Radiological mapping and characterization at the Barsebäck nuclear power plant

Leif Spanier, Scandpower AB
Lars Håkansson, Barsebäck Kraft AB

Radiological Characterisation for Decommissioning Workshop
Studsvik 2012-04-17 - 19

SCANDPOWER
Risk Management

A member of the Lloyd's Register Group

Lloyd's Register
LIFE MATTERS

Outline

- Background
- Aim and scope of the KAKA project
- Sampling of land, ground water and sea bed
- Scanning of land
- Results
- Discussion
- Buildings
- Conclusions

Barsebäck NPP

SCANDPOWER
Risk Management

A member of the Lloyd's Register Group

Lloyd's Register
LIFE MATTERS

Background

- Barsebäck NPP
  - 2 BWR, ASEA Atom, 600 MW_{el},
    - B1 1975 – 1999
    - B2 1977 – 2005
  - External Main Recirculation Loops
  - Mark II type containment

  - Barsebäck Kraft AB owned by Ringhals AB
  - Properties owned by EON Kärnkraft Sverige AB
    - Decommissioning will be performed by EON
  - 15 km north of Malmö, Sweden
  - 20 km east of Copenhagen, Denmark

  - Few fuel damages during time of operation
  - Few control rod leakages
  - Low moisture in the steam
  - No buried pipes

Background

- Barsebäck NPP will be decommissioned
  - Buildings are planned to be dismantled
  - Area is planned to be released for free use
- A number of projects are ongoing or planned to support the planning of the decommissioning
  - KAKA (KArtläggning och KAtegorisering av anläggning och omgivning – Mapping and categorization of the plant and the surroundings)
    - Started 2008 with a preliminary study
    - Main project will be finished 2012

Aim of the KAKA project

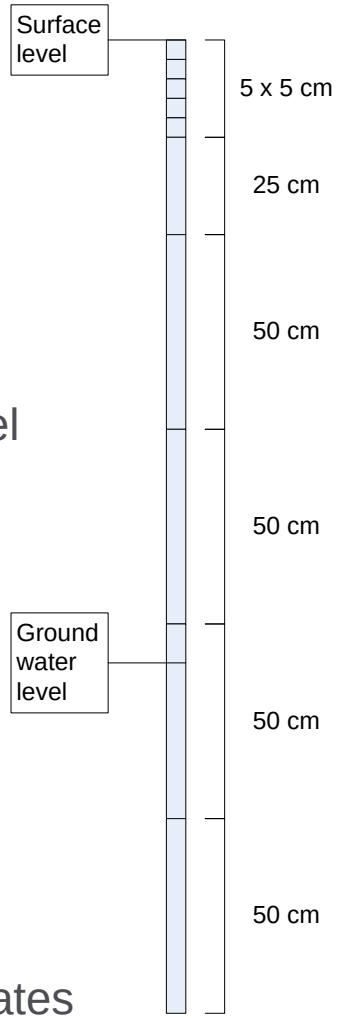
- Aim of the KAKA project
  - Serve as basis for the planning of the decommissioning of the Barsebäck NPP site
  - Waste and cost estimation
  - Investigate and develop methods for detection of relevant env. Hazards
  - Knowledge generation
  - Requirements from the SSM, Swedish Radiation Protection Authority
    - SSM FS 2008:19

Scope of the project

- Mapping and characterization of
  - Radioactive contamination
  - Environmental hazards
- All areas included
  - Part 1
    - The surrounding land, ground water and sea bed (< 2 m deep)
  - Part 2
    - The buildings (except radioactive waste and storage)
    - The systems
- Sampling and in-situ scanning of radiation
- Sampling and scanning strategy
  - Biased by historical events and expectation of elevated contamination
  - Extrapolation of the result will probably be conservative
- This presentation cover the radiological investigation of Part 1

Sampling of land, ground water and sea bed

- 200 surface soil samples
  - 20 cm x 20 cm x 5 cm (depth)
- 100 drill cores
  - 100 to 570 cm length, should reach below ground water level
  - 1000 drilled soil samples
- 70 ground water samples
- 100 vegetation samples
- 8 pond sediment samples
- 14 sea bed samples
- Positioning of the sampling
  - Drill cores by differential GPS
  - Others by measuring distance to fixed objects
  - The positions were given relative the plants internal coordinates
  - Uncertainty was approximately ± 1 m



