



N O R S E D E C O M

Environmental solutions for the energy industry

Norway's disposal site for oil industry NORM

Per Varskog, Norse Decom AS, Norway

Oil industry NORM – “LSA scale”



NORSEDECOM

- ✓ Oil industry NORM originates as a co-precipitate with Group II elements, when present as waste usually in the form of barium sulphate.
- ✓ The mother nuclides are ^{226}Ra and ^{228}Ra , and in some cases ^{210}Pb .
- ✓ ^{226}Ra is a long-lived alpha emitter (half life 1600 years) originating from the ^{238}U series.
 ^{228}Ra is an beta emitter with a half life of 5.75 years originating from the ^{232}Th series.



Sampling of typical LSA scale containing separator mass.

Activity and mass



NORSEDECOM

- ✓ **Original definition of radioactivity :**
1 Curie \equiv activity of 1 gram radium
1 Curie = 37 Giga Bequerels (GBq)
- ✓ **Total amount of present LSA scale:**
300 tons \sim 7 GBq \sim 0.2 gram radium
- ✓ **Relation to half life:**
Normal LSA scale isotope ratios:
 $^{226}\text{Ra} : ^{228}\text{Ra} = 3 : 1$ (activity)
 $^{226}\text{Ra} : ^{228}\text{Ra} = 830 : 1$ (mass)
- ✓ **Relation to mass:**
Sulphate scale with 30 Bq/g ^{226}Ra :
Mass ratio Ba : Ra = 6×10^8
Radium content : 2 ppb



Barium sulphate scale in an oil transport pipe.

LSA scale types



NORSEDEC.COM

| Scale type | Main constituent | Main radionuclides | Production type |
|-----------------|------------------|---|-----------------|
| Sulphate scale | Ba/Sr sulphate | ^{226}Ra , ^{228}Ra | Oil |
| Carbonate scale | Ca carbonate | ^{226}Ra , ^{228}Ra | Oil |
| Lead scale | Steel | ^{210}Pb | Gas |
| Sulphide scale | Iron sulphide | ^{226}Ra , ^{228}Ra , ^{210}Pb | Oil and gas |



Temporary LSA scale storage at oil service base.

LSA scale composition



NORSEDECOM

| Oil company | Mass (tons) | Composition (weight %) | | | | |
|-------------|-------------|------------------------|----------------------|-----------|--------------------|-----------|
| | | Water | Heavy oil components | Sulphates | Corrosion products | Sand/clay |
| Company A | 166 | 23.6 | 7.4 | 45.7 | 8.5 | 14.8 |
| Company B | 4.1 | 15.9 | 1.4 | 77.9 | 2.0 | 2.8 |
| Company C | 0.5 | 11.8 | 1.5 | 75.4 | 6.8 | 4.5 |
| Company D | 17.0 | 45.4 | 6.6 | 39.0 | 6.1 | 2.9 |



Platforms at Ekofisk.

LSA scale activity



NORSEDEC.COM

| Oil company | Activity concentration (Bq/g) | | |
|-------------|-------------------------------|-------------------|-------------------|
| | ^{226}Ra | ^{228}Ra | ^{210}Pb |
| Company A | 21.5 (9.7 – 74.1) | 11.2 (3.3 – 28.9) | 2.4 (<0.2 – 11.8) |
| Company B | 19.3 (16.3-23.6) | 7.3 (6.4-8.6) | 2.7 (2.0-3.7) |
| Company C | 20.8 | 9.6 | 1.8 |
| Company D | 40.4 (4.9-100) | 3.7 (0.4-13-3) | 13.8 (2.3-49) |



Flare bridge at Ekofisk.

Where to find LSA scale



NORSEDEC.COM

Oil production

- ✓ Production tubulars
- ✓ Christmas trees
- ✓ Risers
- ✓ Oil-water separators
- ✓ Topside tubes before oil-water separation
- ✓ Water discharge system

