

RADIOLOGICAL SURVEY OF THE AREA AROUND AN OLD NIOBIUM MINE AND TREATMENT PLANT

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1: Institute for Energy Technology, IFE, Norway

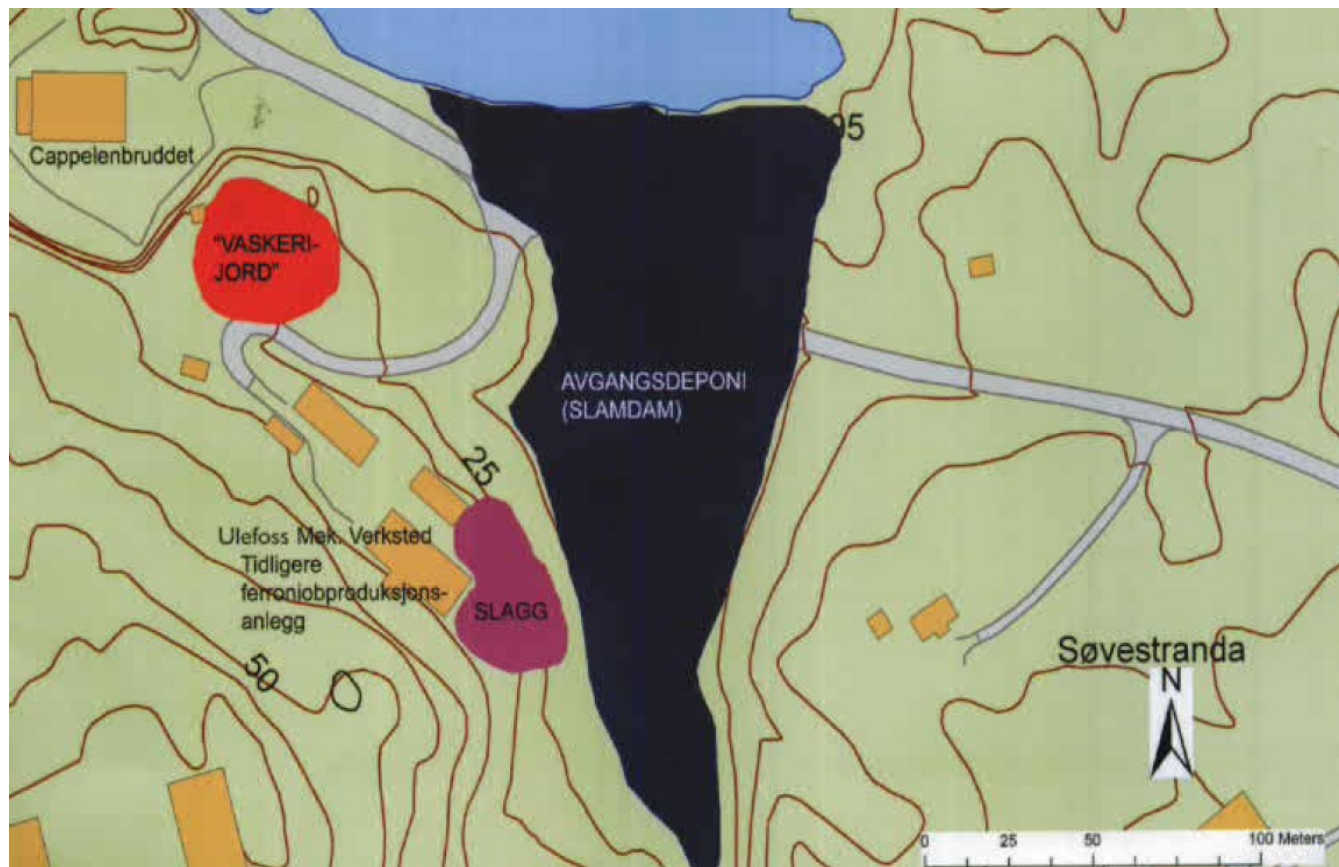
2: Central Mining Institute, GIG, Poland



Søve mines

- 1650s – 1927: Iron mine in the area
- 1920: Sovite discovered. ~0.8% Niobium and small amounts of U and Th
- 1951 – 1965: Niobium production
- Treatment of 100000 – 130000 tonne mineral/y
- Production of 350 – 400 tonne Nb/y

