Safety analysis of the transportation of radioactive waste to the Konrad final repository – Methods and results –

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Overview

- Introduction
- Normal (accident-free) transport
- Transport accidents
- Summary and Conclusions

Introduction

The new Konrad Transport Study 2009

- Safety analysis for assessment of the transport risks associated with the transportation of radioactive waste with negligible heat-generation to the Konrad final repository in Germany
- Revision of the former Konrad Transport Study performed by GRS in 1991
  - implementing an **updated waste database**
  - considering the **actual planning status** and more realistic assumptions
  - applying **improved methods** (e.g. a Lagrangian dispersion model and new data for release fractions)

- **Radiological transport risks:**
  1. Potential radiation exposure of people from normal (accident-free) transportation
  2. Radiological risks and consequences (radiation exposure and contamination levels) associated with transport accidents

Transport Scenarios

The Reference Scenario

- Result of the waste data survey and transport modalities ➡ realistic scenario
- Transport amount per year: **2300 shipping units** with 1 cubical or 1-2 cylindrical containers of radioactive waste
- 50 shipping units per week on average
- **80 % transport by rail and 20 % by road** (i.e. 40 shipping units per rail and 10 per road on average per week)
- approximately **8 rail transports per week** with 2-3 waste wagons per regular standard goods train (no dedicated trains)
- **5-10 road transports per week** (depending on the truck's load capacity)

Additionally, two other – more **hypothetical** – scenarios were also considered:

- 100 % transport by rail
- 100 % transport by road

Normal Transport: Method

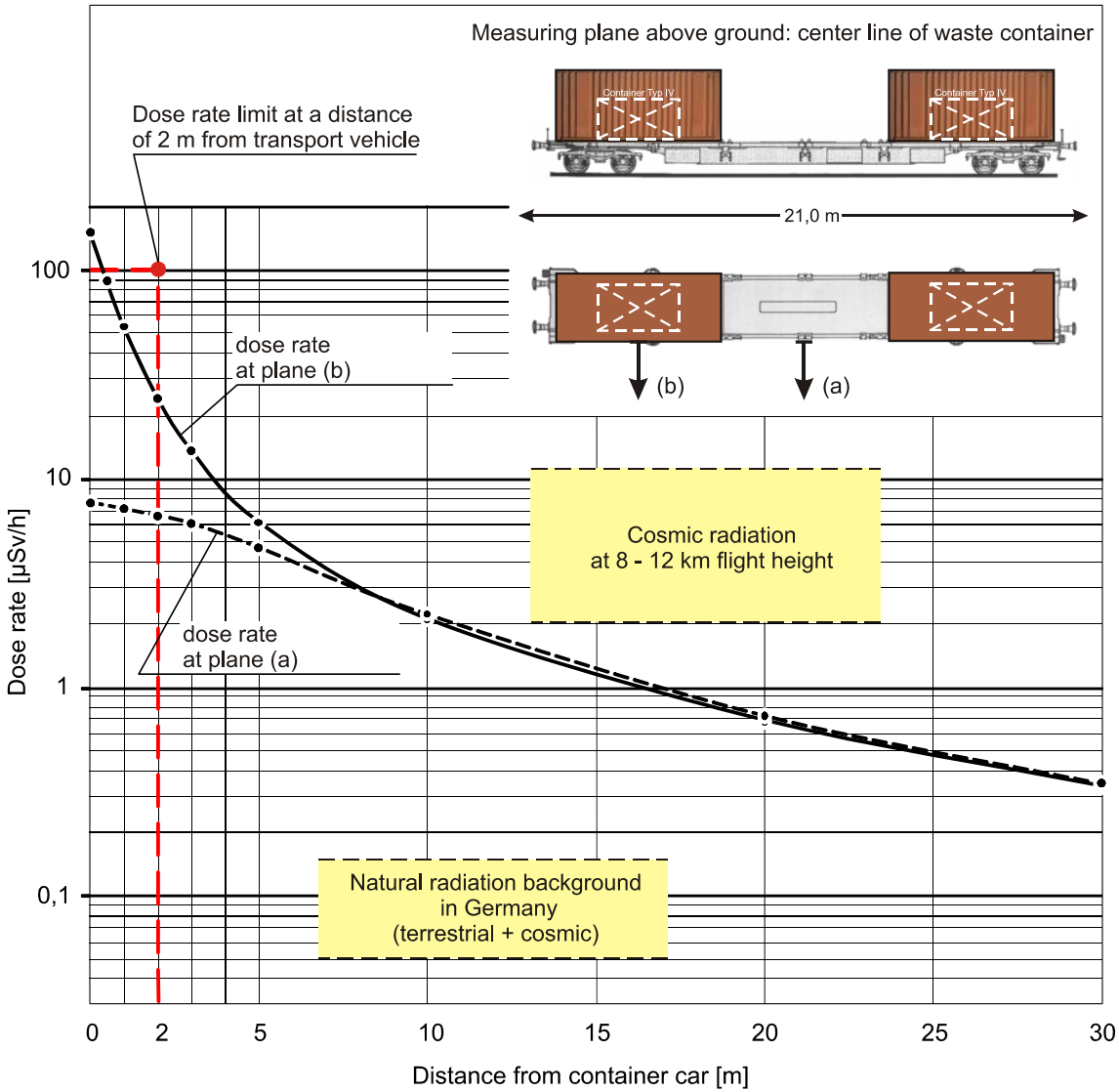
Objective

- **Deterministic** assessment of **potential radiation exposure** associated with **normal (accident-free) transportation** of radioactive waste for
  - the general public
  - the transport personnel

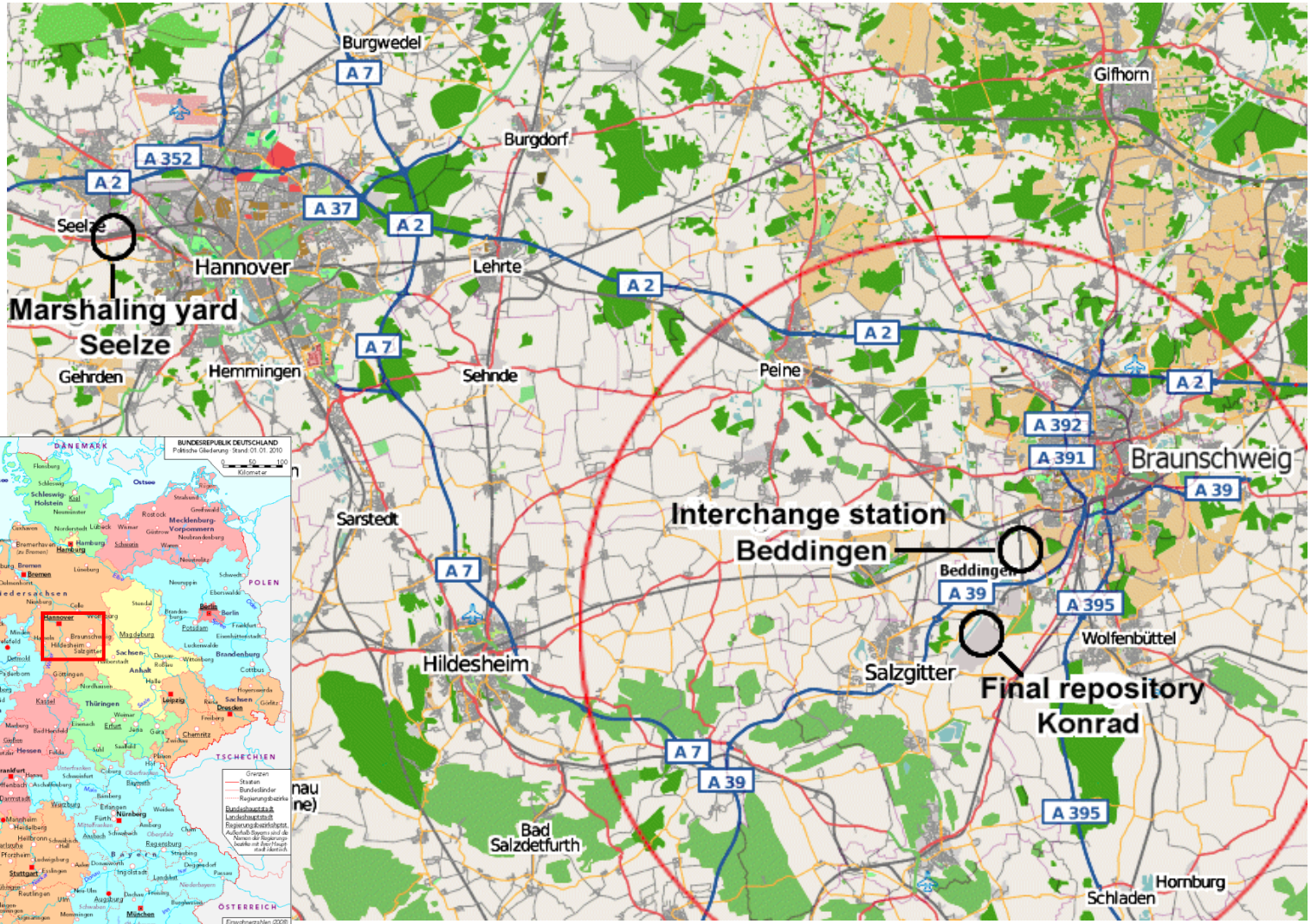
1. Detailed **exposition analysis** to identify the **representative person(s)**
2. Determination of **local dose rates** of waste containers and transport configurations at different distances

