is set at 1 GBq for long-lived radionuclides undergoing alpha conversion. The exception applies to cases where the RAW packaging contains a used sealed radionuclide sources whose activity exceeds the specified limit, and where further division would contradict the ALARA principles. The repository operator (SURAO) approves this exception. This is not relevant in the field of NORM.

In the case of NORM materials without further processing (treatment), it cannot be assumed that the limit values specified in the Conditions of Acceptability will be achieved. Conversely, when NORM waste is processed to reduce its volume and increase its specific activity (e.g. by incinerating filter cloths used in the production of titanium dioxide pigments), the limit values for the disposal of non-combustible residues must be considered, and the waste must be packaged in accordance with the acceptance criteria.

The expected procedure when an operator of a workplace with material containing elevated levels of natural radionuclides removes these radioactive substances as radioactive waste

We do not expect/assume that operators of facilities handling materials with elevated levels of natural radionuclides will consider obtaining a radioactive waste management license, although this cannot be completely ruled out. Given the technical and personnel/staffing requirements, this option is unlikely to be effective for most facility operators. The usual approach, if necessary, to dispose of waste with a higher content of natural radionuclides is to hand it over to one of the existing radioactive waste management license holders, who will arrange for disposal.

The licence holder must meet the following requirements:

- The scope of its operating licence or documentation must include the possibility of handling RAW containing natural radionuclides from other sources/producers;
- In the case of material containing U and Th and meeting the definition of source nuclear material, it must also hold a licence to handle nuclear material of the appropriate type and quantity.

It should also be noted that before accepting the processed waste/RAW package, SÚRAO (as the organisation responsible for safe storage/disposal) requires proof that the waste containing natural radionuclides could not be disposed of otherwise than as radioactive waste.

According to the data provided by SÚRAO for the period 2006-2023, 416 packages with an approximate weight of radioactive waste of 44.5 t and an activity of ^{238}U 3.3 x 10^{11} Bq were delivered for disposal/storage.

Denmark

Organisation – Nuclear Transparency Watch / NOAH Friends of the Earth Denmark

Role – Representing civil society regarding nuclear transparency and public participation

1. Waste Inventory and Management

Denmark has NORM waste with the following definition 'waste'.

Type of NORM waste:

- Waste from offshore oil and gas extraction

Quantity: Eight Danish companies are licensed to manage and store NORM waste. All together, they store approximately 500 tons of NORM waste in approximately 70 20-foot containers.

Management of NORM is carried out via a decentralised system; the NORM waste is stored by 8 different companies. Danish decommissioning does not receive NORM waste.

NORM waste is currently treated and stored. According to the Danish Health Authority, there is an obligation to minimise the amount of NORM waste. One private company is licensed to decontaminate the waste (figures from 2020).

2. Reuse and Recycling

No reuse or recycling data are known for current or planned disposal.

3. Waste Treatment

For waste treatment, one company is licensed to physically clean the waste ("fysisk afrensningsmetode").

4. Disposal Options

No current disposal program data are known.

According to the Ministry of Health (2020), the authorities are working on a solution for disposal methods (current/planned), but so far, they primarily see it as the task of the operators.

No information on containers / disposal challenges or WAC issues.

5. Safety Case

Data not known.

6. Workshops and follow up

Would like to be involved in the following topics, all for NORM wastes:

- Safety case methodologies (NORM)
- Long-term disposal strategies (NORM)
- Reuse and recycling options (NORM)
- Inventory management (NORM)

Information is not known about research priorities within Denmark.

International collaboration benefiting topics, based on the fact that there is no disposal program in place yet, it is assumed they would like to be involved in the following topics:

- Development of safety case methodologies (NORM)

- Waste treatment and disposal technologies (NORM)
- Long-term monitoring and surveillance (NORM)
- Reuse and recycling strategies (NORM)

7. Additional information

No data provided.

Estonia

Organisation – University of Tartu

Role – Research entity

1. Waste Inventory and Management

Estonia has NORM waste with the following definition 'NORM waste consists primarily of radioactive waste containing NORM, including NORM residues that are not intended for future use. NORM residues are materials containing or contaminated with naturally occurring radioactive substances resulting from a specific activity, with activity or activity concentration exceeding established clearance levels, and intended for future use.

Estonia doesn't have DU waste class definition as no enrichment nor fuel reprocessing is present in the country.'

Type of NORM waste:

- Mainly metal waste (equipment and pipelines from water treatment companies)
- Small amounts from materials get caught at customers (rare earth metals)

Quantity: About 8 tons. Annual addition 200-300 kg.

Management of NORM is carried out via a centralised system.

NORM waste is currently managed via; minimisation at source – as much as possible, the waste is separated from clean material. Only certain parts of the equipment and piping are contaminated. Sorting diminishes the amount of waste significantly. Based on experience decontamination is not economically viable with our technology. It is then conditioned before disposal; the waste is grouted. It is then stored in metal containers until the disposal facility is ready. It will then be disposed of – however, it has not been decided yet, whether it will be disposed of in an intermediate depth silo at 60-80 m below the ground or at the surface facility. Based on WAC, it could be disposed of in both.

The WMO is responsible for the waste management of NORM (the above processes).

2. Reuse and Recycling

No reuse or recycling is currently used. But it could be used for shielding in high-level waste containers -Estonia holds depleted uranium (originating from DSRS containers), which is considered radioactive waste. A container with this waste could be used for shielding of higher activity waste during disposal, if needed. No safety information available yet, as it is in the early stages of the disposal solution.

3. Waste Treatment

For waste treatment methods for disposal, cementation (both near surface and silo) is foreseen.

4. Disposal Options

The disposal program is in development (silo and near surface facility). NORM waste is suitable for ne-su according to WAC. If there is free capacity in silo NORM waste will be disposed of in silo. But it will require re-packaging of the waste as different types of containers will be accepted in the silo.

Considered disposal methods were engineered landfills; however, for such a small waste amount, it's unreasonable to develop a separate disposal concept. Disposal in lower layers of the municipality landfill could be a reasonable option, but to gain public acceptance is unlikely.

A half-height 20ft freight container is to be used.

Disposal challenges include:

- Conditioning of the waste in the container and subsequent placement at the disposal facility.
- If near surface facility is selected, the waste will be grouted inside near surface facility due to possible crane overload issues.
- If silo disposal will beised materi, theal has to placed be in different containers and will require additional cutting before grouting.

WAC are nuclide based; no other NORM related criteria are used.

5. Safety Case

Safety case is in development, NORM waste is covered.

Preliminary post-closure safety assessment is done. Covered elements so far in safety case: safety policy and objectives, system/facility description, hazard and risk assessment, safety measures and controls, monitoring and continuous improvement. So far, radiological safety has been demonstrated through the safety assessment.

Timeframes considered are, 100 000 years for silo and 15 000 years for near-surface facility.

6. Workshops and follow up

Would like to be involved in the following topics, all for NORM wastes and an additional topic:

- Safety case methodologies (NORM)
- Long-term disposal strategies (NORM)
- Other – Gas emissions solutions for disposal from Ra-226

Research priorities are of interest for NORM:

- Development of safety case methodologies (NORM)
- Long-term safety assessment and modelling (NORM)

International collaboration benefiting topics:

- Development of safety case methodologies (NORM)
- Waste treatment and disposal technologies (NORM)

7. Additional information

No data provided.

France 1

Company – Egis

Role - Architecture, consulting, construction engineering and operating firm. Egis doesn't have extensive experience in managing NORM and/or DU waste, and do not have relevant information on most of the responses on the questionnaire, so we will refrain answering if we don't have relevant information to provide.

1. Waste Inventory and Management

France has both NORM and DU wastes with the following definition 'ASN "Waste management NORM regulatory developments" document: material naturally rich in natural radionuclides' 'DU (from ANDRA website) product enrichment: a solid, stable, incombustible, insoluble and non-corrosive material: uranium oxide (U_3O_8), which takes the form of a black powder.

Type of NORM waste:

- All industry that has to do with radiological inventory,
- Extraction of rare earths from monazite,
- Rare earth processing and production of rare earth pigments,
- Production of thorium compounds, manufacture of products containing thorium and mechanical working of these products,
- Processing of niobium/tantalum ore and aluminum,
- Oil and gas production, excluding exploration drilling,
- Production of geothermal energy, excluding geothermal energy,
- Production of titanium dioxide,
- Thermal phosphorus production,
- Zircon and zirconium industry, including refractory ceramics industry,
- Mineral extraction (mines),
- Production of phosphate fertilisers,
- Cement production, including maintenance of clinker kilns,
- Coal-fired power stations, including boiler maintenance,
- Phosphoric acid production,
- Production of primary iron Tin, lead and copper melting activities; glassmaking, foundry, iron and steel industry and metallurgy using refractory ceramics refractory ceramics,
- Filtration treatment of groundwater circulating in magmatic rock,
- Extraction of natural materials of magmatic origin, such as granitoids, porphyry, tuff, pozzolan and lava.

No quantity of NORM provided.

DU quantity: once re-enriched, the stock of depleted uranium currently present in France represents a deposit of around 65,000 tonnes of natural uranium

Waste management of NORM, they have 4 hazardous waste disposal facilities that are allowed to dispose of NORM.

2. Reuse and Recycling

Currently, for reuse/recycling; ANDRA - DU: Depleted uranium has been used regularly for several years as a support matrix for MOX fuel, produced in France at the Melox plant in Marcoule. This flow represents around one hundred tonnes per year. DU Valorisation: Once re-enriched, the stock of depleted uranium currently present on French territory represents a deposit of around 65,000 tonnes of natural uranium, or around eight years of the requirements of France's current nuclear power plants. Re-enrichment can be used as a fuel based on enriched natural uranium (ENU). In the longer term, depleted uranium, particularly from a second enrichment cycle, could be used to meet the needs of the world's fast neutron reactor fleet. In addition to its energy potential, depleted uranium has properties, some of which have already been exploited in non-electronic sectors (batteries, thermoelectric catalysts, reversible thermochemical heat storage). Orano's R&D program is looking at ways of recovering value from uranium by exploiting these properties. However, according to the ASN, there are uncertainties surrounding these potential uses. ANDRA is conducting a feasibility study on a storage concept for depleted uranium in the event that all or part of the depleted uranium stock cannot be recovered under acceptable technical and economic conditions. Depleted uranium is used in non-electronuclear industries as radiological shielding or as a counterweight.

3. Waste Treatment

Waste management options include minimisation at source and disposal.

Waste management for DU includes reuse/recycling.

In France, the producer of waste is responsible of the waste management for both NORM and DU.

4. Disposal Options

There is a current disposal program for NORM. For now, DU is considered recoverable and not a waste to dispose of.

Selected methods for NORM disposal are near surface (4 disposals sites/ facilities are allowed to handle NORMs)

No selected methodologies for DU disposal.

5. Safety Case

No information provided

6. Workshops and follow up

Do not want to be involved.

7. Additional information

No additional information provided.

France 2

Company – Andra

Role – Radioactive waste management organization

1. Waste Inventory and Management

France has both NORM and DU wastes with the following definition 'In France, NORM are radioactive substances of natural origin resulting from professional activities using raw materials naturally containing radionuclides which are not used for their radioactive properties, and whose mass activity concentration(s) exceed(s) one or more exemption limit values defined in French regulations. DU: Uranium is said to be "depleted" when its composition in light isotopes (uranium 235 and 234) has been reduced to less than 0,4% (around 0,3%). DU are not classified as waste in France, but as a material that could be reused.'

Type of NORM waste:

- Extraction/processing of rare earths from monazite,
- Production, manufacture of thorium compounds and mechanical working of these products,
- Ore processing,
- Zircon and zirconium industry,
- Phosphate fertilizer production.

Quantity of NORM; NORM that are not disposed of in conventional repositories are disposed of by Andra and represent around 25,000 m^3.

DU quantity; Around 340 000 tons of heavy metal (at the end of 2023).

Waste management of NORM, Centralised national registry: French "inventaire national" Other: the inventory of conventionally managed NORM is not included in the national inventory.

Waste management options for NORM include disposal.

Waste management for DU includes reuse/recycling and storage.

In France, for NORM, dedicated disposal managers (Andra is one of them) is responsible for the disposal of NORM waste. And the producers are responsible for reuse/recycling and storage of DU.

2. Reuse and Recycling

Currently, for reuse/recycling of DU, a part of the DU is used to manufacture MOX fuel. In the future, fuel for generation IV reactors.

There is reuse of NORM or DU / research being conducted into for disposal.

3. Waste Treatment

No waste treatment methods for NORM specified yet.

4. Disposal Options

There is a current disposal program for NORM. But not for DU.

Selected methods for NORM disposal are engineered landfills, shallow depth disposal for the part of NORM classified as LL-LL waste. Landfills in operation, shallow depth is under study.

No selected methodologies for DU disposal.

Disposal challenges for NORM; For the LL-LL waste part, a shallow depth disposal is studied for several years in France. The main challenge is long-term safety for a shallow depth disposal, which is still under definition.

WAC for NORM; Level of massic activity (under 100 Bq/g for engineered landfills), activity of Thorium, Radium, Uranium contained. There is no WAC defined for the shallow depth disposal project.

5. Safety Case

There is a safety case for NORM.

No information provided for DU – not considered waste in France.

Preliminary safety studies have been carried out for the NORM low-level long-lived waste in a shallow depth disposal project. The issues at stake are linked to the presence of chemical salts in these NORMs (nitrates, ammonium), leading to potential marking of the aquifer, very long-term impacts due to end-of chain elements (Ra-226 and 228, Pb-210, Pa-231), and the chemical toxicity of uranium. Case of shallow disposal: To demonstrate the very long-term safety of shallow depth disposal, so-called "conventional situations" are studied: they consider conservative assumptions of degradation of the parameters representing the safety functions of “isolating the waste from man and the environment”, “limiting the release of radioactivity”.

Timeframes for NORM; For NORM studied for a shallow depth disposal: a “classical safety case” is implemented before 50 000 years (normal evolution scenarios, altered evolution scenarios and human intrusion scenarios). Beyond 50 000 years, so-called conventional situations are studied: they consider conservative assumptions of degradation of the parameters representing the safety functions of “isolating the waste from man and the environment”, “limiting the release of radioactivity”

6. Workshops and follow up

France would like to be involved in the workshop and follow up, including the following topics;

- Safety case methodologies (NORM)
- Long-term disposal strategies (NORM)
- Chemical toxicity of uranium (NORM)
- Long term uncertainties (NORM)
- Impact of climate change (NORM)

7. Additional information

No additional information provided.

Germany

Company – DMT GmbH & Co.KG

Role - DMT is a contractor for the WMO for DGR development. As an engineering & consulting company in the filed of mining, DMT supports mining companies in managing mine water, which might result in the generation of NORD waste.

1. Waste Inventory and Management

Germany has both NORM and DU waste. And they have the following definition 'NORM is defined as residue from industrial or mining activities. Depending on the activity, they have to be considered as radioactive waste. Both the act on radiation protection (in German: Strahlenschutzgesetz – StrlSchG) as well as the regulation on radiation protection (in German: Strahlenschutzverordnung – StrlSchV) have paragraphs on the handling of NORM. In Germany, there are larger amounts of DU in the possession of the company URENCO. These are not classified as waste, but as resource (although there have been legal debates in the past years, if they would need to be classified as waste depending on depletion – up to my knowledge, so far, they are still classified as a resource). Legacy waste from DU ammunition owned by the state is considered waste.

Type of NORM waste:

- Industrial by-products,
- Mining residues (incl uranium mining),
- waste from geothermal energy production,
- waste from the oil and gas industry, etc., if the activity is above a legal threshold. If the waste is below this threshold, it is not considered radioactive waste.

Quantity of NORM; According to the report "Amount of NORM residues for final disposal concept" [Mengenaufkomment an NORM-Rueckstaenden fuer das deutsche Entsorungskonzept] by the federal ministry for radiation protection (BfS), a quantity of approx. 35 kilo-tonnes of NORM every 10 years (approx. 23 cubic meters / 10 years) is expected.

Quantity of DU; No specific information available. The current capacity for the storage of depleted UF6 is approx. 38 kilo-tonnes and approx. 59 kilo tonnes for U_3O_8 at the URECNO site in Gronau. The degree of use is not published.

Inventory management; Centralised national registry: for NORM waste in decentralised storage facilities (for subsequent final disposal). Decentralised (regional or local national registries): For DU form uranium enrichment, this information is available at URENCO. The DU from ammunition should be stored in decentralised storage facilities and be on record there, or are still in the possession of the German military.

Management options for NORM include waste minimisation at source and disposal.

Management options for DU include reuse/recycling (e.g., re-enrichment of DU).

Waste minimisation is managed by the producer, and disposal is the WMO (in Germany: BGE) for NORM and re-use and recycling of DU is completed by URENCO. Reenrichment of depleted uranium will in this case be done by URENCO to produce uranium for fuel production (3-5% enrichment).

2. Reuse and Recycling

No knowledge for reuse within a disposal facility for NORM or DU.

3. Waste Treatment

Waste treatment methods are dependent on the initial waste form; waste needs to be dry and inert for final disposal for NORM. For DU, specialised treatment (e.g., deconversion to U_3O_8) for long term storage of DU.

4. Disposal Options

The current disposal program for NORM and DU is in development. The Konrad repository (DGR) for low and intermediate waste (including NORM) is expected to go into operation by 2029.

The selected disposal method for NORM is a deep geological disposal / dedicated disposal site. Deep geological disposal for NORM classified as radioactive waste, dedicated disposal sites for NORM below an activity threshold and therefore, not classified as radioactive waste.

No current disposal method for DU – all radioactive waste needs to be disposed of in DGRs by law.

The disposal container will be those approved for the Konrad repository (DGR).

No specific disposal challenges for NORM, the WAC applied to those wastes as well. Nor challenges for DU.

5. Safety Case

Germany has a safety case for NORM and DU.

Long-term safety assessment for both NORM and DU has been done for all waste approved to be disposed of in the Konrad repository (DGR). The assessment is checked and updated every 5 years.

Timeframes for the safety case are 1 million years.

6. Workshops and follow up

Germany would like to be involved in workshops and follow up, including the following topics:

- Reuse and recycling options (NORM and DU)
- Inventory management (NORM)

Research priorities are:

- Waste minimisation at source (DU).

7. Additional information

Not aware of ongoing or upcoming projects on disposal of waste, but there are projects on waste generation and monitoring (Application: geothermal energy).

Greece

Company - NCSRD

Role – Organisation is not involved in managing NORM. There is some DU in their interim storage (safeguard material).

1. Waste Inventory and Management

Greece has both NORM and DU waste. They have the following definition 'NORM is waste because contains also other hazardous substances besides natural radionuclides. DU is a safeguard material.

Type of NORM waste:

- Industrial by-products (phosphogypsum, red mud, fly ash),
- Waste from the oil and gas industry (scales, sludge, drilling mud).

Quantity of NORM: Huge volume of phosphogypsum, red mud and fly ash, as well as thousands of tons of drilling mud.

Quantity of DU; volume of DU is less than some tons.

Inventory management for NORM and DU is managed via a national and centralised system, respectively.

Management options for NORM include reuse/recycling, storage and then disposal.

Management options for DU include reuse/recycling and then storage.

The producer is responsible for the management of NORM. When there isn't a producer anymore, the state is responsible for the management.

The NCSRD, which is a state-owned organisation, is responsible for the storage of DU.

2. Reuse and Recycling

Currently, the reuse/recycling of NORM is sometimes used to produce commodities, but no further information is provided – noted that they could find out.

3. Waste Treatment

No waste treatment methods for NORM, just direct disposal of phosphogypsum and red mud.

No waste treatment currently for DU, just storage at the moment.

4. Disposal Options

There is no current disposal program for NORM or DU.

The selected disposal methods for NORM are near surface and dedicated disposal sites. Dedicated disposal sites for phosphogypsum and red mud. Since the considered types of disposal methods in the country are: Near surface with and without engineered barriers, as well as borehole for DSRS, near surface with engineered barriers will be possibly used for other NORM like scales and sludges.

The selected disposal method for DU is near surface, since the considered types of disposal methods in the country are: Near surface with and without engineered barriers as well as borehole for DSRS, near surface with engineered barriers will be possibly used for DU wastes.

The considered types of disposal methods for DU in the country are: 1) Near surface with and without engineered barriers; 2) borehole for DSRS. There was none for NORM as it is considered in the country.

5. Safety Case

No safety case for NORM or DU.

There is a radiological impact assessment for phosphogysum sites.

6. Workshops and follow up

Greece would like to be involved in workshops and follow up, with regards to the following topics:

- Safety case methodologies (NORM and DU)
- Long-term disposal strategies (NORM and DU)
- Reuse and recycling options (NORM)

Research priorities include;

- Development of safety case methodologies (NORM and DU)
- Long-term safety assessment and modeling (NORM and DU)
- Waste treatment and disposal technologies (NORM)
- Reuse and recycling technologies (NORM)

International collaboration topics;

- Development of safety case methodologies (NORM and DU)
- Waste treatment and disposal technologies (NORM and DU)
- Long-term monitoring and surveillance (NORM)
- Reuse and recycling strategies (NORM)

7. Additional information

No additional information.

Netherlands

Company – NRG

Role – the TSO

1. Waste Inventory and Management

The Netherlands has both DU and NORM wastes. The definition is as described ‘DU Depleted Uranium is a special category of NORM: TE-NORM (Technically Enhanced Naturally Occurring Radioactive Material). This type of waste is safeguard material and therefore stored in special dedicated surface facilities. The containers as well as storage rooms are controlled by the IAEA. Most Dutch NORM waste is deposited in designated landfills (96.5% in 2014) as specific exempt material. Only a fraction is recycled (0.1% in 2014), and a small fraction is regarded as radioactive waste that requires licenses, special treatment, and storage (3.4% in 2014). Waste from the phosphorous industry is also a special category of NORM waste, and it has specially dedicated surface facilities, but it is not considered a safeguarded material. Other types of NORM waste are processed with cementitious materials in 200 l drums. At COVRA, radioactive waste is divided into four categories: HLW (non-heat generating and heat generating), LILW (including NORM-waste), short-lived waste and exempt waste. Roughly speaking, the IAEA categories high-level waste and intermediate-level waste equate broadly with the Dutch category HLW and the IAEA categories low-level waste and very low-level waste with the Dutch category LILW. Depleted Uranium falls under NORM waste. Low- and intermediatelevel radioactive waste (LMRA), including NORM: A special category within LILW constitutes of NORM-waste above 10 times the general clearance levels (see NPRA draft, 2024). This NORM-waste arises, among others, when radioactive substances that occur naturally in, for example, industrial ores (such as phosphate ores) are concentrated in the waste during processing. Other examples of industries that produce NORM-waste are the pigment industry, steel industry, zircon industry, oil and gas industry, geothermal industry and industry treating scrap metals (see NPRA draft, 2024).

