Overview of the legacies of the former radium production in Olen – summary of radiological data

EMRAS II WG 2 – interim meeting October, 4-7

Olen: overview of legacies

UMTRAP storage	Licensed facility	Built in the 80s for radioactive waste from former production
Bankloop storage	Licensed facility	Built in 2006 for waste from remediation of banks of Bankloop stream
D1 landfill	To be remediated	Residues non ferrous + radium extraction, rubbles from dismantlement Ra facility
S1 landfill	To be remediated	Residues non ferrous extraction + some sediments dredged from Bankloop
Contamination on plant site	To be remediated	Patchy contamination
Left-over Bankloop	To be remediated	Residual contamination after remediation

Olen site: overview

Radium production in Olen: the legacies

The UMTRAP facility (built 1985 – 1986)

Contains production residues + left-over of production;

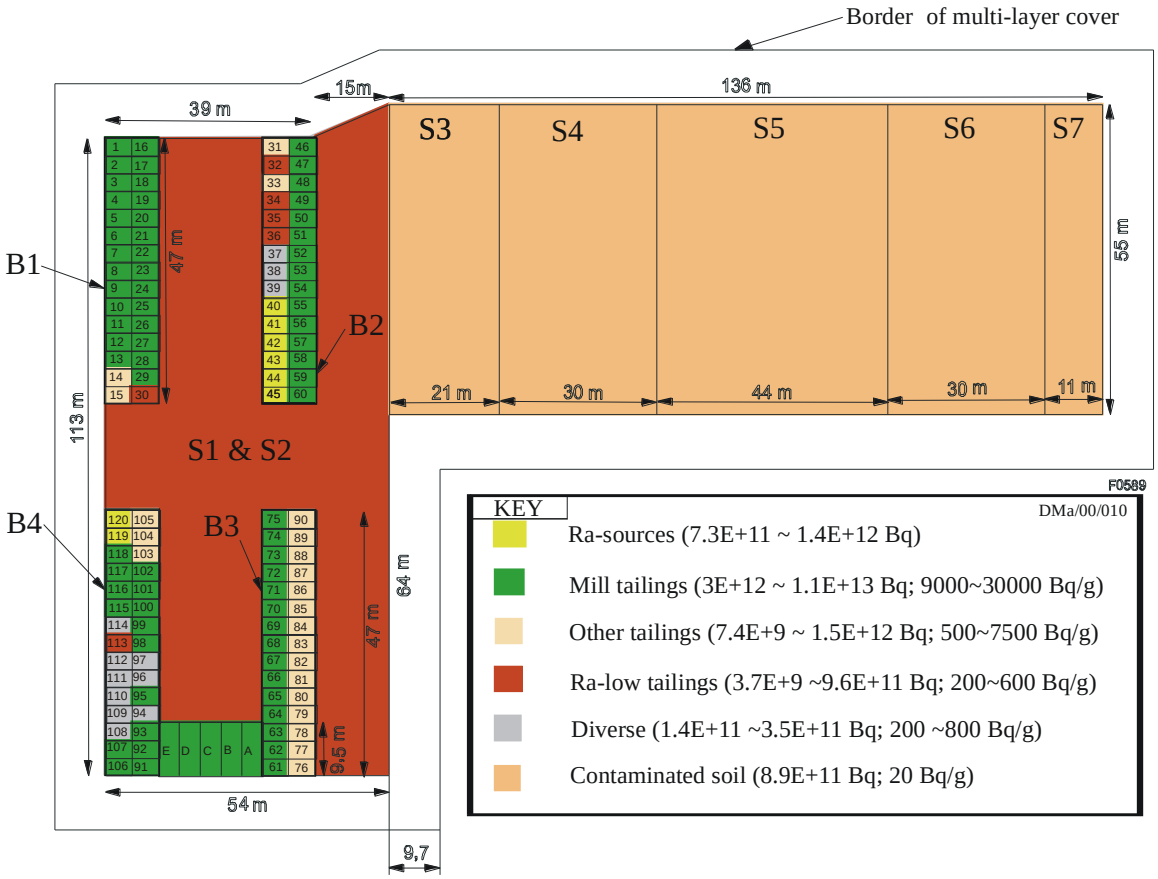
Inventory:

- Radium needles (200 g Ra-226);
- Tailings (2000 T) with Ra activity concentration up to 30 000 Bq/g;
- 14000 T other residues with Ra-226 (Ra-226 concentration up to 7500 Bq/g);
- 60 000 T contaminated soils and materials from dismantlement (average Ra concentration 15 Bq/g).

