

## **Water Law Specific Regulation of the German Repository Konrad - 11474**

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### **ABSTRACT**

In addition to a Plan Approval License according to the German Atomic Energy Act a Water Law Permit is required for the disposal of radioactive waste with negligible heat generation in the Konrad repository. It considers the impact of radioactive as well as non-radioactive harmful substances on the near-surface groundwater. Due to the Water Law Permit the operator of the repository has (a) to register the disposed of radioactive and non-radioactive harmful substances and (b) to balance them. To meet these requirements the Federal Office for Radiation Protection (BfS) as operator and permit holder had to develop a concept accordingly. Thus, BfS defined threshold values for recording and for balancing the harmful substances. It had to be verified that by applying these values an adverse effect of disposed of waste packages on the near-surface groundwater can be excluded. The Lower Saxony Water Management, Coastal Protection and Nature Conservation Agency (NLWKN) as the responsible water law regulatory authority evaluated this concept.

### **INTRODUCTION**

In May 2002, 20 years after application, the Ministry for Environment of the German Federal State Lower Saxony licensed the construction and operation of the Konrad site by a Plan Approval License [1] according to the German Atomic Energy Act (AtG) as a facility for the disposal of solid or solidified radioactive waste with negligible heat generation. According to the designated location of the repository the German Federal State Lower Saxony has issued the license for Konrad. After several lawsuits the Federal Administrative Court as last instance finally confirmed this license in 2007.

As the disposal of radioactive waste in the Konrad repository is suspected to have an adverse effect on groundwater the operator had to apply for an appropriate permit. Therefore, together with the Plan Approval License a Water Law Permit for the disposal of radioactive waste in the Konrad repository was granted. In a formal way this permit is an amendment to the Plan Approval License.

While the water law specific requirements were already discussed by the operator [2, 3] and by the waste producing side [4, 5], respectively, here the responsible water law regulatory authority Lower Saxony Water Management, Coastal Protection and Nature Conservation Agency (NLWKN) presents its evaluation of the Water Law Permit and the operator's concept to comply with it.

### **MODEL OF CONTAMINANTS MOBILIZATION**

The Konrad repository [6, 7], located near the city of Salzgitter in the German Federal State Lower Saxony is constructed in a depth of 850 m within an iron ore formation of sedimentary origin, which reveals a low, but existent hydraulic permeability. However, 400 m of clayey strata above the repository are assumed to be impermeable and thus, form a hydraulic barrier. Furthermore, the groundwater in the area is in general stratified into an upper groundwater zone of low salinity, referred to as near-surface groundwater and a deep groundwater zone below 150 m of depth, which remains almost static due to high salinity (Fig. 1).

Based upon these conditions a model approved by the Water Law Permit was developed to describe the mobilization of contaminants out of the radioactive waste via the groundwater path, and finally their availability in the biosphere in a very conservative approach [8]. According to this model radioactive and non-radioactive substances, which are disposed of in the Konrad repository become dissolved in 1 million m<sup>3</sup> of groundwater, as the groundwater within

the drained repository rises again after operation has ceased. The approved model volume of 1 million m<sup>3</sup> is calculated from the totally excavated volume of the repository. Without any interaction with the underground the contaminated deep groundwater enters the near-surface groundwater. Through this transition the contaminated deep groundwater is diluted by a model factor of 1:10.000.