Gas production

- ✓ Anywhere in the system from the risers to the flares

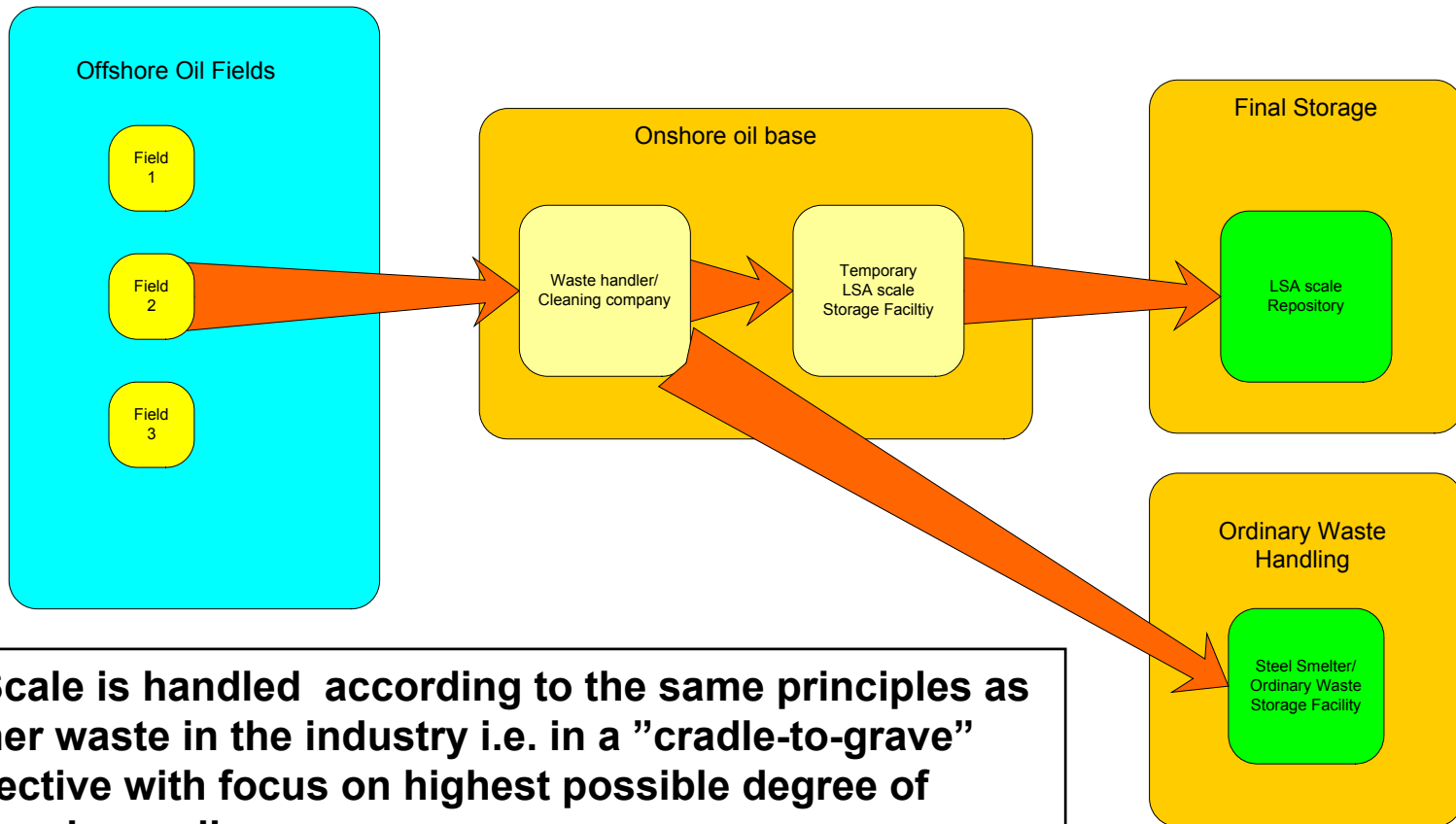


Author pretending to monitor for LSA Scale on decommissioned installation.