Samples

SCANDPOWER
Risk Management

A member of the Lloyd's Register Group

Lloyd's Register
LIFE MATTERS

Analysis of gamma emitting nuclides

- 1500 samples in total were analyzed for radioactive nuclides
- All samples were analyzed on Barsebäck for gamma emitting nuclides
  - Environmental laboratory at the site
  - 4 Pi Lead shield
  - 30 % HPGe with electric cooling
  - Sample treated and put in a 100 ml calibrated plastic pot on top of the detector front end
  - 1 hour acquisition time
  - Mn-54, Co-60, Sb125, Cs-134, Cs-127, Eu-152, Eu-154, Eu-155

Analysis of Hard-To-Detect nuclides

- 120 samples were also analyzed for HTD nuclides
- VKTA in Dresden Germany
  - H-3, C-14, Cl-36, Ca-41, Fe-55, Ni-59/Ni-63, Sr-90, Nb-94, Tc-99, I-129, Pu-238,239/240,241, Am-241, Cm-242,243/244
  - Samples were treated to separate out the appropriate nuclide
  - Transuranic elements were measured by alpha spectroscopy
  - The other + Pu-241 by Liquid Scintillation Counting
  - The samples were also measured for gamma emitting nuclides

Result of the analysis
Number of samples where nuclides are detected

MDA for surface soil samples

Nuclide	Samples w detected	MDA BVT Bq/g	MDA VKTA Bq/g	Nuclide	Samples w detected	MDA BVT Bq/g	MDA VKTA Bq/g
H-3	11		0.9 [1)]	Sr-90	7		0.005
C-14	4		0.01	Sb-125	2	0.01	0.0006
Cl-36	12		0.001	Cs-134	6	0.003	0.0003
Mn-54	40	0.01	0.0003	Cs-137	216	0.003	0.0003
Fe-55	3		0.01	Eu-152	11	0.005	0.0004
Co-60	182	0.003	0.0003	Eu-154	77	0.006	0.0003
Ni-59/63 [2)]	13		0.01	Eu-155	8	0.007	0.0005