Licensed facility

Monitoring program: Radon monitoring at the surface – monitoring of surface + underground water.

UMTRAP: design of installation



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UMTRAP: design of installation

Welding of copper foil

Side slope – silty sand, broken gravel, rubble stones

UMTRAP: safety assessment and monitoring

Safety assessment performed by SCK-CEN (2003/2004)

Normal evolution scenario => trivial dose

Intrusion scenario => up to 600 mSv/y for dwellings on site.

UMTRAP: safety assessment and monitoring

UMTRAP monitoring			
	# points	Min	Max
Rn-222 concentration outdoor (Bq/m^3)	3	56	105
Ra-226 concentration surface water (mBq/l)	2	13.3	20.9
Ra-226 concentration grondwater (mBq/l)	4	6.2	19.5

Radium production in Olen: the legacies

The Bankloop stream

Discharge water to the nearby river => accumulation of radium in sediments

⇒ Dredging ⇒ sludges disposed on the banks.

Dose rate upto 5 µSv/h. ~ 7000 m^2 contaminated area

Remediation between 2006 – 2008

29 000 m^3 of remediation materials brought to a licensed storage facility

Average Ra-226 activity concentration 3.2 Bq/g

Next to radium, also Cd (max. 1078 mg/kg) and Co (max. 3410 mg/kg) contamination

Cost of remediation project: 5.3 MEur (1.75 MEur for Environmental authority – rest for company);

Remediation of Bankloop river

Operational Procedure for clean-up operations:

Excavation works:

1. dose rate measurement

< 0.2 µSv/h ⇒ STOP

> 0.2 µSv/h ⇒ go to step 2

2. measure activity concentration Ra-226

< 0.5 Bq/g (depth < 1m) or 1 Bq/g (depth > 1m) ⇒STOP

> 0.5 or 1 Bq/g ⇒ dig out – waste on disposal site

– some residual contamination was left over

Design of “Bankloop” storage

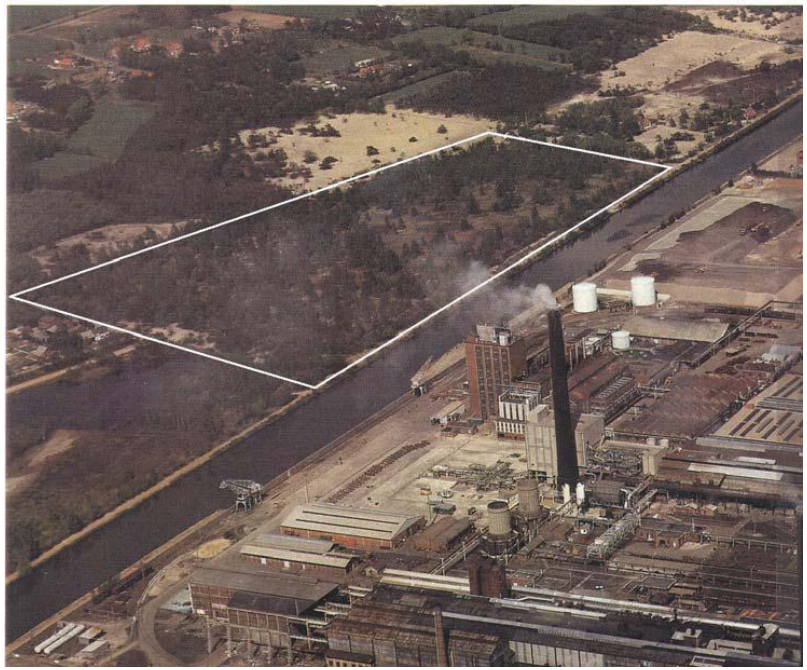
Under the facility: from bottom up
- 50 cm clay layer ($k < 10^{-10}$ m/s)
- HDPE foil
- Geotextile
- 40 cm draining layer with drainage system for leachate
- Geotextile