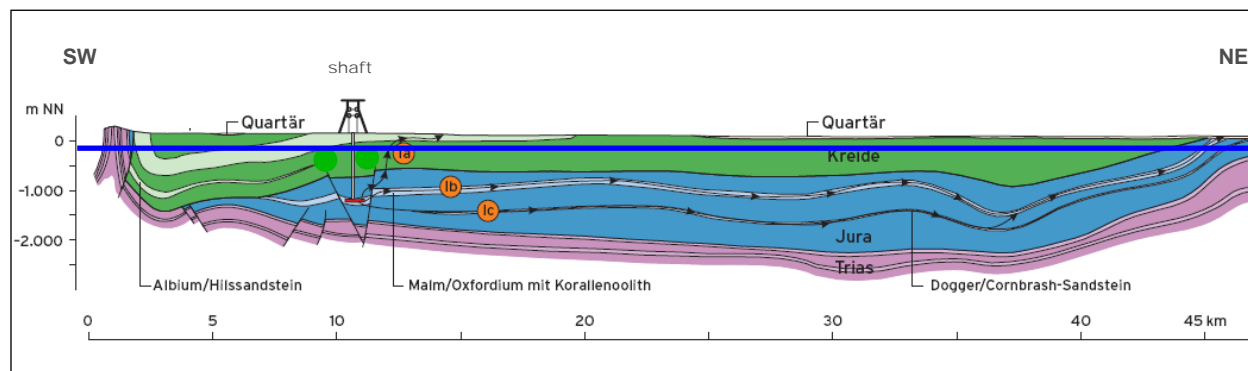


Figure 1. Sketch of the underground of the Konrad repository, which shows possible transport pathways (1a-c) of contaminated groundwater. Note the horizontal blue line marking the stratification into the upper near-surface groundwater and the deep groundwater zone below. The repository is marked in red (modified after [9]).

## LEGAL REQUIREMENTS

The Water Law Permit refers to the Lower Saxony Water Act (NWG) in accordance with the German Groundwater Ordinance (GrWV). In general the subject of protection is to prohibit any action, which has an adverse effect onto the groundwater. However, as the deep groundwater is considered to be no subject to any utilization the Water Law Permit's applicability is restricted to the protection of the near-surface groundwater.

The Groundwater Ordinance determines specific substances, which have an adverse effect onto the groundwater, but only in a qualitative way. Definite concentration limits of specific substances are determined by other regulations, foremost the German Drinking Water Ordinance (TrinkwV).

In addition to the substance specific total mass limits (in the case of radionuclides: activity limits) allowed by the Water Law Permit to dispose of the operator and permit holder has to comply with two collateral clauses, which require the following:

(1) The operator has to control the composition of the waste to dispose of. Radionuclides and non-radioactive harmful substances need to be continuously registered and balanced on a substance specific and quantitative base. Harmful substances, which have an adverse effect and which are not covered by the permit are not allowed to be disposed of.

In the case of the already existing conditioned wastes (so-called legacy wastes) the substance specific composition of the packages has to be estimated.

(2) The responsible water law regulatory authority has to be informed four weeks before about the start of operation. The yearly data of the actual disposal are compiled in an annual report, which has to be forwarded until 31<sup>st</sup> of March of the following year. The nuclide specific activity and mass of the disposed of radioactive inventory as well as the substance specific masses of the non-radioactive harmful substances have to be indicated.

Furthermore, in the justification of the Water Law Permit several details are regulated. (1) It is not necessary to conduct additional chemical analyses to gain information about the substance specific waste composition. Instead, the radioactive waste is characterized by the waste generator using already existing information, operational documentation and applicable experiences for compiling a waste package data sheet. The operator of the Konrad repository has the opportunity to check the waste packages for proving the specified data. (2) Trace impurities are

neither registered nor balanced as long as they reveal no adverse effect on the near-surface groundwater. All substances, which cannot be determined in a quantitative manner, are defined to be trace impurities. The item of trace impurities refers to the scale of differentiation, i.e., to which extent it is reasonable and possible to distinguish components of waste for the required waste characterization. (3) The Water Law Permit defines the frame of legal requirements for operation of the Konrad repository. Thus, the responsible water law regulatory authority is committed to issue detailed requirements, when approving the operator's concept as well as during its implementation. Moreover, the Water Law Permit has to be reassessed by NLWKN on a regular base.