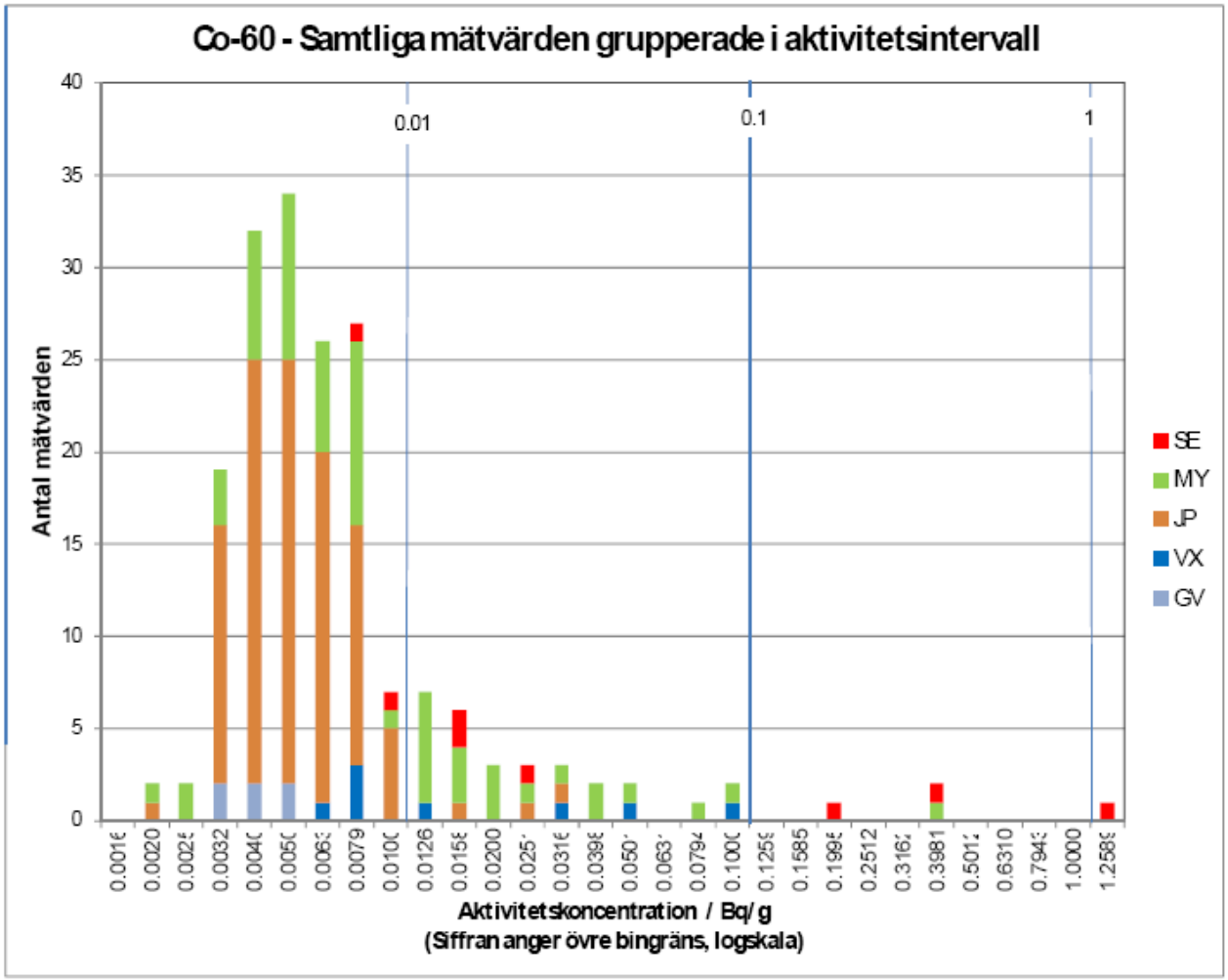
[1)] Ground water Bq/l

[2)] Assumed ratio 1:100

Co-60 , activity concentration in surface soil, drilled and sediment samples

Co-60 Result

- Release criteria may be calculated with RESRAD
- Release criteria for free use from USA gives ~ 0.1 Bq/g
- This will be tried also at Barsebäck



SCANDPOWER Risk Management

A member of the Lloyd's Register Group

Lloyd's Register

LIFE MATTERS

In-situ scanning with NaI

- 3”x3” NaI detector/DIM-296, Ortec
- MCA digiDART-LF, Ortec
- ISO-cart with 5 cm lead shield
- Tripod stand

