Monitoring of a Near Surface Repository

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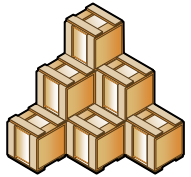
Monitoring of a Near Surface Repository

- Monitoring is needed to ensure the radiological and environmental safety through out the whole life cycle of of the repository.

Monitoring in different site phases



Phases

Site investigation

Site pre-operation

Site operation

Site closure

Site post-closure

timeline

Monitoring

automatic monitoring

laboratory sampling

Actors

constructor

site operator

authorities

institutional control

How to plan the monitoring (1/3)?

- Monitoring needs and techniques have to be taken into account already in the early site definition and design phase.
- Various industry and other domains provide lot of examples, how monitoring can be performed. These should also be followed.
- Monitoring system should be designed to be modular and expandable allowing adoption of novel techniques.
- Although a fully automated, reliable 24/7 on-line monitoring system would be an ideal target to aim to, budgetary and other issues induce that the repository monitoring system will be a hybrid solution with automated measurements, laboratory sampling and human interventions (visual inspections etc.).

How to plan the monitoring (2/3)?

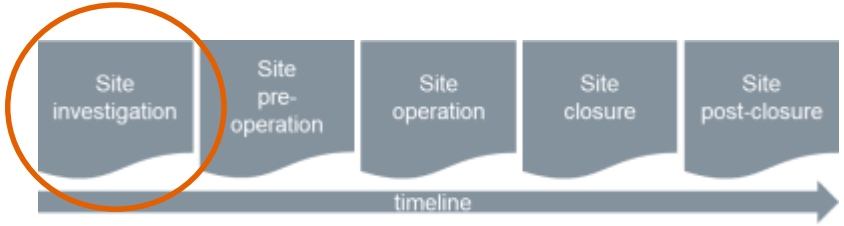
- Basic principles for the design of the repository is that it operates safely with or without monitoring, which is only used to confirm the operation

- However to mitigate or prevent events occuring because of special conditions, automated or human initiated actuators and controls can also be installed in the repositories.

- Monitoring should adopt Condition Based Monitoring principles, if possible. This would give early warnings, before actual events oocur.

How to plan the monitoring (3/3)?

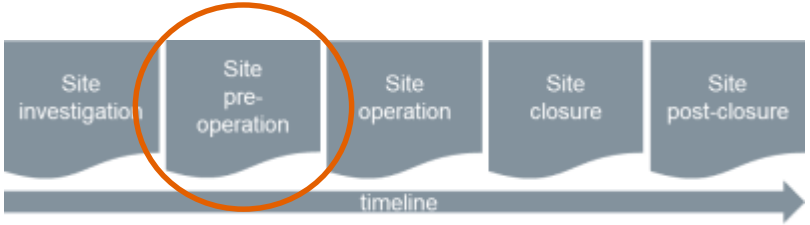
What to measure? Site investigation



- *First step - studies to find the suitable location!*

- Ground water
  - Characteristics, water accumulation, discharge areas, flow directions
- Surface water run-off conditions
- Weather conditions (including historical)
  - Precipitation, temperatures, air temperature, wind speed
- Biosphere
  - Flora and fauna
- Radiation background level

What to measure? Site pre-operation



- Many of the operation phase monitoring will already start in the pre-operation phase.
- Monitoring systems should be installed, tested and ready to be started before the actual operation starts.

What to measure? Site operation

- Radiation safety
  - Radiation levels (perimeter based)
  - Radiation doses
- Ground water
  - Characteristics, water accumulation, discharge areas, flow directions
- Surface water run-off (amount, direction, …)
- Weather conditions (including historical)
  - Precipitation, temperatures, air temperature, wind speed
- Biosphere
  - Flora and fauna
- Radiation background level

