



# Free Release of Ground Areas at the Greifswald Site

OECD/NEA Workshop  
Studsvik, April 2012

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# Aerial view on the EWN site in 1999



## Content:

1. Operational history, categorisation und measurement procedures
2. In-situ gamma-spectrometry und practical examples
3. Subtraction of the Cs-137 share from the Chernobyl accident and/or nuclear weapon fallout (individual case)

# Operational history

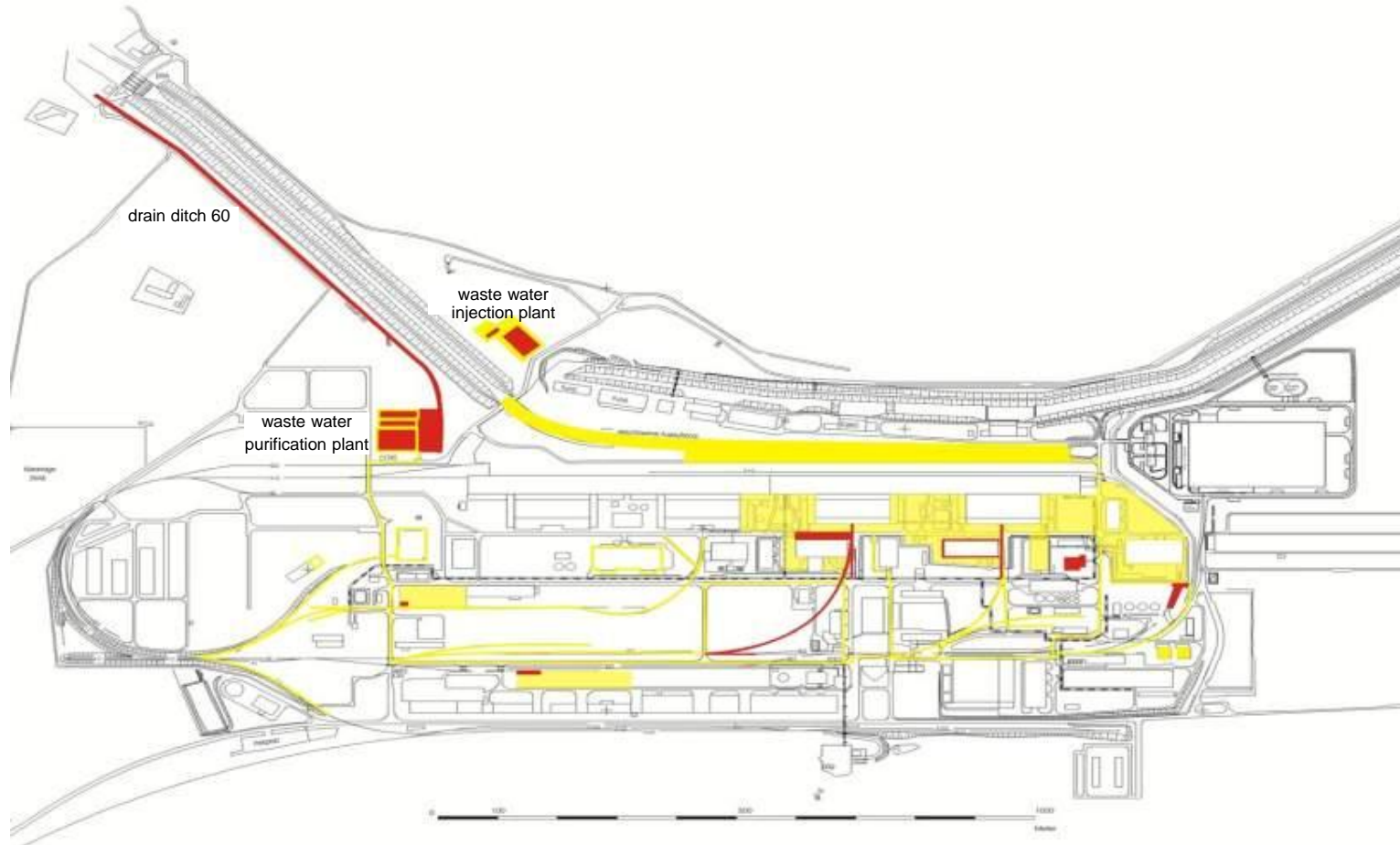
- Commissioning of units 1 to 4 1973 - 1978
- Trial operation of unit 5 1989
- Shut-down 1990
- Dismantling of construction site since 1990
- Decommissioning licence 1995  
afterwards start of dismantling
- Notice of assessment for ground areas 1999