➡ Determination of the potential **effective dose per year** for the representative persons resulting from waste shipments

Normal Transport: Results
Typical spatial distribution of local dose rate



Traffic infrastructure in the expanded Konrad region



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OpenStreetMap

Normal Transport: Results
Maximum annual radiation exposure of the public

Population Group/ Route	Distance	Effective Dose (mSv/a)		
		100 % rail	100 % road	80 % rail/ 20 % road
Rail transport:				
Residents, main transport route (time spent exclusively outdoors)	**5 m**	ca. 0.025	---	**ca. 0.02**
Residents, marshaling yard Beddingen (25 % outdoors/ 75 % indoors)	> 130 m	ca. 0.005	---	ca. 0.004
Residents, marshaling yard Seelze/Hannover (25 % outdoors/ 75 % indoors)	ca. 100 m	ca. 0.017	---	< 0.014
Employees of the slag reprocessing plant	**> 50 m**	< 0.004	---	**ca. 0.003**
Road transport:				
Residents, main transport route (time spent exclusively outdoors)	5 m	---	ca. 0.025	ca. 0.005
For comparison:				
Relevant annual statutory dose limit			**1.0**	
Natural radiation exposure			**2.1**	

Normal Transport: Results
Maximum annual radiation exposure of transport personnel

Function/ Route	Effective Dose (mSv/a)		
	100 % rail	100 % road	80 % rail/ 20 % road
Rail transport:			
Marshaling yard Beddingen			
-Shunter	ca. 0.2	---	ca. 0.16
-**Shunting engine driver**	< 0.4	---	**< 0.32**
-**Power unit driver (transfer tour to Konrad)**	ca. 0.06	---	**< 0.05**
Marshaling yard Seelze/Hannover			
-Shunter	ca. 0.1	---	ca. 0.08
-Marshaling hump	ca. 0.2	---	ca. 0.16
Road transport:			
Truck driver/escort	---	< 1.1	**ca. 0.6**
For comparison:			
Relevant annual statutory dose limit	**6 (Kat B)/20 (Kat A)**		

Transport Accidents: Method

Objective

- **Probabilistic** risk assessment of the **potential radiological consequences** associated with **transport accidents**

1. Detailed analysis of **transport modalities**
2. Determination of frequency and severity of transport accidents (**impact load**)
3. Determination of **release behavior** and **activity inventory**
4. Monte-Carlo transport accident simulation with generation of **source term**
5. Calculation of radiological consequences (atmospheric dispersion modeling)

➡ Determination of the potential **committed effective dose** and the associated **probability** of occurrence for the Konrad region (25 km radius)