Mining area



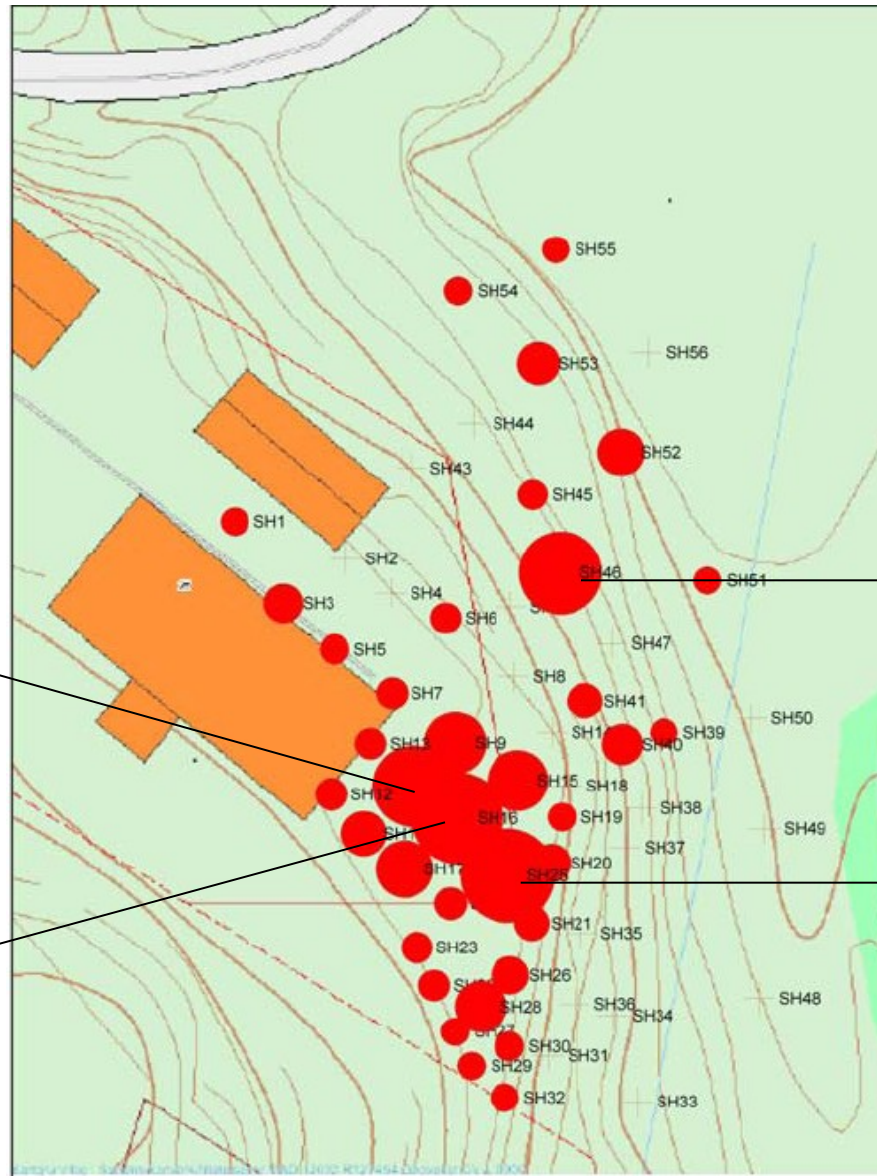
Earlier studies

- 1500 – 2000 m³ material contaminated with U and Th
- Slagg area: 40x15 m; 40-60 kBq/kg of Th og U
- Contaminated soil: 50x50 m