## Start of categorization of the ground areas

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**Total area approx. 1.7 km<sup>2</sup> (170 ha)**

# Classification of the EWN areas into the radiological categories



contaminated - red, potential contamination - yellow

# Categorization

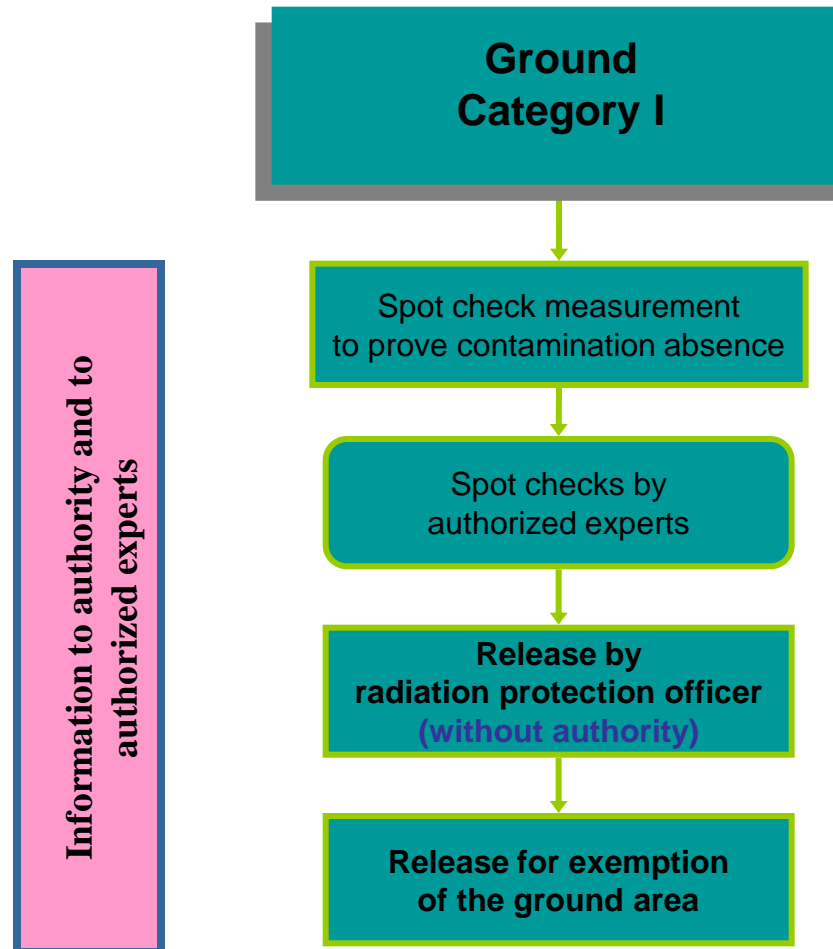
Categorization is always made according to technological aspects and the evaluation of the operational history

- **Category 1 - Contamination free**  
contact with radioactive material can be excluded
- **Category 2 - Potential contamination (suspicion)**  
due to operational history a contact with radioactive material or spreading of contamination can't be excluded
- **Category 3 - Contaminated**  
contact with radioactive material

# Spot check measurements on ground areas free of contamination (Category 1)

- spot check measurements to confirm the categorization according to operational history
- deposition only by airborne activity during the 18 years of operation
- indicator for artificial nuclides from the Greifswald NPP is the nuclide Co-60
- proof that contamination has not deeply penetrated into the soil
- measurement procedure:
  - uncollimated in-situ-gamma-spectrometry
  - gamma-spectrometrical evaluation of samples
- required detection limits for Co-60: **0.015 Bq/g** or **0.1 Bq/cm<sup>2</sup>**
- after spot check measurements procedures that could cause contamination are not allowed