Waste handling



NORSEDECOM



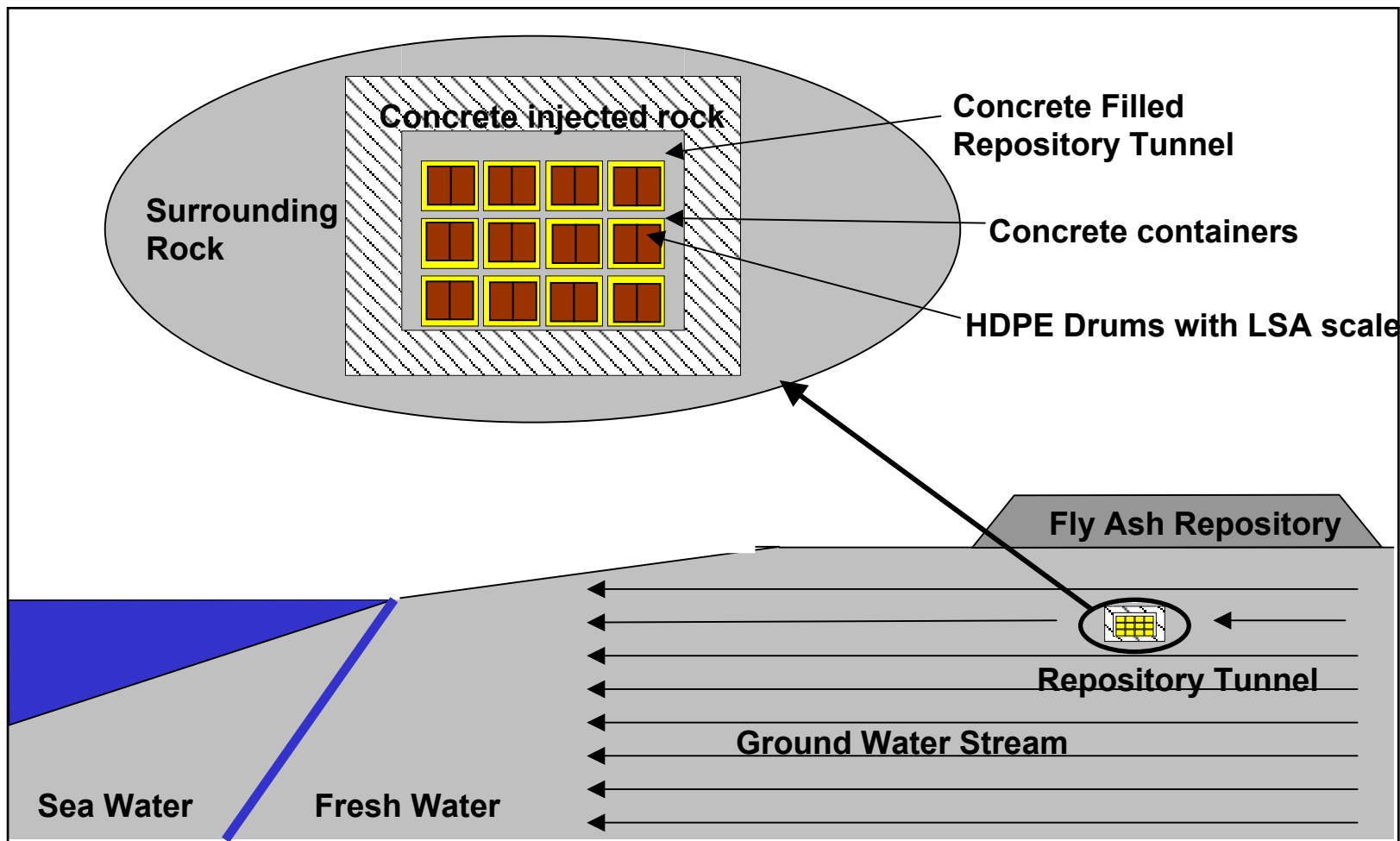
LSA Scale is handled according to the same principles as all other waste in the industry i.e. in a "cradle-to-grave" perspective with focus on highest possible degree of reuse and recycling.

Therefore, LSA Scale contaminated objects is cleaned by e.g. high-pressure water jetting facilitating recycling of the component steel and minimisation of the NORM waste.