Doserate 1m

3.0 $\mu\text{Sv/h}$

3.8 $\mu\text{Sv/h}$

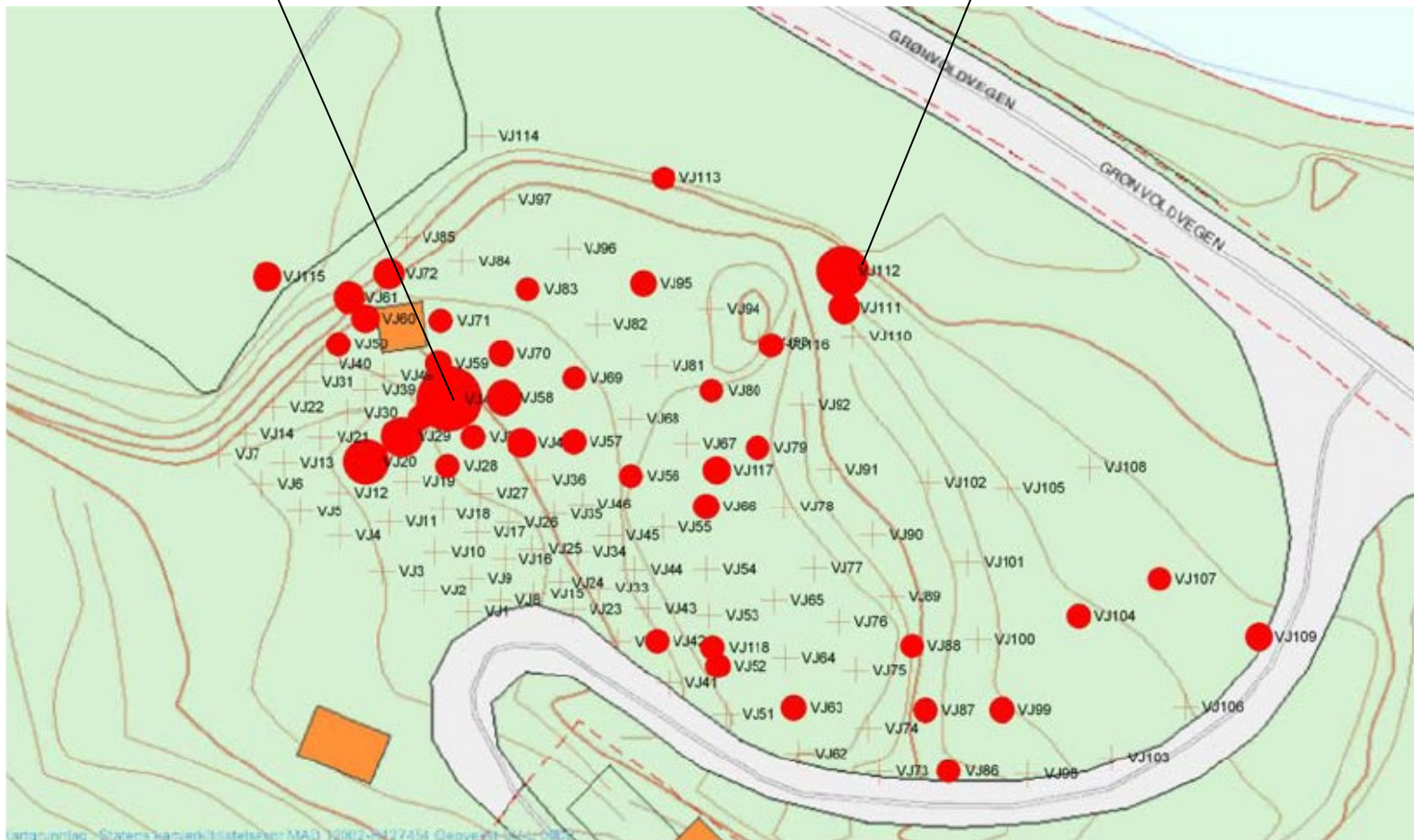


3.1 $\mu\text{Sv/h}$

4.0 $\mu\text{Sv/h}$

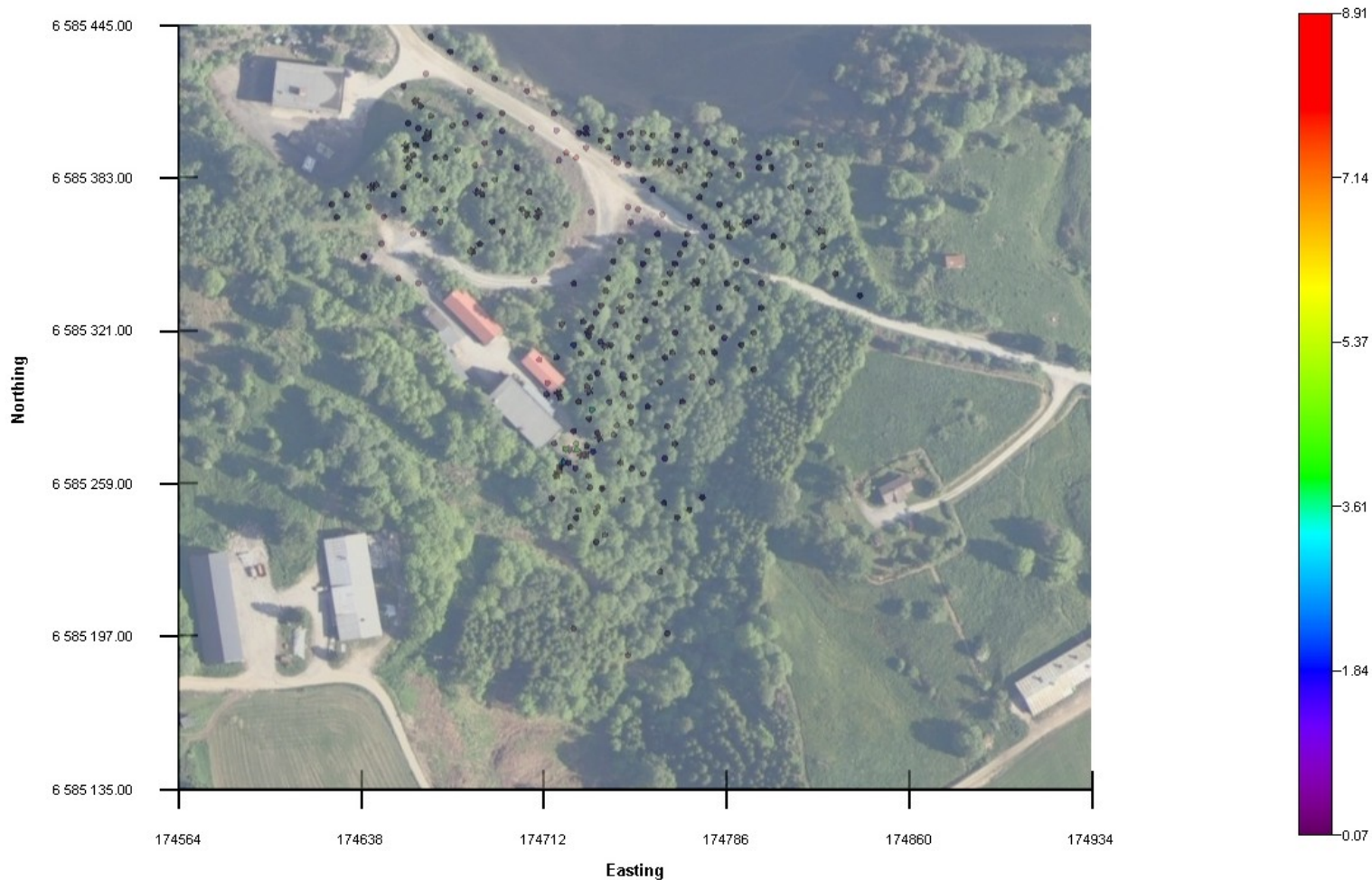
2.6 $\mu\text{Sv/h}$

1.7 $\mu\text{Sv/h}$

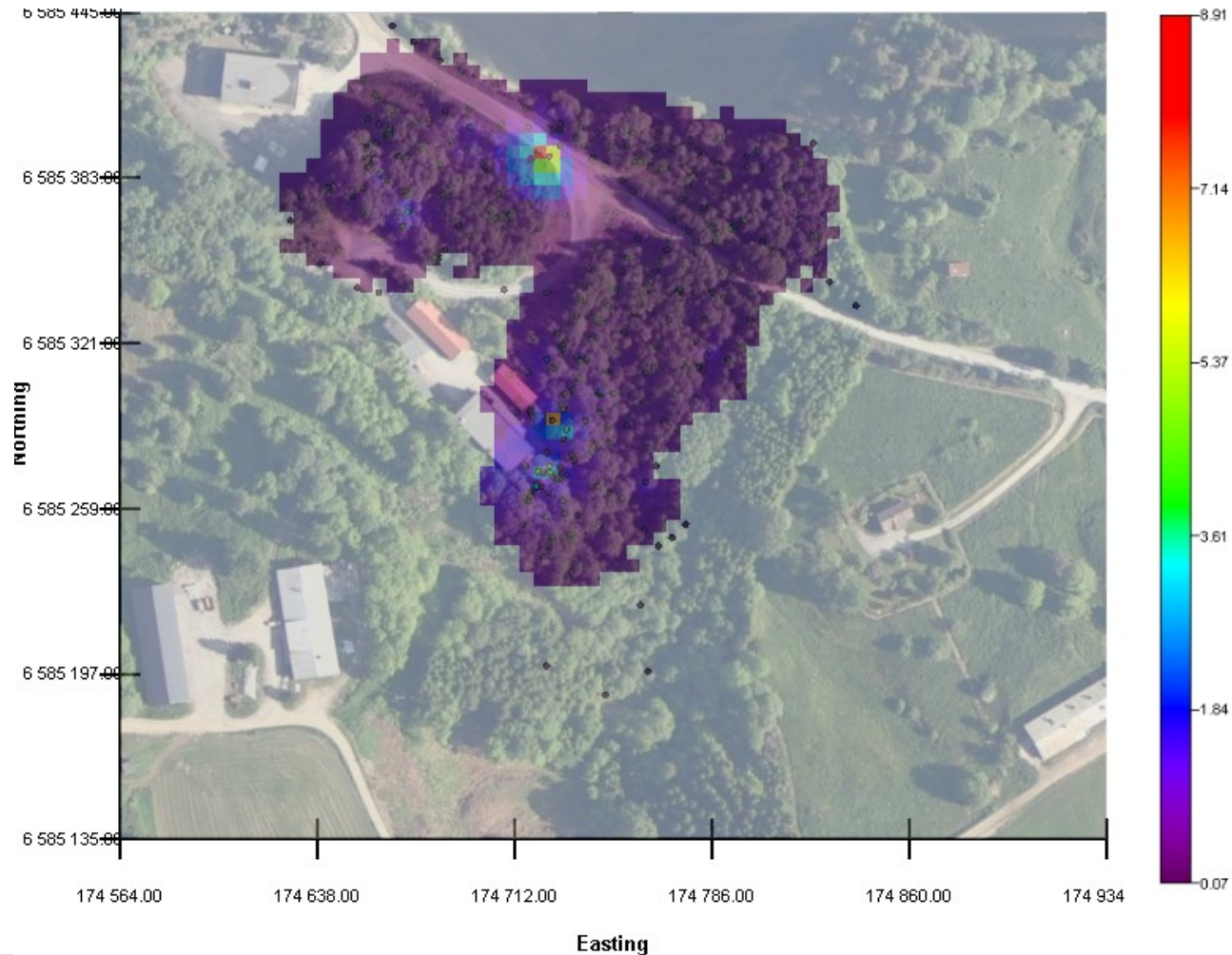


Doserate 1m