SCANDPOWER
Risk Management

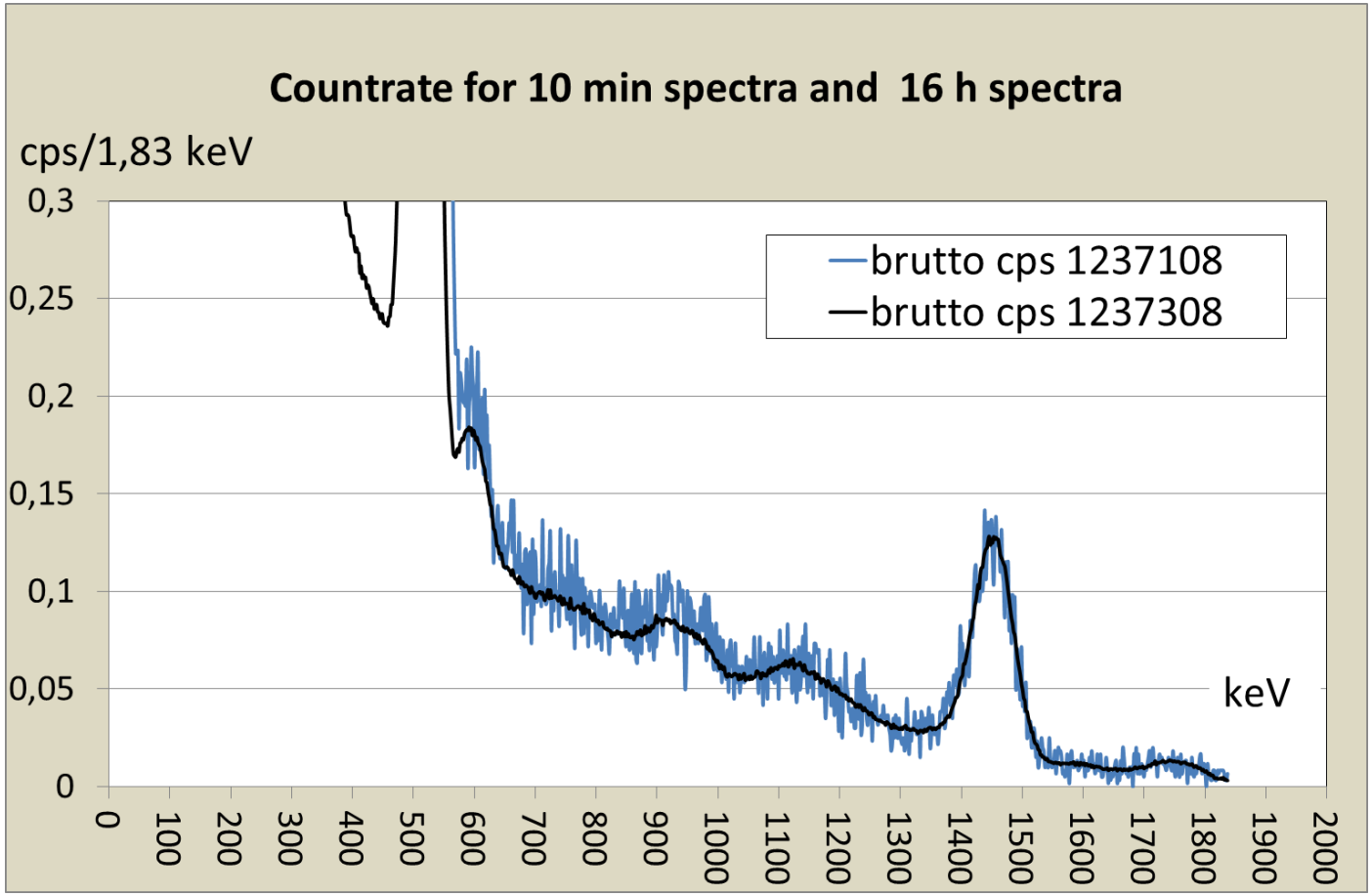
A member of the Lloyd’s Register Group

Lloyd’s Register
LIFE MATTERS

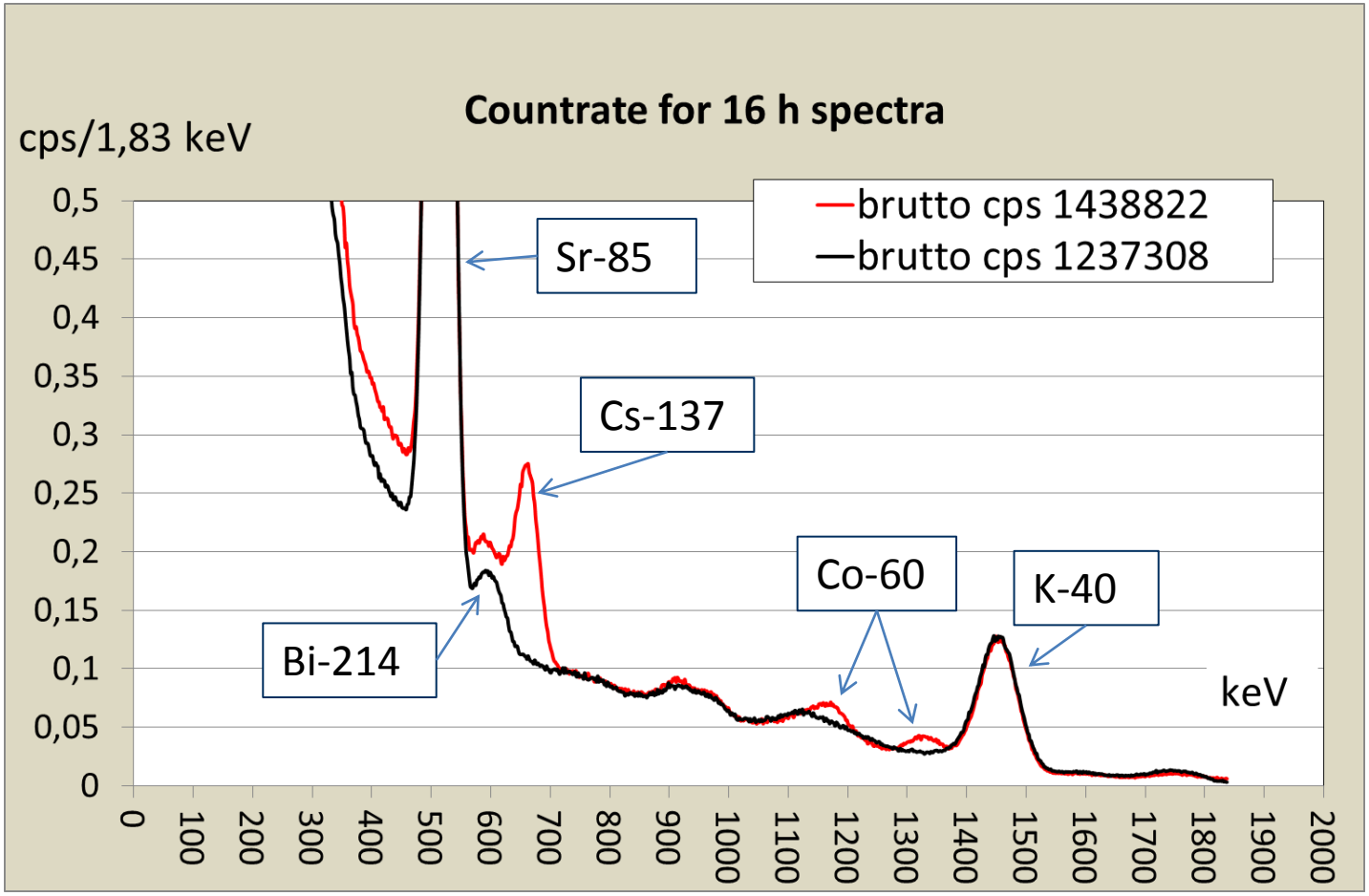
In-situ measurements

- 1200 spectra collected
- 10 min or 1 hour or 16 hours (#50)
- Sr-85 (514 keV) used for energy stabilization
  - ~ 2 kBq for 10 min spectrum, 200-400 Bq for long aquisition times
- Co-60 and Cs-137 main nuclides
- Detector efficiency (Bq/m^2) was calculated from point source measurements