Type of NORM wastes: NORM waste is a special category that can be classified as LMRA (Laag en Middel Radioactief Afval) or ZELA (ZEer Laag radioactief Afval). NORM-waste arises, among others, when radioactive substances that occur naturally in, for example:

- industrial ores (such as phosphate ores) are concentrated in the waste during processing,
- the pigment industry,
- steel industry,
- zircon industry,
- oil and gas industry.

Quantity of DU and NORM wastes:

COVRA publishes the amount of stored waste each year in its yearly reports. Other companies that store NORM waste report their storage capacity to the government. For this questionnaire, we have not consulted other companies other than COVRA. Approximately 6710 m3 NORM waste from the phosphorus industry is currently stored at COVRA’s premises (Jaarrapport, 2023). Since 2020, COVRA no longer receives phosphorous waste in 20 ft containers.

DU is NORM waste from uranium enrichment: COVRA publishes its amount of depleted uranium each year. The volumes stored in 2019, 2020, 2021, 2022 and 2023 were in m3: 16356, 16536, 18736, 18760 and 18760 (Jaarrapport, 2023). Estimated by 2030 - 28172 m3. Estimated by 2130 49 360 m3 (National radioactief afval inventarisatie, 2022).

The inventory of DU and NORM waste is managed by the following; All NORM waste that is above the clearance levels and DU waste is registered and stored at COVRA. NORM waste below the exemption limits is dumped at the designated landfills. On 6 February 2018, Directive 2013/59/Euratom was implemented in Dutch legislation. This means that for a large number of radionuclides, the generic exemption and release have been adjusted, with the result that certain materials must be designated and managed as radioactive (residual or waste) substances as of 6 February 2018, which was not the case before this date. The implementation of Directive 2013/59/Euratom mainly impacts NORM materials that are reused or dumped at the designated landfills and not so much on the NORM that is transported to COVRA. The management routes for materials classified as radioactive (residual or waste) substances as of 6 February have also changed. Previously, this waste could be transported to, for example, a waste incineration plant or an ordinary landfill, but since then, the processing of these materials has become subject to registration or a permit. NORM waste streams are largely determined by waste from the pigment industry sector and the steel industry sector (in the period 2018-2020, on average, together more than 95% of the mass/volume). All these NORM flows end up at the so-called 'designated landfills', three currently operational in the Netherlands. Further information on the impact of the implementation of Directive 2013/59/Euratom and a prognosis for the future of NORM can be found in the RIVM report [7 (M. van der Schaaf, P.D.B.M. Bekhuis, L.H.A. Boudewijns, Radioactieve rest- en afvalstromen in Nederland. Een inventarisatie. RIVM-rapport 2022-0073. 2022. Rijksinstituut voor Volksgezondheid en Milieu. Bilthoven. 2022)]

Options for managing NORM wastes are currently via treatment, blending with non-radioactive material, reuse/recycling, storage and then disposal.

For DU, pre-treatment is completed, then reuse/recycling, storage and then disposal.

For the above options, the management of NORM and DU is completed by COVRA - All NORM waste above the exemption limits is shipped and stored at COVRA. The Dutch state owns 100% of COVRA's shares. All waste stored at COVRA's premises is owned by COVRA. The producer pays for the packaging, handling, transport to and storage at COVRA and the eventual final disposal. All DU waste is shipped and stored at COVRA. The producer pays for the packaging, handling, transport to and storage at COVRA and the eventual final disposal.

Currently, there is no disposal facility for DU in the Netherlands. Research has previously been conducted into the final disposal of DU within Clay and Rock Salt. In the latest programme COPERA, which evaluates the disposal of the Netherlands' radioactive waste within Rock Salt and Clay, the possibility of using DU as backfill or container shielding was considered. No specific research into how safety can be demonstrated was performed. It was only evaluated what other reuse options there are, and if there is sufficient backfill volume to use the total volume of DU waste. The research concluded the following: - The use of a super container with DU as a buffer and shielding material was ruled out for use in rock salt. The main reason is that the DU inventory would need to be converted back to UF6, which has a high cost. The amount of the inventory needed for shielding would be limited, and the interaction of the concrete and HLW outer container wall would likely speed up the container degradation over time. For a disposal facility in clay, depleted uranium as aggregates in a cementitious material have been studied. Gamma-shielding calculations have been made to show how much thinner the thickness of the concrete buffer can be compared to the buffer made with calcite aggregates.- Use as part of the structural areas of a disposal facility; Due to the nature of rock salt as a host rock, the main idea behind achieving safety is limiting the addition of foreign materials and allowing the rock salt itself to provide sealing and ultimately to use its impermeability to prevent the egress of radionuclides. This, therefore, limits the use of DU within the disposal facility as a backfill material or container shielding. It was concluded that sufficient backfill volume is required in the disposal concept to use all DU waste. Additionally, if one considers only the transport tunnel of the upper and lower levels and the service tunnel a total backfill volume nearly equivalent to the DU volume is required. The effect of using DU as an aggregate in salt cement with regards to the sealing ability of the backfill is not well studied. Further, the DU containing backfill is to be treated as a radioactive material which complicates operational and, if needed, remedial actions. Also, failure of a container and leakage of radioactive material may be concealed by the radioactive materials in the backfill. If DU disposal as backfill material is shown to be safe, one could also consider a disposal facility design that includes dedicated DU disposal rooms that will be backfilled with DU containing backfill, which would avoid the disposal container costs Within

NRG's research programme, a limited study will be conducted to evaluate how safety could be demonstrated if DU is used as a backfill material or for filling the relevant transport tunnels within the disposal facility. In COVRA's research programme into geological disposal of waste, the use of depleted uranium is progressively taken in steps. Firstly, the floor of the underground tunnelling structure in clay host rock is being evaluated. Secondly, the concrete segments of the tunnels will be investigated.

2. Reuse and Recycling

Reuse/recycling of NORM is currently completed in the Netherlands via the following way; Specifically released NORM material can possibly also be mixed with non-radioactive material under certain conditions, with a view to recycling and reuse. From an environmental hygiene point of view, there is a preference for reuse over disposal (landfill and final storage). Reuse also offers opportunities from an economic point of view. That is why reuse routes have been developed for various radioactive waste materials, such as the melting down of contaminated or activated steel. This creates steel that can be reused and a radioactive residual product that can sometimes also be (partially) reused. This is done at the Studsvik steel smelters in Sweden, Energy Solutions in the United States and until 2018 at the Siempelkamp smelter in Germany. NRG in Petten and Cleanstream in Ter Apel have an installation to remove radioactive scaling (precipitation) from steel and to clean the steel. There are also several routes to immobilise the radionuclides in NORM materials. After shaping and hardening, the material is then suitable for various types of reuse. NORM waste subject to registration may, in principle, be deposited at designated landfills. In this case, the waste will also have to meet the other (environmental) requirements of the landfill, for which, for example, requirements are set for the leachability of heavy metals. These landfills can process large quantities of NORM waste (tens of thousands of m3 per year) but are also suitable for smaller NORM waste streams (from a few m^3). The landfill site is regarded as the final storage facility for this waste. The NORM waste transported to COVRA often has a higher activity concentration and is destined for final disposal. Sometimes sludge streams are created, for example, in oil and gas production, which, in addition to a certain amount of radionuclides, also contain other (chemotoxic) substances. In the Netherlands, the companies Begemann Milieutechniek, ATM and Reym specialise in processing various sludge streams and separating them into partly reusable components. As with reuse, the residues that arise from the processing of radioactive materials are ultimately disposed of as radioactive waste via the routes.

Currently NORM and DU is not reused within the disposal process and no specific research is being conducted for NORM wastes, however some research is being performed into DU reuse.

3. Waste Treatment

Waste treatment methods for NORM are not carried out, direct disposal. The majority of NORM waste below the relevant exemption criteria is placed in designated landfill sites for final disposal. The other NORM waste is stored at COVRA and to be disposed of in the far future. The majority of NORM waste below the relevant exemption criteria is placed in designated landfill sites for final disposal. The other NORM waste is stored at COVRA until 2130, at which point it should meet the exemption criteria.

Waste treatment methods for DU include; Cementation, Specialised treatment (e.g., deconversion to U_3O_8). The vast majority of NORM waste stored at COVRA originates from the uranium enrichment industry. This waste is stored in DV70 containers. In the OPERA (clay) and COPERA (rock salt) Safety Case it is assumed that the depleted uranium will be conditioned in a KONRAD Type II container and disposed of. Based on the safety case, it is assumed that the calcinate does not go into the final storage facility but can be released.

4. Disposal Options

There is a disposal program for NORM wastes; The majority of NORM waste below the relevant exemption criteria is placed in designated landfill sites for final disposal. The other NORM waste is stored at COVRA and to be disposed of in the far future.

There is a selected disposal program for DU; The DU will be placed in a Deep Geological Disposal facility in Clay or Rock Salt. The waste will be stored in DV70 containers. In the OPERA (clay) and COPERA (rock salt and clay) Safety Cases, it is assumed that the depleted uranium will be conditioned in a KONRAD Type II container and disposed of. NRG is performing further research to evaluate the reuse of a rock salt repository within a disposal facility and how safety could be demonstrated. COVRA is looking at the characteristics of the U_3O_8-granules in order to optimize the design of cementitious materials for the use of depleted uranium as a shielding and structural material in a disposal facility in clay host rock.

Currently engineered landfills are used for NORM disposal; the majority of NORM waste below the relevant exemption criteria is placed in designated landfill sites for final disposal. The other NORM waste is stored at COVRA and to be disposed of in the far future.

Currently deep geological disposal is planned for DU; DU is destined for final disposal in a deep geological disposal facility in the Netherlands. As part of the research into a final disposal concept, various containers have been evaluated to determine the most favoured solutions, considering the current constraints. Within the COPERA research, the DV70, an alternative cylindrical container design, reuse, and all Konrad containers were considered. The current preferred container is the Konrad Type II container.

Disposal challenges for NORM; linked to the possible change of directives and, therefore, requirements for managing NORM waste.

Challenges for DU disposal; The Netherlands has a reasonably large quantity of DU in relation to other waste forms requiring disposal in a deep geological disposal facility. Due to the large volume and the fact that the radiotoxicity of DU does not decrease over time, it is important to demonstrate safety on a very long scale for this waste stream. Something that can be evaluated to help reduce costs is to reuse the DU more effectively during disposal rather than requiring thousands of containers.

WAC issues for NORM; NORM waste subject to registration may, in principle, be deposited at designated landfills. In this case, the waste will also have to meet the other (environmental) requirements of the landfill, for which, for example, requirements are set for the leachability of heavy metals.

WAC issues for DU;

- Interim storage - Depleted uranium (DU) is converted to a stable oxide (U_3O_8) and stored in standardised containers.
- Disposal - in case of disposal in a clay formation: From the present generic disposal concept, it follows that for disposal in clay, a KONRAD type II container can be used to condition the DU for disposal. The waste will be conditioned using concrete containment, in which DU is incorporated as a fine aggregate.
- Disposal - in case of disposal in a rock salt clay formation: This disposal concept is under development, so there are currently no WACs.

5. Safety Case

The Netherlands has a safety case for NORM; Mineralz Maasvlakte BV has obtained a license from the Dutch nuclear safety authority ANVS to dispose low active NORM in a landfill (C3 deponie). To obtain the license, Mineralz has shown that this disposal facility is safe. Note that also nonradioactive hazardous wastes are and will be disposed of in this landfill. The safety study covers both waste types and is not the "shape" of a typical safety case for radioactive waste only. NORM that cannot be disposed of by Mineralz is collected by COVRA and taken into interim storage

The safety case for DU is in development; safety case for DU waste has been performed as part of the OPERA and COPERA research programs managed by COVRA.

The radiological impact assessment for the period after closure for NORM; Mineralz Maasvlakte BV has obtained a license from the Dutch nuclear safety authority ANVS to dispose low active NORM in a landfill (C3 deponie). To obtain the license, Mineralz has shown that this disposal facility is safe. Note that also nonradioactive hazardous wastes are and will be disposed of in this landfill. The safety study covers both waste types and is not the "shape" of a typical safety case for radioactive waste only.

The radiological impact assessment for DU are as follows; DU will not be disposed of in a landfill. In the safety case for disposal in a clay formation, doses and radiotoxicity concentration in biosphere water have been calculated for the normal evolution scenario.

Time frames for NORM safety case NA.

Time frames for DU safety case are as follows; DU will not be disposed of in a landfill. In the safety case for disposal in a clay formation, the radiotoxicity concentration in biosphere water has been calculated over a billion years. It is indicated that, at these times, the calculation basis becomes highly stylised and is largely illustrative because considerable changes would be expected to occur in both the biosphere and the geosphere

6. Workshops and follow up

The Netherlands would like to partake in workshops and follow up, including the following topics;

- Long-term disposal strategies (NORM and DU)
- Reuse and recycling options (NORM and DU)
- Inventory management (DU)
- Safety case methodologies (DU)

Research priorities are as follows:

- Development of safety case methodologies (DU)
- Reuse and recycling technologies (DU)
- Long-term safety assessment and modelling (DU)

International collaboration is of interest for NORM and DU:

- Development of safety case methodologies (NORM and DU)
- Waste Treatment and disposal technologies (NORM and DU)
- Long-term monitoring and surveillance (NORM and DU)
- Reuse and recycling strategies (NORM and DU)

7. Additional information

Future projects include; NRG is currently looking into the reuse and recycling of DU in its research program.

Norway

Company – DSA

Role – R&D

1. Waste Inventory and Management

Norway has both NORM and DU waste. They use the following definitions: NORM waste as radioactive waste, but managed and disposed separately from radioactive waste from nuclear facilities, research, medicine and disused sealed sources. DU is not considered as radioactive waste.

Type of NORM wastes:

- Oil and gas,
- Processing industries and from alum shale.

Quantity of NORM: 1653684 tonnes of NORM waste, of which 6103 is from petroleum industry waste.

Quantity of DU: ca 4 tonnes in total.

Inventory management of NORM is registered at repositories, and DU is registered at DSA and managed under safeguards.

NORM is managed via waste minimisation at the source and then disposal. DU is just stored, and then returned to the Norwegian vendor, which sends it back to the producer.

For NORM, the repositories are privately owned by non-government companies, and the DU producer is responsible.

2. Reuse and Recycling

No reuse/recycling is currently used or planned.

3. Waste Treatment

No waste treatment for NORM, just direct disposal.

No waste treatment for DU, only storage until shipped back to the producer.

4. Disposal Options

The current disposal plan for NORM wastes is at dedicated disposal sites.

No disposal plan for DU as returned to the producer.

Drum barrels are used/planned to be used.

The challenge of disposal for NORM is that organic radioactive waste has no treatment and disposal options. Large inventory of NORM is costly to dispose of.

WAC for NORM: According to Regulations on the application of the Pollution Control Act on radioactive pollution and radioactive waste based on the specific activity of material: Ra-226 (NORM-waste) specific activity conc < 1 Bq/g not radioactive waste Ra- 226 (NORM-waste), specific activity conc > 1 Bq/g and < 10 Bq/g hazardous waste / radioactive waste may either be disposed of at licensed repository or discharged on getting a license from DSA. NORM-waste specific activity conc > 10 Bq/g and total activity > 10.000 Bq radioactive waste to be disposed of at a licensed repository.

No WAC information for DU.

5. Safety Case

Norway has a safety case for NORM, but not DU.

The basic elements of long-term safety assessment for NORM are scientific assessments, engineering barriers, and regulatory oversight.

6. Workshops and follow up

Norway would like to be involved in workshops and follow up for the following topics:

- Long-term disposal strategies (NORM and DU)
- Strategies for management of radioactive waste with TOC (total organic carbon) > 10 % (NORM)
- Safety case methodologies (DU)
- Inventory management (DU)

Research priorities are as follows:

- Waste characterisation and inventory management (NORM and DU)
- Development of safety case methodologies (DU)
- Reuse and recycling technologies (NORM)
- Long-term safety assessment and modelling (NORM)
- Communication and transparency with the public (NORM)

International collaboration topics are as follows:

- Development of safety case methodologies (DU)
- Waste treatment and disposal technologies (NORM and DU)
- Long-term monitoring and surveillance (NORM)
- Reuse and recycling strategies (NORM)

7. Additional information

No other additional information

Poland

Company – institute of nuclear chemistry and technology.

Role – research and development.

1. Waste Inventory and Management

Poland has both DU and NORM wastes. Their definition is as follows 'There is no generally accepted definition; ad hoc definitions taken from publicly available literature NORM - naturally occurring radioactive matter, natural matter containing environmental radioisotopes in small, natural concentrations depleted uranium (DU) is a chemically toxic, radioactive by-product obtained as a result of the uranium enrichment process.

Type of NORM wastes:

- Mining waste,
- Uranium mine dumps.

Quantity of NORM: several dumps in the area of the former exploitation of uranium mines.

Quantity of DU: 9400 kg

There is no precise information on the management of NORM and DU; they currently store NORM and DU wastes.

The only answer provided for the DU management system is the state-owned organisation ZUOP.

2. Reuse and Recycling

They do not reuse/recycle the waste currently or planned.

3. Waste Treatment

No waste treatment methods for NORM, just direct disposal, storage in heaps.

No waste treatment methods for DU, only temporary storage. Stored in two places: in near surface Rozan repository and in storage oat Swierk, at ZUOP.

4. Disposal Options

No current disposal program for DU or NORM, for NORM, there is no future plan, just storage for now. DU will 'probably' transfer to the new build near-surface repository for temporary storage. The considered disposal method for DU would be a deep geological facility.

No planned container usage for either.

Disposal challenges for NORM are difficult to comment on, but maybe full protection of existing mining waste heaps.

Disposal challenges for DU, would be moving the DU from temporary storage and from the existing repository which will be closed in the coming years, to the new facility.

No WAC for NORM, and only safe packing required for DU.

5. Safety Case

No safety case for DU or NORM, or radiological impact assessment.

6. Workshops and follow up

Poland would like to be involved in future workshops and meetings looking at the following topics:

- Long-term disposal strategies (NORM and DU)
- Reuse and recycling options (NORM and DU)

Their research priorities are as follows:

- Waste characterisation and inventory management (NORM and DU)
- Development of safety case methodologies (NORM and DU)
- Reuse and recycling technologies (NORM and DU)

Internation collaboration topics:

- Development of safety case methodologies (NORM and DU)
- Waste treatment and disposal technologies (NORM and DU)
- Reuse and recycling strategies (NORM and DU)

7. Additional information

No additional information provided.

Portugal

Company – IST-ID / Research

Role - IST-ID is the research entity. IST acts as WMO by being responsible for the management of radioactive waste produced in the national territory, including spent sealed sources and the management of NORM (except for mining waste). In its centralised storage facility, IST also stores DU material.

1. Waste Inventory and Management

Portugal has both NORM and DU waste. In Portugal and according to the National Plan, NORM is classified as radioactive waste while DU material is managed under the safeguards material regime.

Types of NORM waste:

- industrial by-products (old coal industry and phosphogypsum tailings),
- building materials,
- waste from the oil and gas industry,
- scrap metal.

Quantity: Info from IST – WMO:

- NORM waste - Approximately 10 cubic meters stored at the centralised National Radioactive Storage Facility (PRR), IST.

DU – DU material is, at the moment, stored at a specifically confined area in the PRR, due to absence of other suitable place for it at the Campus of Loures. For security reasons, information about the amount of DU is confidential. Inventory management of NORM and DU is carried out via a centralised system.

NORM waste is currently managed via minimisation at source – clearance and exclusion levels (Ministerial Ordinance n. 138/2029, May 10th, updates from the Ministerial Ordinance n. 44/2015, February 20th, adopting the clearance and exclusion levels as the same levels set by Council Directive 2013/59/Euratom). DU excluded. NORM waste with activity concentration higher than the clearance and exclusion levels is to be stored at the National Radioactive Storage Facility (PRR), IST until other future option is available

NORM producers are responsible for waste minimisation (DU excluded). Storage is as above.

2. Reuse and Recycling

No recycling or reusing of radwaste is carried out at IST.

3. Waste Treatment

For waste treatment methods, only storage without preparation for pre-disposal or disposal.

4. Disposal Options

Concerning NORM waste and DU materials and, as far as it is known:

There are no disposal plans for NORM waste or DU materials.

No planned containers.

No planned route. Unknown challenges.

No WAC is being applied.

5. *Safety Case*

No safety case for disposal for NORM waste or DU materials

6. *Workshops and follow up*

Would like to be involved in the following topics, all for NORM waste and DU materials/wastes, and an additional topic:

- Safety case methodologies (NORM and DU).
- Long-term disposal strategies (NORM and DU).
- Inventory management (NORM and DU)
- Reuse and recycling (NORM).

Research priorities are of interest for NORM/DU:

- Waste characterisation and inventory management (NORM and DU).
- Development of safety case methodologies (NORM and DU).
- Long-term safety assessment and modelling (NORM and DU).
- Communication and transparency with the public (NORM and DU).

International collaboration benefiting topics:

- Development of safety case methodologies (NORM and DU).
- Waste treatment and disposal technologies (NORM and DU).
- Long-term monitoring and surveillance (NORM and DU).
- Reuse and recycling (NORM)

7. *Additional information*

No additional information provided.

Slovenia

Company – ARAO

Role – takeover of NORM RW, long term monitoring and maintenance of closed NORM (TENORM) sites.

1. Waste Inventory and Management

Slovenia has both NORM and DU wastes. With the following definition provided, 'NORM is in line with Slovenian regulations classified as RW'.

Type of NORM waste:

- Industrial by-product (e.g., TiO2 production),
- Legacy waste from Uranium mining (tailings).

Quantity of NORM; Jazbec mine tailings repository (disposal site), 1,910,425 t of mining tailings are permanently deposited, with an average content of 53 g U_3O_8/t (or 7.7 kBq of U-238/kg), and a total deposited activity of 21.7 TBq. The Boršt hydrometallurgical tailings repository (disposal site) 730,450 t of waste is deposited in the repository, i.e. 610,000 t of hydrometallurgical tailings, 111,000 t of mining tailings and 9,450 t of contaminated materials from the decontamination of the repository environment (mining tailings, contaminated soil, construction waste). The total activity of the deposited materials is 48.8 TBq.

Quantity of DU: No DU currently, DU in 7 protective containers intended for industrial radiography and then will be re-used.