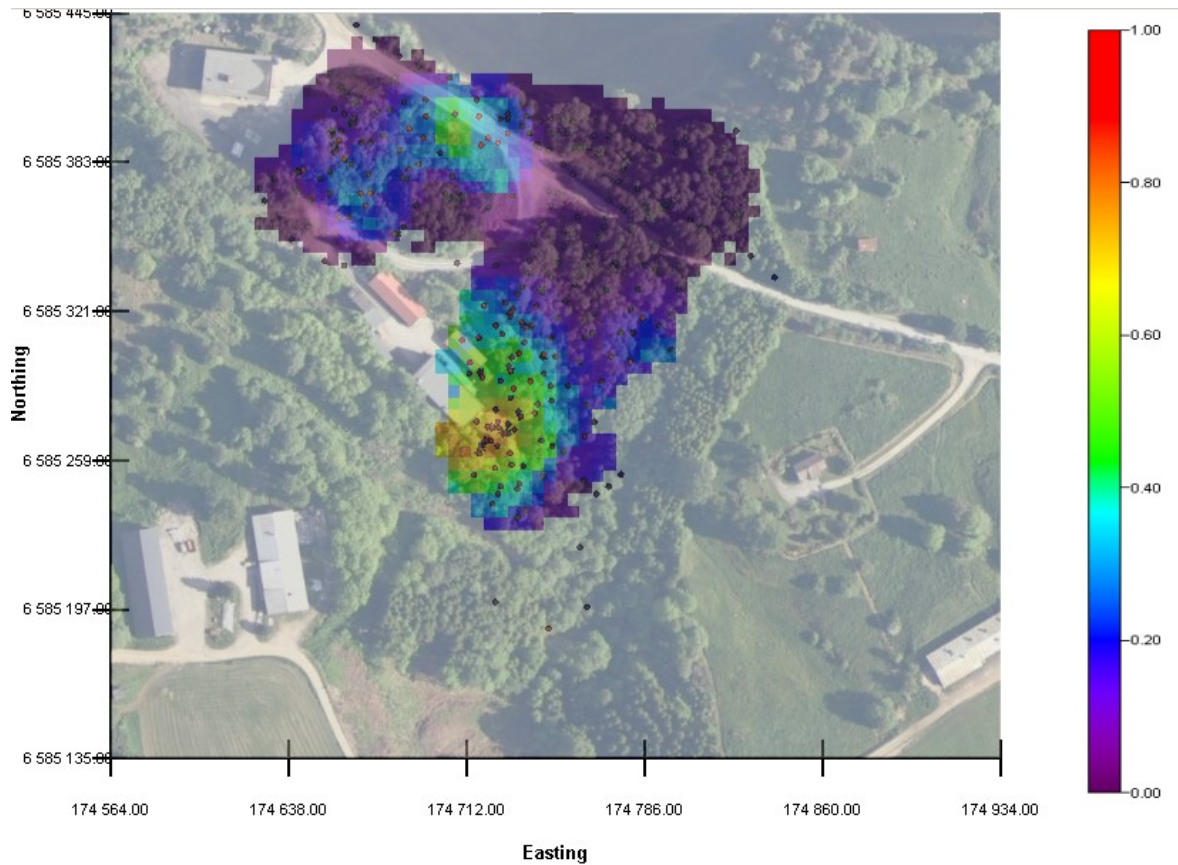
Doserate measurements (PORANO)



Traditional estimate (IDW)



IK Probability map – 0.4 $\mu\text{Sv}/\text{hour}$ threshold



Radionuclides in slag (Bq/g)

	Slag A	Slag B	Soil
^{238}U	66 ± 14	9.6 ± 0.5	0.16 ± 0.05
^{226}Ra	55 ± 8	9.3 ± 1.4	0.18 ± 0.03
^{210}Pb	60 ± 40	8.6 ± 1.2	0.17 ± 0.07
^{232}Th	54 ± 10	29 ± 2	0.18 ± 0.04
^{228}Ra	74 ± 4	29 ± 1	0.20 ± 0.03
^{228}Th	74 ± 3	27 ± 1	0.19 ± 0.02

Slags (Bq/g)

Description	^{226}Ra	^{228}Ra
Slag 1	43 3	58 3
Slag 2	22 4	55 2
Slag 3	5.0 0.5	26.6 0.8
Slag 4	9.3 0.2	28.7 0.9
Slag 5	85 9	66 3

Contaminated soil area (Bq/g)