In-situ measurements - Spectra



In-situ measurements - Spectra

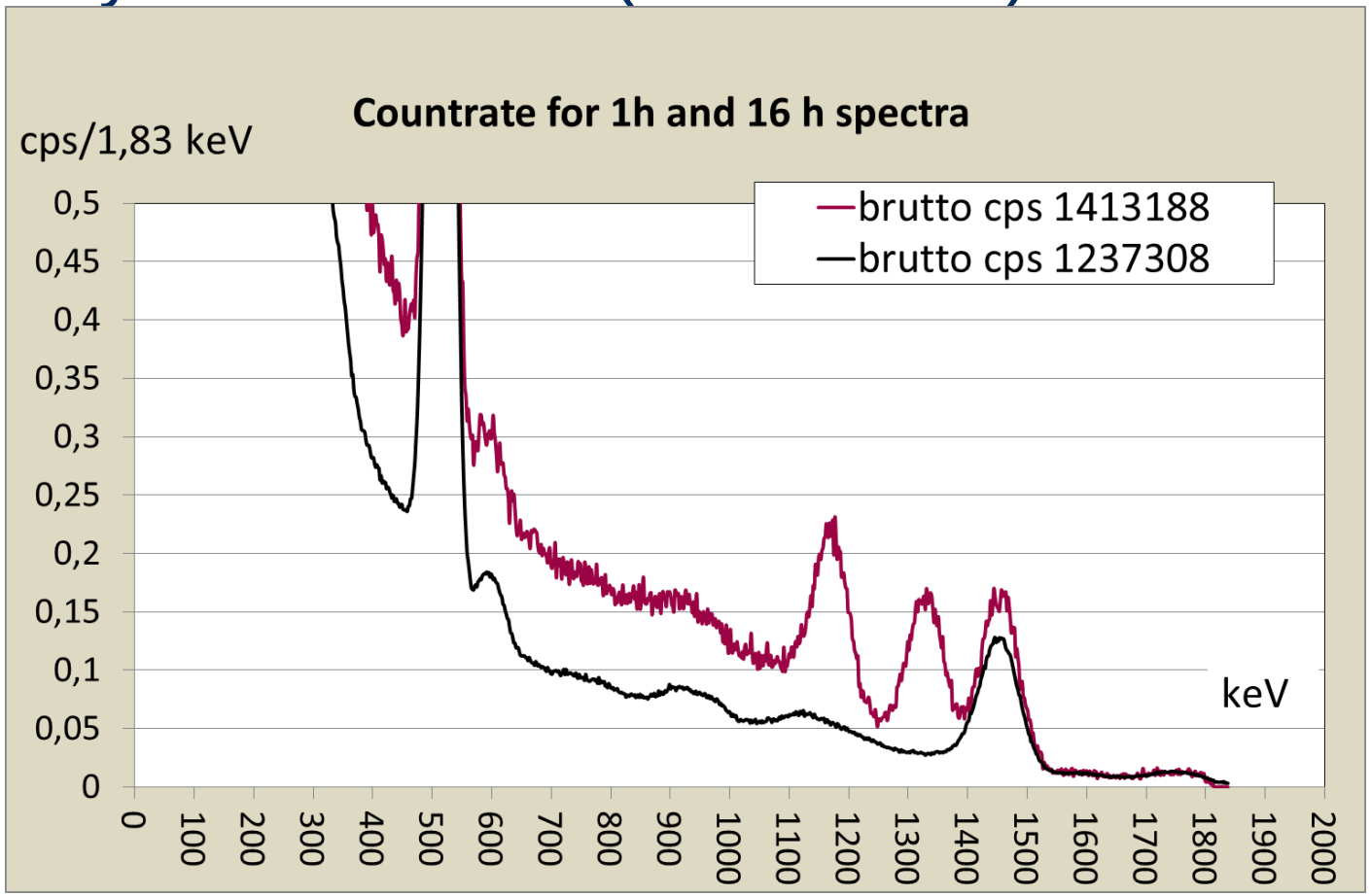


SCANDPOWER
Risk Management

A member of the Lloyd's Register Group

Lloyd's Register
LIFE MATTERS

In-situ measurements – Spectra
Activity concentration (surface soil)



SCANDPOWER
Risk Management

A member of the Lloyd's Register Group

Lloyd's Register
LIFE MATTERS

Co-60 results from NaI in-situ scanning and sediment samples
Locations where Co-60 is detected in yellow