LSA scale repository concept



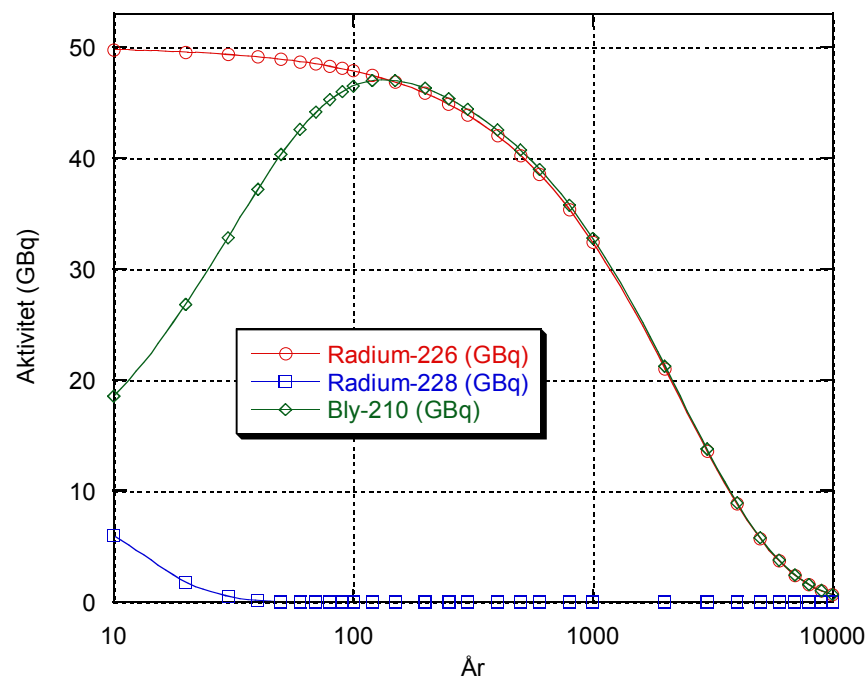
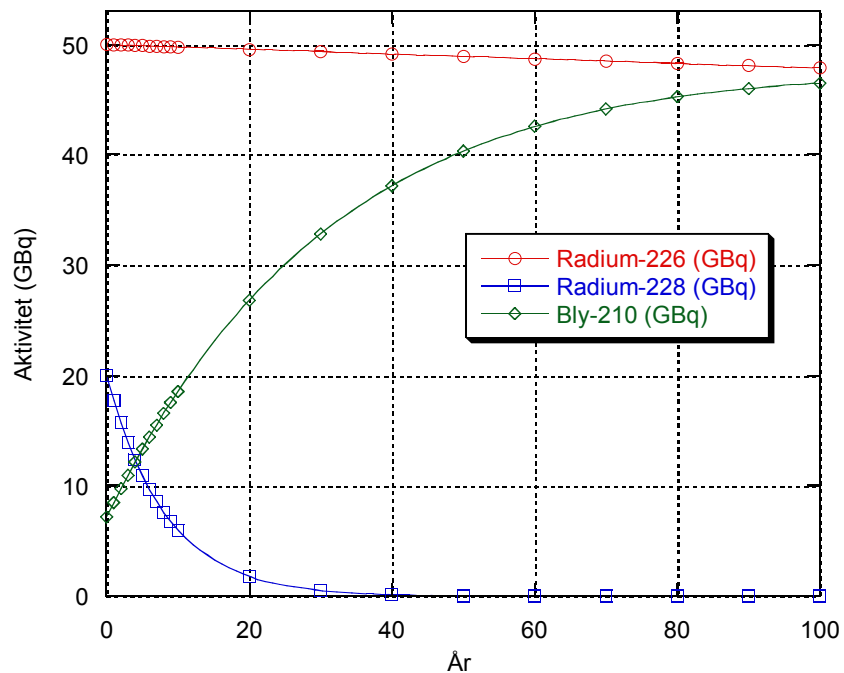
NORSEDEC.COM



