

Exploration and development of a large, 300-meter-deep ATEs (Aquifer Thermal Energy Storage) in gravel deposits in a Quaternary glacial channel at Zurich Airport

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Manager Aadorf

Experts for energy and mineral resources from the earth – we dig it.

Geo Explorers develops the responsible, sustainable exploration, use and management of underground resources.

Geology – Groundwater – Geothermal Energy – Geophysics – Development – Planning – Construction Supervision – Measurement Techniques – Analysis

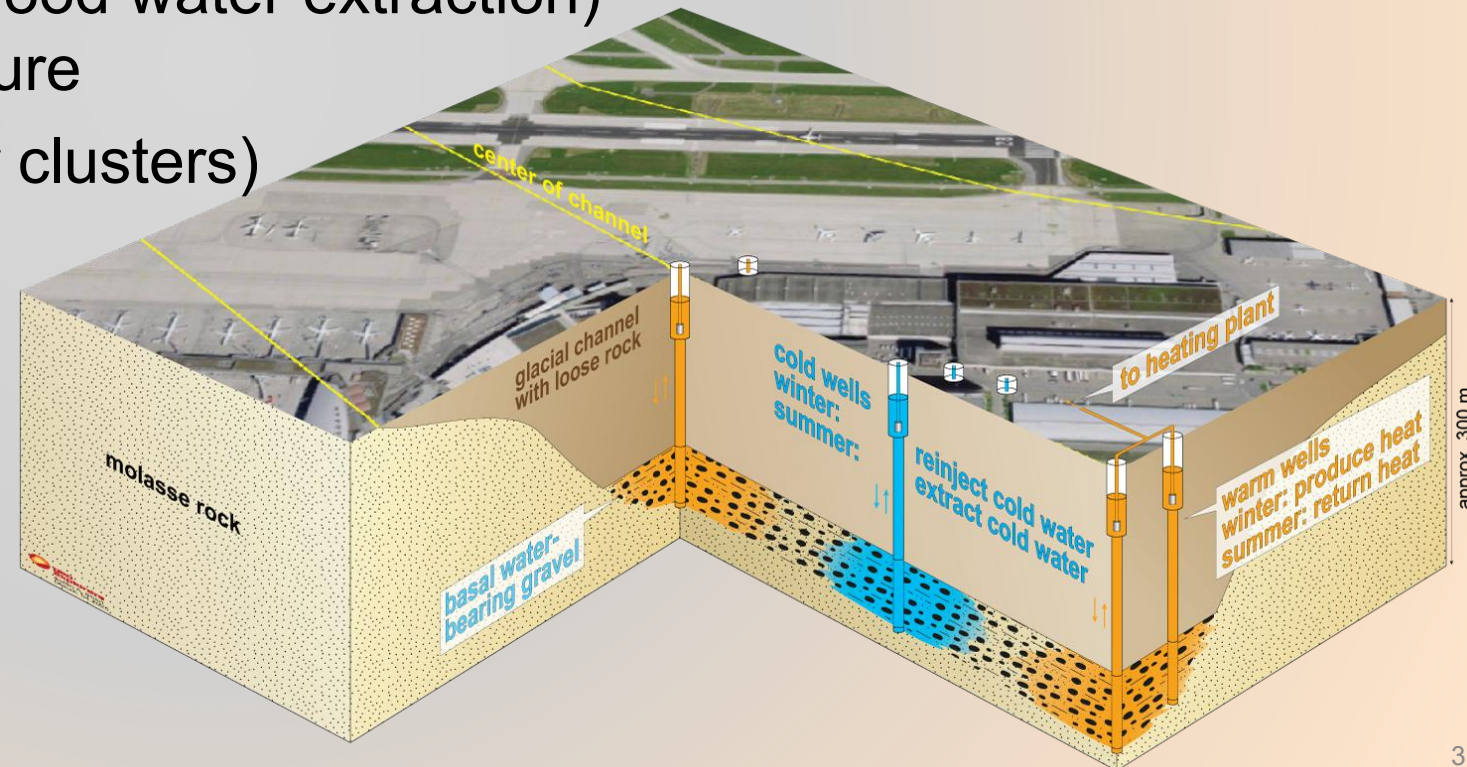
Outline

- Quick overview of what ATES (specific to Zurich Airport) is
- Development of an ATES at Zurich Airport
 - Phase 1: geophysical exploration
 - Phase 2: sounding boreholes
 - Phase 3 & 4: test wells and testing
 - Phase 5: site development
- Conclusions

