



Remediation of a Chlorinated Solvent Source Area Through Excavation and ISCO in the Unsaturated Zone at a Former Industrial Site in São Paulo, Brazil

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AGENDA



Conceptual Site Model



Challenges for Source Zone Investigation and Remediation



Source Zone Remediation Strategy



Removal of Underground Structures and Excavation

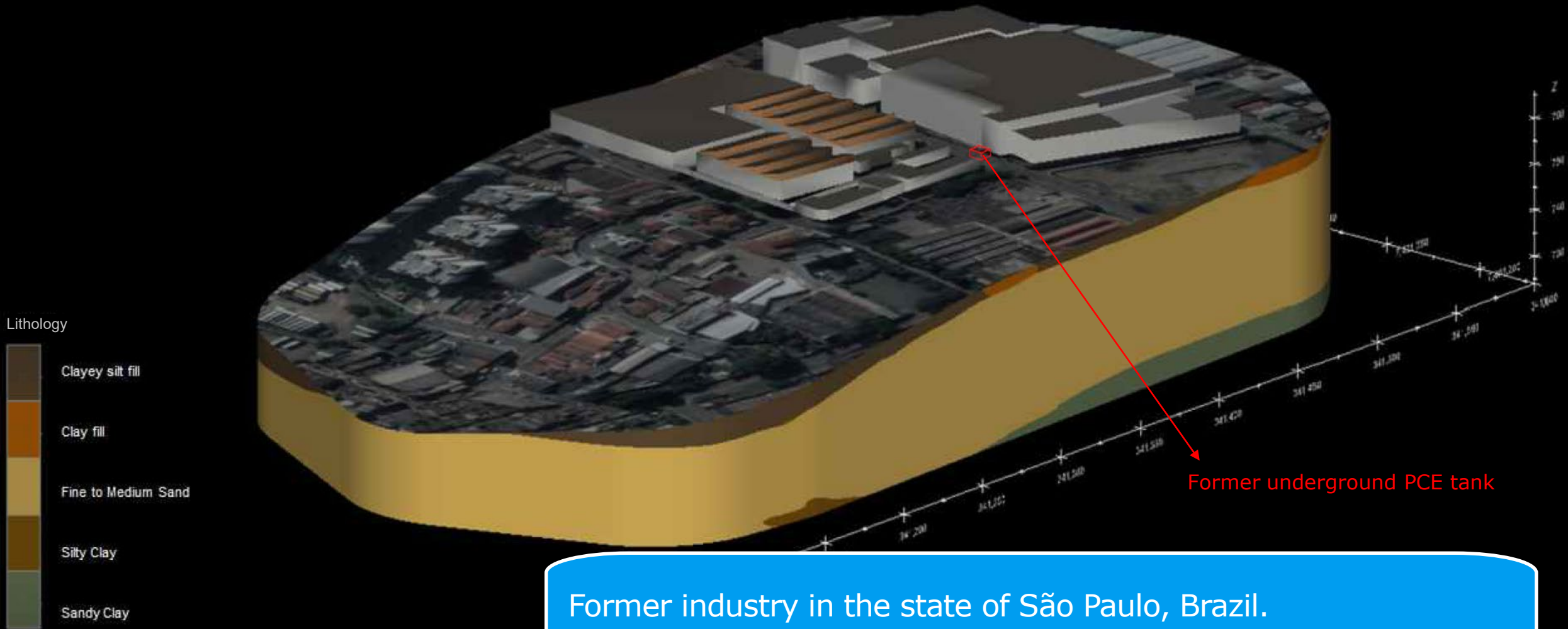


Application of ISCO in the Unsaturated Zone