## CONCEPT OF DECLARATION

The approved substance specific total masses of the Water Law Permit, which are determined numerally, appear in many cases quite low to meet the object of the Konrad repository to dispose of all German radioactive waste with negligible heat generation. Nevertheless, its justification enables to execute the Water Law Permit, because accordingly trace impurities are neither registered nor balanced. In fact the cause for an adverse effect has to be determined by the substance specific concentration limits of the Drinking Water Ordinance and other regulations applicable. Therefore, certain substances are considered as trace impurities having no adverse effect on the near-surface groundwater as long as these concentration limits are not exceeded. Consequently, the amount of radioactive waste to be disposed of is limited by the total substance specific masses, which are determined numerally in the Water Law Permit plus a certain mass of trace impurities (the upper limit for a trace impurity is set by a declaration threshold value).

To go into detail the waste producing side has to specify a specific substance contained in the radioactive waste in a qualitative way for registration by the operator, if (1) its description threshold value specified in mass-% of a single package or a batch of identical packages and specific for each substance is exceeded. If the concentration of a specific substance is higher and (2) even exceeds its declaration threshold value the operator will balance it. By this it is possible to track the degree of the substance specific capacity utilization in the Konrad repository. The description threshold values and the declaration threshold values are calculated by the approved concentration limits in accordance with the model of contaminant mobilization. Anyhow, the substance specific solubilities are taken into consideration.

The concept takes into consideration that already before the point of time, when the Plan Approval License was jurisdictionally confirmed in 2007, radioactive waste was generated and in almost all cases conditioned, though according to waste acceptance requirements, which were yet not finally revised [10]. Thus, a division in previously generated waste (so-called legacy waste) and in newly generated waste, i.e., generated since the final confirmation in 2007, is necessary.

The determination of the composition of previously generated waste is estimated on the base of operational documentation available, as well as by verifying the plausibility of data. Due to radiation protection neither to open the packages nor to analyze their content is required. To this end, a waste package data sheet for a single package or for a batch of identical waste packages is compiled (see below). The same characterization procedure is applied for newly generated waste with the difference that the available information here is much better than in the case of previously generated waste. Thus, it is allowed that previously generated waste packages contain up to five times more harmful substances than allowed for newly generated waste. Therefore, (1) the declaration threshold values for balancing the substances disposed of are up to five times higher than in the case of newly generated waste. (2) In any case the waste producing side has to specify a specific substance for registration using the description threshold value either from 1% on in the case of newly generated waste or from 5% on in the case of previously generated waste.

Though the content of harmful substances of previously generated waste is assumed to be higher than in newly generated waste the declaration threshold values are calculated such that due to a conservative approach a limited contingent of previously generated waste remains to be allowed. However, this contingent is limited to 5% of the total waste mass disposed of in the Konrad repository. As the existing amount of previously generated waste already exceeds 5% of the expected total waste mass to be disposed of requalification measures need to be performed, which are realized by, e.g., using approved containers. If the proportion of previously generated waste would be higher than 5% the total mass of harmful substances, which can be disposed of in the Konrad repository would decrease.

The quantitative characterization of the substance specific composition of radioactive waste is done with the help of a substance database, which is maintained by the operator. The entries in this database have to be approved by the responsible water law regulatory authority. The entries are done for single substances as well as for so-called substance vectors (analog to radionuclide vectors), which describe a definite waste product generated by a definite process. The substance vector itself is composed of several substances. Also by the containers used to pack the radioactive waste substances are placed in the repository. These have to be registered (if applicable: and balanced) as well, what is done with the help of a related container database.

To characterize waste packages for disposal the waste generator compares their composition and origin with the substance and the container database to choose the applicable entries (as mentioned before: if the substance specific description threshold values are exceeded). Currently, the entries in the substance database are examples based on estimations of the frequency of specific substances in radioactive waste packages. These entries, which rely on long-time operational and inspectional experience, are to verify during implementation. Additionally, the substance database is completed by actual data on the waste composition, when indicated. To ensure this continuous and appropriate data on the real waste composition is needed.