NORM and DU radioactive waste are currently managed via a centralised national registry, as both are a part of the national classification system for radioactive waste.

NORM is managed via disposal.

DU is managed via waste minimisation at source and reuse/recycling.

NORM is managed by ARAO, the national WMO for the disposal of NORM.

Management of DU is completed by the holders of the DU if it's reused/ recycled. When /if taken over by ARAO, then it will be ARAO's responsibility to find the solution in reuse or final disposal.

2. Reuse and Recycling

Currently, for reuse/recycling, In line with national policy and strategies, RW and sources primarily to be returned to suppliers or producers. If this is not possible, they are to be handed over to the ARAO for appropriate treatment, conditioning and storage in the centralised storage facility for institutional RW – continuously.

NORM waste has been reused in the past, as backfilling material for the two existing disposal sites, Jazbec and Borst.

For DU, they try to avoid the reuse of it in disposal facilities; therefore, reuse/recycling is already supported by the holder before being taken over by the ARAO (WMO).

3. Waste Treatment

No treatment of NORM carried out, just direct disposal.

Waste treatment of DU is encapsulation; the DU material will be packaged in standard drums and then in concrete disposal containers.

4. Disposal Options

There is a current disposal program for NORM, but one is being developed for DU.

NORM is disposed of via dedicated disposal sites – two existing closed disposal sites for the disposal of mine and hydrometallurgical tailings.

A near surface disposal site is planned for DU, with a concrete reinforced disposal container.

NORM disposal challenges include long-term monitoring and maintenance of closed disposal sites.

DU disposal challenges include final packaging in disposal containers.

WAC for NORM, is site/ facility specific, regulated by rules on radioactive waste management and approved by the national regulator.

WAC for DU, for interim storage, there is a WAC for the storage facility and for disposal, there is a WAC.

5. Safety Case

Slovenia has a safety case for NORM; it was not directly a part of the safety case for the LILW repository (in construction), but was/is part of the safety analysis report for the closed disposal sites Jazbec and Boršt (mine and hydrometallurgical tailings).

They have a safety case for DU.

A post-closure radiological impact assessment has been completed for NORM and DU, as it was a condition to close both the disposal sites / the repository for the DU.

No specific timeframes were defined for NORM, both sites are closed and long term monitoring and maintenance are performed without time limitation. No specific DU timeframe, an overall timeframe based on other radioactive waste inventories is considered.

6. Workshops and follow up

Slovenia would like to be apart of workshops and follow up, including the following topics:

- Long-term disposal strategies (NORM)
- Reuse and recycling options (NORM and DU)
- Safety case methodologies (DU)

Research and development priorities include;

- Waste characterisation and inventory management (DU)
- Reuse and recycling technologies (DU)
- Communication and transparency with the public (NORM and DU)
- Development of safety case methodologies (NORM)
- Long-term safety assessment and modelling (NORM)

International collaboration topics include:

- Development of safety case methodologies (NORM and DU)
- Waste treatment and disposal technologies (DU)
- Long-term monitoring and surveillance (NORM and DU)
- Reuse and recycling strategies (NORM and DU)

7. Additional information

No future project planned currently.

In response to a request for additional information on Slovenia, further details of their waste management approach to NORM and DU have been provided. The information comes from the 8th Slovenian report to the IAEA Joint Convention (IAEA Joint Convention, August 2024). As well as a presentation provided during the workshop (details in Section 3).

South Korea

Company – Korea Atomic Energy Research Institute.

Role – Research and Development.

1. Waste Inventory and Management

South Korea has neither NORM or DU waste[1].

Inventory management of NORM completed by centralized national registry.

Management options for NORM and DU include waste minimisation at source, treatment and reuse/recycling. These are managed by the owner organisation.

2. Reuse and Recycling

Reuse and recycling are used for research into shielding by using the waste type. Safety is demonstrated based on national safety rules.

3. Waste Treatment

Waste treatment methods for NORM and DU include encapsulation and cementation.

4. Disposal Options

They have a current disposal program for NORM and DU.

NORM and DU are disposed of via near surface, currently encapsulating the waste. They are within metal drums and concrete reinforced containers.

5. Safety Case

South Korea has a safety case for NORM and DU.

Radiological impact assessment has been performed, looking at Engineered and Natural Barrier, Regulatory Compliance and Standards, Monitoring and Surveillance.

Timeframe for NORM and DU; depending on national regulations, international guidelines, and the characteristics of the disposal site.

6. Workshops and follow up

South Korea would like to be involved in workshops and follow up, including the following topics;

- Safety case methodologies (NORM).
- Long-term disposal strategies (NORM).
- Reuse and recycling options (NORM and DU).
- Inventory management (NORM and DU).

Research priorities:

- Waste characterisation and inventory management (NORM and DU).
- Reuse and recycling technologies (NORM and DU).

International collaboration topics:

[1] Note this could be a mistake from the questionnaire, due to the information on how South Korea handles its NORM and DU waste provided.

- Waste treatment and disposal technologies (NORM and DU).
- Reuse and recycling strategies (NORM and DU).

7. Additional information

Future projects are happening;

- Advanced Characterisation Techniques,
- Innovative Waste Treatment Technologies,
- Real-Time Monitoring Technology.

Switzerland

Company – PSI

Role – Conditioning and interim storage of waste from medicine, industry and research which might contain these wastes.

1. Waste Inventory and Management

Switzerland has both NORM and DU waste types. With the following definition 'there is no specific definition for NORM or DU waste. One reason might be that all waste will go to geological disposal'

The type of NORM waste comes from industry and research.

Quantity of NORM and DU; in total, several cubic meters - difficult to estimate

Inventory management for NORM; PSI is responsible for all waste from the medicine industry and research - conditioning and interim storage. Amounts have to be entered into a national. From Nagra webpage (only in German: Die Nagra erfasst alle Abfälle Die Nagra führt ein zentralesInventar: Im Verzeichnis ISRAM (Informationssystem für radioaktive Materialien) erfasst sie systematisch die Menge sowie die chemischen und physikalischen Eigenschaften der bereits bestehenden Abfälle. Dokumentiert sind die radioaktiven Abfälle, die in Kernkraftwerken anfallen und in den Zwischenlagern aufbewahrt werden, ebenso wie die Abfälle aus Medizin, Industrie und Forschung. Zudem gibt es auch MIRAM, das modellhafte Inventar für Abfälle, die bereits vorhanden sind und künftig anfallen. Es basiert auf ISRAM. Die Nagra muss schon heute wissen, wie viele Abfälle dereinst in einem Tiefenlager entsorgt werden und was für Eigenschaften diese haben. So kann sie das Tiefenlager ausreichend gross projektieren und fundierte Daten für Sicherheitsanalysen bereitstellen.

Waste management options for NORM include waste minimisation at source, pre-treatment, treatment, blending with non-radioactive material, reuse/recycling, conditioning, storage and disposal.

Waste management options for DU include waste minimisation at source, pre-treatment, treatment, blending with non-radioactive material, reuse/recycling, conditioning, storage and disposal.

Management systems of NORM and DU for waste from industry (except from NPPs) and research, PSI is responsible for collection, conditioning and interim storage and Nagra for its final disposal in a geological repository.

2. Reuse and Recycling

Some radionuclides from research waste might be reused for research purposes in Switzerland.

3. Waste Treatment

Waste treatment methods for NORM include encapsulation, cementation, no treatment direct disposal, plasma burner if this is looked at as different from vitrification (at ZWILAG). Research waste includes a wide spectrum of waste/radionuclides, therefore PSI had/has to develop specific treatment options for the specific wastes and get confirmation for these options from the implementer (NAGRA) and regulator (ENSI).

Waste treatment methods for DU include encapsulation, cementation and plasma burner if this is looked at as different from vitrification (at ZWILAG). Research waste includes a wide spectrum of waste/radionuclides, therefore PSI had/has to develop specific treatment options for the specific wastes and get confirmation for these options from implementer (NAGRA) and regulator (ENSI).

4. Disposal Options

There is a current disposal program for NORM and DU. NORM and DU waste is included in the wastes in CH, not specifically as NORM and DU.

Deep geological disposal has been chosen for both legacy NORM waste—previously conditioned at PSI—and depleted uranium (DU). According to Swiss regulations, all radioactive waste must be disposed of in a deep geological repository (DGR). However, NORM waste not previously conditioned at PSI may be placed in surface disposal facilities under special authorisation, provided it contains no additional artificial isotopes. In such cases, it is exempt from DGR requirements.

Drums and cubic concrete containers to be used for disposal container.

Disposal challenges for NORM and DU are conditioning recipes for waste from industry and research.

The WAC for NORM and DU are defined by ENSI (regulator) which should be in accordance to IAEA guidelines

5. Safety Case

Safety case not applicable to NORM and DU, as they are included in the waste type inventory and for all wastes, there is a safety case defined (in CH).

Radiological impact assessment is part of a general license application sent in November 2024 from Nagra to ENSI.

Timeframes for the safety case are 100,000 years.

6. Workshops and follow up

Switzerland would not like to be included in workshops or follow up.

7. Additional information

No additional information provided.

Ukraine

Company – SSTC NRS

Role – TSO

1. Waste Inventory and Management

Ukraine has both NORM and DU waste, with the following definition 'Technologically-enhanced naturally occurring radioactive material (TENORM) is a radiation source of natural origin that, as a result of human economic and industrial activities, has been concentrated or made more accessible, resulting in additional radiation (beyond natural background radiation). DU (low-enriched Uranium): Low enriched uranium - uranium that contains less than 20% of the isotope uranium-235, or uranium-233, or a mixture of both. Depleted uranium - uranium that contains less of the radioactive isotope uranium-235 compared to natural uranium. Depleted uranium (0.4% enrichment - percentage of U-235 in uranium as a chemical element) is used as shielding against gamma radiation in medicine and in the construction of transport containers for radioactive materials. Products containing depleted uranium include gamma defectoscopes, radiation heads, protective containers such as "Gamarid", BGI, and others. Accounting and control of nuclear materials is conducted independently from other radioactive waste accounting. These include: containers made of depleted uranium; products, devices, powders, and solutions containing uranyl nitrate; sealed sources containing uranium hexafluoride

Type of NORM waste; these are materials with increased levels of natural radionuclides that are formed and/or produced as a result of activities not related to the use of nuclear energy such as;

- Mining of minerals (non-uranium) in underground mines and shafts,
- Extraction of minerals and raw materials in surface conditions (quarries, oil development),
- Processing of minerals and raw materials with increased levels of natural radionuclides (ferrous, non-ferrous and rare metals, oil),
- Porcelain and earthenware production,
- Production of phosphate fertilisers,
- Technologies using zirconium sands,
- Production of refractory materials,
- Manufacturing and/or use of industrial materials and products with thorium-containing compounds,
- Technologies related to the production and/or application of titanium dioxide pigments,
- Use in the construction industry of waste materials such as ash and slag, in which the concentration of natural radionuclides increases during the combustion of solid fuels,

Quantity of NORM: analysis of radioactive waste contaminated with technologically-enhanced naturally occurring radiation sources (Ra-226, Th-232, K-40) received from oil and gas industry enterprises during the period 2010-2015 showed that the designed amount of such waste could reach up to 100 tons annually. A comprehensive assessment of materials contaminated with technologically-enhanced naturally occurring radiation sources from other industries has not been conducted at this time.

Quantity of DU: The collection, compilation, analysis, and submission to the IAEA of information regarding the quantity of DU waste is carried out by the Ukrainian nuclear and radiation safety regulator. This information is not publicly available.

Inventory management of NORM: A draft strategy for managing oil and gas industry materials contaminated with naturally occurring radionuclides is being developed. Under partnership between Norwegian regulatory body (DSA) and Ukrainian regulatory body (SNRIU) and its TSO (SSTC NRS), action plans include analysing Ukrainian industrial activities with potential NORM generation by 2027, plus developing two regulatory documents: "General Safety Provisions" and "Radiation Safety Requirements and Rules" for managing NORM materials.

Management options for NORM; none; Until 2013 State Specialised Enterprises for Radioactive Waste Management accepted for interim storage oil and gas extraction waste (pipes and sludges). After that, realistic conditions for storing TENORM-contaminated materials at these facilities ceased due to the volume of accumulated waste from the oil and gas industry. TENORM-contaminated waste is now accumulating at oil and gas industry enterprises sites. Formally, TENORM does not currently fall under the definition of radioactive waste and is not classified as such. As a result, management options for these materials are not defined, and there are no regulatory documents governing the handling of such waste.

Management options for DU: storage.

Management system for NORM; Until 2013, TENORM contaminated pipes and sludges received from oil and gas industry enterprises were considered as radioactive waste. Currently, TENORM does not fall under the definition of radioactive waste and is not classified as radioactive waste, so management options for these materials are not defined, and there are no regulatory documents governing the handling of such waste. TENORM-contaminated waste is now accumulating at the industry enterprises where they were produced.

Management system for DU; State Specialised Enterprises for Radioactive Waste Management are responsible for the DU waste management.

2. Reuse and Recycling

Reuse / recycling; From 2013 to 2015, the State Specialised Enterprises for Radioactive Waste Management launched and successfully tested a project for the mechanical decontamination of pipes from oil and gas industry companies. Sludges received from oil and gas companies undergo conditioning through solidification by cementation at their places of origin, followed by placement of the cement matrix in certified IP-2 type packaging for transportation and temporary storage as low and intermediate level radioactive waste.

Reuse within a disposal facility for NORM; clean pipes that have undergone mechanical decontamination and meet the criteria for clearance based on dose rate and surface contamination levels are used as scrap metal. Waste minimisation is achieved by obtaining approximately one ton of clean scrap metal for every 20 kg of radioactive waste. General exchange, supply-exhaust, and aspiration ventilation systems with automatic control and efficiency monitoring were installed for the mechanical decontamination process of tubing. An "Instruction on the operation of the ventilation system during the technological process of mechanical tubing decontamination" was developed, approved, and implemented. Facility personnel received training and certification on the safe operation of the ventilation system, compliance with occupational safety requirements, and radiation safety during tubing decontamination operations.

DU is not reused in Ukraine.

3. Waste Treatment

Waste treatment for NORM is cementation; sludges received from oil and gas companies undergo conditioning through solidification by cementation at their places of origin, followed by placement of the cement matrix in certified IP-2 type packaging for transportation and temporary storage of low and intermediate level radioactive waste. Waste generated at the State Specialised Enterprises for Radioactive Waste Management as secondary radioactive waste during the decontamination of pipes contaminated with technologically enhanced naturally occurring radiation sources consists of solid radioactive waste in the form of powdery mineral particle chips contaminated with TENORM. These are stored as solid radioactive waste.

No treatment methods for DU, just direct disposal.

4. Disposal Options

No current disposal plans for NORM or DU. For NORM, to be developed in the coming years as part of the Strategy for the Management of Materials, Equipment, and Waste from the Oil and Gas Industry Contaminated with Naturally Occurring Radionuclides, along with accompanying regulatory documents. For DU, Currently DU waste is stored at State Specialised Enterprises for Radioactive Waste Management sites.

Disposal methods for NORM or DU wastes have not been considered or selected in Ukraine.

Disposal containers; Sludges received from oil and gas companies were placed in the form of the cement matrix in certified IP-2 type packaging for transportation and temporary storage. TENORM contaminated products are not considered as radioactive waste in Ukraine and are not accepted for disposal and storage due to their large volumes. Due to the lack of facilities and methodologies for processing, the treatment of such materials is also not carried out. There is also no regulatory framework and concept for managing materials contaminated with TENORM.

WAC for NORM; TENORM-contaminated pipes are accepted as gamma-emitting radioactive waste with unknown specific activity, using classification as "low" or "medium" active based on the criterion of absorbed dose rate in air at a distance of 0.1 m from the surface where the radioactive waste is located. Sludges, after conditioning and solidification, are accepted as solid radioactive waste based on specific activity, which is the classification criterion for assigning these radioactive wastes to a particular category. To be developed in the coming years as part of the Strategy for the Management of Materials, Equipment, and Waste from the Oil and Gas Industry Contaminated with Naturally Occurring Radionuclides, along with accompanying regulatory documents.

5. Safety Case

No safety case for NORM or DU.

Ukraine does not have a post-closure radiological impact assessment for NORM or DU wastes.

Due to the absence of relevant legislation, time intervals have not been defined

6. Workshops and follow up

Ukraine would like to be involved in future workshops and follow up for the following topics:

- Safety case methodologies (NORM and DU)
- Long- term disposal strategies (NORM and DU)
- Reuse and recycling options (NORM and DU)
- Inventory management (NORM and DU)

International collaboration topics include:

- Development of safety case methodologies (NORM)
- Waste treatment and disposal technologies (NORM)
- Long-term monitoring and surveillance (NORM)
- Reuse and recycling strategies (NORM)

7. Additional information

Future projects; Under the partnership between the Norwegian regulatory body (DSA) and Ukrainian regulatory body (SNRIU) and its TSO (SSTC NRS), by 2027 there are plans to conduct an analysis of industrial activities in Ukraine associated with the potential generation of materials containing natural radionuclides, along with: * Development of the regulatory document "General Safety Provisions for the Management of Materials Containing Natural Radionuclides" * Development of the regulatory document "Radiation Safety Requirements and Rules for Safe Management of Materials Containing Natural

Radionuclides" * Development of the regulatory document "Procedure for Monitoring, Sampling, and Determining Characteristics of Materials Containing Natural Radionuclides.

United Kingdom 1

Company – Galson Sciences Limited

Role – Consultancy Group

1. Waste Inventory and Management

The UK has both NORM and DU wastes. They have the following definition ‘The UK has a large inventory of uranium materials, comprising depleted, natural and low-enriched uranium (DNLEU). UK management and disposal strategies refer to DNLEU, although the term DU is used throughout this document. In the UK, DU is considered a zero-value asset radioactive material and is not currently declared as a waste; NORM - Low Level Radioactive Waste.

Type of NORM waste:

- Thorium coated lens manufacturers,
- Academic uses of U and Th compounds,
- Titanium dioxide industry,
- Zirconia industry,
- Extraction of China clay,
- Management of contaminated land,
- Oil and gas industry.

Quantity of NORM; The following are estimates of the annual quantities of solid NORM waste generated that currently require management at specialist facilities that are permitted to manage radioactive waste. There remain some uncertainties about these estimates. Oil and gas – offshore ~ 160 Tonnes/yr; Oil and gas – onshore < 20 Tonnes/yr; Titanium dioxide ~ 10 Tonnes/yr; Zirconia industry ~0.04 Tonnes/yr; Thorium coated lens manufacturer ~ 1 Tonnes/yr; Contaminated land, very variable. Total < 300 tonnes.

Quantity of DU: 184,000 tU from civil fuel enrichment and civil spent fuel reprocessing; 8,000 tU from defense programs [note: data are taken from the 2019 Inventory for Geological Disposal (IGD), published in 2021].

Inventory management of NORM is via a centralised national registry and DU via the UK radioactive waste inventory and IGD.

Waste management options for NORM include: waste minimisation at source, blending with non-radioactive material and disposal. The UK follows waste hierarchy principles, which prioritise waste prevention and minimisation.

Waste management options for DU include; Pre-treatment, Reuse/ Recycling, Conditioning and Storage. Pre-treatment: DU currently stored as UF_6 (hex) is assumed to be deconverted to U_3O_8 for onward storage and disposal. Deconversion of DU tails currently takes place at the Tails Management Facility (TMF) operated by Urenco ChemPlants, details here: https://www.urenco.com/global-operations/urenco-chemplants Reuse/ Recycling: Re-enrichment of DU tails where this is justified by market economics. Conditioning: Some DU, notably that arising from reprocessing activities at the Thermal Oxide Reprocessing Plant (THORP) as well as miscellaneous DU, is assumed to be encapsulated in a cementitious grout for disposal (after deconversion to U_3O_8), although such conditioning is not currently being implemented. Uranium is considered a zero value asset nuclear material and is not classed as a waste. The UK Nuclear Decommissioning Authority (NDA) considers that no single option will be appropriate to manage the uranium inventory in its entirety due to its diverse nature. The preferred option is to be determined for each component of the inventory on a case by case basis. The current approach for the management of NDA’s uranic materials is therefore to store them in their current form or, where necessary, to reduce their intrinsic chemical hazard through deconversion to more passively safe forms more suitable for ongoing storage, followed by repackaging and consolidated storage. NDA states that continued storage does not provide an end point for uranium materials. UK legislation requires that NORM containing wastes originating from specified industries are subject to regulation if the concentration of NORM exceeds specified values. If the concentration of NORM in the waste is less than the specified values in legislation, or the waste arises from an industry not specified in the legislation, the radioactive substances legislation does not apply. This is because government has concluded it would be disproportionate to apply radioactive substances controls to these wastes. Waste not captured by the radioactive substances legislation is known as "out of scope". The policy is to facilitate the sustainable and efficient management of Low Level Radioactive Waste in line with the "waste hierarchy" principle. This requires a policy framework which enables and encourages waste producers to avoid the production of unnecessary waste, and to manage actual arisings in the most environmentally appropriate way. Most NORM waste is disposed of as exempt radioactive waste in landfills that are permitted to accept controlled wastes.

The management system of NORM and DU is as follows;

- Waste minimisation at source: Producer (NORM),
- Blending with non-radioactive material: Producer (NORM)
- Disposal: Producer, facility operator (NORM and DU; state owned organisation determines strategy (NWS/NDA)),
- Pre-treatment: Urenco ChemPlants (UCP, a subsidiary of Urenco – one of the waste producers) (DU),
- Conditioning: Waste producers Storage: State owned organisation (NDA) determines strategy; producers (Urenco and Sellafield Ltd implement) (DU),
- Disposal: Producer, facility operator (NORM and DU; state owned organisation determines strategy (NWS/NDA)).

2. Reuse and Recycling

Reuse/recycling of DU currently in the UK, is sometimes conducted, where re-enrichment of DU is sometimes conducted (as opposed to using fresh natural uranium from mining, milling and conversion), depending on market economics.

DU waste reused during its disposal process; Nuclear Waste Services (NWS's) Uranium Integrated Project Team (U-IPT) evaluated various ways in which to use the DU to realise some kind of benefit within a geological disposal facility. It concluded that there are several ways in which it would be feasible to use the UK inventory many times over, for example, as mass backfill or as part of structural components, avoiding the need for (or reducing the size of) dedicated disposal vaults for DU. These are referred to as 'GDF-use' options. The most credible of these is disposal of containerised DU in the service and transport tunnels for other waste types in place of some mass backfill. Source: Final report of the U-IPT, 2016, NDA Report no. NDA/RWM/142. Considered at the conceptual design level – not currently implemented. However, the U-IPT also considered long-term safety implications of DU disposal – refer to the report above for details.