Aquifer Thermal Energy Storage (ATES)

- Open, natural storage system (as opposed to previously discussed closed systems)
- Requires favourable hydrogeological settings:
 - Permeable, water-bearing layer capped by impermeable layer
 - Low- to no-flow conditions within aquifer (= reservoir) → low hydraulic gradient
 - High hydraulic conductivity (good water extraction)
 - Sufficient volume & temperature
- Use of several wells (doublets or clusters)
- Bidirectional energy exchange
 - Storage of heat in summer
 - Extraction of heat in winter

→ Exploration is essential!



Development of an ATES at Zurich Airport

Phase 0
studies,
budget
2011, 2019-
2022

Phase 1
geophysical exploration
2022 / 2023



Phase 2
3x sounding boreholes
2023



Phase 3
test well P6-1
2024



Phase 4
test well P18-1 (doublet)
2025



Phase 5
site development
since 2025/2026

✓ Exit

✓ Exit

✓ Exit

✓ Exit

exploration with risk capital

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Exit



Exit



Exit



Exit

exploration with risk capital

Phase 1

geophysical exploration

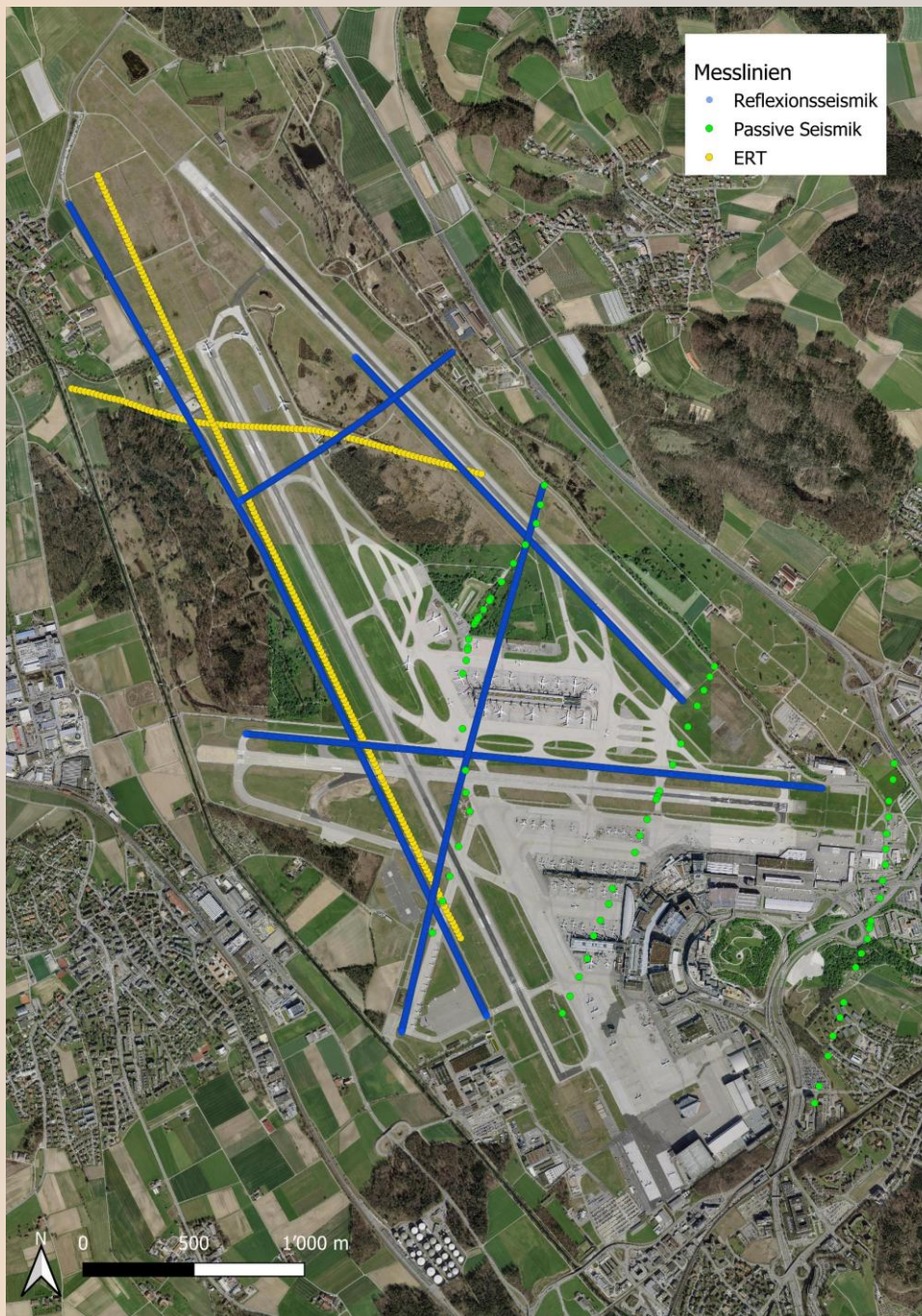
2022 / 2023



Goals:

- Channel location
- Channel geometry
- Channel depth
- Channel composition

- Placement of sounding boreholes
- borehole depth



Phase 1

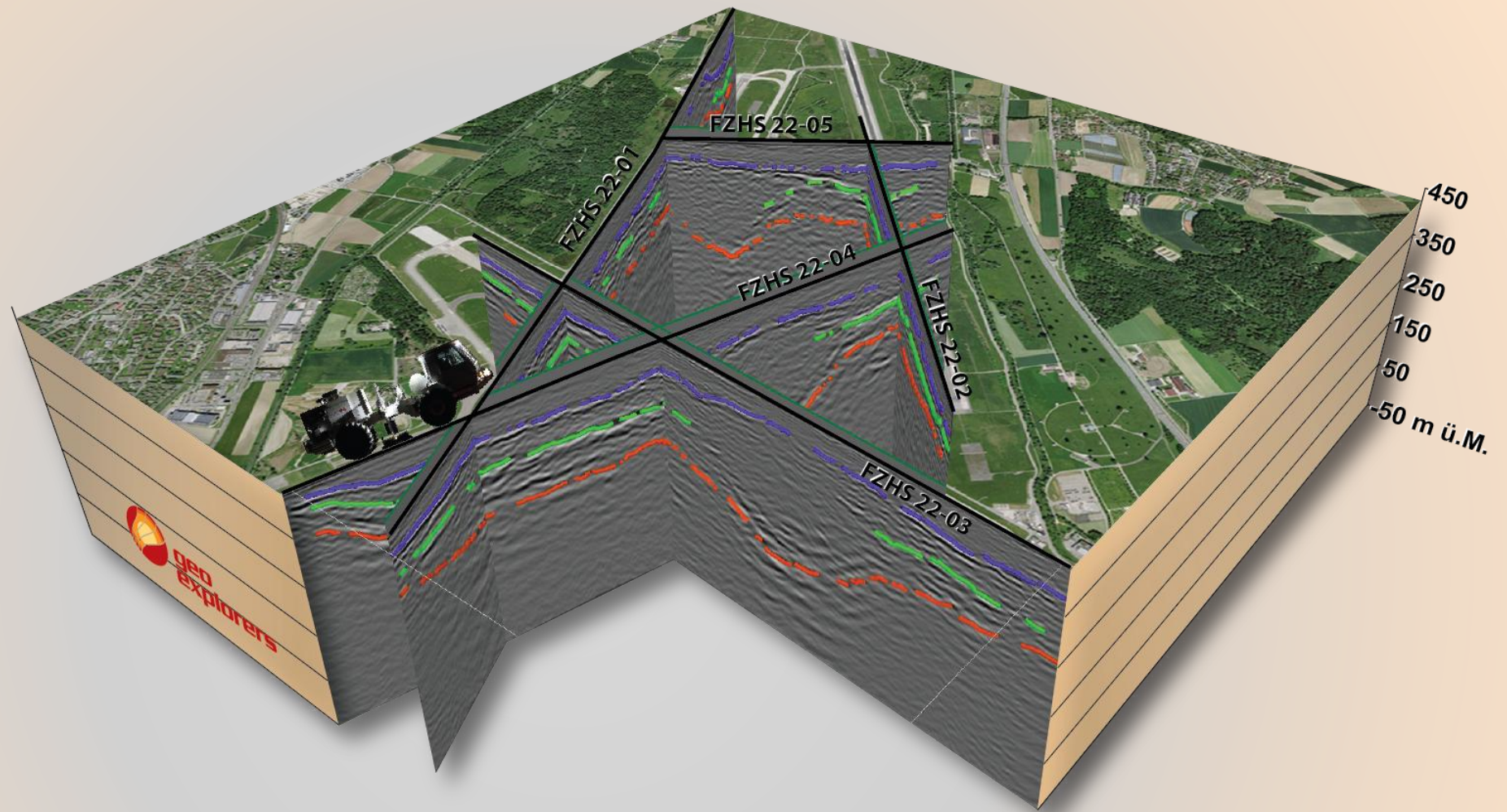
geophysical exploration
2022 / 2023



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Findings:

- Channel is deeper (about 300 m) and wider than assumed
- Channel fans out into two channels in the North
- Indications of gravel deposits at base of the middle of the channel