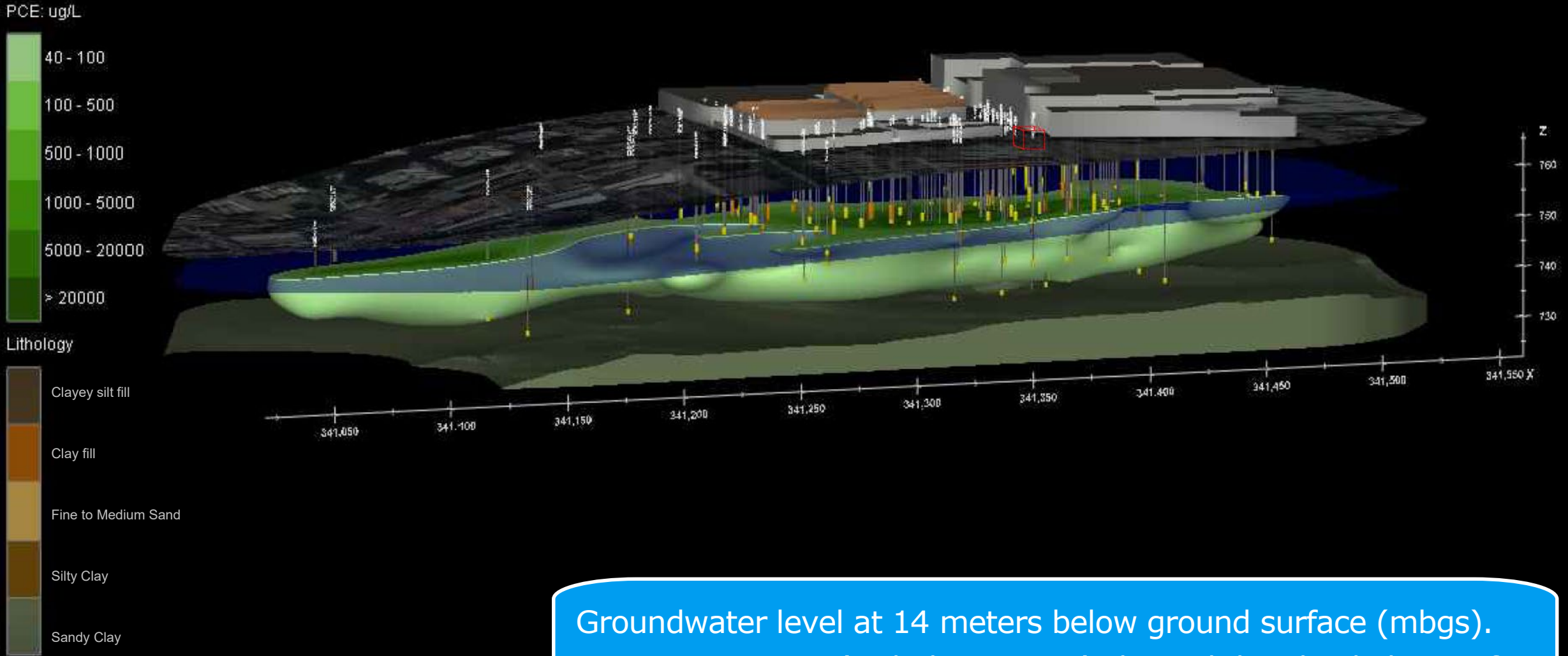
Results and Lessons Learned

SITE LOCATION



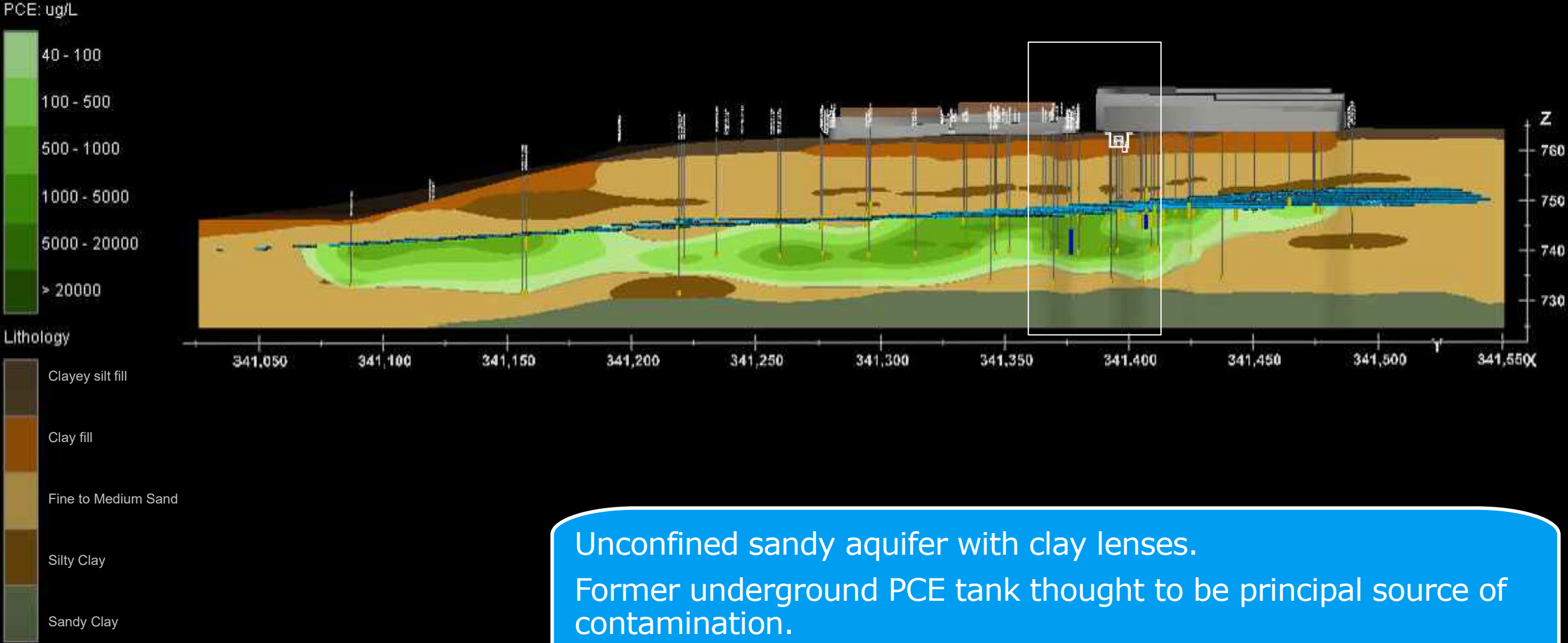
Former industry in the state of São Paulo, Brazil.
Underground storage tank was used for PCE (removed in 2013).
Surrounded by residential areas.

SITE INVESTIGATION



Groundwater level at 14 meters below ground surface (mbgs). Site investigation (including MiHPT) showed dissolved plume of chlorinated carbons extending for over 200m, reaching residential areas.