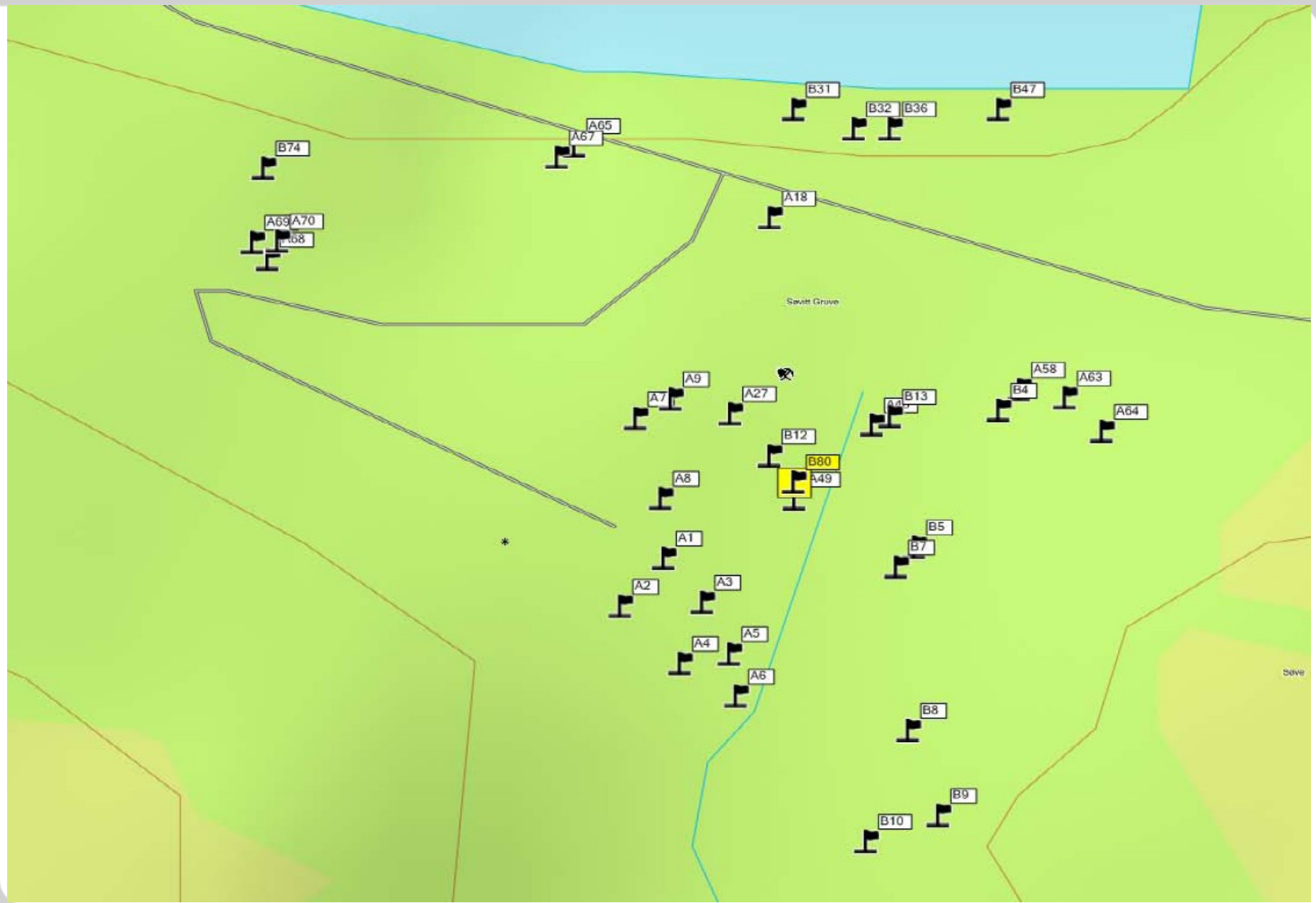
	Soil A	Soil B	Soil C
^{238}U	10.9 ± 2.2	5.2 ± 0.3	1.0 ± 0.5
^{226}Ra	12.5 ± 1.8	3.3 ± 0.5	0.88 ± 0.04
^{210}Pb	13.6 ± 1.4	2.7 ± 0.3	0.89 ± 0.14
^{232}Th	15.4 ± 1.8	7.7 ± 0.5	1.0 ± 0.6
^{228}Ra	18.8 ± 0.8	8.7 ± 0.3	1.00 ± 0.07
^{228}Th	19.5 ± 0.8	8.3 ± 0.3	1.08 ± 0.05