SCANDPOWER
Risk Management

A member of the Lloyd's Register Group

Lloyd's Register
LIFE MATTERS

Discussion

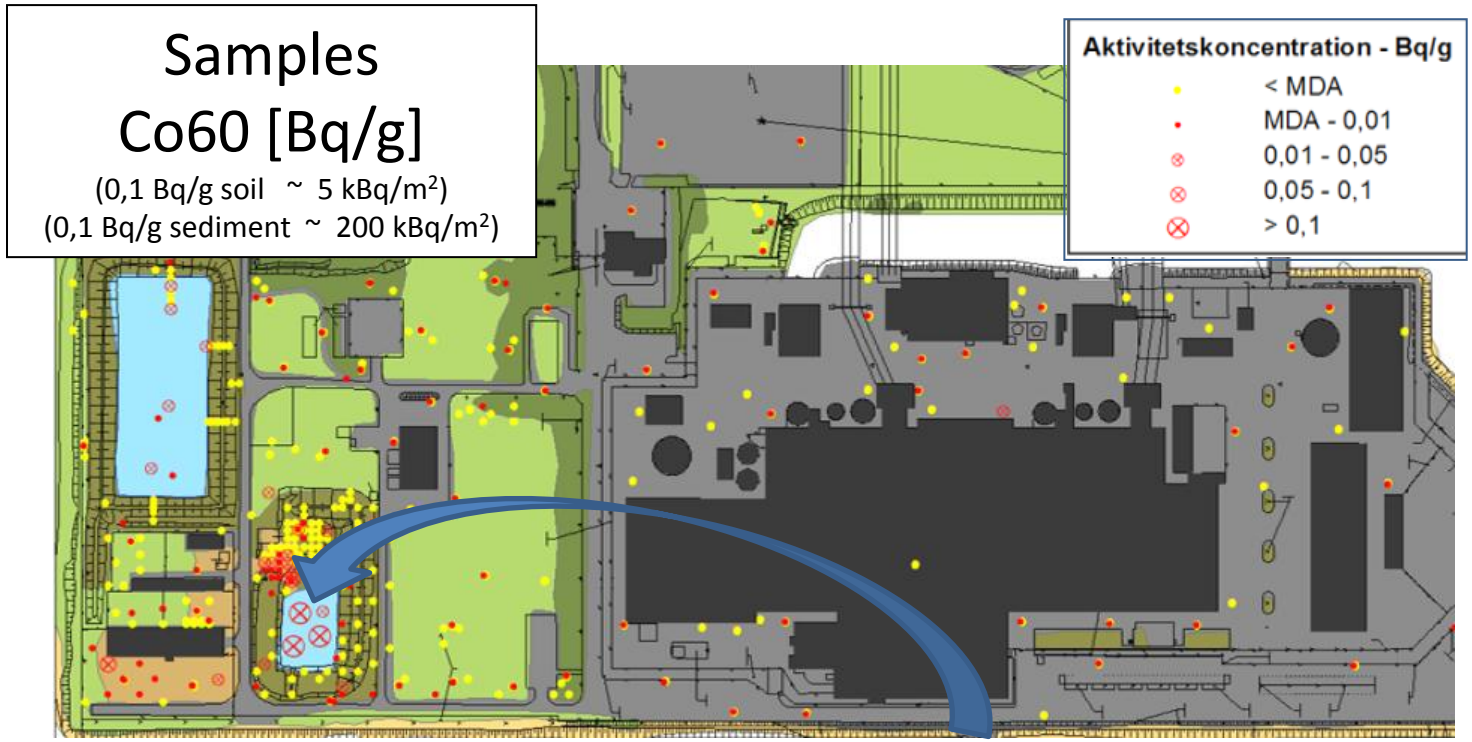
- Co-60 comes from cleaning of the sea cooling water channel
- Source is Barsebäck

- Cs-137 comes from dredging of the harbour
- Source is Barsebäck and Tjernobyl, estimated 50:50

- When the Öresund current comes from north, there is some enrichment of water released activity in the harbour and cooling inlet channel
- The Cs-137 from Tjernobyl that fell down in the Baltic sea was slowly transported to Öresund and some of this was deposit in slow water bays like the harbor