What to measure? Site operation

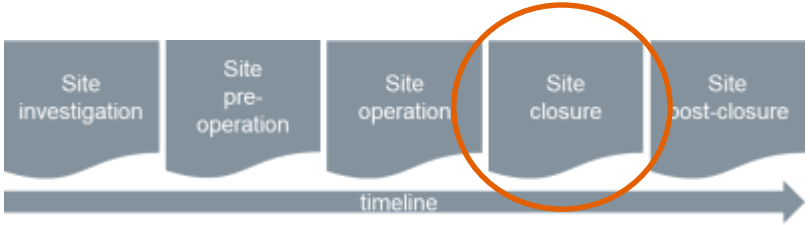
- Leakage waters from drains
  - Flow rate and location of the leakage
  - Chemical composition of the leakage water, including radioactive isotopes
- Leakage of gasses
- Condition of the waste packages
  - Surface contamination, dose rate
- Intactness of the engineered (and/or natural) barriers
  - Can be challenging

What to measure? Site operation

- Weather conditions
  - Precipitation, temperatures, air temperature, wind speed
  - Weather forecasts for future weather related event mitigation/prevention
    - E.g. extreme weather conditions
      - Protective measures to prevent flooding waters to enter the repository
      - Stormwater handling systems (active or passive)

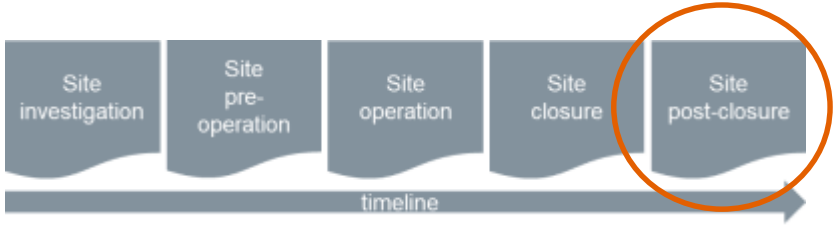
- Perimeter protection and access control

What to measure? Site closure



- Most or all of the operation phase monitoring will continue during the site closure phase.

What to measure? Site post-closure



- Post-closure safety should not be based on active measures (like monitoring)
- Many of the operation phase monitoring should continue also in the site post-closure phase. Critical system monitoring must continue.
- Measured historical data and documents need to be stored reliably and securely (*see later the data management*).

Examples of monitoring technique possibilities

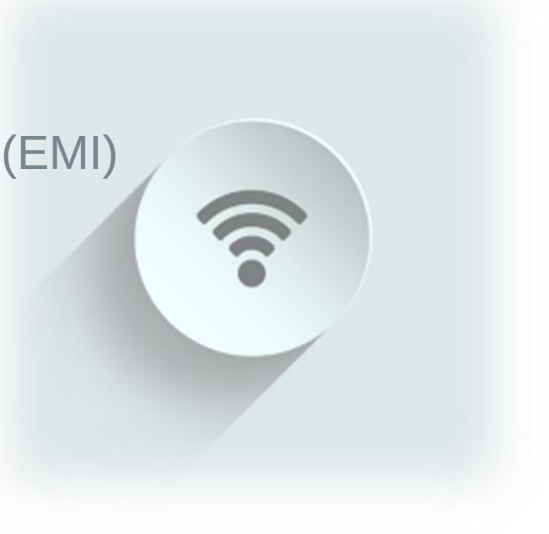
- Geophysical methods
  - Boreholes
  - Seismic monitoring
  - Pressure cells
- Material measurements
  - Displacement sensors
  - Moisture sensors
  - Strain gages
- Ground water
  - Groundwater sampling
  - Groundwater wells
- Leakage waters
  - Flow-meters
  - Pressure gauges
  - Sampling
- Weather
  - Weather stations (rain, temp, …)
- Radiation
  - Dosimeters (personal + automatic on-line measurements)
  - On-line radiation level measurements
- Visual inspections
  - Camera based
  - Human based

Wired or wireless data transfer?

- Novel sensors and radio technologies provide the opportunity to create extensive wireless sensor networks to monitor and control complex systems without wires.
- Wireless enables the mobility of personnel and applications creating new ways to rationalize the operations in all business sectors.
- Freedom from wires opens opportunities to develop systems into processes, where wired systems would not be possible to be implemented.