3. Waste Treatment

No waste treatment methods for NORM, just direct disposal

Waste treatment for DU includes, encapsulation and specialised treatment (e.g., deconversion to U_3O_8). Encapsulation: It has been recommended that the UK undertake an assessment of whether the operational and post-closure hazards posed by the uranium inventory can be reduced by cement-encapsulation. specialised treatment (e.g., deconversion to U_3O_8): Some uranium materials require conditioning or treatment to be suitable for long term interim storage, for example, deconversion of UF_6 to U_3O_8.

4. Disposal Options

Disposal program for DU is in development.

Current disposal method for NORM is Engineered landfills, most NORM waste is disposed of as exempt radioactive waste in landfills that are permitted to accept controlled wastes. More than half of the solid NORM waste generated by the oil and gas sector is disposed of to sea in line with domestic and international best practice. Some hazardous waste is sent to the Low Level Waste (LLW) Repository in Cumbria. The estimated annual volume is less than 300 tonnes, Most NORM waste is disposed of as exempt radioactive waste in landfills that are permitted to accept controlled wastes. More than half of the solid NORM waste generated by the oil and gas sector is disposed of to sea in line with domestic and international best practice.

Disposal method chosen for DU is, Deep geological disposal.

Near surface was considered, however for DU – insufficient (radiological and volumetric) capacity at the low level waste repository, even if DU were declared a waste. Engineered landfill also considered, but DU – challenging to make a robust post-closure safety case that fulfils UK regulatory requirements.

Currently, conceptual disposal container designs have been developed for DU. These are assumed to be 500 litre stainless steel drums (handled in 2x2 stillages) and stainless steel combined transport and disposal containers (TDCs) for others (three height permutations). Refer to the 2019 Inventory for Geological Disposal for further details.

Key disposal challenges for DU; Identifying a suitable location for disposal of DU, as part of wider GDF siting.

WAC challenges for DU; Site / facility specific WAC and/or Conditions for Acceptance for pre-treatment (deconversion) of DU and for consolidation of DU at the Capenhurst site. Disposal is not yet implemented and a GDF is not yet available so there are no associated WAC at this time. The generic specification for waste packages containing DNLEU can be regarded as preliminary WAC for geological disposal of DU in the UK.

5. Safety Case

The UK has a safety case for NORM; for NORM disposal at the LLW Repository, an environmental safety case has been produced.

N/A safety case for DU. A generic disposal system safety case has been published (in 2016). DU is included. However, as no disposal facility has been identified for DU there is not a site specific safety case (as pertains to definition in footnote 1).

For NORM wastes, a radiological impact assessment has been performed for the LLW Repository. ‘Long-term’ means at all times after the completion of disposal and the end of active institutional control of the site (currently anticipated to be 2230 AD for the Extended Disposal Area; EDA). Four exposure pathways are considered: groundwater, gas, coastal erosion and human intrusion. The radiological assessment requires the use of conceptual and mathematical models (implemented via computer codes) and the results depend on the models used. To support and build confidence in the models used and the outcomes of the assessments, continued monitoring of the site and the facility throughout the period of authorisation is required.

Timeframe for NORM waste - ‘Long-term’ means at all times after the completion of disposal and the end of active institutional control of the site (currently anticipated to be 2230 AD for the EDA).

6. Workshops and follow up

The UK would like to be involved in workshops and follow up, for the following topics;

- Safety case methodologies (NORM and DU)
- Long-term disposal strategies (NORM and DU)

- Reuse and recycling options (NORM and DU)
- Inventory management (NORM and DU)
- Current management practices for DU in other countries.
- Regulatory requirements pertaining to DU and demonstration of compliant management practices against these.

Research priorities include;

- Waste characterisation and inventory management (DU)
- Development of safety case methodologies (NORM and DU)
- Reuse and recycling technologies (DU)
- Long-term safety assessment and modelling (DU)
- Communication and transparency with the public (DU)

International collaboration include;

- Waste treatment and disposal technologies (NORM and DU)
- Long-term monitoring and surveillance (NORM and DU)
- Development of safety case methodologies (NORM and DU)
- Reuse and recycling strategies (DU)
- Reuse and recycling: The UK is interested in identifying opportunities for enhanced application of the waste hierarchy with respect to DU

7. *Additional information*

Future projects; Yes, updates to the work of the U-IPT are currently in flight by NWS.

Source references for responses on DU:

[1] Radioactive Waste Management, Geological Disposal: Investigating the Implications of Managing Depleted, Natural and Low Enriched Uranium through Geological Disposal, NDA/RWM/142, 2016

[2] Generic specification for waste packages containing DNLEU NDA/WPS/230/01, available here:

[3] https://assets.publishing.service.gov.uk/media/5e86fc18e90e0706f4cfcce4/NDA_WPS_230_01_-_GD__Generic_Specification_for_waste_packages_containing_DNLEU.pdf **(doesn't work)**

[4] 2019 UK Inventory for Geological Disposal, available here: https://www.gov.uk/government/publications/2019-inventory-for-geological-disposal

[5] CoRWM position paper on the UK uranium inventory and management options, available here:

[6] https://assets.publishing.service.gov.uk/media/64c8ff81d8b1a70011b05ecc/corwm-consideration-uk-uranium-inventory-management-disposal-options.pdf

[7] NDA uranics credible options summary (Gate A), 2014, available here: chrome-

[8] https://assets.publishing.service.gov.uk/media/5a7f50a5e5274a2e8ab4b6cc/Uranics_Credible_Options_Summary__Gate_A_.pdf

Sources references for NORM:

[1] 2014_Strategy for the management of Naturally Occurring Radioactive Material (NORM) waste in the United Kingdom

https://assets.publishing.service.gov.uk/media/5a7d8e37e5274a6b89a50c38/Final_strategy_NORM.pdf

[2] 2016_RWM_Geological Disposal Safety Case Production and Management

[3] https://assets.publishing.service.gov.uk/media/5a81eafb40f0b62302699dcf/NDA_Report_no_DSSC-431-01_-_Geological_Disposal_-_Safety_Case_Production_and_Management_Report.pdf

[4] 2015_EA_Review of LLW Repository Ltd's 2011 environmental safety case – Assessments https://assets.publishing.service.gov.uk/media/5a81504fe5274a2e87dbcf21/Assessments.pdf

United Kingdom 2

Company – Nuclear Waste Services

Role - Safe management and disposal of the UKs inventory of NORM and DU waste

1. Waste Inventory and Management

The UK has both NORM and DU wastes. They have the following definition 'NORM – waste, DU – Asset, safeguard material'

Type of NORM waste:

- Industrial by-products
- Contaminated land remediation

Quantity of NORM; ~201,000 tonnes/year (solid) and ~218 million cubic meters/year (Liquid) (Estimated as of 2014). Uncertainties are applicable in these estimates, of note are; instances where no distinction between exempt and on-exempt wastes is provided, disposal may not occur on a yearly basis, excludes reflection of waste sent for specialist treatment

Quantity of DU; DU is not classified as waste. ~110,000 tonnes (Heavy Metal) of UK-owned Uranium is stored, ~8800 tonnes future arisings assuming enrichment operations for next 20 years (Heavy Metal) (Estimated as of 2022). NWS Assumes an inventory for disposal (should DU be classified as waste) of 192,000 tU within the Inventory for Geological Disposal (IGD)

Inventory management of the waste; Centralised national registry: DU - Not classed as waste. Not currently tracked: NORM – estimates collated within 2014 Strategy for Management of NORM.

Waste management options for NORM include waste minimisation at source, treatment, blending with non-radioactive material, reuse/recycling, conditioning and disposal.

For the above, the following occurs:

- Waste minimization at source: NORM – and Prevention through separation, decontamination and characterisation such that exemption can be applied if below certain concentration thresholds.
- Treatment: NORM – Volume reduction (solids), wastewater treatment (liquids), filtration (gaseous), specialist treatment when required.
- Blending with non-radioactive material: NORM – Cement or grout to facilitate safe handling and transport (this would be considered conditioning)
- Reuse/ Recycling: NORM - Recovery Conditioning: NORM – to facilitate; safe handling and transport (as above blending) or re-use and recovery in special cases.
- Disposal: NORM - Appropriate consignment to Landfill (as exempt, controlled Wastes), Discharge to sea or Burial. Where required the Low Level Waste Repository.

Waste management options for DU include storage and then disposal.

For the above, the following applies;

- Storage: DU – Safe and Secure Storage as an asset.
- Disposal: DU- illustrative plans for disposal of DNLEU exists within the generic Disposal System Specification, generic Disposal System Safety Case and IGD, should it be declared waste

For NORM management systems, the following are responsible;

- Waste minimization at source: waste owners
- Treatment: NORM – Waste Owners/Treatment operators
- Blending with non-radioactive material: NORM – Waste Owners/Treatment operators
- Reuse/ Recycling: NORM – Waste Owners/Facility operators
- Conditioning: NORM – Waste Owners/Facility Operators
- Storage: NORM – Waste Owners
- Disposal: NORM – Facility Operators

For DU management systems, the following are responsible;

- Storage: DU – Waste Owners.
- Disposal: DU- NWS (Should it be declared waste)

2. Reuse and Recycling

Reuse/recycling; NORM – re-use to extend life of resources, recovery through use in industrial resources, DU – Reuse options for DU are unspecified therefore continued designation as zero value asset.

3. Waste Treatment

For DU, used as backfill material is under consideration. U-loaded Backfill (if classed as waste) or DU-Co-disposal (If classified as waste) with Immobilized Pu waste forms. Concept and detailed design development and safety case development for identified disposal option.

Waste treatment methods for NORM include cementation and specialized treatment (e.g., deconversion to U_3O_8) or no treatment.

Cementation - to facilitate handling and safe transport.

Specialized treatment (e.g., deconversion to U_3O_8) NORM – Small volumes as required : Oil containing liquid - conventional waste water treatment and when required specialised organic and inorganic removal; Solids – chemical treatment of scales, contaminated equipment de-scaling, contaminated land radionuclide removal (soil washing and filtration), incineration of combustibles containing NORM subject to environmental permitting; Gas – filtration, hydrocyclones.

No treatment, direct disposal: NORM – Gas + Liquid: subject to environmental permits; Solids: landfill as exempt or reuse in other processes

4. Disposal Options

There is no current waste disposal program for NORM or DU.

Waste disposal methods for NORM, near surface and engineered landfills, either when applicable or when NORM is exempt.

Waste disposal method concept for DU is deep geological disposal, which is currently a baseline concept (if classified as waste).

NORM – if applicable at Low Level Waste Repository ISO Containers

DU – If classified as waste 500L drums and Stainless Steel Transport and Disposal Containers (TDC) (TDC is at Concept design stage and required Waste package specification development).

NORM disposal challenges include the uncertainty in waste generation (volume and timing) from industrial activities and contaminated land and therefore volume/type of waste and treatment/disposal capability requirements.

DU disposal challenges include – (If considered Waste) Volume of material contributing to GDF footprint, concept optimization for site specific considerations and efficiency, R&D on performance demonstration for safety case.

WAC issues for NORM; for NORM waste to landfill an annual mass limit per consignor is applied based on specified dose criteria. For NORM waste at the Low Level Waste Repository the radiological and non-radiological capacities are defined for the site.

5. Safety Case

The UK has a safety case for NORM – environmental safety case.

Safety case for DU; If classed as waste the a Generic disposal System Safety Case for GDF will require inclusion for DU and Operational and Post Closure Safety Cases.

Radiological impact assessment for NORM; for wastes sent to Low Level Waste Repository impacts are considered in the Environmental Safety Case.

Radiological impact assessment for DU; - assumptions for the potential inventory of DNLEU for disposal was modelled within the generic Disposal System Safety Case, Total System Model which includes U, Th, Pu, Am, Cm, Np, Pa, Ac, Ra, Pb, Ho, Eu, Sm, Cs, I, Sn, Ag, Pd, Tc, Mo, Nb, Zr, Sr, Se, Ni, Cl, C. Safety is demonstrated by a requirement to ensure quantities of radionuclides (or toxic substances) entering the groundwater do not compromise safety. A mean risk factor is calculated for disposal concepts and demonstrated to be below the risk guidance level (10^-6 year^-1).

Timeframe for NORM; Low Level Waste repository Environmental Safety Case considered active control of the site for 100 years.

Timeframe for DU; the Generic Disposal System Safety Case assumes geological stability for 300,000 years post GDF closure where there is increasing levels of uncertainty in environmental changes beyond this time scale.

6. Workshops and follow up

The UK would like to b involved in workshops and follow up, for the following topics;

- Safety case methodologies (NORM and DU)
- Long-term disposal strategies (NORM and DU)
- Reuse and recycling options (NORM and DU)
- Inventory management (NORM and DU)

Research priorities include;

- Waste characterisation and inventory management (DU)
- Development of safety case methodologies (NORM and DU)
- Reuse and recycling technologies (DU)
- Long-term safety assessment and modelling (DU)
- Communication and transparency with the public (DU)

International collaboration include;

- Waste treatment and disposal technologies (NORM and DU)

7. Additional information

Future work; Exploratory work is ongoing into management and disposal of DU (should it be categorized as waste) looking at maturing the baseline GDF disposal concept and assessment of alternative concepts for disposal and/or management (as described in Q13)

Appendix B - ASTRA Task 5.3 questionnaire

Evaluation of RWM strategies for the disposal of waste bearing naturally occurring long-lived radionuclides.

This questionnaire has been developed by a sub-task group of the EURAD-2 Work Package 3 – ASTRA. Task 5, within ASTRA, aims to analyse management strategies for diverse and challenging wastes by supporting exchanges of experiences and best practices in the forum for community of practice between Large Inventory Member States (LIMS) and Small Inventory Member States (SIMS). To elaborate disposal strategies and waste management solutions for specific challenging wastes that do not meet existing Waste Acceptance Criteria (WAC) and investigate shared solutions for different radioactive wastes: sharing of predisposal & disposal activities and facilities, strategic issues not addressed in previous projects. This work builds on EURAD-1 ROUTES which identified Radium, Thorium and Uranium (Ra/Th/U) bearing waste and Depleted Uranium (DU) as challenging wastes requiring suitable management and disposal options.

The objective of sub-task 5.3, is to consolidate learning internationally on the lifecycle of management of wastes containing high concentrations of long-lived naturally occurring radionuclides or technically enhanced naturally occurring radionuclides, in order to optimise treatment, packaging, storage, and ultimately disposal concepts of such waste. In gaining insight into the current inventory and disposal programme for dealing with such waste, this will allow us to work to optimise waste management, improve long-term safety strategies and develop the required input for future research programmes to address any unresolved challenges.

The questionnaire covers seven categories (General, Inventory and Management, Reuse/Treatment /Disposal, Safety Case and Long-Term Safety, Workshops and Follow-up, Research and Development (R&D) Needs, and Additional Information) for which we would like to ask you a set of open questions. In addition, we have formulated some general statements and would like to find out if you agree or disagree with each of them.

We have generated a web-based version of the questionnaire using Microsoft Forms (Click here for Link) However, if you prefer to use the Word document, please send your response to McGrath, Z.K. (Zoe) mcgrath@nrg.eu and Browning, K.M. (Kelvin) browning@nrg.eu. If you have any questions, please don't hesitate to contact us.

Note that throughout this questionnaire, **NORM** is used to refer to Ra/Th/U bearing NORM wastes, and **DU** is used to refer to depleted uranium from enrichment or spent fuel reprocessing activities. This questionnaire will refer to NORM and DU as 'waste', however, if your country **does not** currently classify either of these as 'waste' and uses another term and/or will never refer to them as waste, please provide answers in the relevant questions to define your countries current position and then continue to answer the remaining questions as if the term 'waste' is used.

General Information Questions	
Q1	**Country** *Please provide the name of your country*
	Click here to enter text.
Q2	**Organisation** *What is the name of your organisation or institute, and what is your organisation's role in managing NORM and/or DU waste?*
	Organisation / Institute: Click here to enter text. **Role:** Click here to enter text.
Q3	**Contact Information** *Please provide the name, email address, and position of the contact person responsible for this survey.*
	Name: Click here to enter text. **E-mail address:** Click here to enter text. **Position:** Click here to enter text.

Waste Inventory and Management	
Q4	**Inventory of NORM and/or DU Waste** *Does your country (now and/or in the foreseeable future) manage NORM and/or DU waste?*
	☐ NORM ☐ DU ☐ Both ☐ Neither
Q5	**Waste Definition** *Please provide details on how your country defines NORM and/or DU? Stating which definition applies to which waste type, if applicable.* *(e.g., waste, exempt material, RAW, safeguard material etc.).*
	Click here to enter text.
Q6	**Type of NORM Waste** *What types of NORM wastes are considered in your country that contain U/Th/Ra? (e.g., industrial by-products, mining, waste from oil and gas etc.).*
	Click here to enter text.

Q7	**Quantity of NORM Waste** *Please estimate the total quantity of NORM waste, actual and/or expected (in tons, tons/year or cubic meters, cubic meters/year) containing U/Th/Ra?*
	Click here to enter text.
Q8	**Quantity of Du Waste** *Please estimate the total quantity of DU waste, actual and/or expected (in tons, tons/year or cubic meters, cubic meters/year)?*
	Click here to enter text.
Q9	**Inventory Management** *How does your country manage/register the inventory of the type of waste(s) selected in Question 4?* *(Please specify for which waste type the options below apply, i.e., NORM or DU)*
	☐ Centralised national registry Click here to enter text. ☐ Decentralised (regional or local registries) Click here to enter text. ☐ Not currently tracked Click here to enter text. ☐ Other (Please specify) Click here to enter text.
Q10	**Management Options** *What options for managing NORM and/or DU wastes are currently implemented or considered?* *(Please elaborate on the selected options, including which waste type the selected option applies to).*
	☐ Waste minimisation at source Click here to enter text. ☐ Pre-treatment Click here to enter text. ☐ Treatment Click here to enter text. ☐ Blending with non-radioactive material Click here to enter text. ☐ Reuse/ Recycling Click here to enter text. ☐ Conditioning Click here to enter text. ☐ Storage Click here to enter text. ☐ Disposal Click here to enter text. ☐ None (Please explain why) Click here to enter text.

Q11	**Management System** *From the selected answer(s) from Q10, please state who is responsible for the management. (e.g., state owned organisation or the producer).*
	☐ Waste minimisation at source Click here to enter text. ☐ Pre-treatment Click here to enter text.

	☐ Treatment Click here to enter text. ☐ Blending with non-radioactive material Click here to enter text. ☐ Reuse/ Recycling Click here to enter text. ☐ Conditioning Click here to enter text. ☐ Storage Click here to enter text. ☐ Disposal Click here to enter text.
Q12	**Reuse / Recycling of Waste** *If reuse and/or recycling is used within your country, please provide details of the purpose, process and applications of such process(es).*
	Click here to enter text.

Reuse (within disposal) / Treatment / Disposal Management	
Q13	**Reuse within a Disposal Facility** *Is NORM and/or DU waste reused during its disposal process? And/or is any research being conducted into the reuse of NORM and/or DU within a disposal facility?* *(Please specify if it is completed or being researched, and for which waste type).*
	☐ Used as backfill material Click here to enter text. ☐ Used for shielding in high-level waste containers Click here to enter text. ☐ Other (Please specify) Click here to enter text. If yes, how is safety demonstrated? Click here to enter text.

Q14	**Waste Treatment Methods** *What treatment methods are/will be applied to NORM and/or DU waste foreseen for disposal?* *(Please select all that apply, specify for which waste type and if this has been chosen due to the foreseen disposal facility, e.g., landfill, stacks, near surface etc.).*
	☐ Encapsulation Click here to enter text. ☐ Cementation Click here to enter text. ☐ Vitrification Click here to enter text. ☐ Specialised treatment (e.g., deconversion to U_3O_8) Click here to enter text. ☐ No treatment, direct disposal Click here to enter text. ☐ Other (Please specify) Click here to enter text.

Q15	**Current Disposal Program:** *Does your country have an ongoing disposal program for NORM and/or DU wastes?* *(Please specify for which waste type the option applies).*
	☐ Yes Click here to enter text. ☐ No Click here to enter text. ☐ In development Click here to enter text. ☐ N/A (please provide a reason) Click here to enter text.
Q16	**Selected Disposal Methods** *What disposal methods are currently used or planned to be used in the future for NORM and/or DU wastes?* *(Please select all that apply, specify the current status of each and waste type for each).*
	☐ Near surface Click here to enter text. ☐ Deep geological disposal Click here to enter text. ☐ Engineered landfills Click here to enter text. ☐ Dedicated disposal sites Click here to enter text. ☐ Other (Please specify) Click here to enter text.

Q17	**Considered Disposal Methods** *What disposal methods were considered but not selected for NORM and/or DU wastes? (Please select all that apply and the reason they were excluded for the waste type).*
	☐ Near surface Click here to enter text. ☐ Deep geological disposal Click here to enter text. ☐ Engineered landfills Click here to enter text. ☐ Dedicated disposal sites Click here to enter text. ☐ Other (Please specify) Click here to enter text.
Q18	**Disposal Container** *What type of container is used, or planned to be used, for disposal?* *(Please specify the waste type if there are multiple answers).*
	Click here to enter text.
Q19	**Disposal Challenges** *What are your country's key challenges in disposing of NORM and/or DU wastes?* *(Please specify the waste type if there are multiple answers).*

	Click here to enter text
Q20	**Waste Acceptance Criteria (WAC) Issues** *What specific waste acceptance criteria are applied in your country for NORM and/or DU wastes for interim storage and/or disposal?* *(Please specify the waste type if there are multiple answers).*
	Click here to enter text.

Safety Case[2], Safety Assessment and Long-Term Safety

Q21	**Safety Case** *Does your country have a safety case for the disposal of radioactive waste, and are NORM and/or DU wastes covered?* *(Please specify the waste type if there are multiple answers).*
	☐ Yes Click here to enter text. ☐ No Click here to enter text. ☐ In development Click here to enter text. ☐ N/A (please provide a reason) Click here to enter text.
Q22	**Radiological Impact Assessment for the Period after Closure** *Has a post-closure radiological impact assessment been performed? What elements are included in the safety case, and if so, how is safety demonstrated on the long-term for NORM and/or DU wastes?* *(Please specify the waste type if there are multiple answers).*
	Click here to enter text.
Q23	**Timeframes for Safety Case** *What timeframes are considered for long-term safety in your safety case for NORM and/or DU waste disposal?* *(Please specify the waste type if there are multiple answers).*
	Click here to enter text.