# Procedure of free release of ground areas of category I

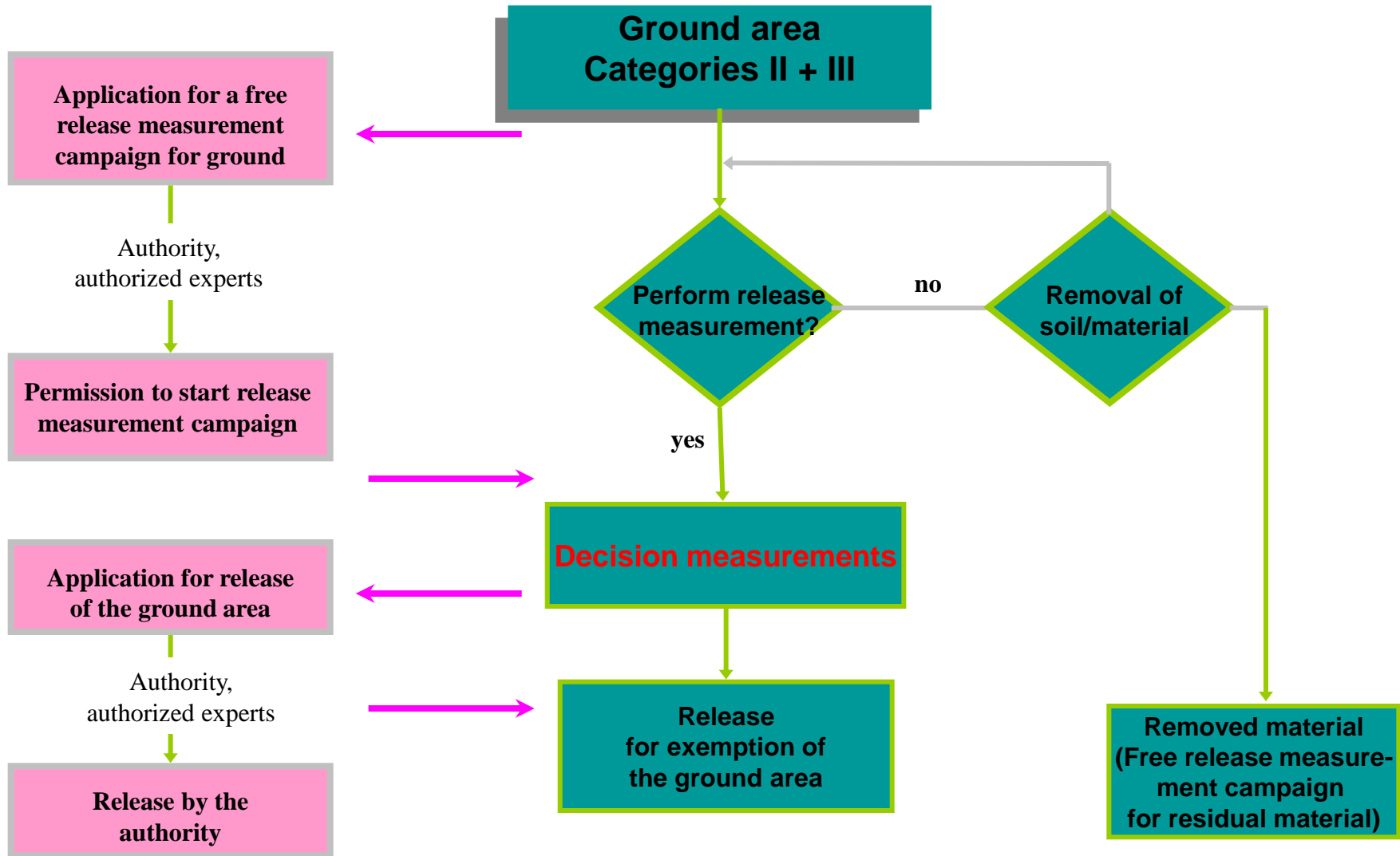




# Prerequisites for the release procedure of ground areas (Categories 2 and 3)

- availability of approved release limit values and boundary conditions (Notice of assessment or since 2004 Radiation Protection Ordinance § 29 and annexes III and IV have to be applied)
- categorization of ground areas
- clearing of the areas and dismantling of all not permanently fixed constructions
- preliminary investigations
  - In-situ gamma spectrometry measurements
  - nuclide vector determination
  - determination of penetration depth
- choice of measurement procedure for clearance measurement
- if necessary, calculation of density of measurements
- existence of a confirmed free release measurement campaign
- after preliminary measurements procedures that could cause contamination are not allowed