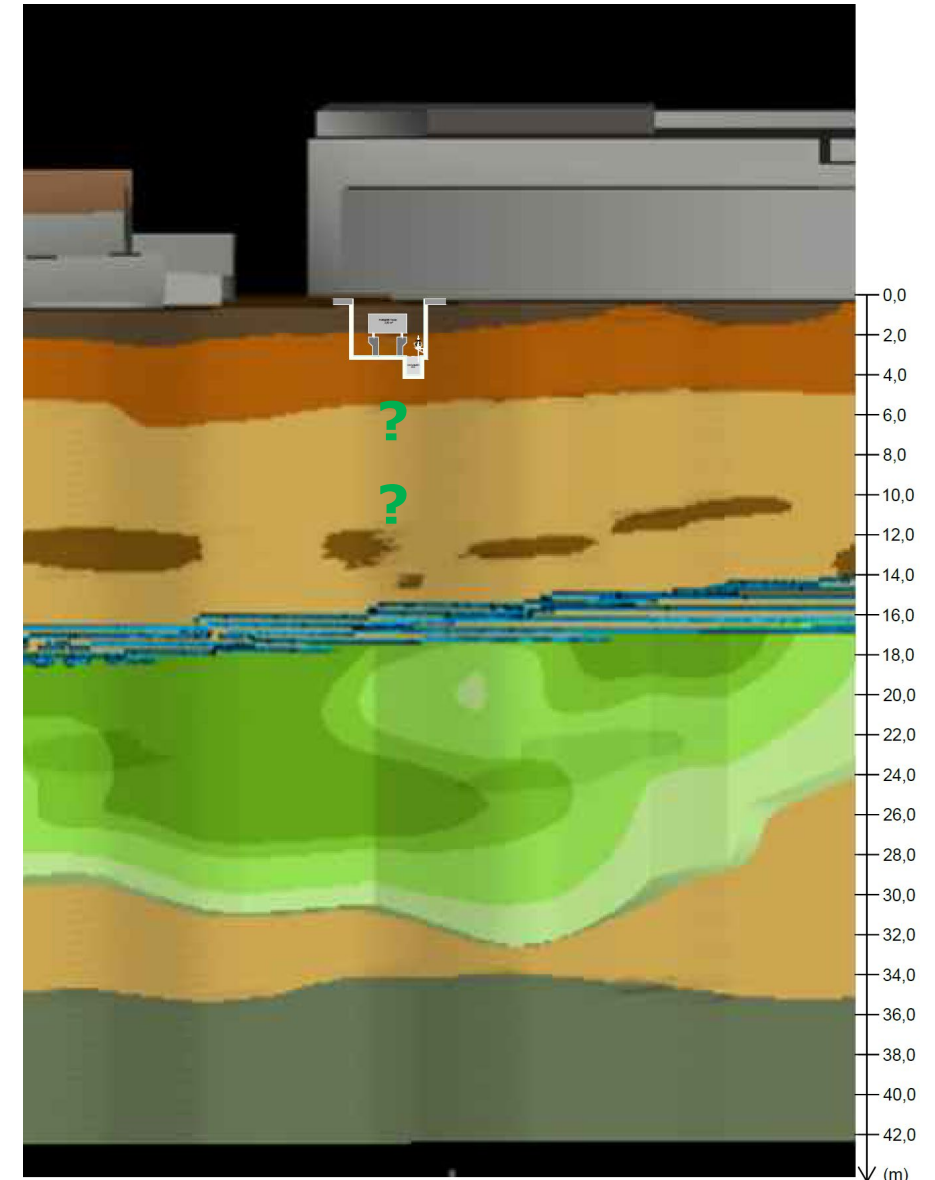
CONCEPTUAL SITE MODEL



Unconfined sandy aquifer with clay lenses.
Former underground PCE tank thought to be principal source of contamination.
Emergency remedial measures were taken to protect receptor: Pump&Treat (P&T) to contain plume and Soil Vapor Extraction (SVE) to mitigate vapor intrusion.

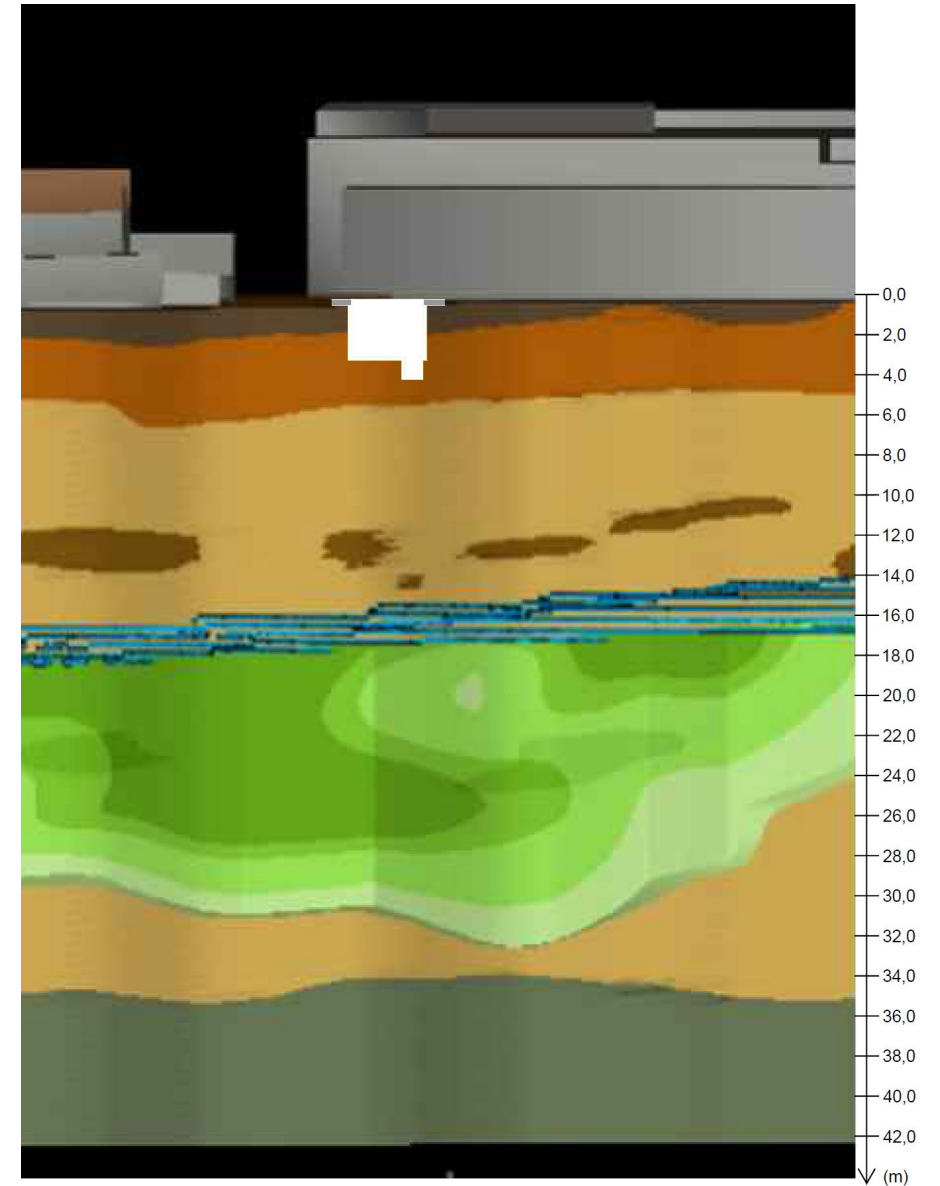
CHALLENGES OF SOURCE ZONE INVESTIGATION AND REMEDIATION

- Remediation of saturated zone will only be effective after successful **source zone removal in the unsaturated zone**;
- **Access limitations:** underground structures (confined space) within small room of building: soil sampling not possible;
- 14 meters of impacted unsaturated zone below building: **excavation not possible.**