✓ Exit

Phase 1

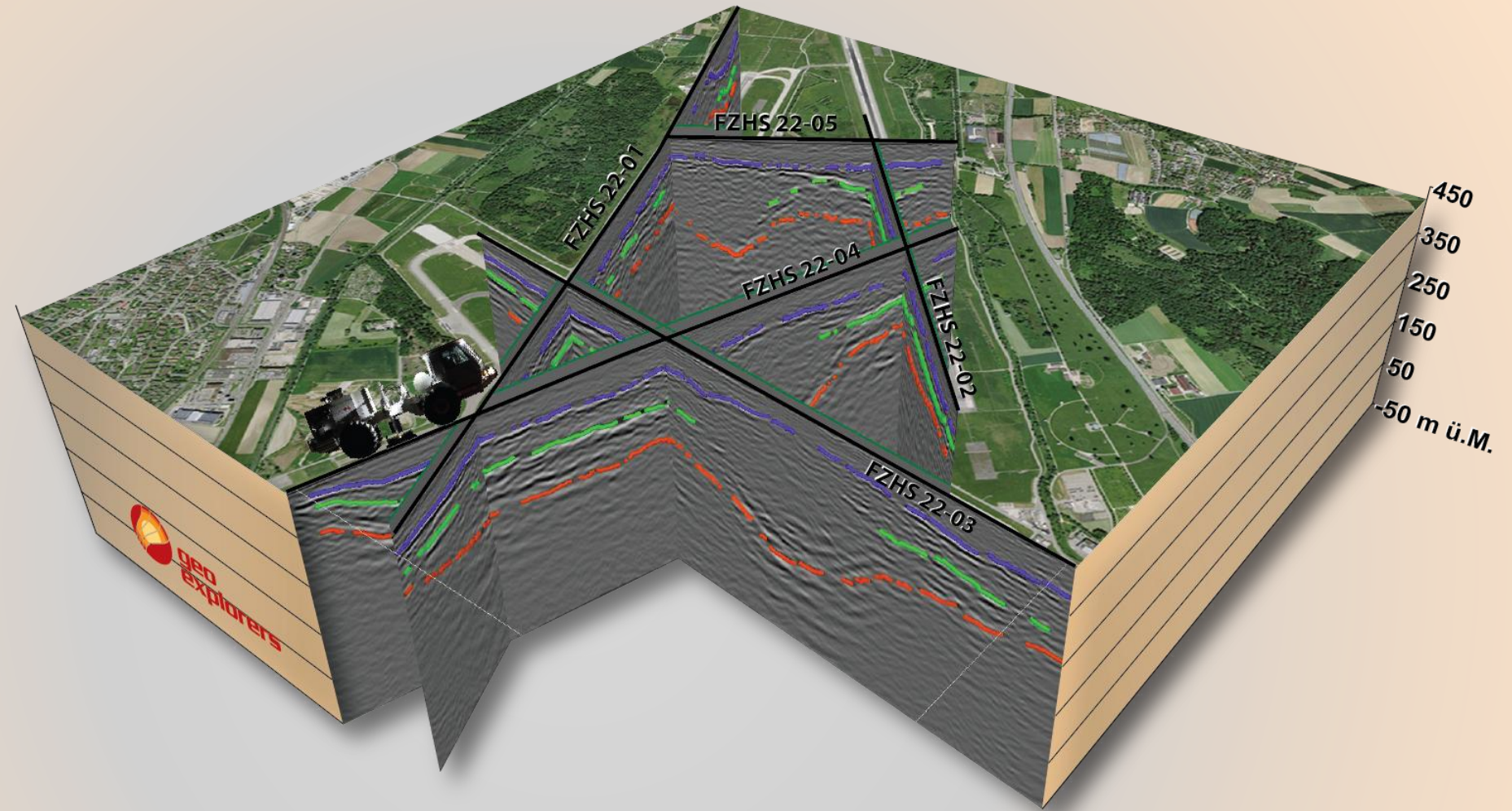
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Phase 2