Main concerns of wireless monitoring with (nuclear related *) monitoring

- Reliability
- Security
- Electromagnetic compability (EMC) / - interference (EMI)
- Spectrum management
- Heavy structures
- (Radiation *)



Wireless technologies overview

- 2G/3G/4G Cellular Networks
- 5G Networks
- Satellite communications
- TETRA
- DECT
- Wireless sensor networks
- WLAN
- WMAN/WiMAX
- Ultra-WideBand, UWB
- Location, identification and presence
- Low frequency Wireless Technologies
- Wireless power
- Other wireless technologies

- Wireless Personal Area Network (WPAN)
- Bluetooth
- Zigbee
- LoRa
- WirelessHART
- ISA 100.11a

- Radio Frequency Identification, RFID
- Near Field Communication, NFC
- Satellite positioning
- Pseudolites

- Visible Light Communication (VLC)
- Infrared communication (IrDA)
- Audio communication

Disadvantages of wireless monitoring

- cyber security
- information saturating radiowaves
- eavesdropping
- unauthorized use
- jamming
- difficult planning
- lower reliability
- lower communication speed
- radiation influence

- wireless technologies cannot be used
- interference with other (measurement) systems
- interference with other wireless systems
- energy sources for the wireless devices
- radiation influence

Advantages of wireless monitoring

- lower installation costs
- lower maintenance costs
- reduced connector failure
- rapid deployment
- less or no wires
- increased mobility and collaboration
- convenience of use
- better access to information

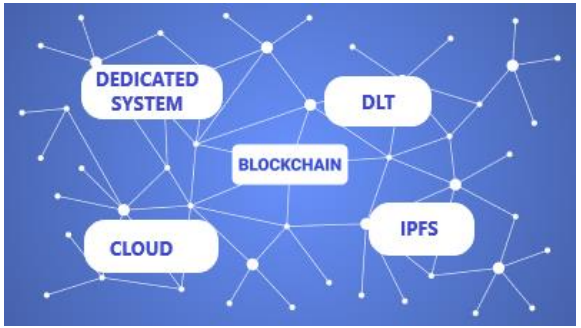
- easier network expansion
- easier network modifications
- security
- access to difficult locations
- option for guest access
- new operation possibilities

Data management (1/2)

- During the lifespan of the repository, lot of data will be created/generated.
- These include safety case and design documentation of the repository.
- Lifespan of the repository can be longer than the lifespan of the the repository operator.

Data management (2/2)

- Data need to be stored securely and reliably. It has to be accessible for the needed stakeholders, including authorities even after the site post-closure phase.
  - Taking into account information security!
- Some information or data might be needed to be open (at least to some ”externals”).
- Data management plan need to be created already in the design phase and maintained during the operation.



Some related links 1/2

- EU Modern2020, Deliverable D2.1: Repository Monitoring Strategies and Screening Methodologies
  - http://www.modern2020.eu/fileadmin/Deliverables/Modern2020_D2.1_Repository_Monitoring_Strategies_and_Screening_Methodologies_Final.pdf
- IAEA, Technical reports series no. 433. Upgrading of Near Surface Repositories for Radioactive Waste
  - https://www-pub.iaea.org/MTCD/Publications/PDF/TRS433_web.pdf
- IAEA, Safety Reports Series No.35, Surveillance and Monitoring of Near Surface Disposal Facilities for Radioactive Waste
  - https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1182_web.pdf
- European Commission, Technical report verifications under the terms of article 35 of the Euratom treaty, Environmental radiological monitoring in Latvia
  - https://ec.europa.eu/energy/sites/ener/files/documents/Art%2035_Technical_report_LV_signed.pdf

Some related links 2/2

- POSIVA 2012-01 Monitoring at Olkiluoto – a Programme for the Period Before Repository Operation
  - http://www.posiva.fi/files/3012/POSIVA_2012-01_web.pdf
- SKB, Technical Report TR-15-01 October 2017, Monitoring Forsmark – evaluation and recommendations for programme update
  - http://www.skb.com/publication/2489674/TR-15-01.pdf
- OECD, R&D and Innovation Needs for Decommissioning Nuclear Facilities
  - https://www.oecd-nea.org/rwm/pubs/2014/7191-rd-innovation-needs.pdf

beyond

the obvious

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