SOURCE ZONE REMEDIATION STRATEGY

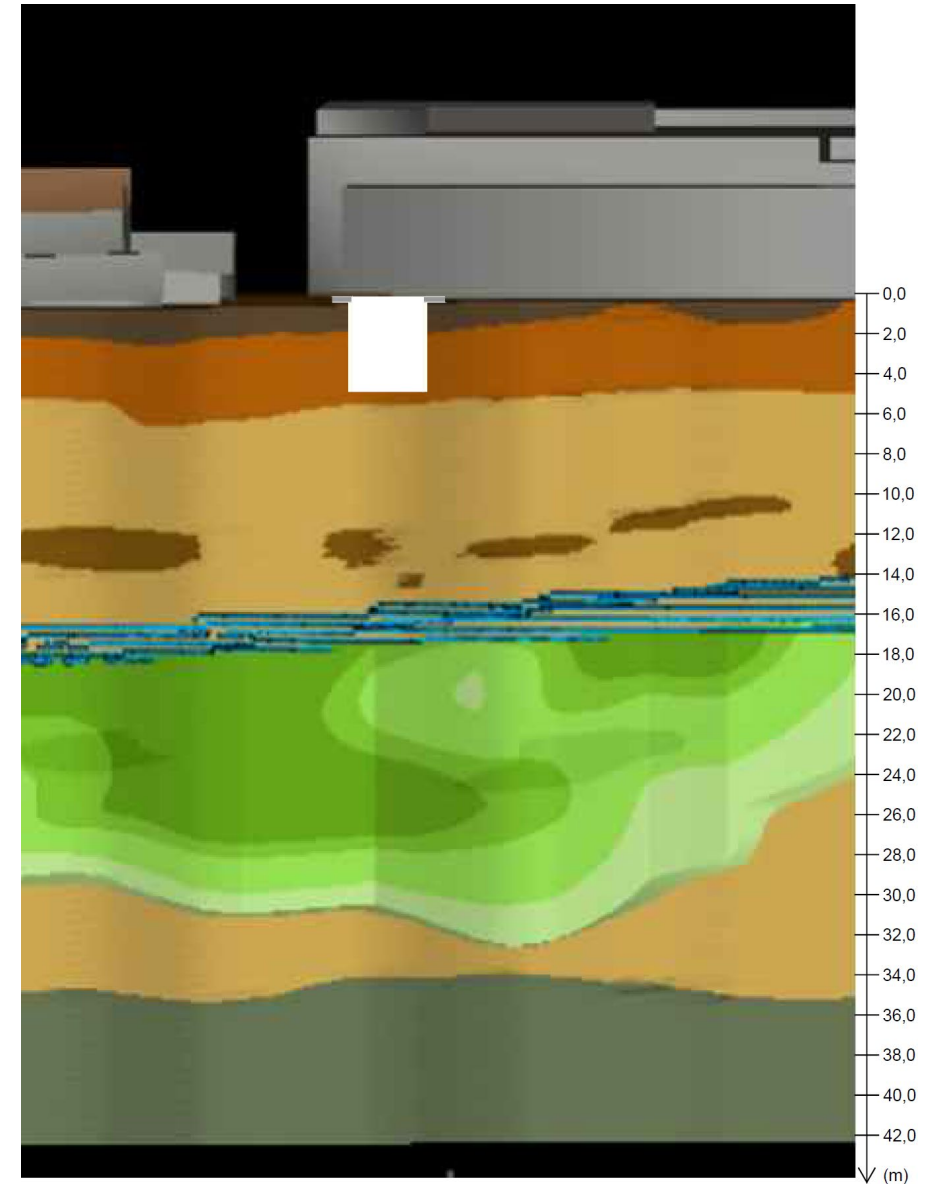
1. Removal of underground structures (3 mbgs)