3x sounding boreholes
2023

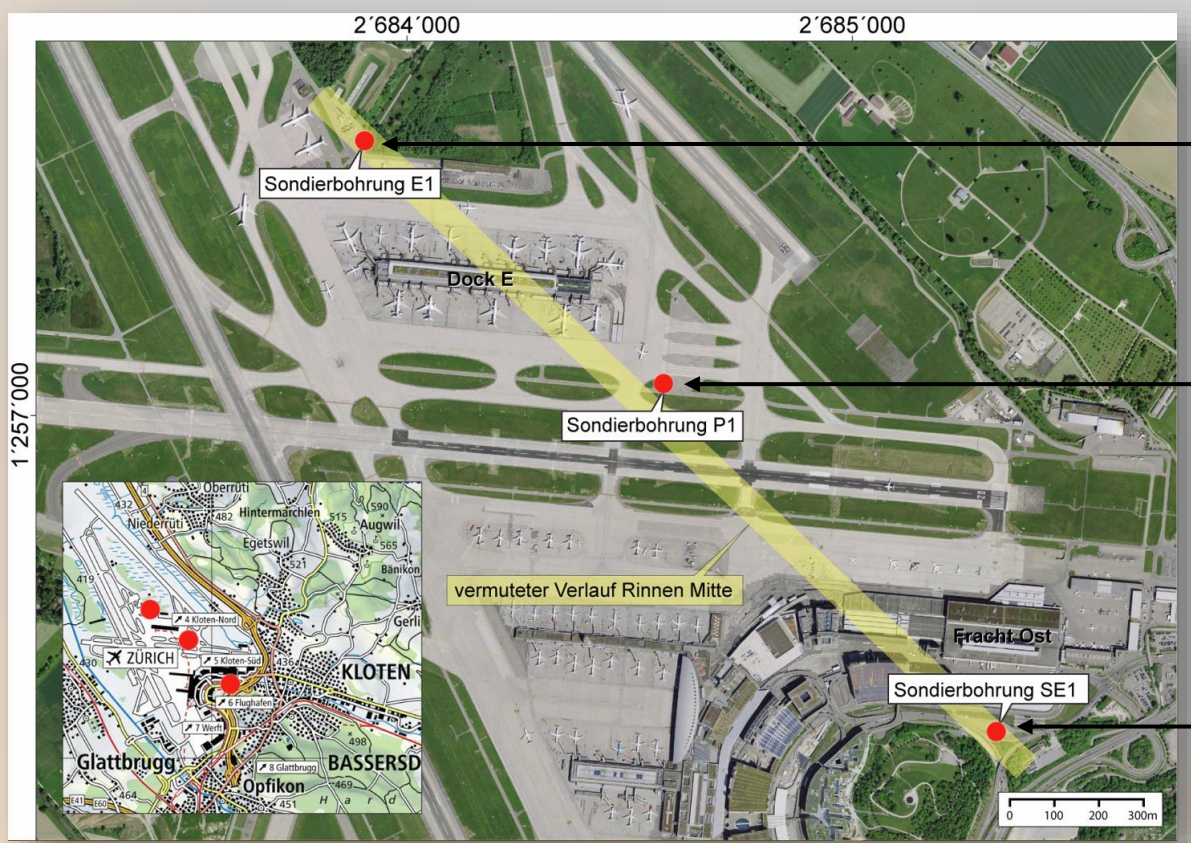


- Goals:**
- Proof of permeable gravels at base
 - Lithological structure

- Best placement of test well
- Planning criteria for test well

- Inexpensive & fast drilling techniques (destructive)
- Logging (gamma, resistivity, temperature, salinity)
- Recharge test

→ Used as monitoring boreholes with piezometers installed



Phase 2

3x sounding boreholes
2023



Goals:

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Findings:

- Proof of permeable, water-bearing gravels (42-56 m thick)
- hydraulic gradient of 0.2 m/km
- groundwater temperature of ~20 °C