# Procedure from application to release of ground areas of categories II and III



# Decision measurement on contaminated or suspected areas

- Measurement density
  - calculated for suspected areas
  - 100 % measured on contaminated areas
- Measurement procedure:
  - collimated and uncollimated in-situ gamma-spectrometry
  - gamma-spectrometric evaluation of samples
  - evaluation of the material in the free release measurement facility
- **Averaging surfaces 1 to 6 m<sup>2</sup> (collimated) or 100 m<sup>2</sup> (uncollimated)**
- application of summation rule (sum formula) for nuclides
- **in individual cases subtraction of the Cs-137 share from Chernobyl accident or nuclear weapon fallout possible**

# In-situ gamma-spectrometric measurements

- Release limit values for unrestricted release:

- for sealed ground areas (e.g. streets)

Co - 60 – 0.2 Bq/cm<sup>2</sup>

Cs-137 – 0.4 Bq/cm<sup>2</sup>

- for non-sealed ground areas (measuring depth 5 cm)

Co - 60 – 0.03 Bq/g

Cs-137 – 0.06 Bq/g

# In-situ gamma-spectrometric measurements

## *Evaluation of measurements*

### Category I (*contamination free*)

Measurements: Spot check without collimator;  
1 measurement per 1000 m<sup>2</sup>

Measurement time: 3000 seconds



# In-situ gamma-spectrometric measurements

## *Evaluation of measurements*

### Category II (*potential contamination*)

Measurements: approx. 4 % of the area with 70° collimator;  
averaging surface 6 m<sup>2</sup>

**or**

100 % of the area without collimator  
averaging surface 100 m<sup>2</sup> (*since 2005*)

Measurement time: 1000 **or** 3000 seconds

# In-situ gamma-spectrometric measurements

## *Evaluation of measurements*

### **Category III** (*contamination*)

Measurements: 100 % of the area with 70° collimator;  
averaging surface 6 m<sup>2</sup>

Measurement time: 1000 seconds

# In-situ gamma-spectrometry

- Germanium-detector with 60 % efficiency
- 30°, 70° and 90°- collimator (tungsten)
- detector support can be tilted and adjusted in height
- Insikont-Software 2.1 (2.46) with following parameters:
  - distance ground - detector 85 cm (partly 100 cm)
  - density of soil 1.3 kg/dm<sup>3</sup> respectively of concrete 2.3 kg/dm<sup>3</sup>
  - reference layer thickness 5 cm or surface contamination
  - averaging surface 1 to 6 m<sup>2</sup> (collimated) or 100 m<sup>2</sup> (uncollimated)
  - measurement time 1000 s (collimated) or 3000 s (uncollimated)

# In-situ gamma-spectrometric measurement on sealed ground



## Decision measurements on rails

- evaluation of rails and sleepers
  1. by dismantling with following release measurement at FRMF **or**
  2. free release measurement by in-situ gamma-spectrometry
- removal of gravel and free release measurement at FRMF
- evaluation of the new ground area by in-situ gamma-spectrometry

Individual case – further use of rails:

Evaluation of rails, sleepers and gravel by in-situ gamma-spectrometry considering the operational history