Workshops and Follow-up

[2] *Note the term 'safety case' in the context of radioactive waste disposal, is defined as a collection of scientific, technical, administrative, and managerial arguments and evidence in support of the safety of a disposal facility. As defined by the IAEA SSG-26 (2012).*

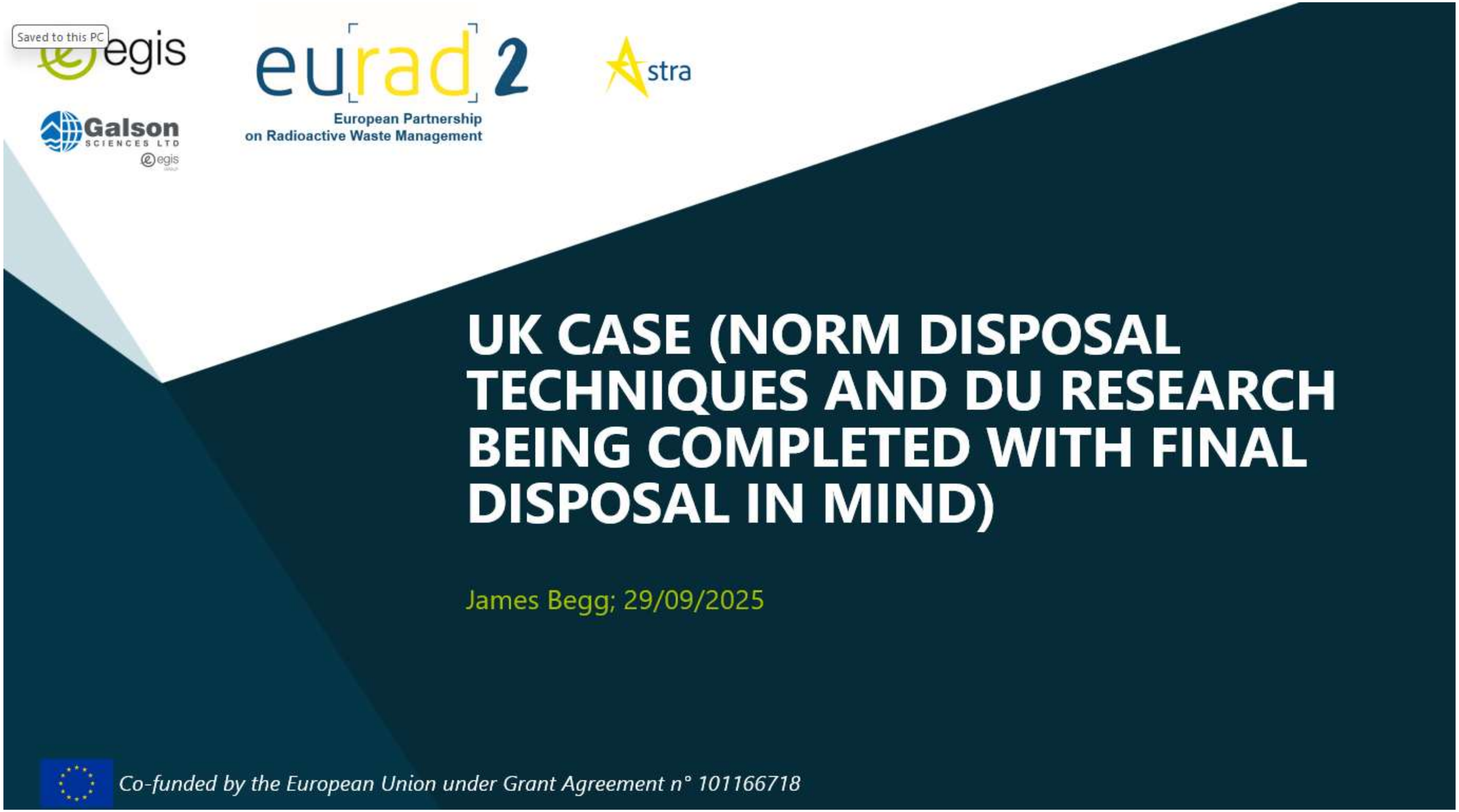
Q24	**Workshops and Meetings** *Would your organisation/institute be interested in participating in a workshop (WS) and follow-up meeting to discuss waste management strategies for NORM and DU wastes?*
	☐ Yes ☐ No
Q25	**Preferred Topics for Discussion** *What topics would you like addressed in future workshops or meetings on NORM and DU waste management?* *(Please select all that apply and specify for which waste type).*
	☐ Safety case methodologies Click here to enter text. ☐ Long-term disposal strategies Click here to enter text. ☐ Reuse and recycling options Click here to enter text. ☐ Inventory management Click here to enter text. ☐ Other (Please specify) Click here to enter text.

Research and Development (R&D) Needs	
Q26	**Research Priorities** *In which areas is further research most needed to improve the lifecycle management of NORM and/or DU wastes?* *(Please select all that apply and specify for which waste type).*
	☐ Waste characterisation and inventory management Click here to enter text. ☐ Development of safety case methodologies Click here to enter text. ☐ Reuse and recycling technologies Click here to enter text. ☐ Long-term safety assessment and modelling Click here to enter text. ☐ Communication and transparency with the public Click here to enter text. ☐ Other (Please specify) Click here to enter text.
Q27	**International Collaboration** *Would your country benefit from international collaboration in the following areas?* *(Please select all that apply and specify for which waste type)*
	☐ Development of safety case methodologies Click here to enter text. ☐ Waste treatment and disposal technologies Click here to enter text. ☐ Long-term monitoring and surveillance Click here to enter text. ☐ Reuse and recycling strategies Click here to enter text. ☐ Other (Please specify) Click here to enter text.

Additional Information	
Q28	**Future Projects** *Does your country have any upcoming projects on the disposal of NORM and/or DU wastes?* *(Please briefly describe them)*
	Click here to enter text.
Q29	**Other Comments** *Please provide additional insights or suggestions regarding managing NORM and/or DU wastes that may guide future research and development efforts.*
	Click here to enter text.

Appendix C – Workshop Presentations

United Kingdom:



A brief background and overview

Information Sources

Strategy for the management of Naturally Occurring Radioactive Material (NORM) waste in the United Kingdom

Department of Energy & Climate Change | Llywodraeth Cymru Welsh Government | DOE | The Scottish Government

July 2014

Standard rules
Chapter 4, the Environmental Permitting (England and Wales) Regulations 2012

Environment Agency

Standard Rules SR2014 No 4

Accumulation and disposal of radioactive waste from the NORM Industrial Activity of the production of oil and gas

Introductory Note

SR2014 No 4

1207-INT-6-1
Version 1.3

Integrated Project Team on Uranium: Phase 2
[Task INT-6]

Review of UK and Overseas Depleted, Natural and Low Enriched Uranium Management

S. Doudou and E.J. Harvey
(Galson Sciences Ltd)

19 May 2014

Quintessa | AREVA | Galson | assist

Galson Sciences Ltd

CoRWM
Committee on Radioactive Waste Management

POSITION PAPER: CoRWM CONSIDERATION OF THE UK URANIUM INVENTORY, MANAGEMENT AND DISPOSAL OPTIONS
July 2023

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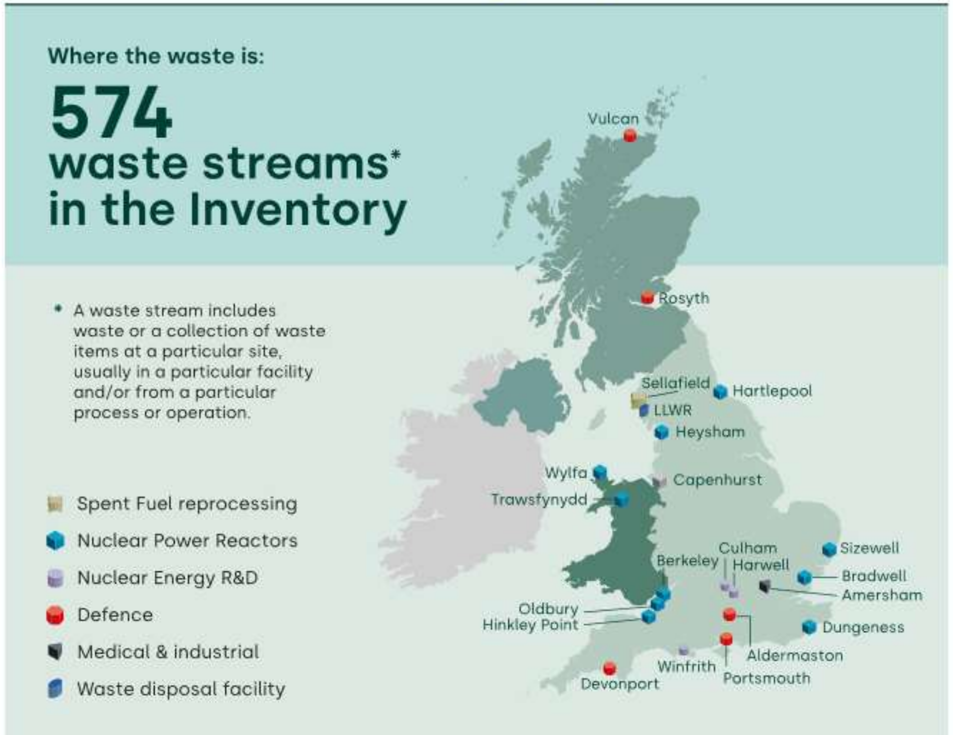
A brief background and overview

UK has a rich legacy of RWM



Today:

- Some definitions / caveats
- NORM sources
- NORM disposal
- *Uranium* inventory
- *Uranium* management
- *Uranium* disposal

https://www.gov.uk/government/publications/2022-inventory-for-geological-disposal/2022-inventory-for-geological-disposal-summary

3

UK DU conversations are caveated!

Definitions

The UK has a large inventory of uranium materials, comprising depleted, natural and low-enriched uranium (DNLEU). UK management and disposal strategies refer to DNLEU.

In the UK, uranium is considered a zero-value asset radioactive material and is not considered as a waste.

NORM - Low Level Radioactive Waste (in some cases).

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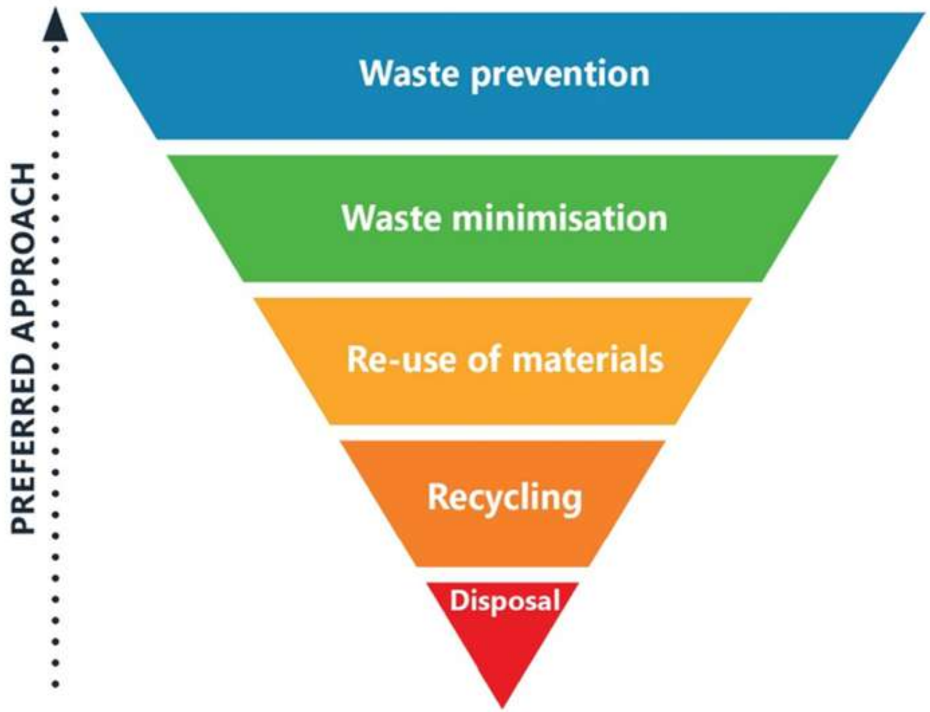
A note on general approach to WM



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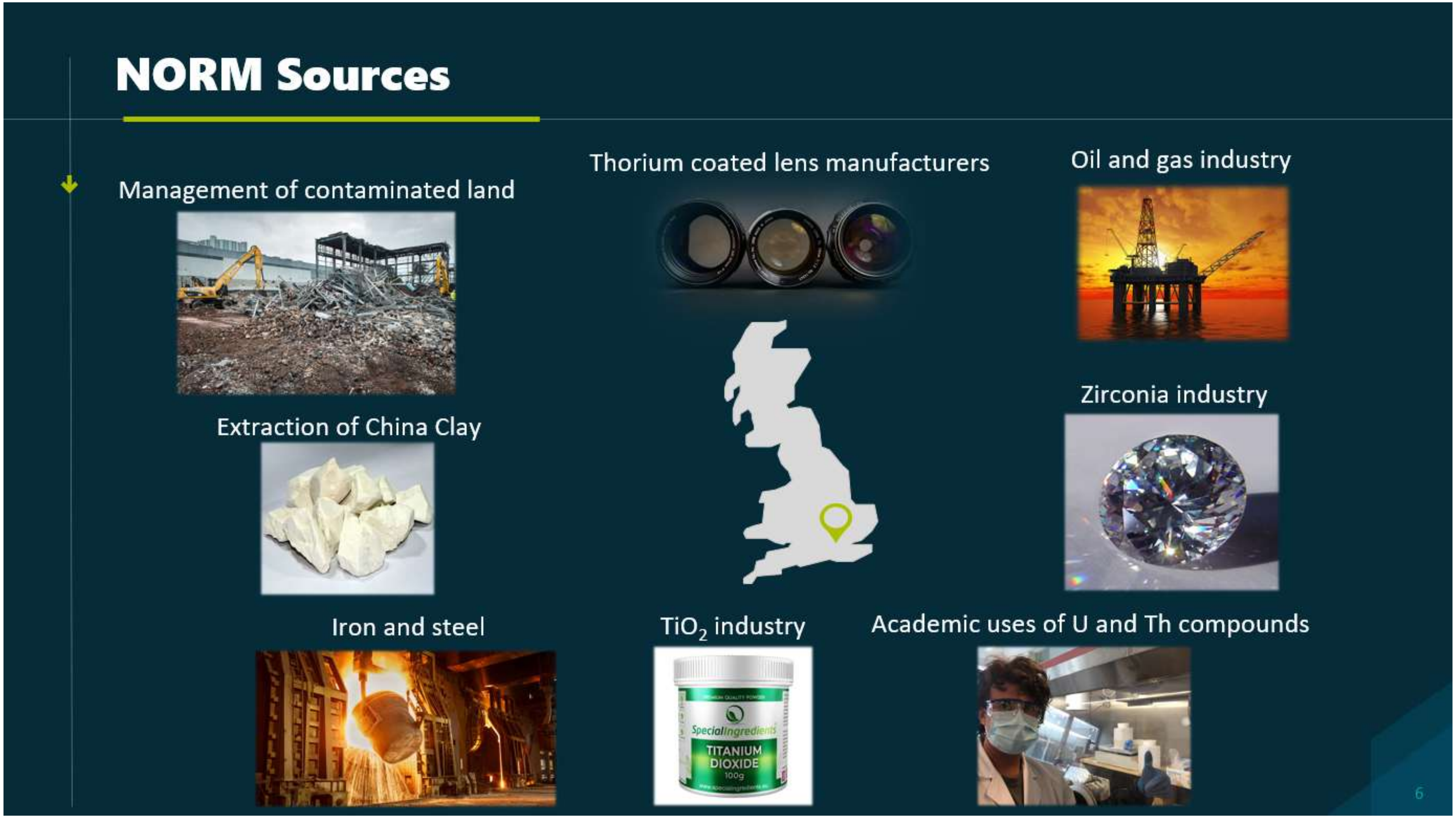
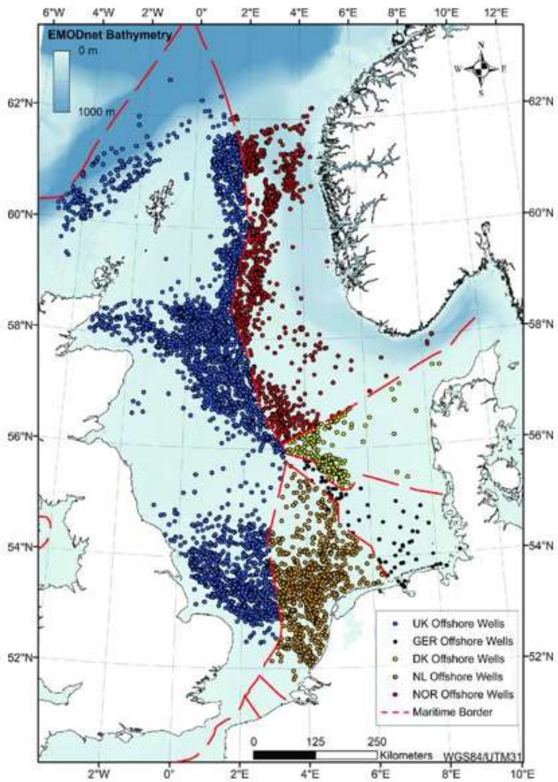

NORM Sources
Management of contaminated land
Thorium coated lens manufacturers
Oil and gas industry
Extraction of China Clay
Zirconia industry
Iron and steel
TiO2 industry
TITANIUM DIOXIDE
Academic uses of U and Th compounds
6

NORM waste amounts - liquid

Oil and gas – 200 000 000 m^3



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NORM waste amounts - liquid

Oil and gas – 200 000 000 m^3




And the next 20 000 slides....

TiO_2 – 4 000 000 m^3

Academic – a few kg

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NORM waste amounts - solid

TiO_2 – 200 000 tonnes

Steel – 10 000 tonnes

Oil and gas – 800 tonnes

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NORM solid waste disposal

Most NORM waste is disposed of as exempt radioactive waste in landfills that are permitted to accept controlled wastes.

The steel industry does not dispose of its NORM waste arisings as they are in demand as inputs to other industrial processes.

More than half of the solid NORM waste generated by the oil and gas sector is disposed of to sea in line with domestic and international best practice

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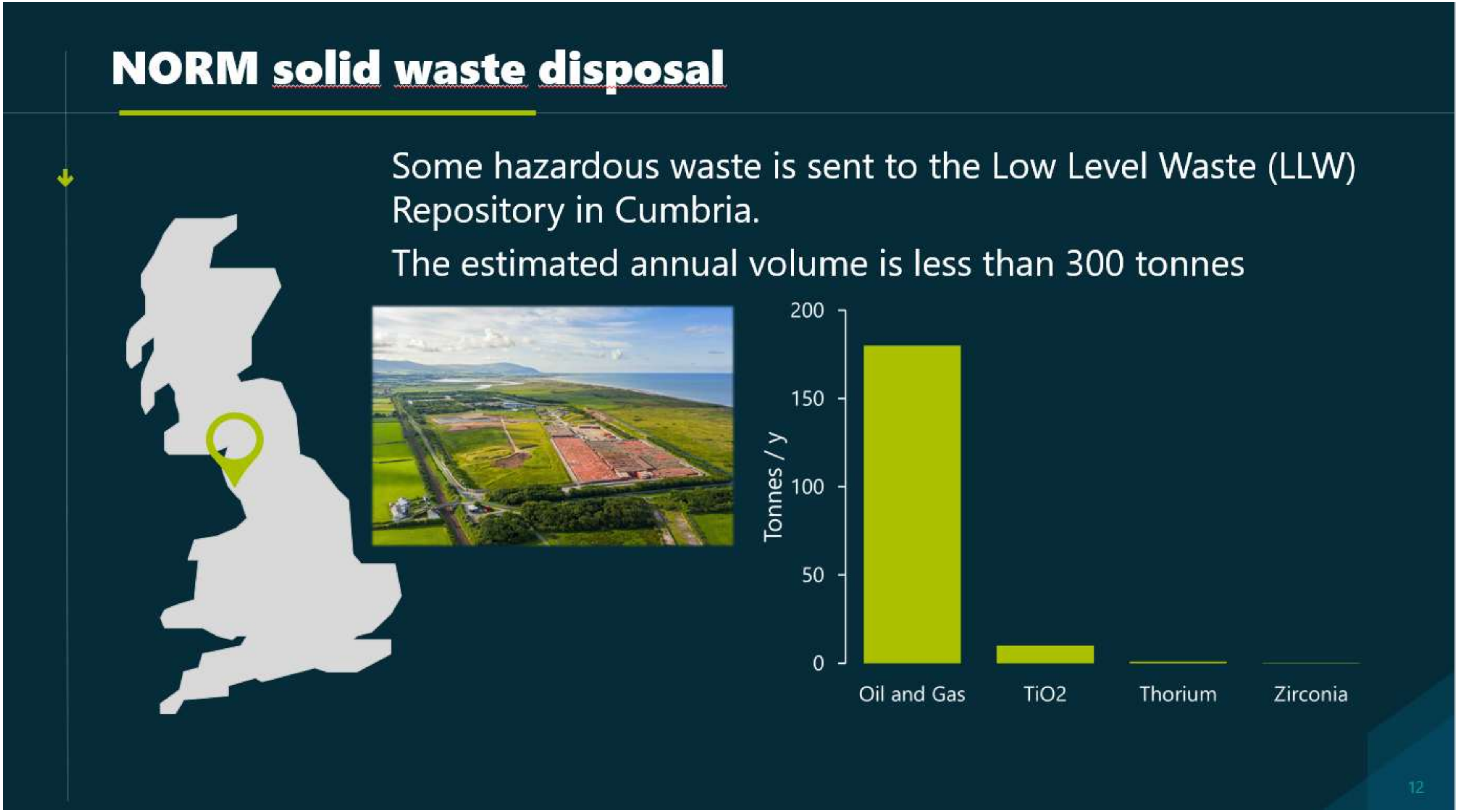
NORM solid waste disposal
Some hazardous waste is sent to the Low Level Waste (LLW) Repository in Cumbria.
The estimated annual volume is less than 300 tonnes
Tonnes / y
200
150
100
50
0
Oil and Gas
TiO2
Thorium
Zirconia
12

A brief focus on oil and gas

Standard rules

Chapter 4, the Environmental Permitting (England and Wales) Regulations 2012

Environment Agency

Standard Rules SR2014 No 4

Accumulation and disposal of radioactive waste from the NORM Industrial Activity of the production of oil and gas

Introductory Note

This introductory note does not form part of these standard rules. These rules only relate to the activity(ies) specified and cannot be taken to allow or control other permittable activities.