SOURCE ZONE REMEDIATION STRATEGY

1. Removal of underground structures (3 mbgs)

2. Excavation of contaminated soil (5 mbgs)

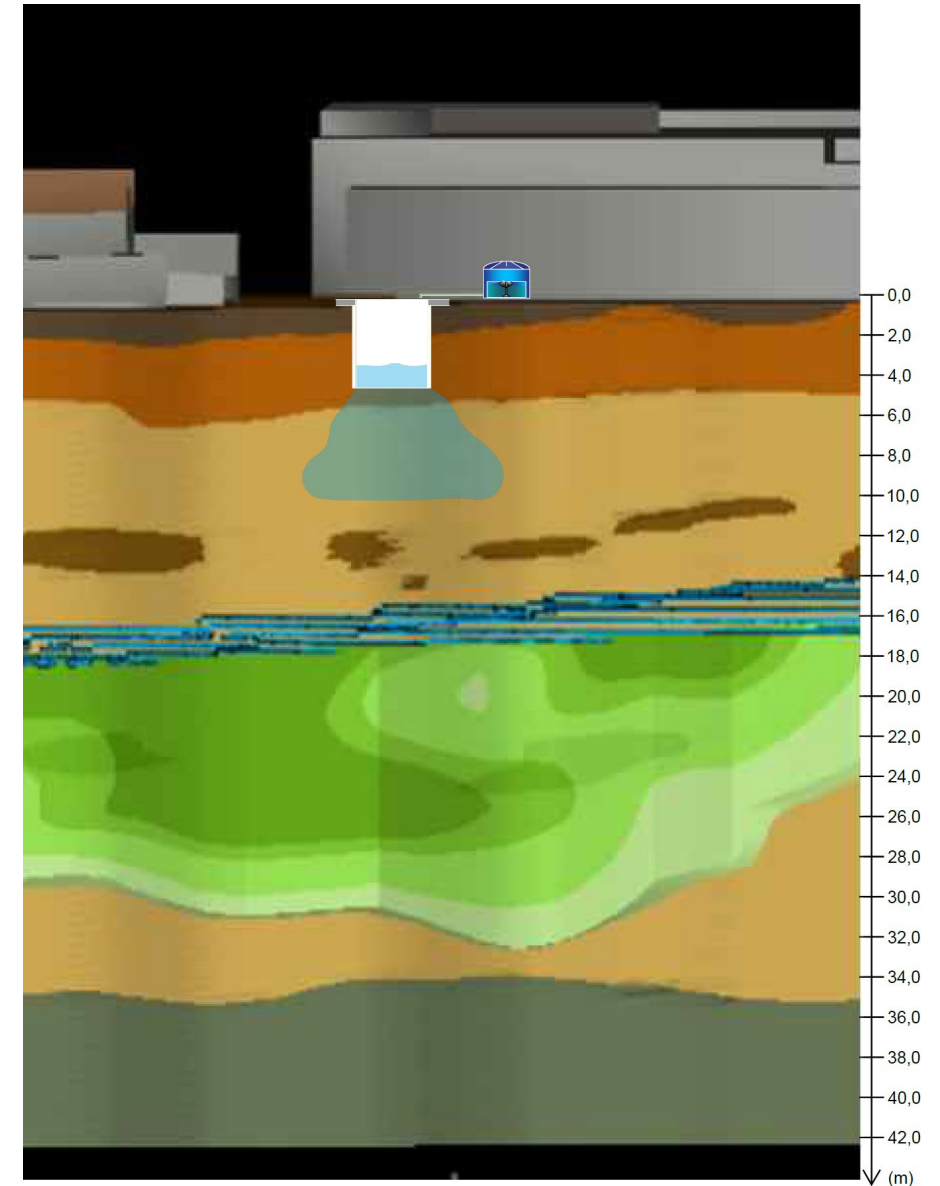


SOURCE ZONE REMEDIATION STRATEGY

1. Removal of underground structures (3 mbgs)

2. Excavation of contaminated soil (5 mbgs)

3. In Situ Chemical Oxidation (ISCO) of contaminated soil (~10 mbgs) using sodium persulfate



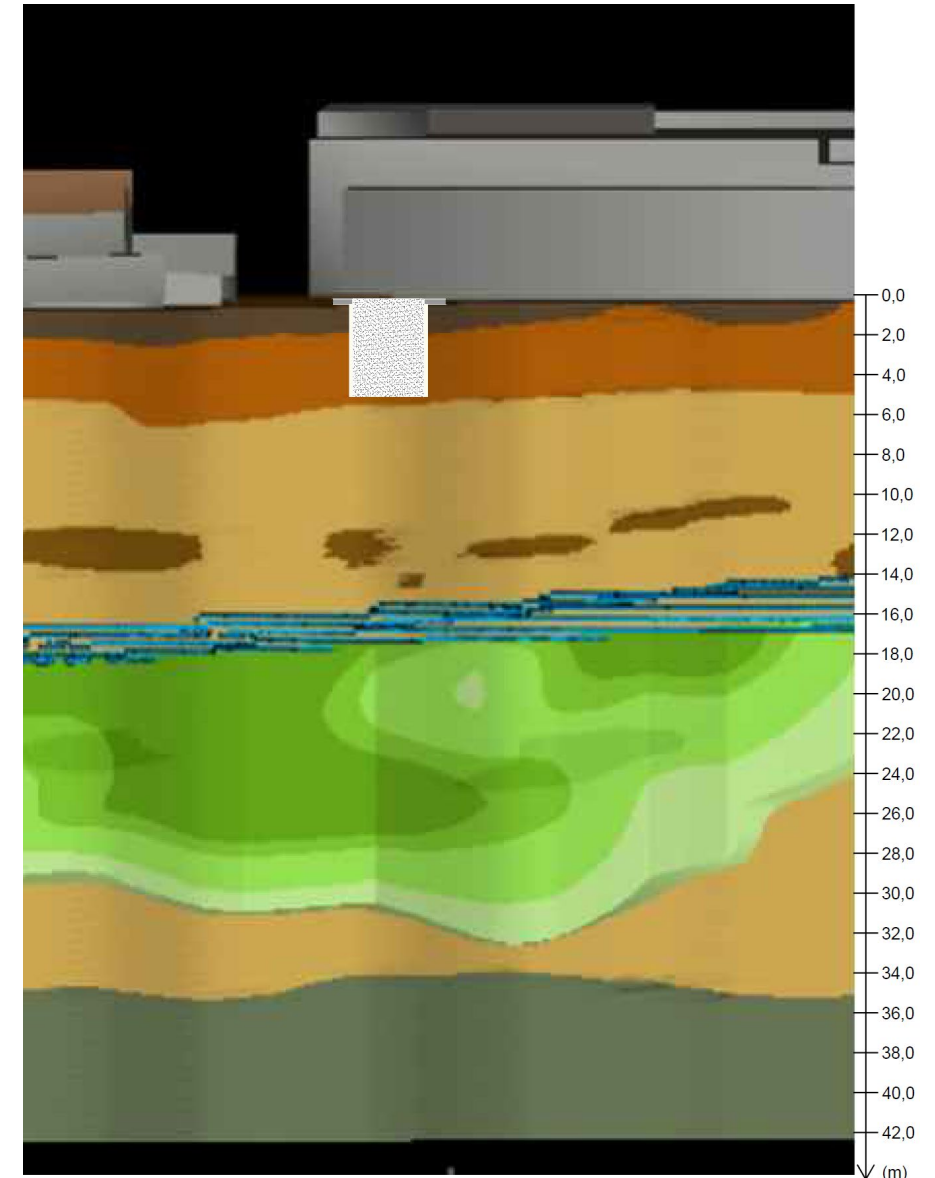
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1. Removal of underground structures (3 mbgs)

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4. Backfilling and compaction (5 mbgs)