# Dismantling of rails

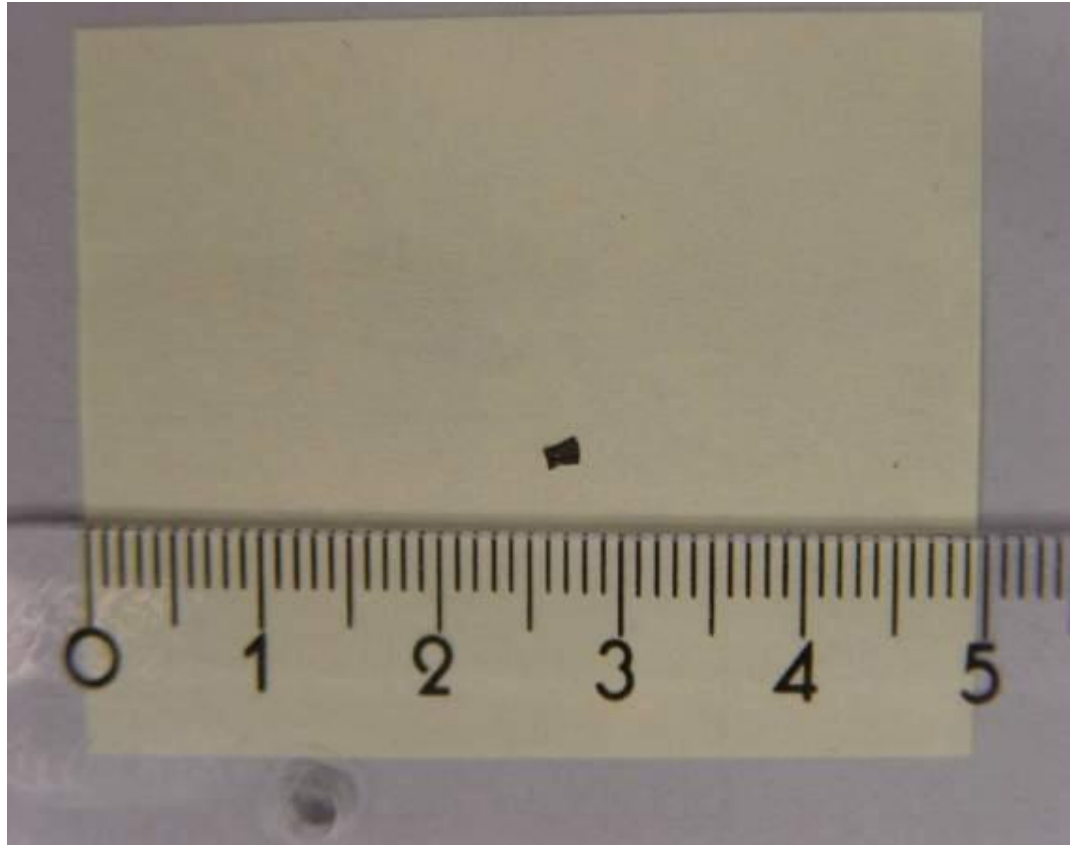




## In-situ gamma-spectrometric measurement on rails



## Metal particle



Mass of particle: 2.5  $\mu\text{g}$  with an activity of  $10^5$  Bq Co-60 detected in a depth of 15 cm in the gravel

## Removal of gravel and filling boxes for the FRMF





## Measurement of unsealed ground (ditch 60)





## Measurement of unsealed ground (ditch 60)



## Ditch 60 after cleaning





# In-situ gamma-spectrometric measurement (preliminary investigation)



## Manual removal of soil in a grid





# Measurement in the Free Release Measurement Facility (FRMF)





# Sewage plant and ditch 60



# The following boundary conditions have to be taken into account during future free release projects:

- Radiological categorization of the areas according to technological deliberations, under consideration of the operation history, to determine an adequate scope of measurements
- Determination of nuclide vector, for which the compliance with the release limit value has to be proven under consideration of the cut-off criterion for summation  $< 10\%$
- Use of averaging surfaces (reference areas) of ca.  $10 \text{ m}^2$  for collimated and some  $100 \text{ m}^2$  for uncollimated in-situ-measurements
- Determination of the necessary measurement time for collimated in-situ gamma-spectrometry concerning the detection limit to achieve
- Determination of a depth profile to calculate the ground activity and to define the necessary depth of abrasion at the surface
- Determination of the scope of measurements (Grid)

# Subtraction of the Cs-137 share from the Chernobyl accident and/or nuclear weapon fallout (individual case)

In the issue 1/96 of the magazine „Strahlenschutzpraxis“ a graphic, which shows the contamination distribution within the FRG, displays a measured contamination interval from 2000 Bq/m<sup>2</sup> up to 4000 Bq/m<sup>2</sup> (1986) for the areas outside the NPP site (areas Greifswald, Demmin, Anklam and Ueckermünde).

To quantify these results in the surrounding area of the NPP Lubmin a measurement programme was developed and implemented in the year 2000. The boundary conditions and findings are summarised below.