When referred to in an environmental permit, these rules will allow an operator to carry on the accumulation and disposal of radioactive waste containing naturally occurring radioactive material (NORM) arising from the production of oil and gas.

The rules allow NORM wastes to be accumulated and disposed of, in the form of gaseous waste, aqueous waste and solid waste. The rules limit the amount of aqueous radioactive waste that can be held on site at any one time and require aqueous and solid wastes to be disposed of within 3 months. The rules authorise these wastes to be disposed of by transfer to operators who are themselves permitted to receive and dispose of these radioactive wastes. The rules allow direct disposal of gaseous wastes to the environment.

In addition, the rules authorise

- the disposal of any residual well stimulation fluids, containing NORM, which have remained underground rather than returned to the surface after use;
- the disposal to the underground strata of NORM present in water brought to the surface from the production of oil and gas.

For clarity, this is NORM that was present in the underground rock before the industrial activity took place, and has either remained there throughout or has been returned underground after being brought to the surface in the oil or gas abstracted from the rock.

The Health and Safety Executive regulates activities involving work with ionising radiation under the Ionising Radiation Regulations 1999 for the protection of the workforce. Those regulations cover accidents and contingency arrangements in the event of accidents involving radioactive materials and waste, including any off-site effects and response.

SR2014 No 4

2.4 Accumulation of radioactive waste

2.4.1 There shall be no accumulation of radioactive waste except of the types of radioactive waste specified in Table 2.

2.4.2 The limits on accumulation given in Table 2 shall not be exceeded.

Table 2: Accumulation of radioactive waste

Waste type	Radionuclide or group of radionuclides permitted to be present in the waste	Limit on activity on the premises at any one time	Maximum period for retention of waste
Aqueous radioactive waste	Radionuclides arising from the permitted NORM industrial activities [1]	30 MBq Ra 226 [2] 30 MBq Ra 228 [2]	3 months
Solid radioactive waste	Radionuclides arising from the permitted NORM industrial activities [1]	None specified	3 months

[1] Radionuclides as listed in table 1 of Schedule 23 to the 2010 Environmental Protection (England and Wales) Regulations [as amended by SI 2011 no 2043].
[2] Limits apply to the specified radionuclides only and do not include the decay products.

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Table 3 : Disposal of radioactive waste				
Waste type	**Disposal route**	**Purpose of transfer [where relevant]**	**Radionuclide or group of radionuclides permitted to be present in the waste**	**Annual activity limit**
Gaseous radioactive waste	A flare or vent for waste gas	Not relevant	Radionuclides arising from the permitted NORM industrial activity	None specified
Aqueous radioactive waste	Transfer to the holder of an environmental permit for the receipt and disposal of aqueous radioactive waste	For any one or more of: - treatment - onward transfer for treatment or disposal - incineration - final disposal	Radionuclides arising from the permitted NORM industrial activity.	None specified
Aqueous radioactive waste, being 1) well stimulation fluid remaining in situ, 2) water containing substances resulting from the operation of the production of oil and gas.	Disposal in the rock formation adjacent to the well bore.	Not relevant	Radionuclides arising from the permitted NORM industrial activity.	None specified
Solid radioactive waste	Transfer to the holder of an environmental permit for the receipt and disposal of LLW	For any one or more of: - treatment - onward transfer for treatment or disposal - metals recovery - final disposal	Radionuclides arising from the permitted NORM industrial activity.	None specified

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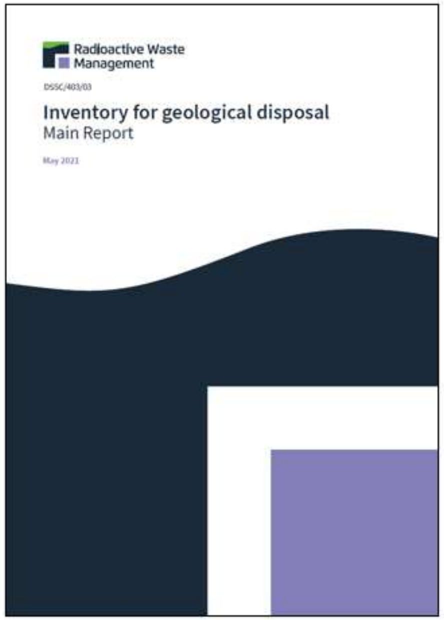
DNLEU – 2019 inventory

Q8	**Quantity of Du Waste** *Please estimate the total quantity of DU waste, actual and/or expected (in tons, tons/year or cubic meters, cubic meters/year)?*
	184,000 tU from civil fuel enrichment and civil spent fuel reprocessing; 8,000 tU from defence programmes



A2 Assumptions regarding quantities

Table A2 - The estimated contents of each waste group

Waste Group	2019 IGD[26]
SILW / SLLW UILW / ULLW RSCs	All 2019 UK RWI ILW, excluding those wastes with an established management strategy of incineration, recycling or near surface disposal All 2019 UK RWI LLW unsuitable for near-surface disposal
DNLEU	184,000 tU from civil fuel enrichment and civil spent fuel reprocessing 8,000 tU from defence programmes

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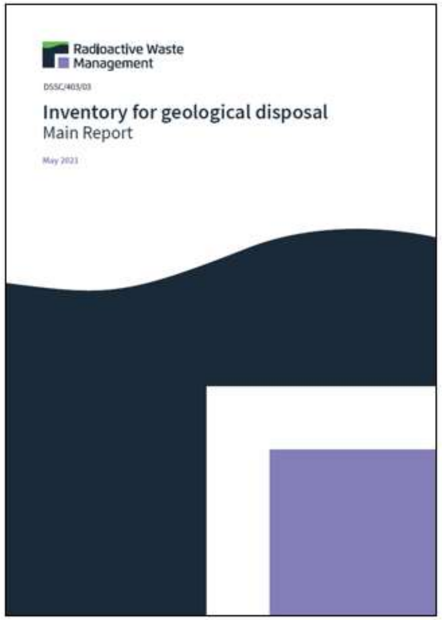
DNLEU – 2019 inventory

Table 3 - Packaged volume associated with each of the waste groups

Waste group	Volume [m³]	Fraction of total [%]
Legacy SILW / SLLW	92,600	12%
Legacy UILW / ULLW	372,000	48%
RSCs	2,610	0.3%
DNLEU	184,000	24%
NB SILW	18,900	2%
NB UILW	22,100	3%
HLW	9,880	1%
Legacy SF	17,000	2%
NB SF	39,400	5%
MOX SF	11,900	2%
HEU	2,470	0.3%
Pu	620	0.1%
Total	773,000	n/a



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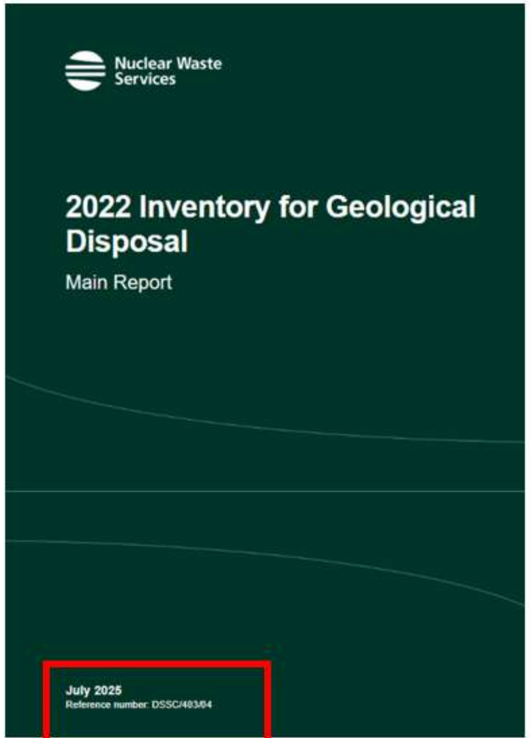
DNLEU – 2022 inventory

Table 9 Changes to the packaged volume of each waste group between the 2019 and 2022 IGDs

Waste Group	2019 IGD [m^3]	2022 IGD [m^3]	Difference [%]
Legacy SILW / SLLW	92,600	87,700	-5.30
Legacy UILW / ULLW	372,000	350,000	-5.79
RCCs	2,610	2,590	-0.573
DNLEU	184,000	192,000	+4.33
NB SILW	18,900	16,800	-11.1
NB UILW	22,100	21,500	-2.55
HLW	9,880	9,370	-5.18
Legacy SF	17,000	16,600	-2.79
NB SF	39,400	60,400	+53.1
MOX SF	11,900	11,700	-1.97
HEU	2,470	103	-95.8
Pu	620	594	-4.16
Total	773,000	769,000	-0.498



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DNLEU Management

Uranium is considered a zero-value asset and is not considered as a waste.

UK Nuclear Decomissioning Authority (NDA) considers that no single option will be appropriate to manage the uranium inventory in its entirety due its diverse nature.

The preferred option is to be determined for each component of the inventory on a case-by-case basis.

The current approach for the management of NDA's uranic materials is therefore to store them in their current form or where necessary to reduce their intrinsic chemical hazard, repackage and consolidate them into a form more suitable for ongoing storage.

NDA states that continued storage does not provide an end point for uranium materials.

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Considered management options

Continued Storage

- Needs confidence in managing the inventory safely in secure storage for 10s y
- Technology and budget to repackage material if necessary
- Some uranium materials require conditioning / treatment e.g., UF_6 to U_3O_8

Recycle – returning uranium material to the nuclear fuel cycle.

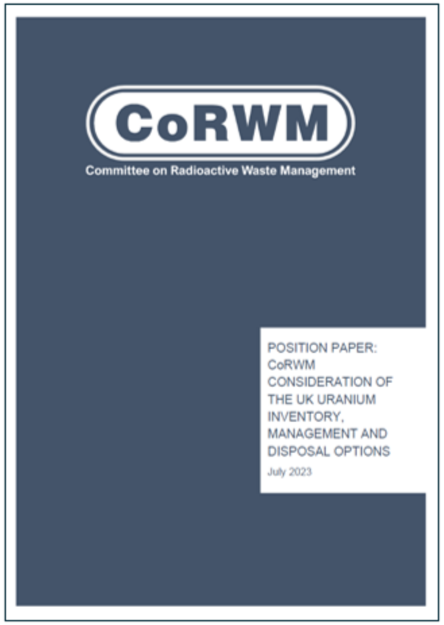
- Suitable facilities for processing clean (unirradiated) and reprocessed (irradiated) uranium
- Economic viability of recycling depends on the prevailing market conditions

Recycle in Light Water Reactors

- Requires a suitable reactor fleet and associated fuel cycle facilities.

Recycle in Advanced Reactors

- Government has no plans for deployment of fast reactors and associated fuel recycle facilities to realise this approach



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Disposal options for the UK uranium inventory

Deep Geological Disposal

A generic safety case has been published. However, as no disposal facility has been identified for DNLEU there is not a site-specific safety case.

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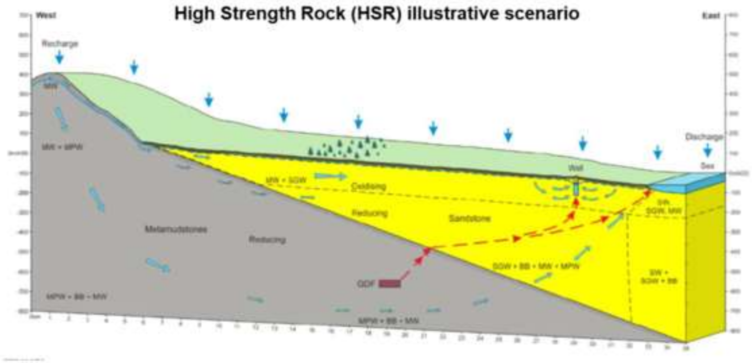
Disposal options for the UK uranium inventory

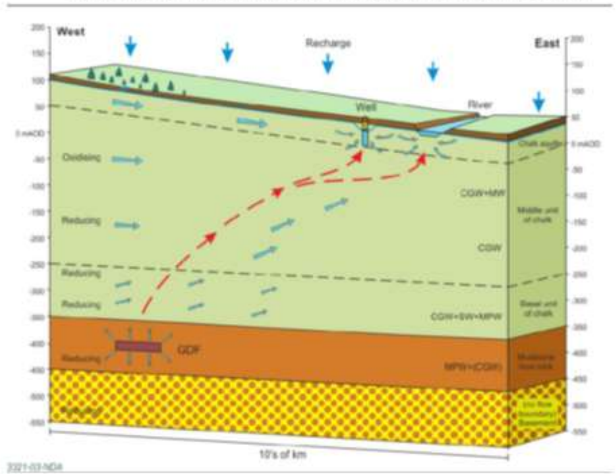
Deep Geological Disposal

A generic safety case has been published. However, as no disposal facility has been identified for DNLEU there is not a site-specific safety case.

2 illustrative environments:



Advective groundwater flow



Diffusion-controlled groundwater movement

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CoRWM (2023) Position Paper: CoRWM Consideration of the UK Uranium Inventory, Management and Disposal Options

21

Disposal options for the UK uranium inventory

Disposal near surface disposal facilities

Near surface disposal of the uranium inventory within a few tens of metres of the surface, was considered by the Uranium IPT to be "unlikely to be feasible for much of the UK" because erosion over periodic glaciation cycles has the potential to bring the disposal zone within reach of large scale human intrusion.

The Uranium IPT concluded that disposal of the uranium inventory at a depth of between 100 – 300 m is feasible in principle, but dependent on site specific conditions.

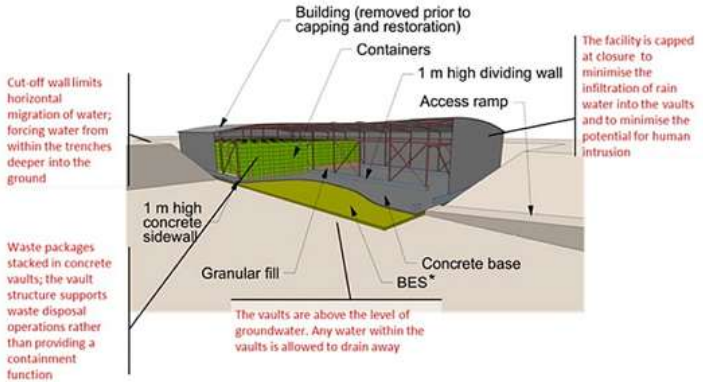
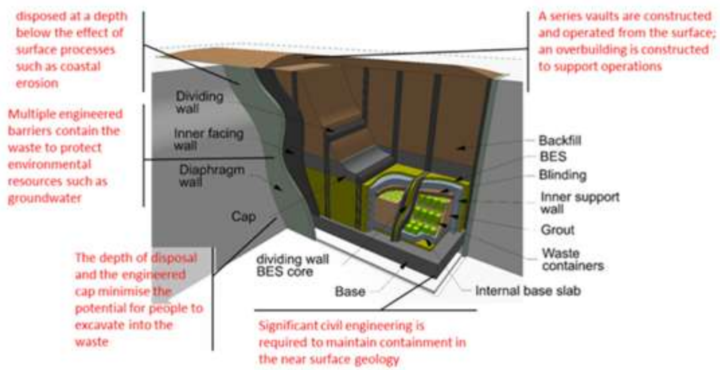


Figure 8. Artist's impression of the at surface concept for a near surface disposal facility for ILW (Source: NDA). BES = bentonite enhanced sand



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NDA (2020) Near-Surface Disposal Strategic Position Paper

22

France:

European Partnership on Radioactive Waste Management

MANAGEMENT OF NORM WASTE IN FRANCE

ASTRA Task 5- Workshop 2

CORDIER Bérengère - Andra

Co-funded by the European Union under Grant Agreement n° 101166718

Date Event

PRESENTATION

Bérengère CORDIER

Andra, within the Safety, Environment and Strategy Department

Engineer on the Waste Management Strategy, more specifically on Low-Level Long-Lived waste

Pilot of studies of a shallow depth disposal for LL-LLW

Background :

IRSN - Safety assessment of reprocessing facilities and fuel cycle (PWR) consistency assessment

ASTRA Task 5 - Workshop 2

2

GENERAL INFORMATION ON NORM WASTE

NORM waste (naturally occurring radioactive materials) is waste **with an increased level of natural radioactivity**, generated by the use or processing of **raw materials naturally rich in natural radionuclides but which are not used for their radioactive properties**.

These uses lead to an accumulation of naturally occurring radioactive substances in residues or process equipment (filters, etc.). Their level of activity poses a risk of exposure to people and requires a radioprotection control.

In France, this waste is classified as very low-level to low-level long-lived waste.

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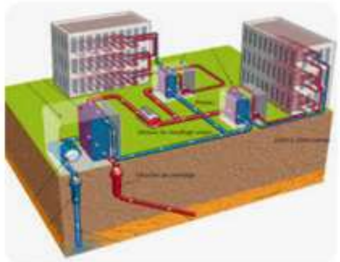
3

GENERAL INFORMATION ON NORM WASTE

Examples of uses:

- Mining: phosphate ore, zircon sand, rare earth extraction
- Industrial activities: production of phosphoric acid, fertilizers, and other phosphate products, smelting, manufacture of refractory materials

- Construction
- Oil production
- Geothermal energy production
- Metallurgical production
- Groundwater treatment



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4

NORM WASTE MANAGEMENT SOLUTIONS IN FRANCE

Depending on their radiological characteristics, french NORM waste is :

- managed on site,
- recycled (used in the construction of buildings or road works)
- disposed of in conventional waste centers : in France, 4 facilities are authorized to receive them
- disposed of in Cires operated by Andra (dedicated to the management of VLLw)
- NORM waste with a higher level of radioactivity (classified as LL-LLW) is stored awaiting a suitable management solution (with other type of LL-LLW for whom shallow depth disposal is currently being studied)

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5

FRENCH REGULATIONS FOR THE MANAGEMENT OF NORMS

Depending on their nature and the risks they pose, these activities are subject to a specific legal regime in France:

- A specific regime for « classified facilities for environmental protection for activities » covered by the Environmental Code
- The regime applicable to mines (Mining code)
- The regime for civil nuclear facilities
- The regime for defense nuclear facilities
- A « local nuclear » regime covered by the french Public Health Code

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FRENCH REGULATIONS FOR THE MANAGEMENT OF NORMS

A decree of May 25, 2005 :

- lists the categories of professional activities concerned.
- prescribes measurement of exposure to naturally occurring ionizing radiation and an estimate of the doses to which the population is likely to be exposed as a result of the facility

The european Directive 2013/59/Euratom ("BSS Decree") was transposed into French law

- Step 1: radiological characterization for manufacturers involved in NORM activities.
- Step 2: comparison of massic radioactivity with some exemption values for natural radionuclides:
  - Exemption values (EV) are:
    - 1 Bq/g for radionuclides in the uranium and thorium series
    - 10 Bq/g for potassium (K40).

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eurad 2

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FRENCH REGULATIONS FOR THE MANAGEMENT OF NORMS

French Public Health Code
Annexe 13-8

Radionucléides naturels	Valeur limite d'exemption en concentration (kBq/kg)
K-40	10
U-238 et sa filiation radioactive (1)	1
Th-232 et sa filiation radioactive (1)	1

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FRENCH REGULATIONS FOR THE MANAGEMENT OF NORMS

- **If the results are less than the exemption values:**
  - ⇒ waste could be disposed of in conventional waste storage facilities according to physical-chemical characterization without taking radioactivity into account
- **If the results are exceeding these values (mass activity is between 1 Bq/g and 20 Bq/g): NORM waste become radioactive substances**
  - ⇒ Waste disposal may only be carried in facilities that have been authorized and that implementing an appropriate radiological monitoring program

Radiographic characterization in industrial facilities

↓

Comparison of analysis results with exemption values

↓ ↓

If > VE: NORM	If < VE : Substance not requiring radiation protection control
Disposed of only in authorized facilities	Disposed of in facilities for conventional waste

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SYNTHETIS : NORM WASTE MANAGEMENT SOLUTIONS IN FRANCE

Radiological activity / Routes	MANAGEMENT	VALORIZATION	DISPOSAL
NORM < 1 Bq/g	No radioprotection control	Possible without restriction	According to the physical and chemical characteristics of the waste
1 Bq/g < NORM < 20 Bq/g	Radioprotection control	Prohibited (except by special permission)	In duly authorized repositories with radiological monitoring
NORM > 20 Bq/g			Radioactive waste disposal

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Czech Republic:

(TE)NORM/DU DISPOSAL & LONG-TERM STORAGE

stra

Atomic Act No. 263/2016 Coll. & Decree on radiation protection No. 422/2016 Coll.

- **Disposed waste** – the chemical inventory is mostly $RaSO_4$ in platinum cases (medical sources), Ra-Be neutron sources, laboratory waste containing natural radionuclides, disused sealed sources, depleted uranium and natural thorium (mostly as $Th(NO_3)4.5H_2O$ and ThO_2)
- **Disposal facilities:**
  - ✓ **ÚRAO Bratrství (disposal)** - developed from a part of abandoned underground premises in the former uranium mine
  - ✓ **ÚRAO Richard (long-term storage - the option currently used)** – developed in a complex of the former limestone mine
- **Specific WAC** - derived case-by-case according conditions in repository and the type and form of waste disposed of / stored. The documentation on WAC identification is usually internal and not publicly available (e.g. U-238, Th-232 and Ra-226 have their limits as specific WAC in the ÚRAO Richard)

eurad2

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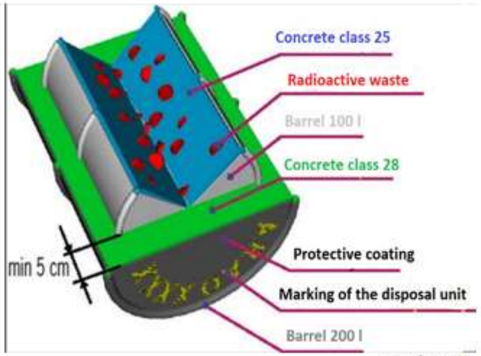
ÚRAO BRATRSTVÍ

- **Disposed RAW** – homogeneous and uniform solidified RAW consisting of or contaminated with natural RNs of the Ra and Th series.
- **Packaging:**
  - ✓ 210 l drums using the cement as solidification media
  - ✓ sandwich container (100 l drum in 200 l drum) with a non-active cemented interlayer
  - ✓ MOZAIK steel container
- Document **„Limits and Conditions of the RAW Disposal Facility Bratrství"** (not publicly available) - packages are checked for:
  - ✓ damage
  - ✓ surface contamination
  - ✓ dose rate equivalent on the package surface
  - ✓ and the content of radionuclides (gamma-spectrometry).