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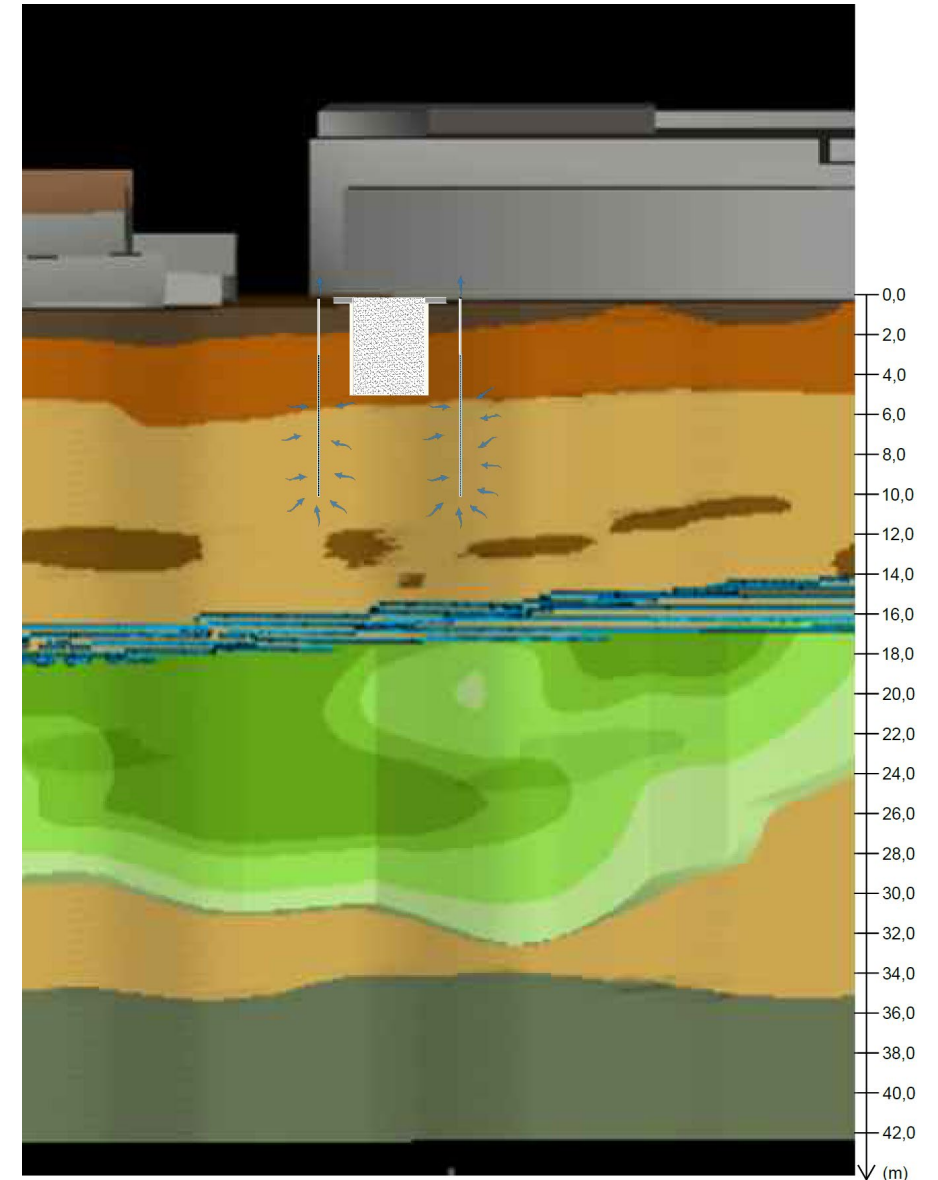
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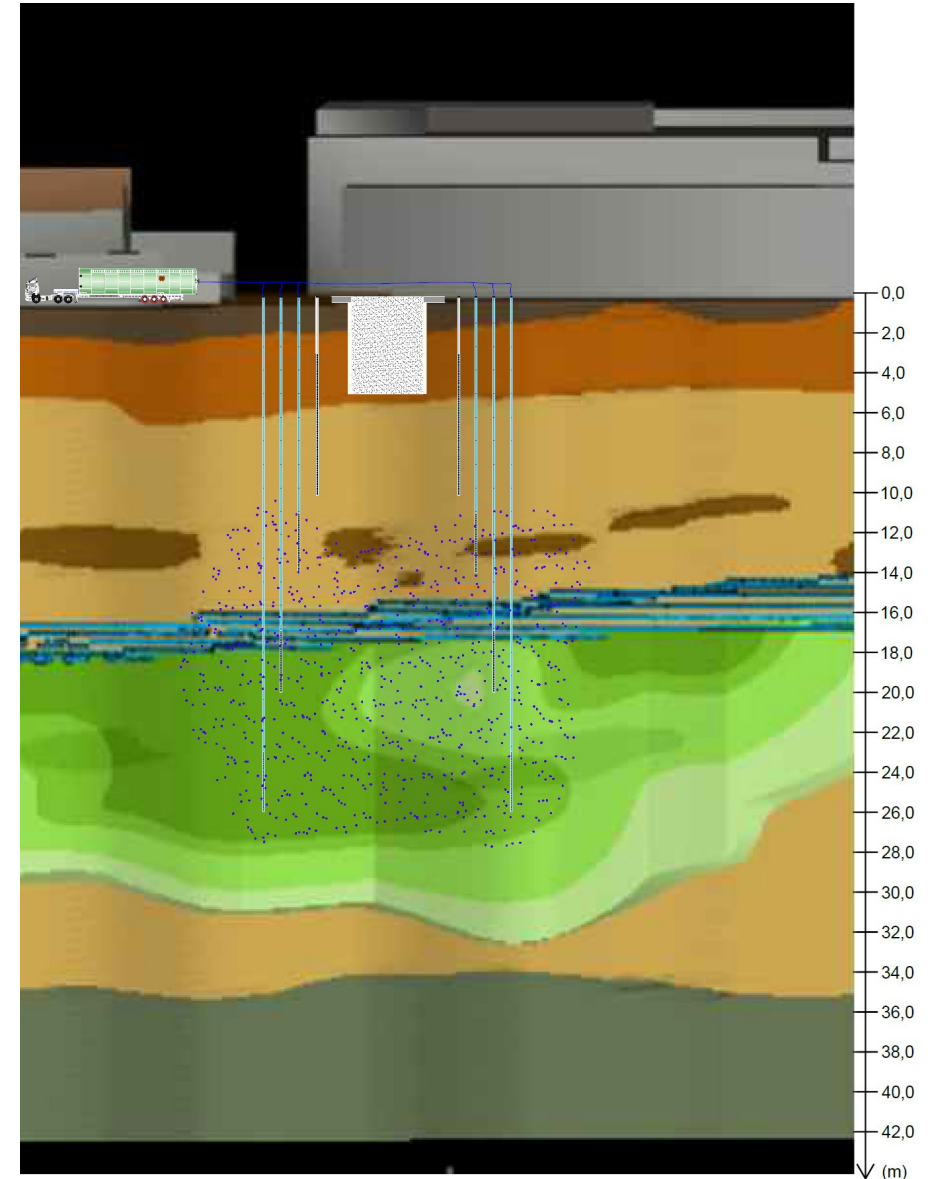
4. Backfilling and compaction (5 mbgs)

5. Soil Vapor Extraction (SVE) wells for extraction of residual mass in the unsaturated zone (10 mbgs)



SOURCE ZONE REMEDIATION STRATEGY

1. Removal of underground structures (3 mbgs)
2. Excavation of contaminated soil (5 mbgs)
3. In Situ Chemical Oxidation (ISCO) of contaminated soil (~10 mbgs)
4. Backfilling and compaction (5 mbgs)
5. Soil Vapor Extraction (SVE) wells for extraction of residual mass in the unsaturated zone (10 mbgs)
6. Injection of nano-bubbles of ozone and persulfate (~26 mbgs) – to be started