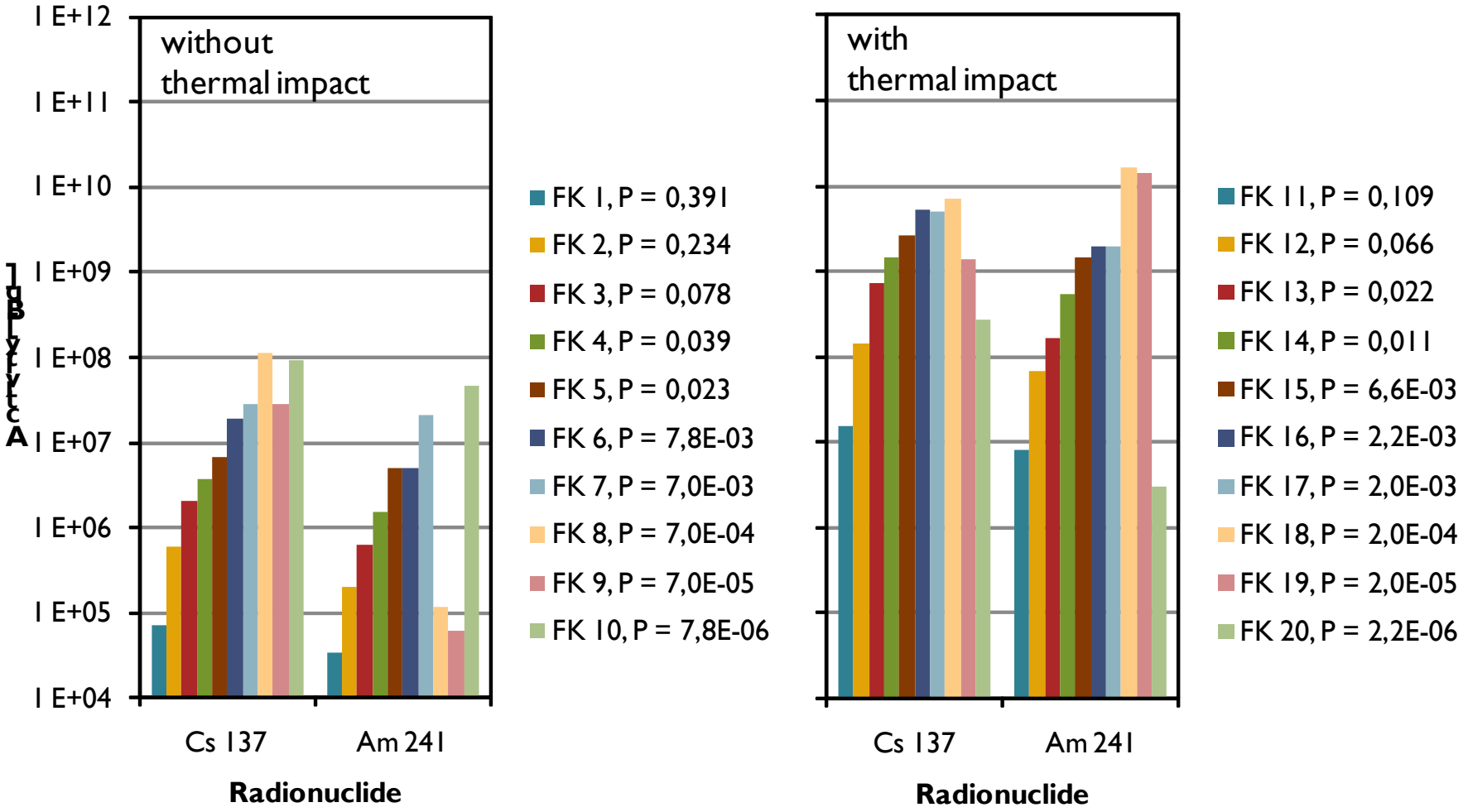
Transport Accidents: Results
Impact Load

Definition of the nine accident severity categories (BK)

Impact Velocity	Fire Duration and Temperature		
	without thermal impact	**thermal impact 30 min, 800 °C**	**thermal impact 60 min, 800 °C**
0 to 35 km/h	BK 1	BK 2	BK 3
36 to 80 km/h	BK 4	BK 5	BK 6
above 80 km/h	BK 7	BK 8	BK 9

Transport Accidents: Results
Source Term: Example

Release categories (FK) with associated conditional probabilities (P)