© SÚRAO



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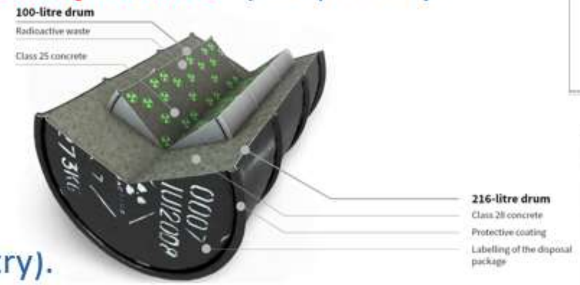
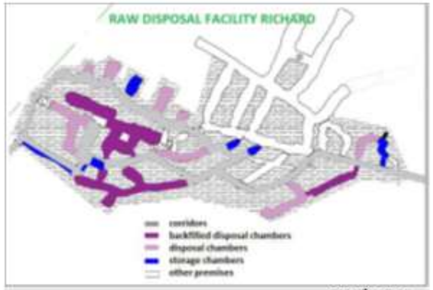
WP3 ASTRA T5 Workshop #2

3

ÚRAO RICHARD

- **Stored RAW** - homogeneous and uniform solidified RAW
- **Packaging** - sandwich container (100 l steel drum in 200 l high-alloy corrosion-resistant steel drum) with a concrete interlayer
- Document **„Limits and Conditions of the RAW Disposal Facility Richard"** (not publicly available) - the packages are checked for:
  - ✓ damage
  - ✓ surface contamination
  - ✓ dose rate equivalent on the package surface
  - ✓ and the content of radionuclides (gamma-spectrometry).





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The total activity of radionuclides in a single package - 1 GBq for long-lived alpha RNs. SÚRAO (WMO) makes an exception for RAW packages containing used SRSs whose activity exceeds this limit and further division would contradict the ALARA principles.

The ongoing project "Preparation of safety analyses for regular safety assessments of radioactive waste repositories in operation" - **assessing the possibility of disposing of waste containing only natural RNs.**

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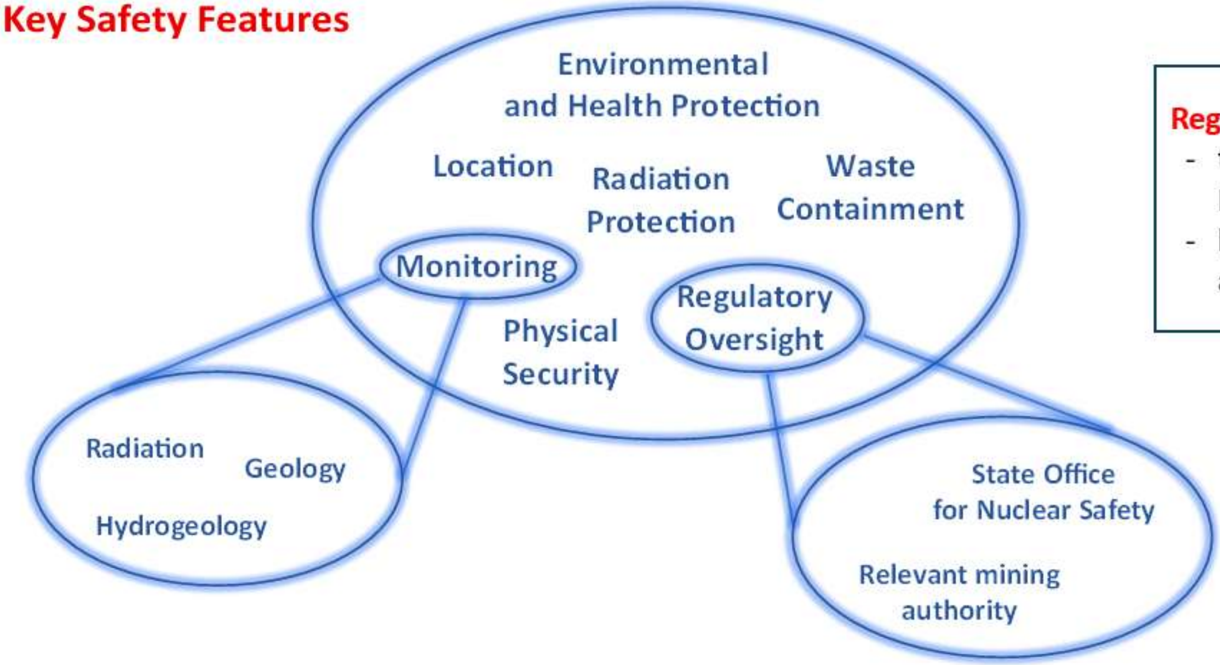
SAFETY ASSESSMENT

A comprehensive system consists of a number of safety features, including geological, hydrogeological, and radiation monitoring, as well as regular inspections by the State Office for Nuclear Safety (SÚJB - regulator) and mining authorities.

Key Safety Features



Regulatory requirements:
- the Atomic Act and its supplementary Decrees, Government Regulations
- legally non-binding Recommendations and Guides (SÚJB)

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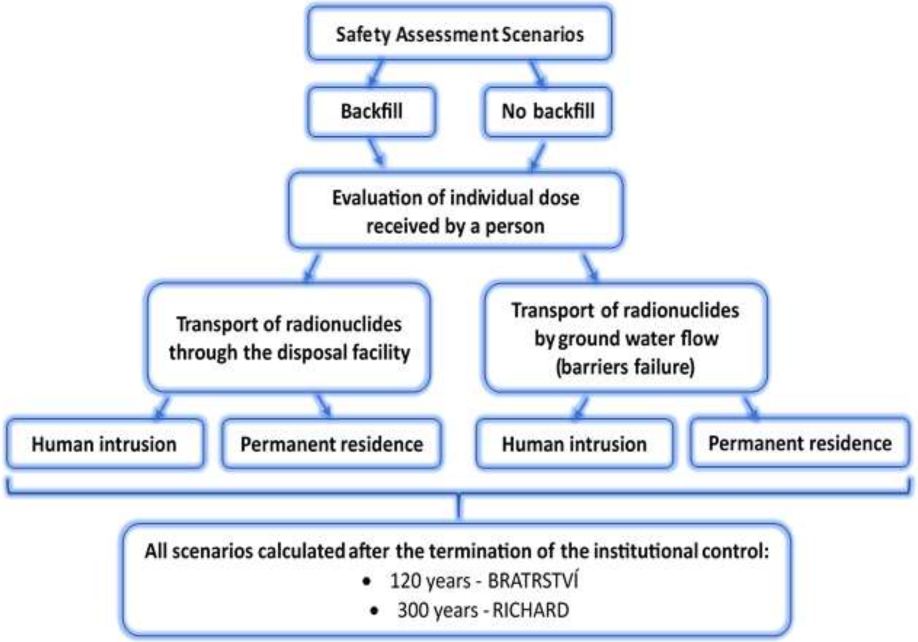
PERIODIC SAFETY ASSESSMENT

Bratrství: SA 2003-2013 - to verify the disposal facility capacity and to propose limits and conditions for its operation and clossure

Richard: SA 2003-2016 - to verify the disposal facility capacity and to reassess the already proposed closure and decommissioning method



Ongoing projects to asses the long-term safety of BRATRSTVÍ and RICHARD repositories - assessing the geological and hydrogeological model, the current and future inventory of radioactive waste and reviewing repository behaviour scenarios. Samples of backfill concrete were taken for experiments to obtain migration parameters for selected RNs in the repository environment.

Ageing Management Programmes developed to support the safe operation of the disposal facilities.

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SPECIFIC ISSUES IN THE MANAGEMENT OF RAW CONTAINING ONLY NATURAL RADIONUCLIDES

- The WMO requires the proof of proper **removal from the nuclear material register** as a condition for accepting RAO containing uranium or thorium for storage/disposal (**except for materials released from NORM workplaces**).
- **The licence holder must meet the following requirements**:
  - the scope of its operating licence or documentation must include the possibility of handling RAW containing natural radionuclides from other producers;
  - must also hold a licence to handle nuclear material of the appropriate type and quantity, when containing U and Th.
- Before accepting the RAW package, SÚRAO (WMO) requires **the proof that it was not possible to dispose of the waste containing natural radionuclides in any way other than as radioactive waste**.

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Czech Republic:

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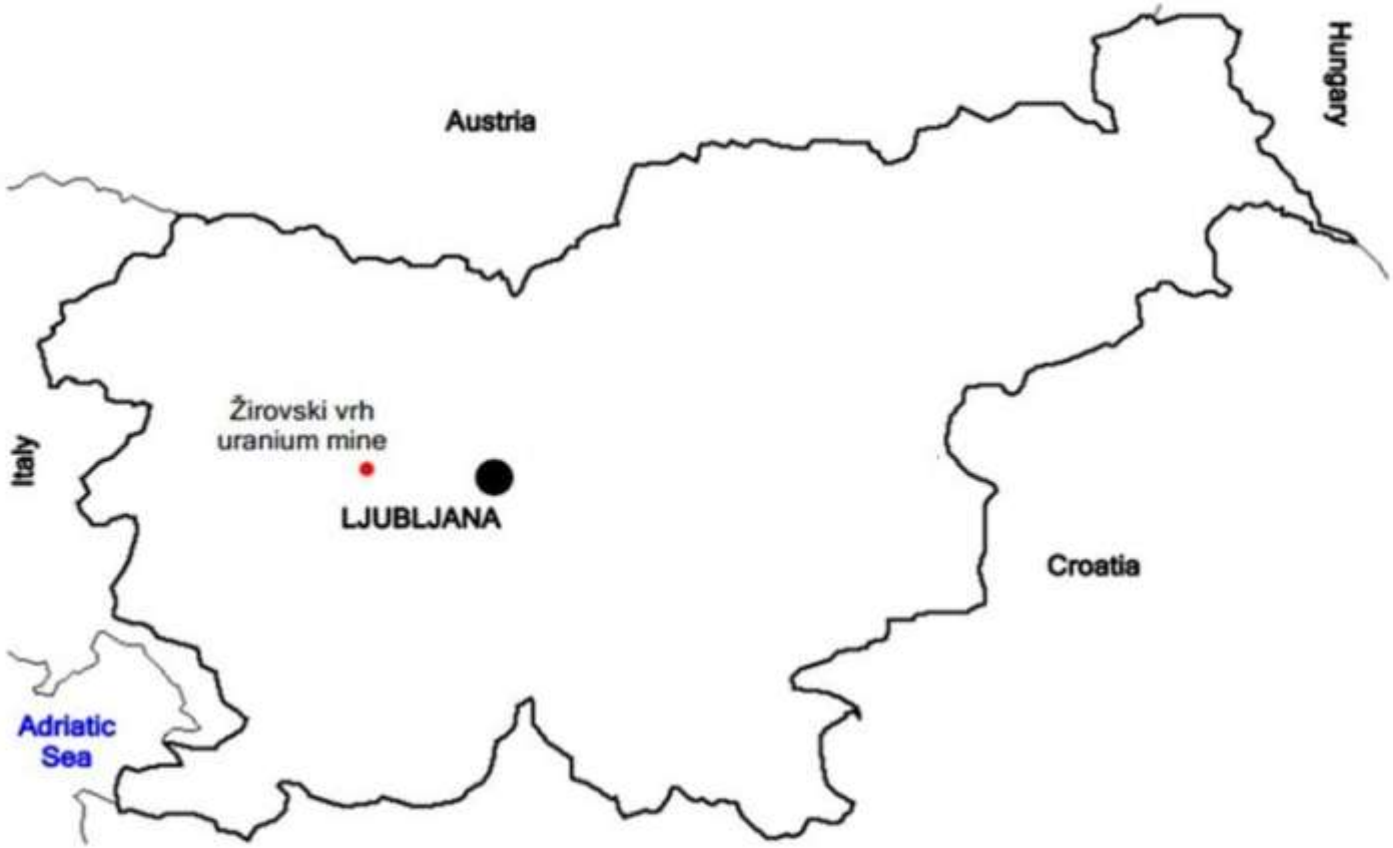
Institutional control and maintenance of closed waste disposal (NORM) sites in Slovenia

ASTRA T5 Workshop 2, 23. 09. 2025

Matej Rupret, ARAO
matej.rupret@arao.si

SIQ ISO 9001 Q-1599

Closed Uranium Mine

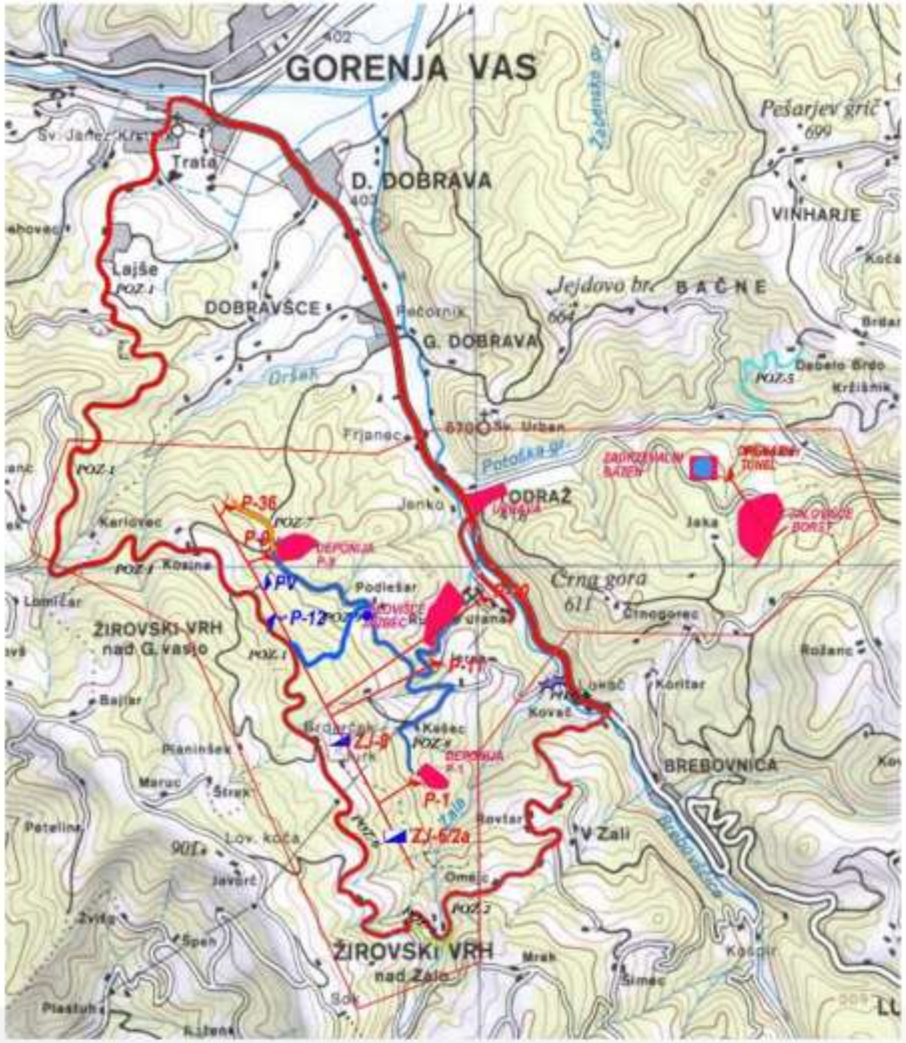


Former Uranium Mine - Žirovski Vrh

Uranium ore was excavated in the Žirovski Vrh area between 1982 and 1990.

- 60 km of underground passages, 430 – 610 m above sea level
- 3 307 000 t excavated rocks
- 633 000 t U-ore extracted
- 452 t yellow cake produced

- Mine tailings were disposed of at the Jazbec disposal site, while hydrometallurgical tailings were placed at the Boršt site.
- ~ 4 000 000 t of unexploited ore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D. DOBRAVA
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Črna gora
ŽIROVSKI VRH
nad G. vasjo
BREBOVNICA
ŽIROVSKI VRH
nad Zalo
V Zali
P-36
P-12
ZJ-6/7a
P-1

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Current status

- *The environmental remediation of the disposal sites and the Uranium Mine was carried out by the public company RŽV d.o.o.*
- *Uranium Mine has been closed and remediated in 2006.*
- *The Jazbec mining waste disposal site was closed in 2015, the Boršt hydrometallurgical waste disposal site was closed in 2025 .*
- *Both sites have become part of the national infrastructure and are now managed by ARAO - responsible for the long-term monitoring and maintenance of these sites.*

Current status

- *Post-closure long-term monitoring and maintenance of closed disposal sites is provided as a public service, managed by ARAO and financed from the national budget.*
- *The safety report for each disposal site defines the scope of monitoring after their closure, throughout the long-term institutional control period.*
- *Annual reports are submitted to the Slovenian Nuclear Safety Administration (SNSA) and the local community.*

Disposal sites - Program of long-term monitoring

Parameters to be followed:

- Radiological: Radon-222 exhalation, Rn-222 conc. in the air, dose rate, conc. U_3O_8 and Radium-226 in drainage water and water from boreholes.
- Physico-chemical: T, pH, water flow and total dissolved solids.
- Hydrology: groundwater level and flow rate of drainage waters.
- Terrain stability.

Disposal Jazbec

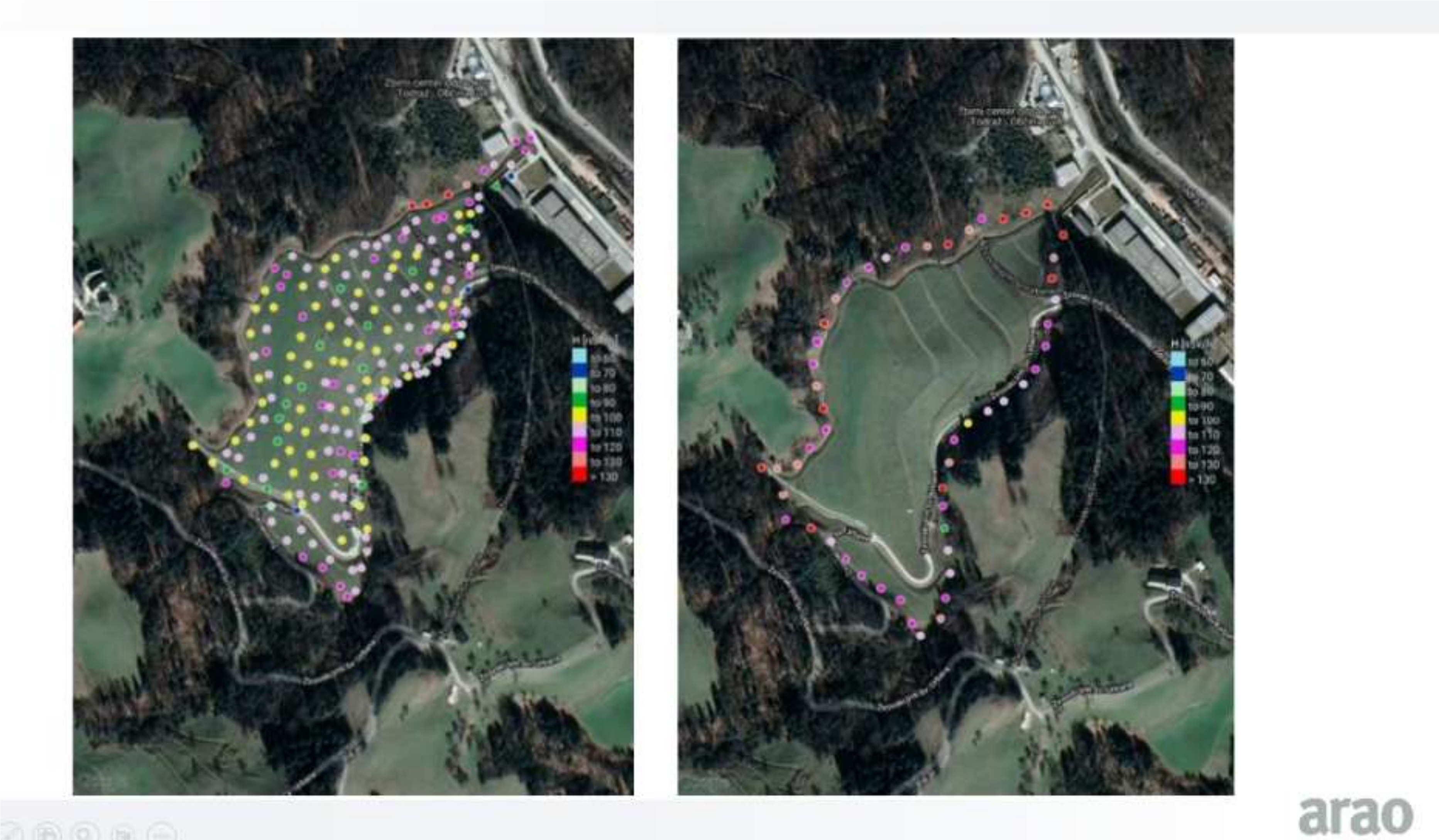
- *1,9 mio t (1 198 900 m3) mining waste, contaminated material*
- *50 - 70 g U3O8/t (activity <10 kBq/kg).*
- *total activity 21,7 TBq*
- *area 74 000 m2*
- *Waste conditioning : Materials were emplaced by bulldozer spreading and compaction. Containers and vessels were filled with liquid concrete.*
- *Details on waste packaging: Contaminated materials from dismantling of the processing plant and crusher were placed in containers (filled with liquid concrete).*
- *Long-term safety: Cover as key element - barrier for radon emissions, water erosion, water infiltration (reducing dissolution and migration). Long-term management and monitoring.*