A critical item is to obtain sufficient knowledge about the chemical composition of the waste packages to assess the compliance to the requirements of the Water Law Permit. To this end it has to be taken into account that some of the water contaminants, e. g. nitrates or metal ions listed in the respective regulations, might originate from different chemical substances, which are potential components of waste packages. However, the Water Law Permit names just 94 substances, which are harmful to groundwater, but it does not list all possible components, which might occur in the waste packages. Therefore, in order to exclude an adverse effect on the near-surface groundwater the concept has to take different kind of substances in specific chemical forms into account.

A reference to the conventional waste law is possible only in a very limited way, because the concept of these non-radioactive regulations refer to the harmful nature of the concentration of single substances. This can result to unlimited masses of some substances in the repository as long as they are not harmful.

## **EXPERIENCES**

In a first step 150 basic substances which can occur in the waste packages to be disposed of at Konrad were identified, which will be added to the substance list with a characteristic code after approval by NLWKN as the regulating authority. The identified substances are organic and inorganic chemical components, which can occur in all waste streams and, therefore, these entries of the substance database are provided by BfS as the permit owner. Also substances not named in the Water Law Permit, e. g., polycyclic aromatic carbon hydrates (PAC), might be listed in the substance database as long as it is approved that by their mass no adverse effect on the near-surface groundwater has to be assumed.

In a second step – based on the basic entries – waste specific materials have been identified, e. g., iron-base alloys or ion exchange resins. First applications for entries of these materials in the substance database were made and can be approved on the basis of the approvals of the basic substances. Entries of waste specific materials can be used to describe certain amounts of waste packages or continuously produced waste streams.

Up to the end of 2010 approximately 25 entries - except the 150 basic entries – were applied for the substance database by different waste generators. Based on these entries, the description of the chemical composition of waste packages will be done (Fig. 2). The waste generator chooses the necessary entries of the substance database up to an accuracy that excludes further impurities, which might be harmful to the near-surface groundwater. In the waste package data sheet the codes of the materials are listed with the corresponding masses.