Activity with time



NORSEDECOM



Stangeneset LSA scale repository

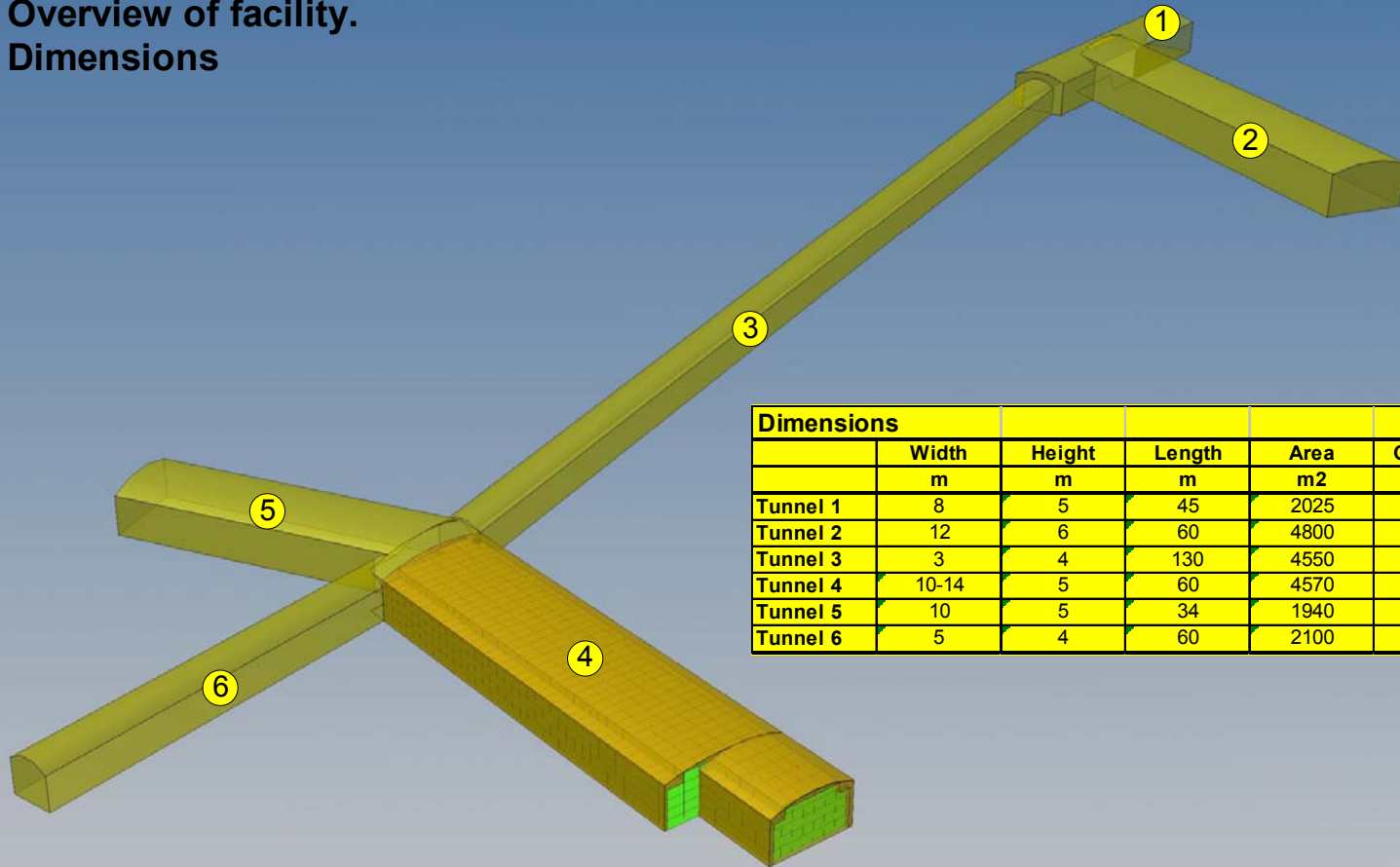


NORSEDECOM



The repository is located in a quarry area on the north side of Fensfjorden. Mongstad refinery site is seen on the far side of the fjord.