Capping:
- 50 cm clay layer ($k < 10^{-10}$ m/s)
- 30 cm drainage layer with drainage system
- 50 cm rooting layer

Bankloop storage: monitoring

Bankloop storage: monitoring			
	# points	Min	Max
Rn-222 concentration outdoor (Bq/m^3)	6	24	199
Ra-226 concentration surface water (mBq/l)	2	8.2	240
Ra-226 concentration grondwater (mBq/l)	4	10.8	380
Ra-226 concentration leachate (mBq/l)	1	175	398

D1 dump



Dump	Area (ha)	Volume (m^3)
D1	10	217,000

D1 dump

D1 dump:

- Started with filling of a previous sand excavation pit with sludge from cobalt production (iron hydroxide and $CaSO_4$)

- Gravel applied to create road for lorries on D1

- included rubbles from first phase of dismantlement radium facility (1955 – 1960)

D1 dump : nuclide vector

Highly inhomogeneous Ra-226 concentration: 40 Bq/kg up to 930 Bq/g

⇒*average* activity difficult to evaluate
According to SCK study (Zeevaert et al. - 1996) ~**7.6** Bq/g Ra-226
Brenk study (Barthel et al. - 2003) ~ **20** Bq/g
Kemakta 2009 ~ **5.3** Bq/g

7 – 8% of waste > 20 Bq/g

U-238 ~ 200 Bq/kg
Th-230 ~ Ra-226
Th-232 ~ background level

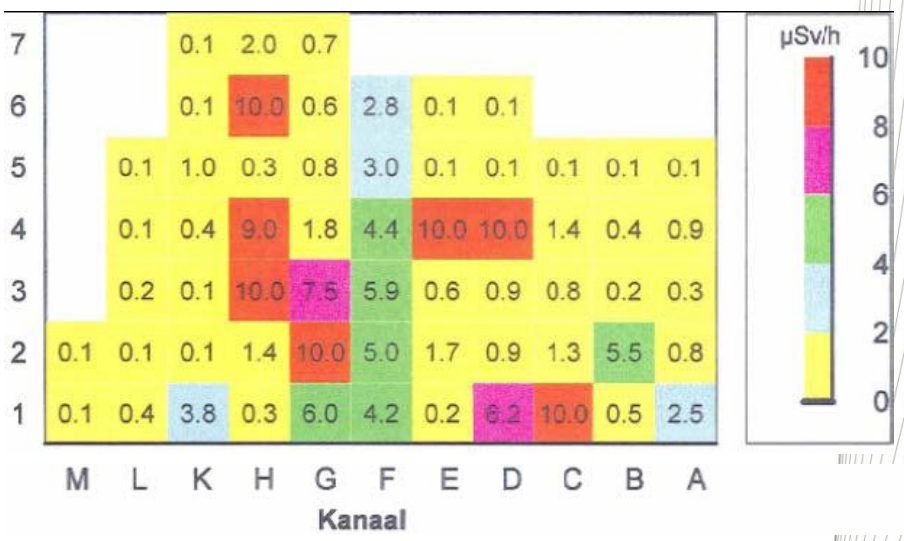
D1: radiological data

SCK measurements campaign 1994, 1996, 2003

- Dose-rate measured downhole in 66 boreholes;
- Dose-rate measured 0.5 m above the surface;
- 197 measurements points:

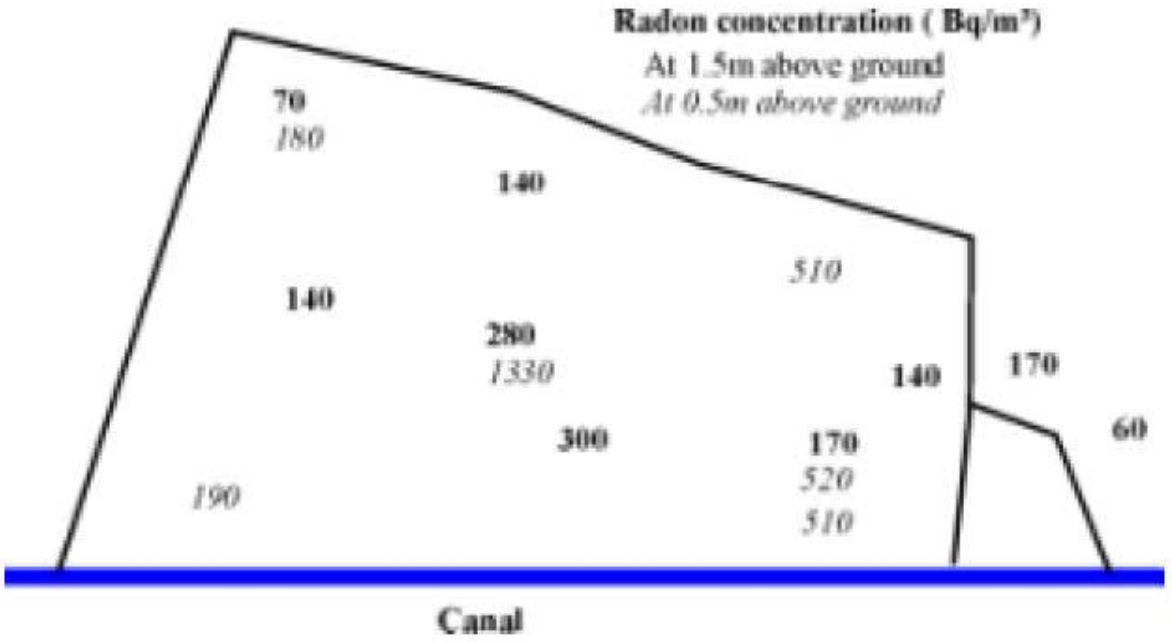
1 “hot spot” with ~ 150 µSv/h
5 data in the range 10 – 30 µSv/h
Other < 10 µSv/h

Dose rate D1



D1: radon measurements

Rn-222 up to ~1300 Bq/m^3 (0.5 m high) – 300 Bq/m^3 (1.5 m high)



D1: groundwater

Scarce data
Measurements for D1
Max. 220 mBq/l **U-238**
409 mBq/l **Ra-226**
0.4 – 0.6 mg/l **thorium** (not confirmed ?)

Heavy metals:
Cobalt up to 10 mg/l
Copper up to 40 mg/l

Indication of Ra-226 migration downward with infiltration rain:
-Ra-226 depletion in many samples in the top 50-100cm: selective leaching due to higher solubility/weaker sorption;
-Ra-226 in excess in the lower part: secondary contamination from migrating Ra-226.

D1: groundwater

2 partially separated (clay layer) aquifers :

- Undeep aquifer 2 m below ground level
- Semi-artesian aquifer 4 m below ground level

Groundwater flows to the North (river Kleine Nete – 850 m from D1 – flow rate 9000 m^3/h)

But water extraction wells from company modifies flow direction of deep groundwater

Olen site: S1 dump

Dump	Area (ha)	Volume (m^3)
S1	2.4	207,000

S1 dump ("Bruine berg"): residues from cobalt production (iron hydroxide and $CaSO_4$) + radium contaminated dredging sludges

Characterisation in 2002 (RWE Nukem)

50 boreholes with a depth = 15 m

- Band of contaminated material 6-8m depth
- Ra-226 ~ 10 Bq/g
- U-238 up to 2 Bq/g
- Th-230 up to 2.6 Bq/g