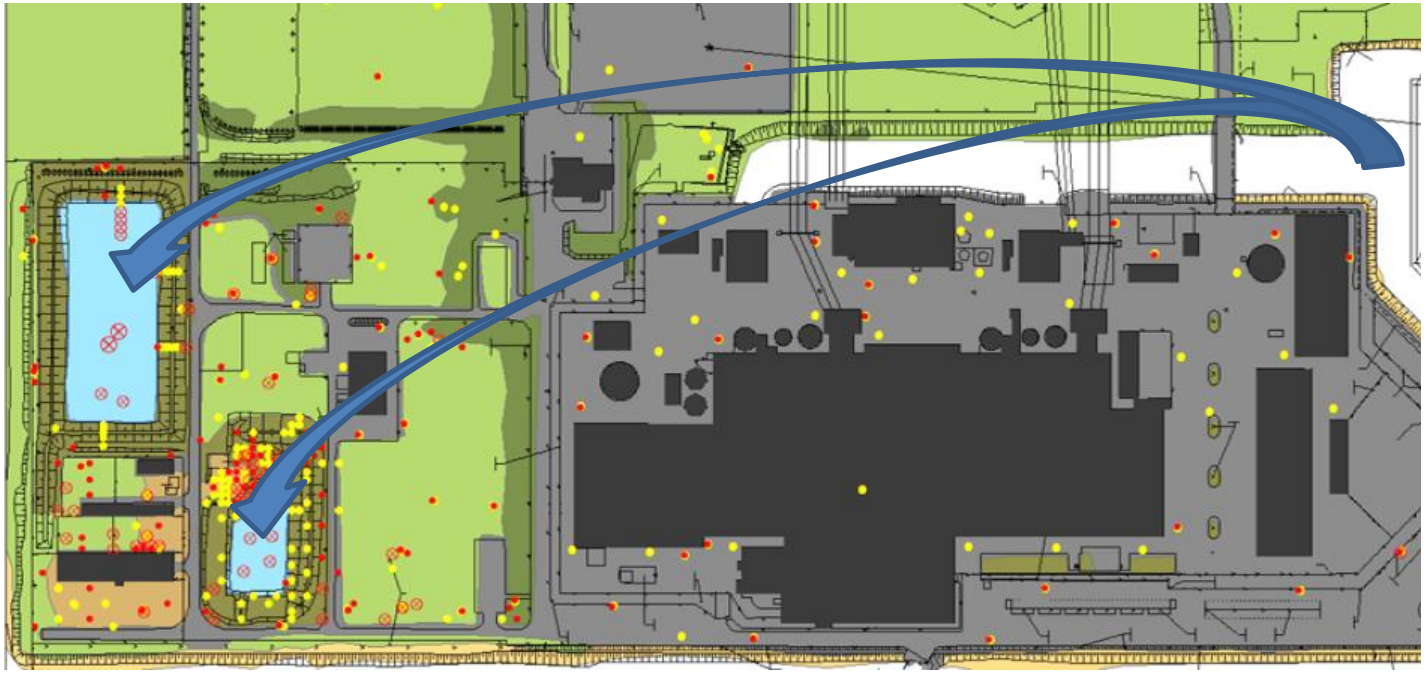
Co-60

- Co-60 comes from cleaning of the sea cooling water channel
- Source is Barsebäck



Cs-137

- Cs-137 comes from dredging of the harbour
- Source is Barsebäck and Tjernobyl, estimated 50:50



Other nuclides

- Other activated corrosion product than Co60 can be correlated by vectors (no vectors could be found in this project). They are estimated to have no major impact on dose calculations.
- H3 and C14 has been shown to be at natural background level in all samples. H3 and C14 could therefore be excluded from future measuring campaigns.
- Cl36, I129 and some other exotic long lived nuclides has not been detected above MDA and can probably be shown to have no major impact on doses by conservative vector estimations.
- The total source term of nuclides belong to the group of transuranes, TRU, are still to be estimated. Measurements indicate low levels.

Buildings and systems

- 160 drilled core samples on concrete
  - Shallow (<5 cm), short (<40 cm) and long (<80 cm)
- 40 material samples on system
- 3000 smear samples
  - Total beta, total alpha and pooled gamma (HPGe)
- Dose rate measurements
- Analysis on resins, chem. decon. Samples

- The analysis and compilation of results of the characterization of buildings and systems is ongoing

Conclusions

- The surroundings of Barsebäck has low radioactive contamination
- Domination nuclides are Co-60 and Cs-137
- Contaminated locations are well correlated with historical events
- No nuclide vectors could be found due to low radioactive levels
- H-3 in groundwater is low < 2 Bq/l
- No transuranic elements were detected
- The major contamination was found to be in the two sedimentation ponds. Should be subject to additional sampling and improved analysis.
- Further improvements on methods include
  - Larger samples and longer acquisition time
  - Scanning with HPGe
  - Improved selection of samples for HTM-analysis
- The preset goals of the characterization of the land was achieved (except vectors)
- The analysis and compilation of the characterization of buildings and systems is ongoing

For more information, please contact:

Leif Spanier

Senior Principal Consultant, Nuclear Business

Scandpower AB

T +46 40 680 64 08

E leif.spanier@scandpower.com

W www.scandpower.com

www.lr.org

SCANDPOWER
Risk Management

A member of the Lloyd's Register Group

Lloyd's Register
LIFE MATTERS