Disposal Jazbec

Disposal Jazbec

Monitoring

Monitoring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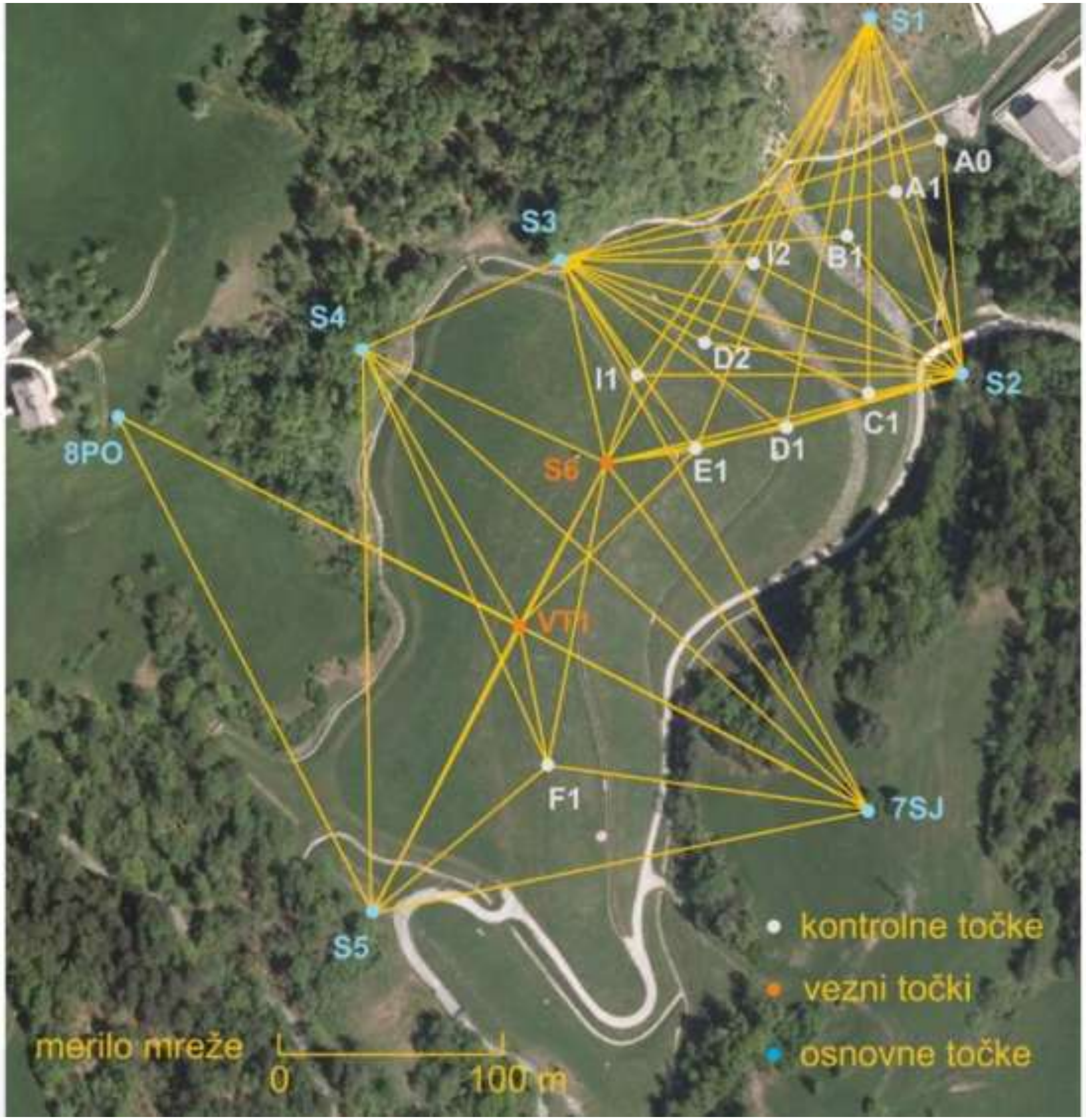
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Maintenace

Disposal Boršt

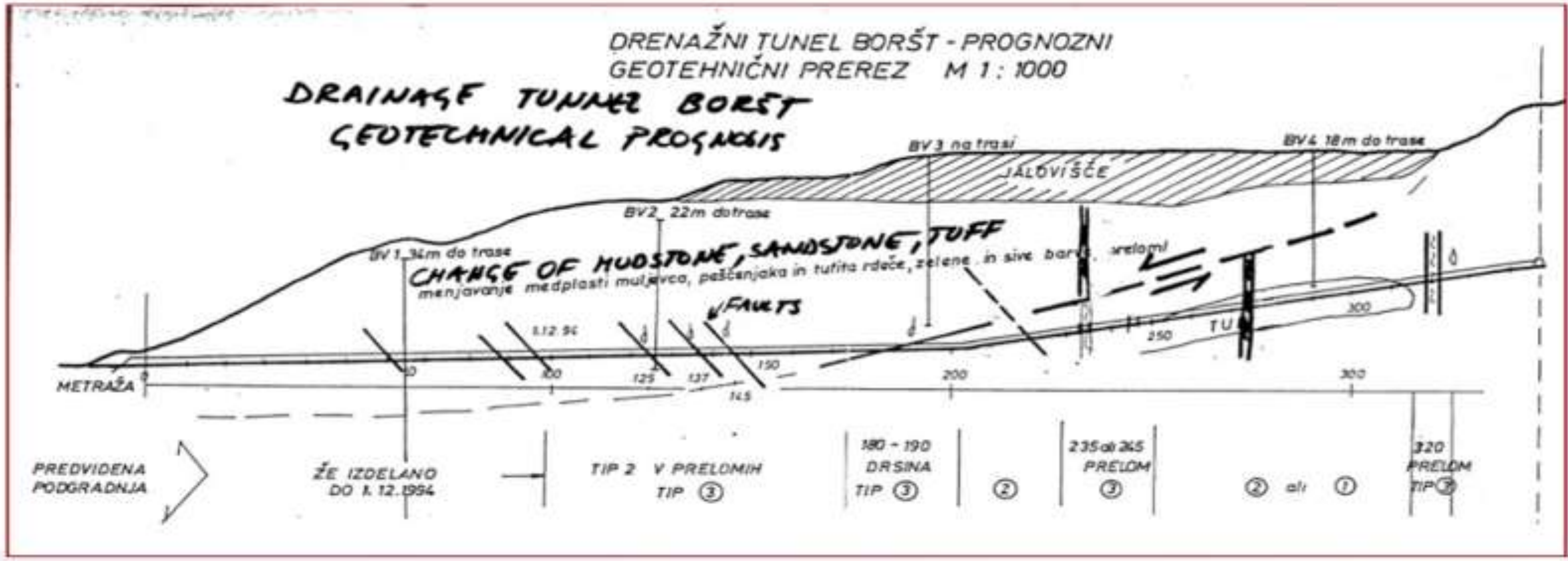
- *0.73 mio t (415 000 m3) hydrometallurgical waste*
- *50-80 g U3O8/t (activity 0.9 kBq U/kg, 8.6 kBq 226Ra/kg)*
- *total activity 48.8 TBq*
- *area 42 000 m2*
- *Waste conditioning : Drying of HMT*
- *Long-term safety: Cover (2.05 m, with 0.5 m clay) as key element - barrier for radon emissions, water erosion, water infiltration. Long-term management and monitoring.*

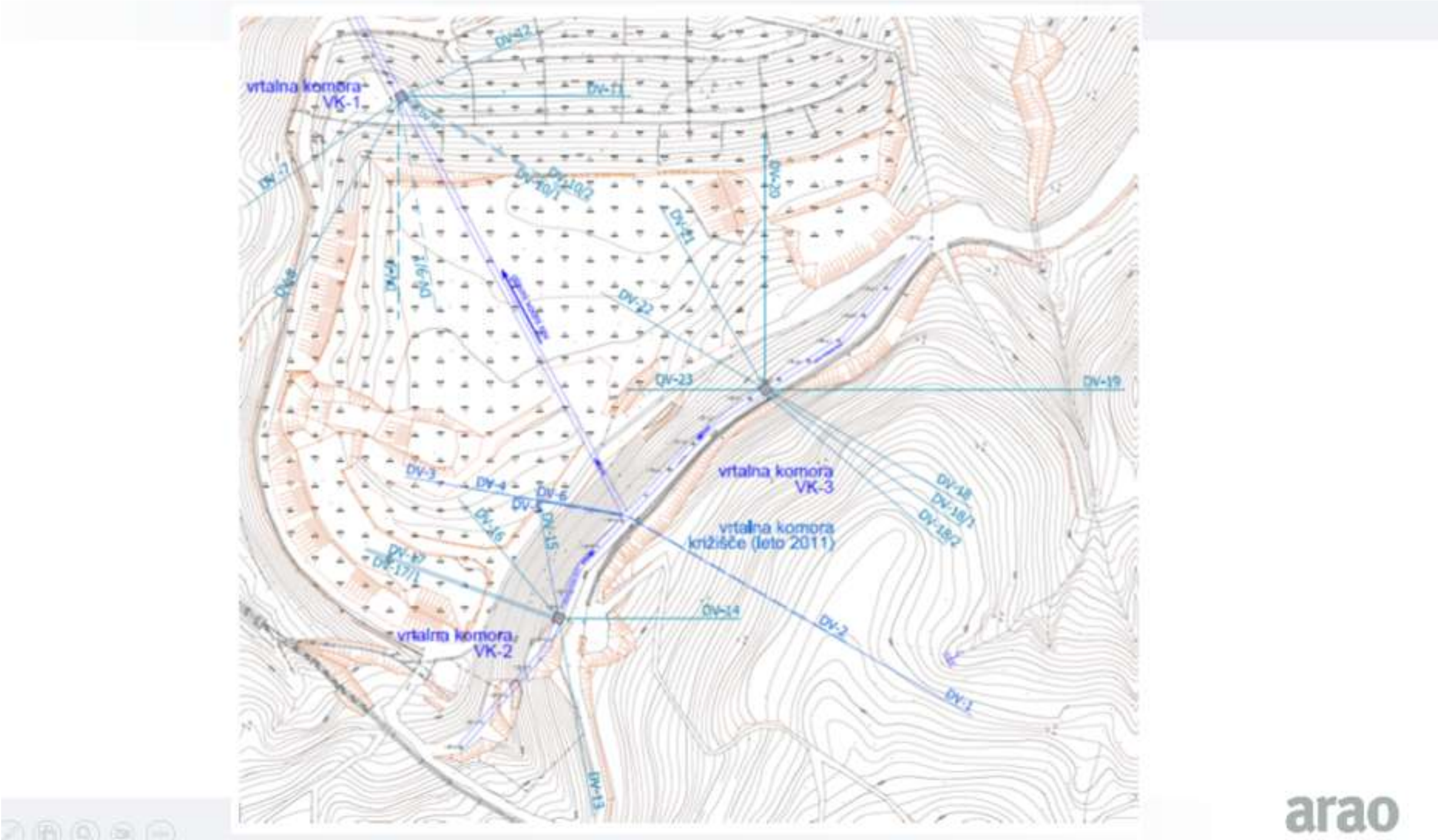
Boršt disposal site

- *In 1990, after an extensive autumn precipitation, a fossil landslide was activated (movement of 1.5 m).*
- *Most of the Boršt disposal site is located on this landslide.*
- *Landslide dimensions: 450 x 250 m, depth 50 m.*

Measures to slow down the landslide

- *1994–1996: construction of a drainage tunnel with two side branches and drainage boreholes.*
- *Movements were reduced to 0.5 cm/year.*
- *After the final remediation of the disposal site (2008–2011), movements reached up to 15 cm/year.*
- *Additional drainage boreholes were drilled in the drainage tunnel (2011, 2016/2017), additional piezometers were drilled and equipped for monitoring groundwater levels (2019).*




vrtalna komora
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DV-11
DV-12
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DV-10/1
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DV-22
DV-23
DV-19
vrtalna komora
VK-3
vrtalna komora
križišče (leto 2011)
DV-18
DV-18/1
DV-18/2
DV-3
DV-4
DV-6
DV-5
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VK-2
DV-13
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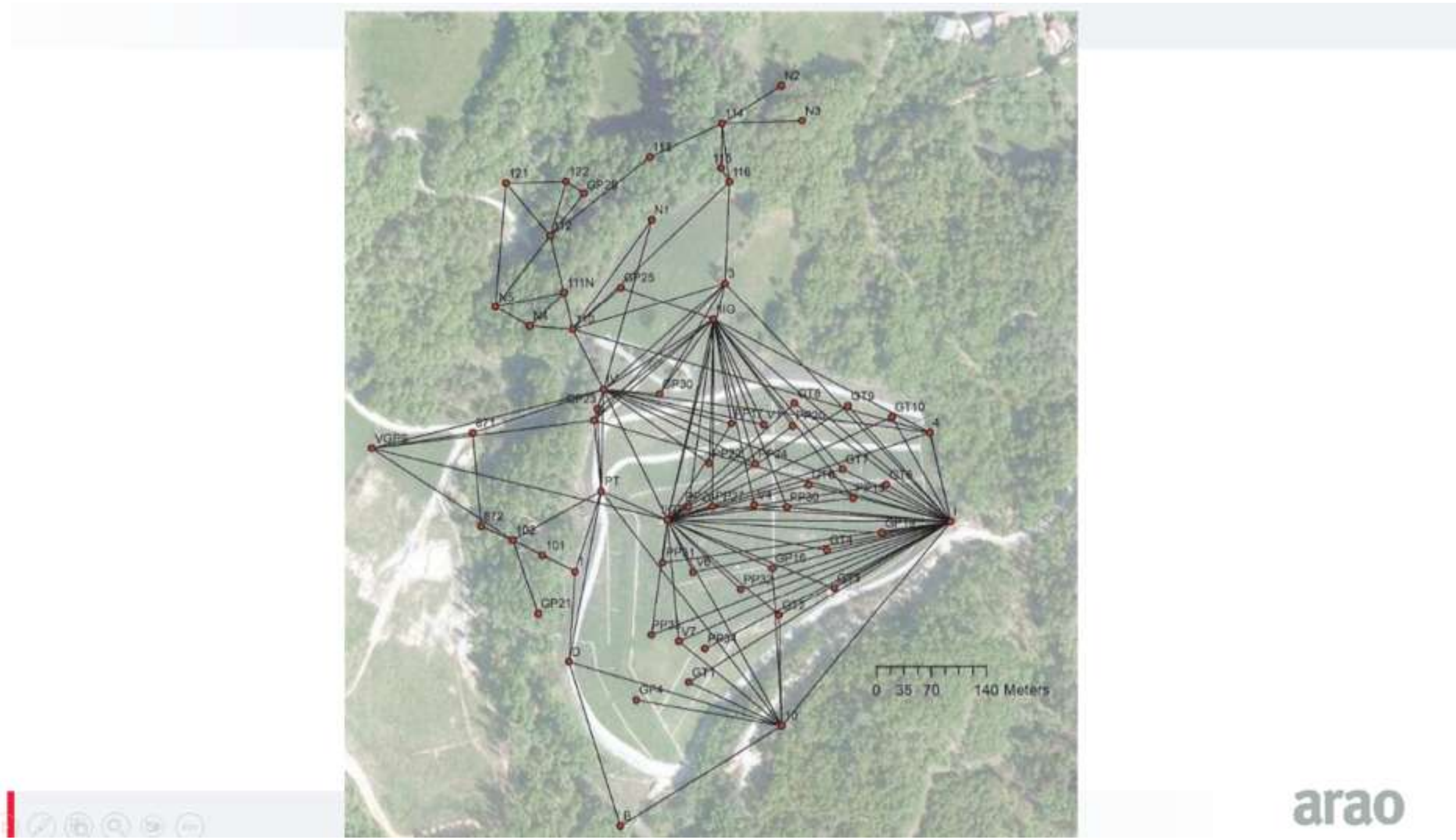
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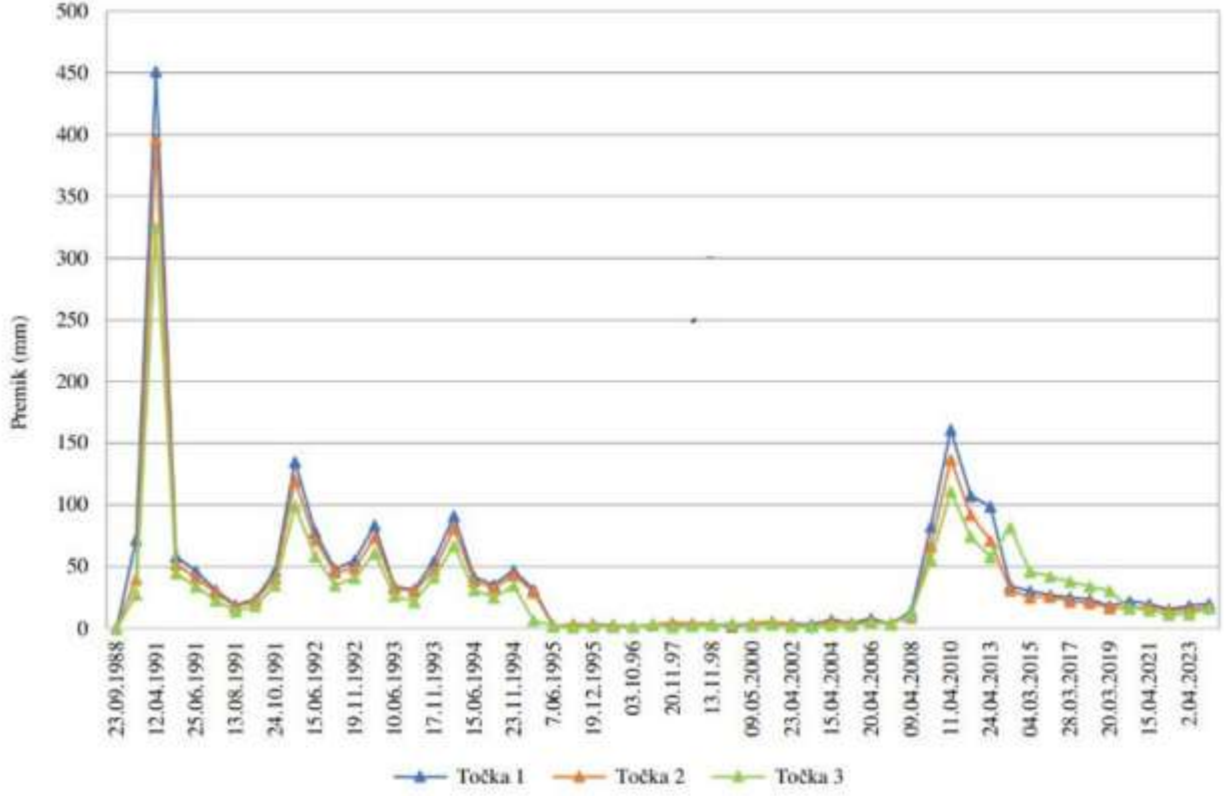
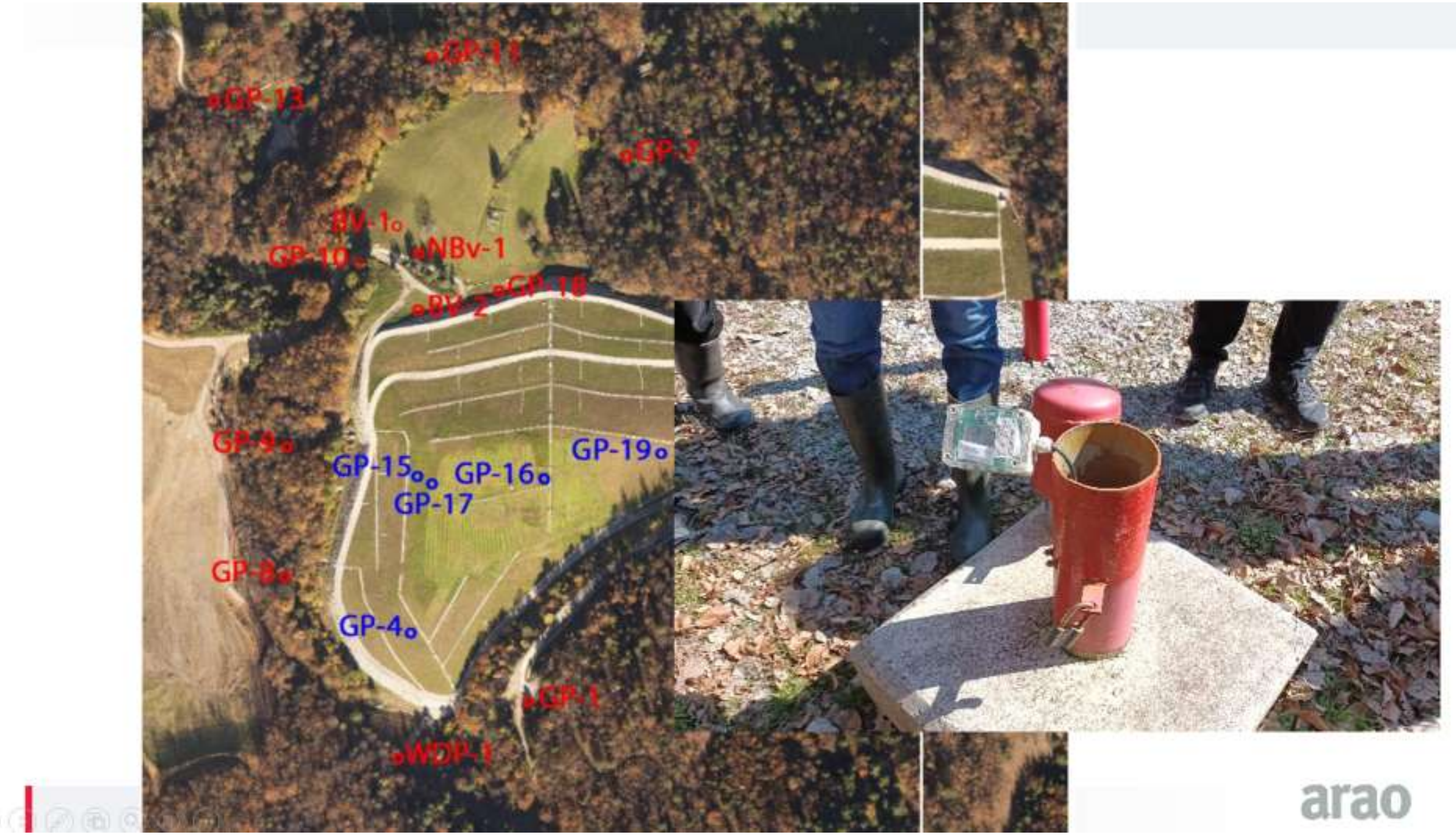


Annual horizontal movements have been around 1.5 cm/year in recent years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GP-8
GP-4
GP-1
WDP-1
arao

Institutional control of closed uranium mine site Žirovski vrh

Dose limits *resulting from activities at the Žirovski vrh Uranium Mine (including the mine itself and the Jezbec and Boršt waste disposal sites) are prescribed at* ***0.3 mSv/year.***

Dose limits are not exceeded *(0.25 mSv for year 2024).*

The long-term control and maintenance of closed uranium mine site Žirovski vrh ***includes physical surveillance, controls to ensure that the ground is stable and monitoring of releases into the environment.***