# Subtraction of the Cs-137 share from the Chernobyl accident and/or nuclear weapon fallout (individual case)

At five places in the area around the NPP Lubmin in-situ-gamma spectrometry measurements were performed:

1. Street Nr. 48/49 (western site area; external monitoring area)
2. upper, open part of the outlet channel - embankment (external monitoring area)
3. Peninsula Struck salt meadows (ca. 1 km north of Turbine Hall North IV)
4. Peenemünde (Island of Usedom) ca. 25 km away from the NPP
5. Wackerow ca. 25 km away from the NPP



# Subtraction of the Cs-137 share from the Chernobyl accident and/or nuclear weapon fallout (individual case)





# Subtraction of the Cs-137 share from the Chernobyl accident and/or nuclear weapon fallout (individual case)

- The chosen areas outside NPP were mostly identical with the areas on the NPP site (grassy area, tree populations in greater distances, sandy soils with a density of approx.  $1.3 \text{ g/cm}^3$ )
- The measuring points were spread within a range of ca.  $200 \text{ m}^2$  (Street Nr. 48/49, Wackerow) up to  $600 \text{ m}^2$  (outlet channel, Peenemünde, salt meadows)
- The scope of measurements amounted to 4% of the above mentioned areas, according to the decision measurements performed at category II areas
- In total 75 measurements were performed.

# Subtraction of the Cs-137 share from the Chernobyl accident and/or nuclear weapon fallout (individual case)

The representative measurement values for the surface contamination amounts to 3419 Bq/m<sup>2</sup> (Cs-137) with a small standard deviation of  $\pm 706$  Bq/m<sup>2</sup>.

From this an activity concentration of 52.6 Bq/kg at a penetration depth of 5 cm can be calculated.

This level of activity concentration was proved by samples from the NPP site, evaluated in the laboratory.

# Subtraction of the Cs-137 share from the Chernobyl accident and/or nuclear weapon fallout (individual case)

As a result of the performed investigations the externally caused Cs-137 share at the area of NPP Lubmin of

**3100 Bq/m<sup>2</sup> (0.31 Bq/cm<sup>2</sup>) and  
47 Bq/kg (0.047 Bq/g)**

can be seen as underlying background radiation. These values consider the surface contamination caused by airborne emissions of NPP Lubmin which have been calculated by Brenk-Systemplanung with 300 Bq/m<sup>2</sup>.

The value amounts to 50 % of the release limit value for Cs-137 for unrestricted release of ground areas.

# Subtraction of the Cs-137 share from the Chernobyl accident and/or nuclear weapon fallout (individual case)

For some specific sites with higher contamination risk the regulatory authority confirmed as site specific Cs-137-underground, which was not caused by the operation of the nuclear facility, the following values:

**2700 Bq/m<sup>2</sup> (0.27 Bq/cm<sup>2</sup>) und  
41 Bq/kg (0.041 Bq/g)**

These values for Cs-137 can be subtracted from all clearance measurements.

# Subtraction of the Cs-137 share from the Chernobyl accident and/or nuclear weapon fallout (individual case)





# Over- and underground facilities

- To exempt an area from the Atomic Law the following is necessary :
  - the area is free measured
  - the remaining overground facilities do not exceed the release limit values or it is proved, that they are free of contamination
  - The underground facilities are assessed and/or measured
- Usually underground facilities will be removed after the release measurement of the area
- For further use a direct complete assessment or measurements are performed where contamination can possibly be found. This happens either on the spot or, if single parts have been removed, in the Free Release Measurement Facility