**Overview of facility.
Dimensions**



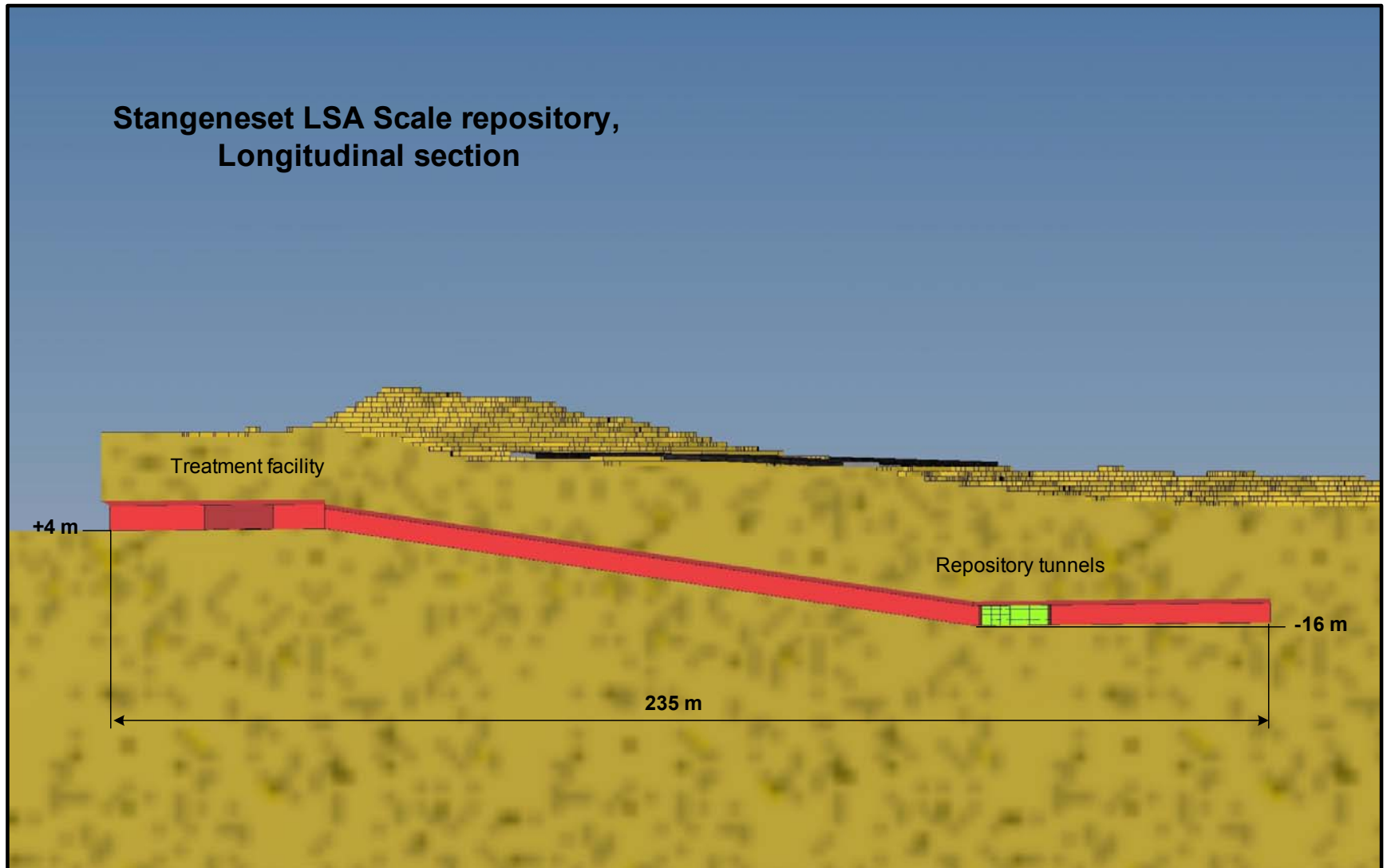
| Dimensions | | | | | |
|------------|-------|--------|--------|------|----------|
| | Width | Height | Length | Area | Gradient |
| | m | m | m | m2 | |
| Tunnel 1 | 8 | 5 | 45 | 2025 | 1:100 |
| Tunnel 2 | 12 | 6 | 60 | 4800 | 1:100 |
| Tunnel 3 | 3 | 4 | 130 | 4550 | - 1:7 |
| Tunnel 4 | 10-14 | 5 | 60 | 4570 | 1:100 |
| Tunnel 5 | 10 | 5 | 34 | 1940 | 1:100 |
| Tunnel 6 | 5 | 4 | 60 | 2100 | 1:100 |

Longitudinal section



NORSEDECOM

Stangeneset LSA Scale repository, Longitudinal section



Environmental monitoring programme



NORSEDECOM

- 4 The monitoring programme has been conducted with sampling in 2005, 2006 and 2007.
- 4 Terrestrial samples, rock, fly ash, birch and "myrull" are collected on surface above the repository.
- 4 Marine samples, sea water, sediment and mussels is taken at the end of the release pipe. Samples taken by diver. Samples of cod are obtained in cooperation with local fishermen as close to the release pipe as possible.
- 4 Ground water from collection pod in bottom of tunnel.



Terrestrial samples
Birch
"Myrull"

Release pipe

Marine samples
Sediment
Mussels
Cod

Facility



NORSEDECOM



Accident at nearby tank facility May 2007



NORSEDECOM



An explosion at the nearby tank facility, on of the repository's worst case scenarios, had as predicted in the consequence assesment no impact on the repository.

As a result of the explosion, though, the treatment o foil containing NORM will be performed at an other location on site.