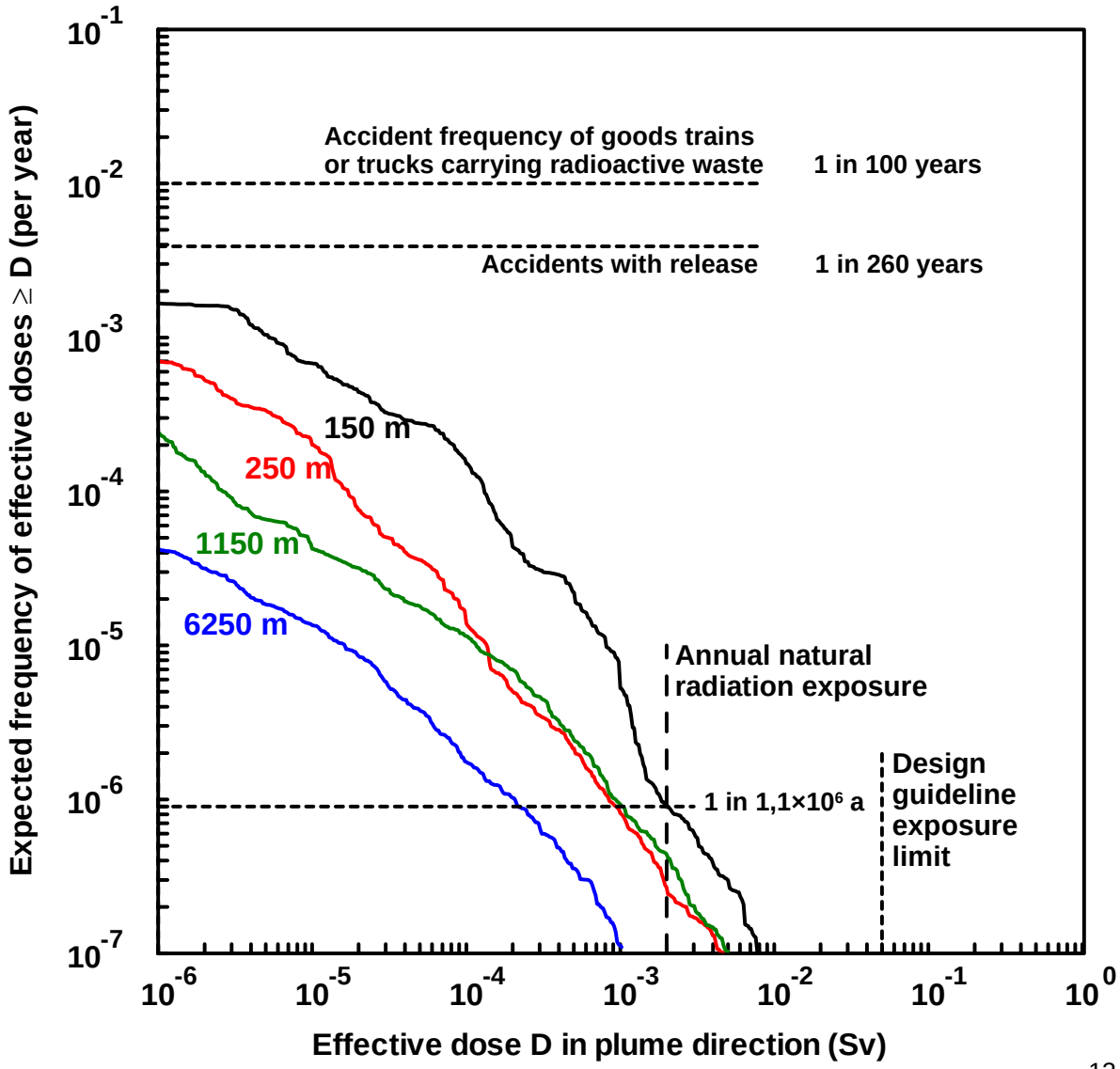
Transport Accidents: Results
CCFD: Frequency distribution of effective lifetime dose

Potential radiation exposure risk for the total population resulting from transport accidents in the Konrad region (25 km area)

Reference scenario:

80 % rail transport/
20 % road transport

All exposure pathways (without countermeasures)



Summary

- The predicted doses arising from **normal** transportation of radioactive waste to the Konrad final repository for the public and the transport personnel are far below the relevant German annual statutory dose limits.

- In the majority of **accidents** with activity release, the predicted effective doses are far below the annual natural radiation exposure level even without countermeasures.

- In all cases, even at a distance of 150 m and down to an expected frequency of 10^{-7} per year the calculated doses stay below the design guideline exposure limit of 50 mSv which is used for orientation.

- The risk of an individual person from transport accidents is reduced by at least one order of magnitude compared to the risk for the entire population in the region of the final repository considered in this study.

Conclusions

- Overall, the results of the **actual transport risk analysis** confirm that **no major associated risks** would result from the converging waste transports destined for the final repository Konrad for the region around the site. This applies to both normal transport and transport accidents.

- The results of the revised transport study for potential exposures and occurrence probabilities respectively, are more than one order of magnitude below the results of the previous study from 1991. This can be attributed to
  - the reduction of the waste amount shipped per year
  - the missing waste stream from reprocessing
  - the updated and enhanced waste database
  - and a more realistic methodical approach.

Thank you for your attention!