Sediments from Norsjø

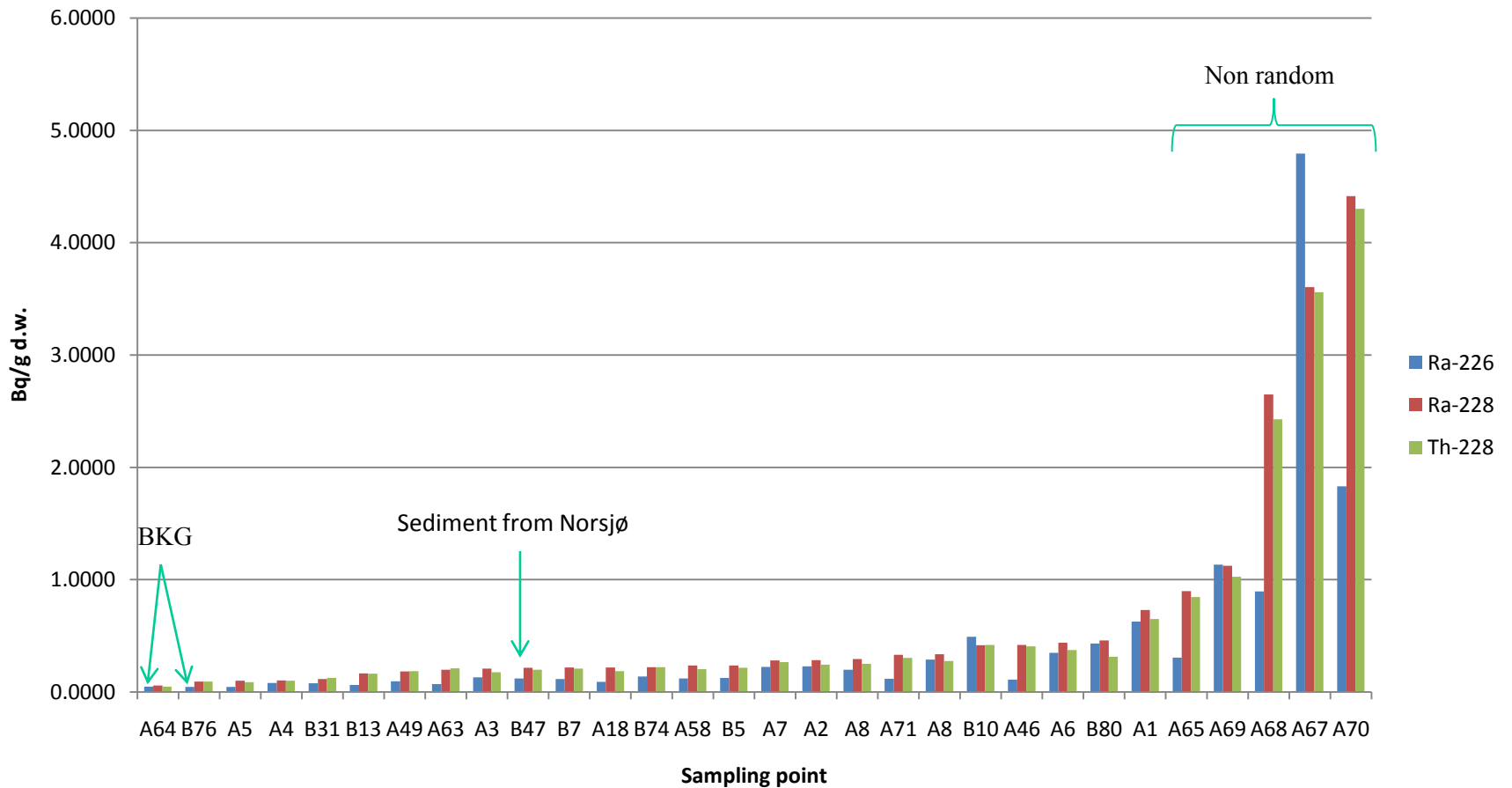
Description	^{226}Ra (Bq/kg)	^{228}Ra (Bq/kg)
2 m from stream outlet	83 8	138 6
10 m from stream outlet	88 11	201 9
15 m from stream outlet	78 6	152 7