Groundwater: max. 0.4 mg/l uranium

Olen site: S1 dump

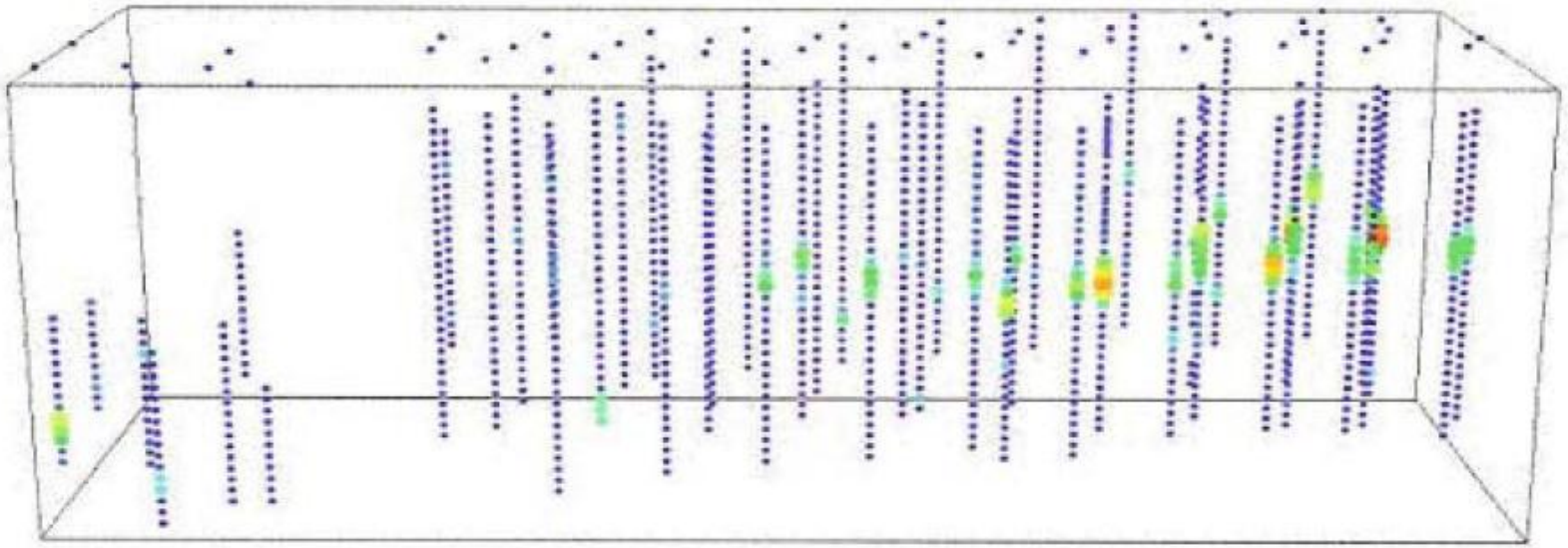


Figure 3-1 *Three-dimensional view of the gamma flux measurements in deposit S1 seen from the south. The figure illustrates the occurrence of a band of radioactive material (shown as green, yellow and red) at 6-8 m depth in the eastern part of the deposit, from (De Ridder and Feyaerts, 2002)*

Olen site: other contamination

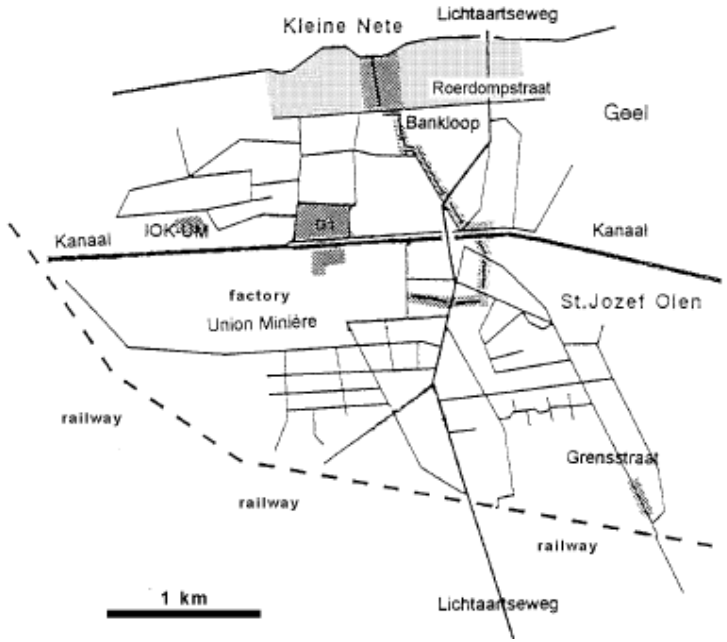
Plant site:

- Survey in 2003;
- Remediation actions 1980-2008;
- Total surface of remaining radiological contamination: 10 550 m^2
- Estimated contaminated volume: 20 000 – 30 000 m^3

Olen site: other contamination

Left-over Bankloop (not included in remediation project):

former flooding zone of Bankloop – now farmland ~ 30 ha
Dose rate between background (80 nSv/h) and 280 nSv/h – max. Ra-226 concentration ~ 1 Bq/g



Olen: radiological assessment

Area “left-over Bankloop” used as test-site in the framework of IAEA **BIOMASS** program (2004)

“*Testing of environmental transfer models using data from the remediation of a radium extraction site*” (L. Sweeck et al.)

Two scenarios:
-Influence of *deep ploughing* ⇒ endpoints Ra-226 concentration in root zone soil, in pasture grass and in cow’s milk
-*Individual dose* to an adult farmer living on the most contaminated area (after 1, 50, 100, 200 and 500 years) with 3 remedial actions (no remediation, removal of most contaminated soil, capping with clean soil layer of 0.5m)

Olen: radiological assessment

Results BIOMASS study:
-Remediation 1: removal of the most contaminated soil
-Remediation 2: capping with clean soil layer of 0.5m

TABLE XVI. TOTAL RADIUM AND TOTAL LEAD DOSE FOR THE DIFFERENT REMEDIAL OPTIONS

		No remediation		Remediation 1		Remediation 2	
		Year 1	Year 500	Year 1	Year 500	Year 1	Year 500
Radium:	CLRP-RAD	6.8	3.6	0.35	0.23	2.0	1.2
	DOSDIM	5.2	3.8	0.29	0.23	3.7	3.5
	OLENRAD-B	8.1	2.5	0.21	0.11	2.6	0.8
	RESRAD (ONSITE)	10.6	5.3	2.1	1.3	6.9	4.2
	RESRAD-OFFSITE	7.3	4.6	0.16	0.1	2.8	1.8
	TAMDYN-UV	11	8.2	0.4	0.3	5	2.7
Lead:	CLRP-RAD	0.32	0.17	0.012	0.009	0.005	0.0064
	DOSDIM	1.0	0.7	0.07	0.03	0.04	0.59
	OLENRAD-B	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
	RESRAD (ONSITE)	0.026	0.78	8.6E-4	0.013	3.4E-4	0.1
	RESRAD-OFFSITE	0.03	0.6	0.001	0.02	1.5E-6	0.02
	TAMDYN-UV	1.1	1.0	0.1	0.1	0.1	0.3

n.c. = not calculated.

Olen: radiological assessment

D1 dump: assessment by SCK-CEN (H. Van Marcke, 1997)

- Normal evolution: ~ 2 mSv/y
- Intrusion (residential scenario): ~ 56 mSv/y

4 remedial options:

1. *Doing nothing*
2. *In situ restoration without digging out waste*
3. *In situ restoration and excavation of waste*
4. *Ex situ storage facility - radioactive waste covered by chemical waste*

Olen: radiological assessment

D1 dump: assessment by SCK-CEN (H. Van Marcke, 1997)

Option	Normal evolution		Residential scenario
	Well (water ingestion) (mSv/y)	Radon (mSv/y)	Total dose (mSv/y)
1	0.0008	2	56
2	0.0001	0.2	50
3	0.0005	0.2	51
4	0.0003	0	< 14

Conclusions and bottlenecks

Putting the puzzle pieces together…

***Global solution** for all legacies (including licensed storage facilities – from storage to disposal …)*

***Milestones**: license "Bankloop" storage runs up to 2015*
+ According to convention with environmental authority, proposal for remediation D1 dump in 2014, S1 in 2019.

Bottlenecks:

- *Proposal of regulatory framework for remediation of radioactively contaminated sites not yet approved at political level …*
- *Long term management of radioactive waste …*
- *…*