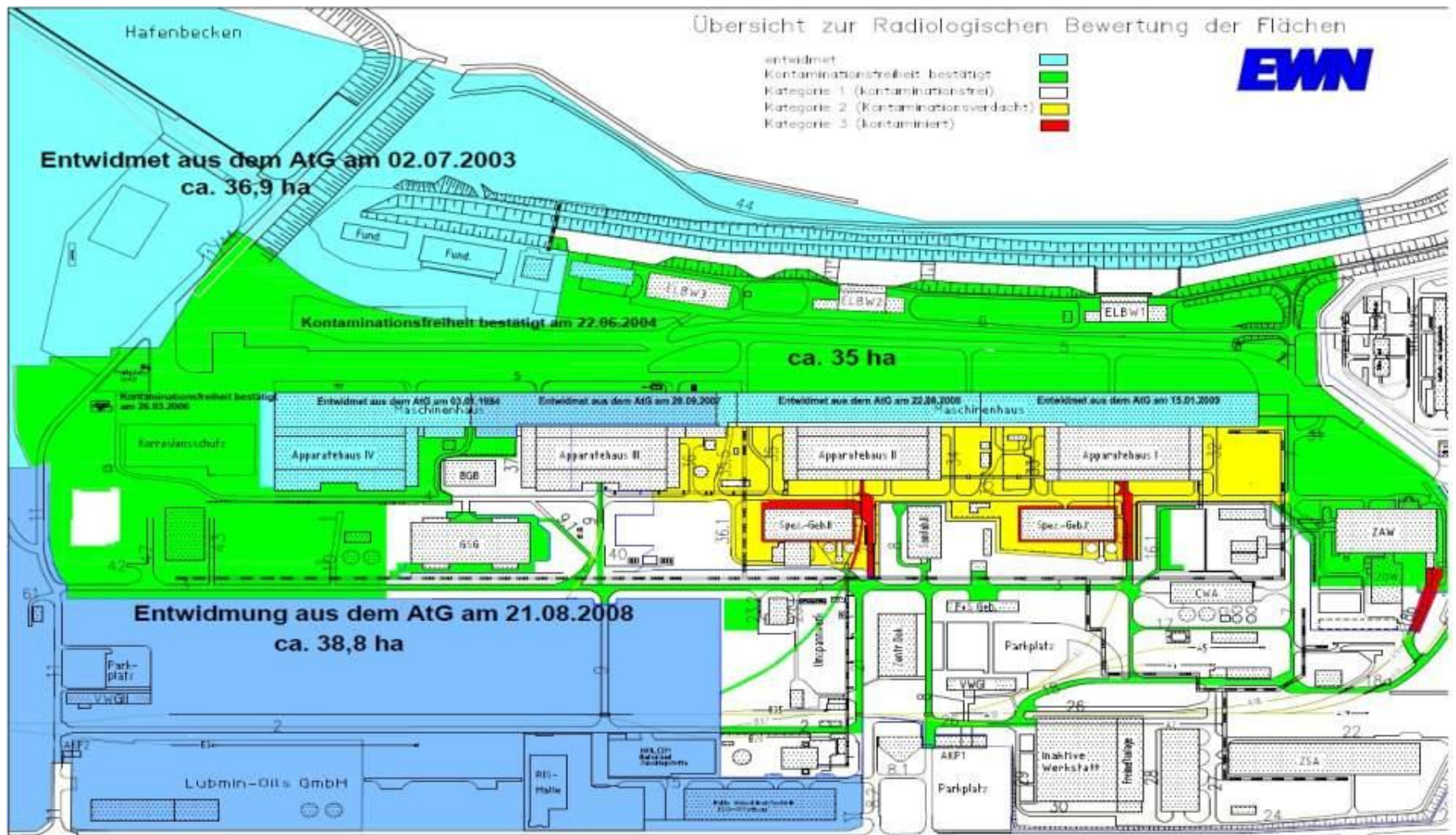
# Exemption of areas

## Prerequisites

- Confirmation that the areas are free of contamination and/or approval of compliance with the release limit value
- Confirmation that neither over- nor underground facilities are left there or confirmation that these ones are free of contamination and/or approval of compliance with the release limit value
- EWN files an application on changing the radiation protection areas
- An independant authorized expert checks the application and the licensing authority confirms it
- EWN files an application for exemption

## Notice of assessment from the authority

- unrestricted release of the areas
- exempted areas are described exactly and land register compatible with the Gauss-Krüger coordinates



Overview of the assessed areas (Stand 31.12.2010)

# Summary

In total an area of ca. 1.234 km<sup>2</sup> has been measured, of which ca. 0.76 km<sup>2</sup> have been exempted.

Category I	ca. 1.10 km <sup>2</sup>
Category II/III	ca. 0.134 km <sup>2</sup>

# Summary

- the approach to classify the areas into the radiological categories has proved very useful
- the used measuring methods, especially the in-situ-gamma-spectrometry, are suitable for the assessment of areas
- the used measuring procedures are practical, flexible and very effective for the assessment of large areas
- procedures had to be developed in detail and approved by the regulatory authority to prove that the areas are free of contamination and/or release measurement of the areas are performed
- all necessary arrangements were made, to comply with the requirements deriving from the radiation protection ordinance, especially with § 29



# Industrial settlement with harbour 2011