Water samples

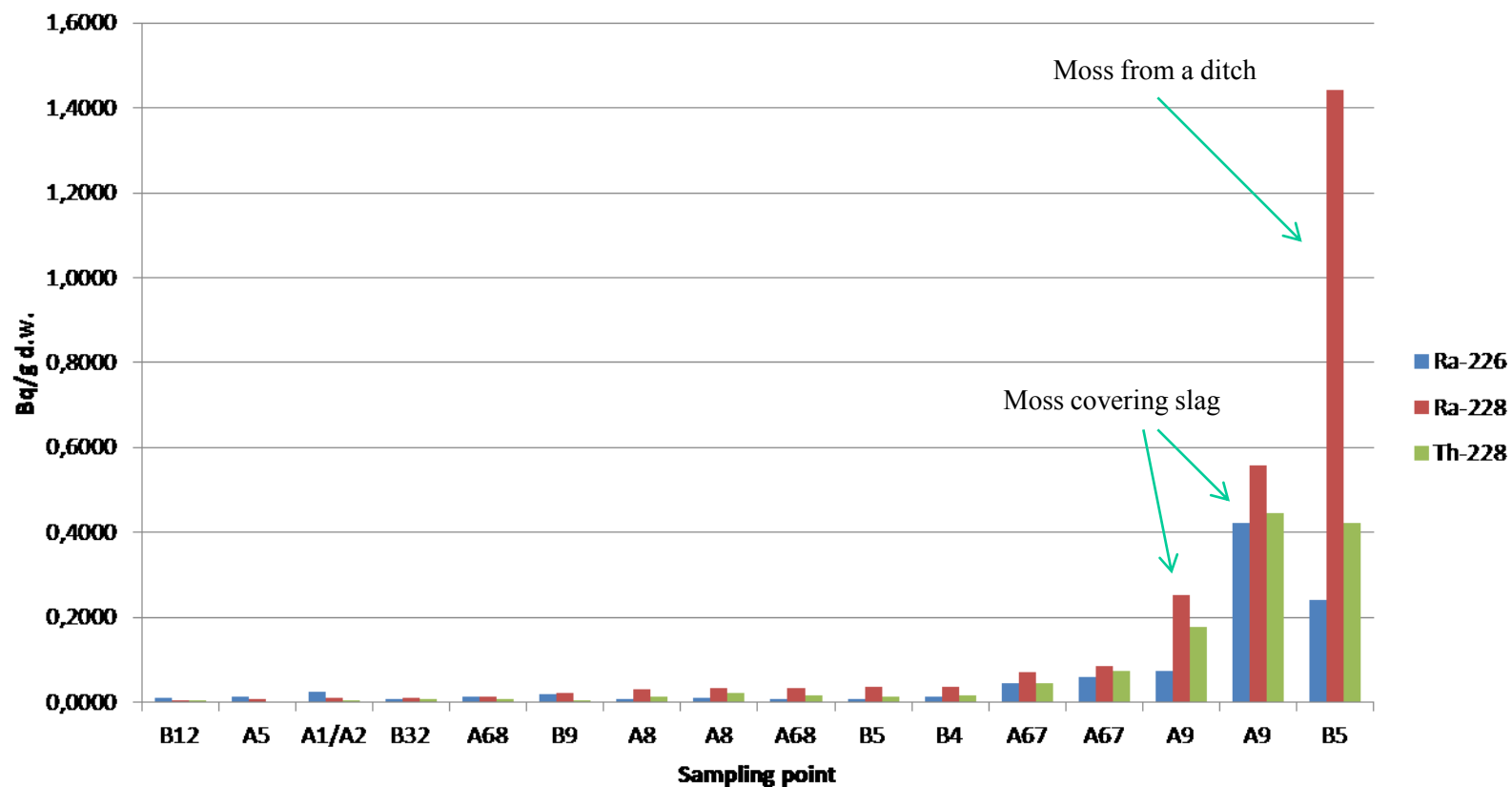
Description	^{226}Ra (mBq/l)	^{228}Ra (mBq/l)
Ditch 1	17 4	132 12
Ditch 2	18 4	61 6
Ditch 3	16 8	183 13
Norsjø	≤ 6	≤ 11



Radionuclides in soil (Bq/g d.w.)



Radionuclides in biota (Bq/g d.w.)



Radionuclides in birch trunks and leafs (Bq/g d.w.)

Sample	Ra-226	Ra-228	Th-228
A8 - Soil	0.29 ± 0.04	0.33 ± 0.01	0.27 ± 0.01
A8 - Trunk	0.011 ± 0.004	0.034 ± 0.003	0.022 ± 0.001
A8 - Leafes	0.008 ± 0.012	0.030 ± 0.008	0.013 ± 0.004
A 67 - Soil	4.8 ± 0.6	3.60 ± 0.14	3.56 ± 0.10
A 67 - Trunk	0.059 ± 0.014	0.086 ± 0.008	0.074 ± 0.004
A 67 - Leafes	0.046 ± 0.006	0.070 ± 0.006	0.045 ± 0.002

Radionuclides in water samples (mBq/l)

Sample	Ra-226	U-234	U-238
Norsjø far from the mine	2.1 ± 0.3	11.2 ± 1.7	5.6 ± 0.9
Norsjø at the stream outlet		5.3 ± 1.0	2.9 ± 0.6
Ground water below the mine	5.3 ± 0.7	233 ± 40	117 ± 20
Stream background	10.1 ± 1.8	421 ± 74	178 ± 31
Stream above the mine area	14.5 ± 1.7	280 ± 51	123 ± 23
Stream at the outlet to Norsjø	18.1 ± 3.5	346 ± 54	155 ± 24
Water from ditch in the lagoon	305 ± 14	10.0 ± 1.5	5.7 ± 0.9

^{230}Th and ^{232}Th : Below detection limit

^{228}Th : Much higher levels in the water from the ditch



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