UNDERGROUND TANK BASIN



PHOTO-1



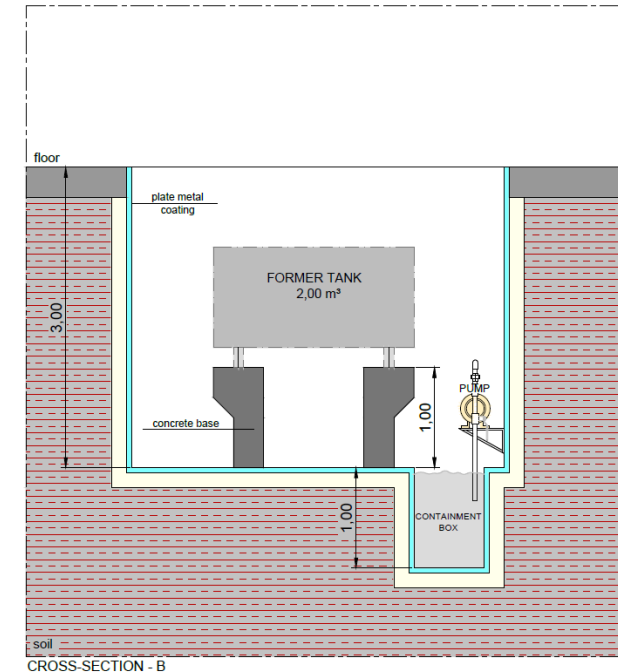
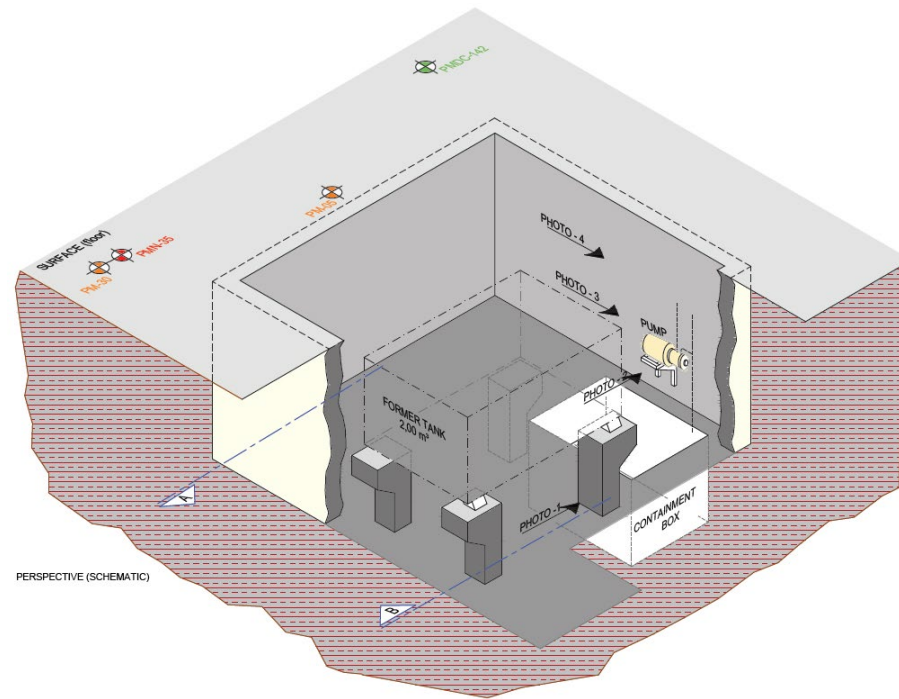
PHOTO-2