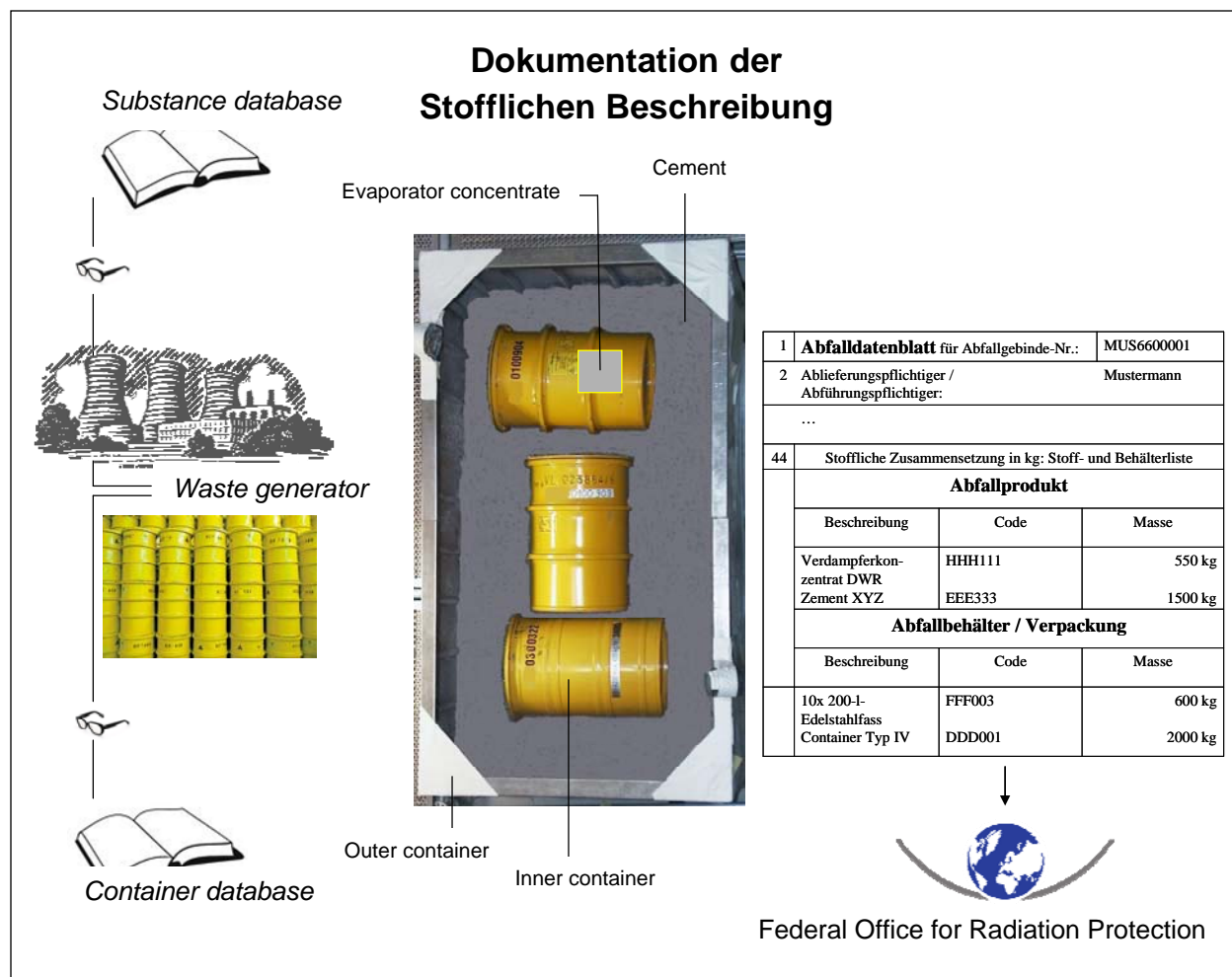


Figure 2. Example of the description of the composition of waste packages with substance specific codes for waste and container components (here: evaporator concentrate, cement for fixing, inner container, outer container). By compiling all substance specific codes to a waste package data sheet a complete description is obtained.

First examples for an application, e. g., the chemical characterization of already existing defined amounts of waste packages with different waste products, are in progress. First results are expected for February 2011 and hence will be presented at the WM 2011 conference.

## CONCLUSIONS

The disposal of radioactive waste with negligible heat generation in the Konrad repository has no adverse effect on the near-surface groundwater, as long as the substance specific concentration limits of the Drinking Water Ordinance and other regulations are not exceeded. This is ensured by calculated substance specific threshold values. As these threshold values are calculated on the base of estimations of the frequency of specific substances in the waste they need to be verified by gradually won data. By this the knowledge of the waste composition will get gradually more exact.

The elaborated concept for registering and balancing of substances leads to a site specific solution for the Konrad repository, which is flexible enough also to handle future developments in the area of radioactive waste management, e. g., new conditioning concepts or new containers for packaging.

The responsible water law regulatory authority NLWKN verifies the operator's concept to register and, where necessary, to balance the substances in the disposed of radioactive waste before it comes into force. NLWKN

approves this concept, when the requirements of the Water Law Permit are met. Nonetheless, also after approval NLWKN might request additional measures, when indicated, which further improve the protection of the near-surface groundwater.

By the Water Law Permit granted together with the Plan Approval License the disposal of radioactive waste is regulated on a legally approved base. One might think about possible extensions regarding the total mass of certain substances or even the total number of substances to be disposed of. Apart from any advantage it should be considered beforehand that finally the total mass is limited by the maximum acceptable concentration of a specific substance in the near-surface groundwater by regulations like the German Groundwater Ordinance and the Drinking Water Ordinance. Already the current concept for registering and, where necessary, balancing the substances disposed of in compliance with the Water Law Permit fully exploits the total concentration limits allowed by these regulations.

## ACKNOWLEDGEMENTS

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