PHOTO-3



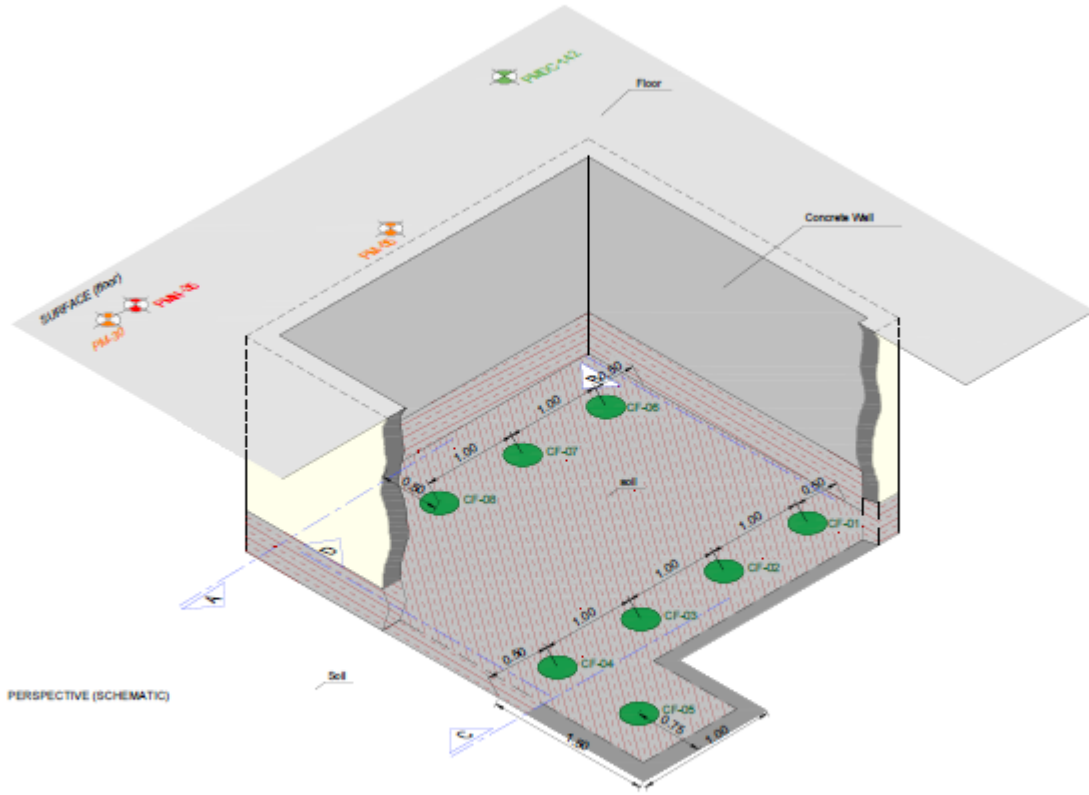
PHOTO-4



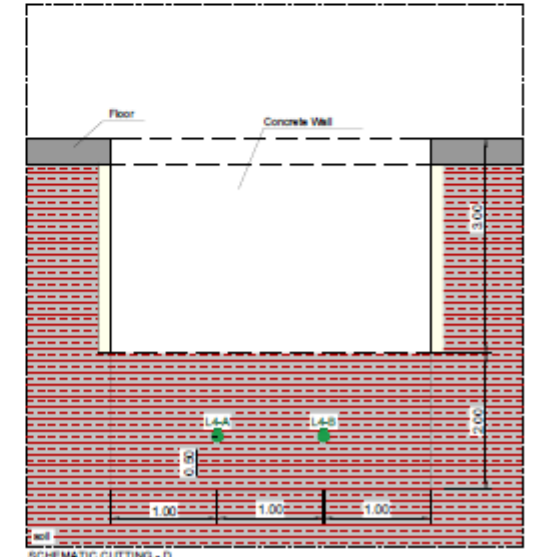
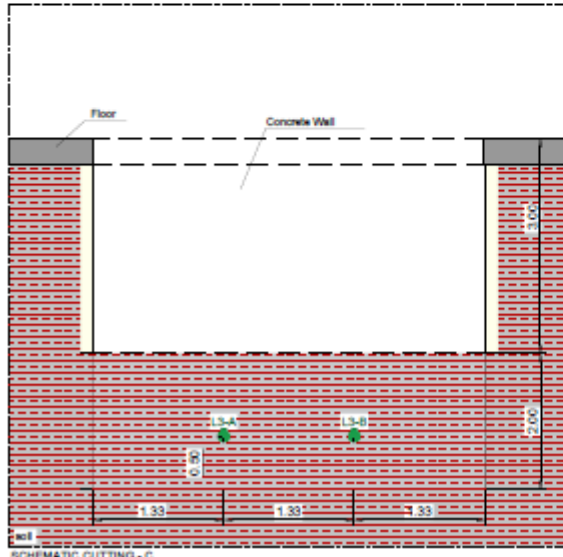
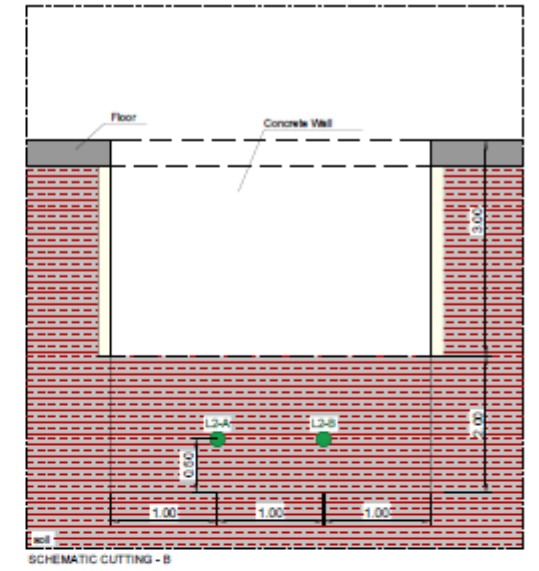
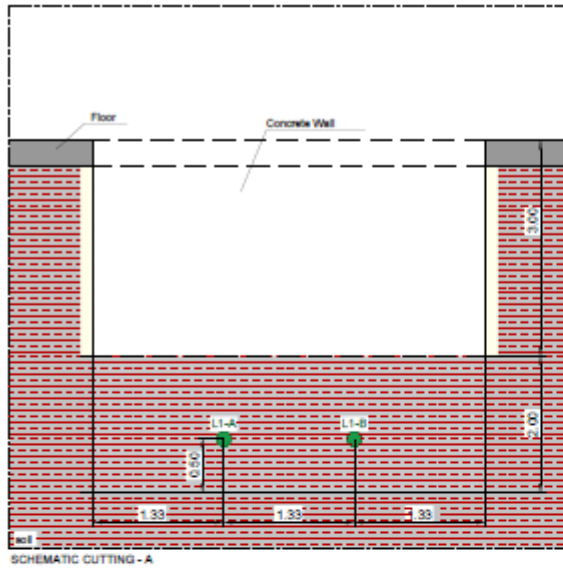
Almost **1200 Liters of product** (>99% PCE)
found in between 2 floors and removed

EXCAVATION AND COLLECTION OF SOIL SAMPLES

Manual excavation to maximum extent feasible: from 3 to 5 mbgs.



Average PCE concentration of **3632 mg/kg** at bottom of pit.



ISCO APPLICATION IN THE UNSATURATED ZONE

- Sodium persulfate with activation by chelated iron (Fe EDTA);
- Soil Oxidant Demand (SOD) calculated as sum of Natural Oxidant Demand (NOD) and stoichiometric demand of PCE: 10.9 g/kg;
- Falling head infiltration test at bottom of pit to estimate infiltration rate;
- Gravity injection of 64 m³ (8 m³/d) of oxidant solution in bottom of pit in 2 infiltration events with 3 weeks interval;
- Alternating batches of persulfate (total of 4500kg) and chelated iron (total of 200kg).



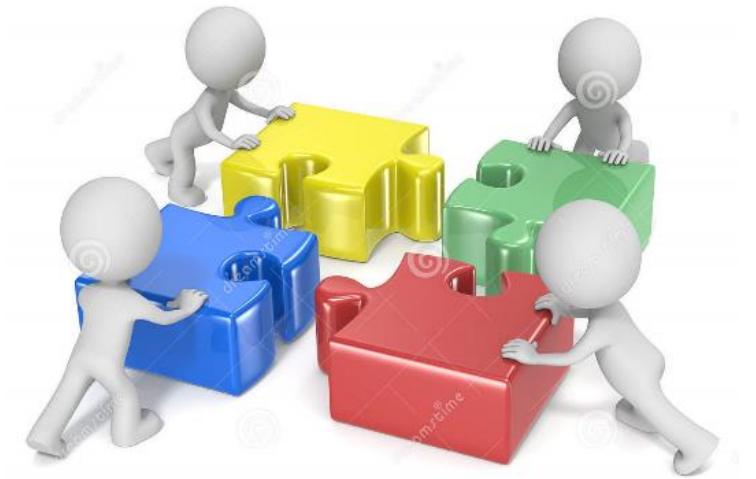
RESULTS AND NEXT STEPS

- Groundwater monitoring in surrounding wells did not show increase of water levels: **no risk of plume spreading**.
- Soil sampling in bottom and sides of pit after ISCO application showed typical **reductions in PCE concentrations exceeding 95%**, demonstrating effectiveness.
- Next step: ISCO application with **nano-bubbles of ozone and persulfate** in the unsaturated and saturated zones.



LESSONS LEARNED

- Sometimes **remediation and investigation** need to run **in parallel**;
- “Not possible” may become possible: focus on **inventive** solutions, comprehensive **H&S** measures and specialized **subcontractors**;
- **Field work during the COVID-19** pandemic required clear procedures and strong communication with client and subcontractors;
- One single remediation technique does not solve complex problems: **treatment train**.



THANK YOU

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