Exit

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3x sounding boreholes
2023



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Phase 3

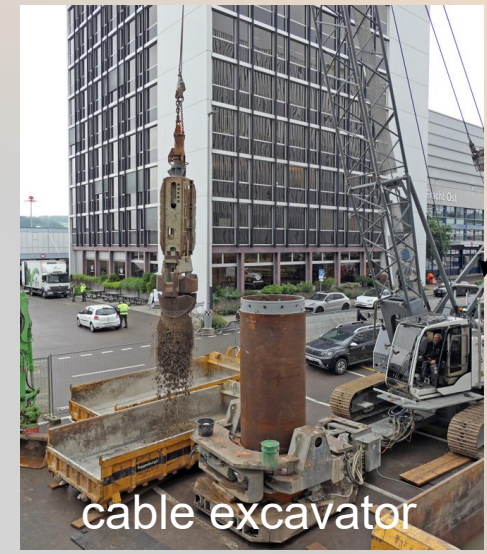
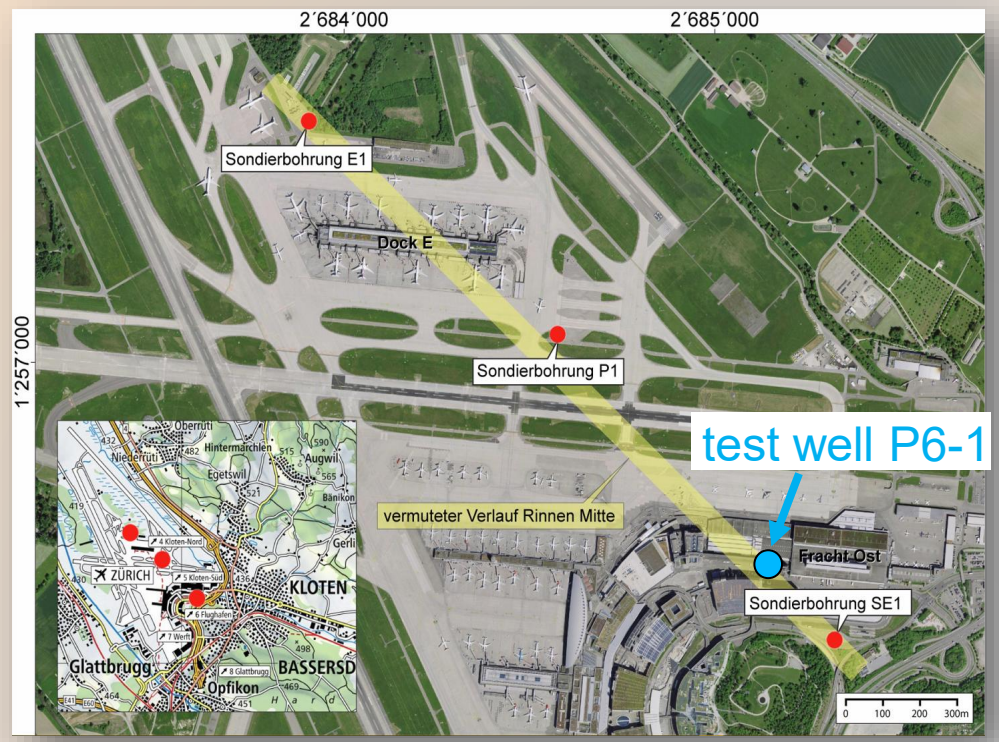
test well P6-1
2024



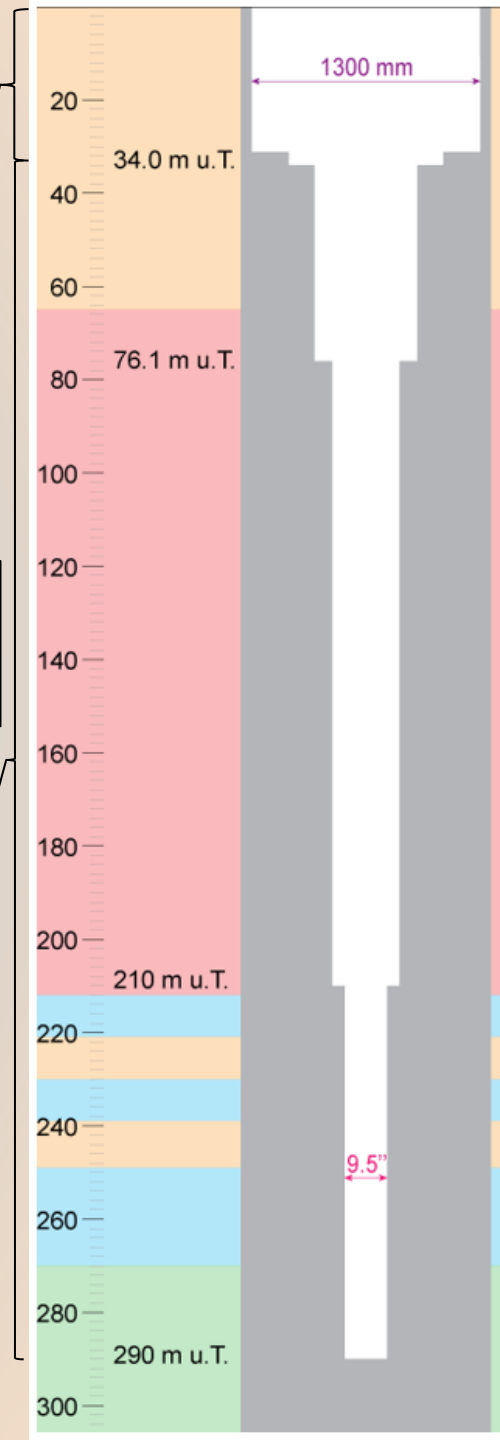
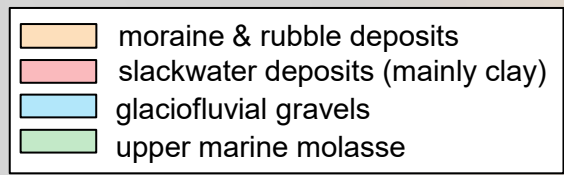
Goals:

- Pumping test: well capacity, yield
- Aquifer characteristics
- Hydrogeological model with simulations

→ Placement of test well no. 2



cable excavator



Findings:

- A total of 42 m of reasonably clean gravels
- Loss of drilling fluid
- Approx. 20 °C warm water can be produced at >3000 l/min
- Getting well sand free takes time → 3x cleaning necessary
- During pumping test: continuous drawdown of water level (>2 m in over 1 km distance) → very slow recovery, negative for drinking water use, very positive for energy storage!



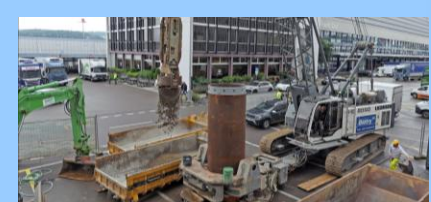
rotary bit drilling

✓ Exit

Phase 3

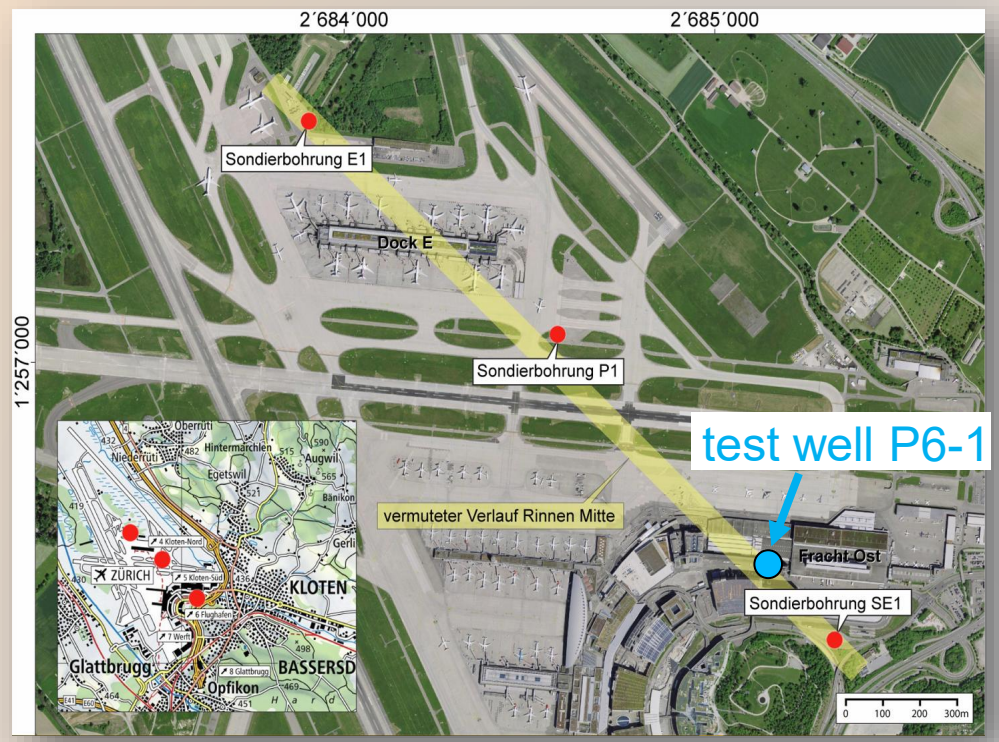
test well P6-1

2024



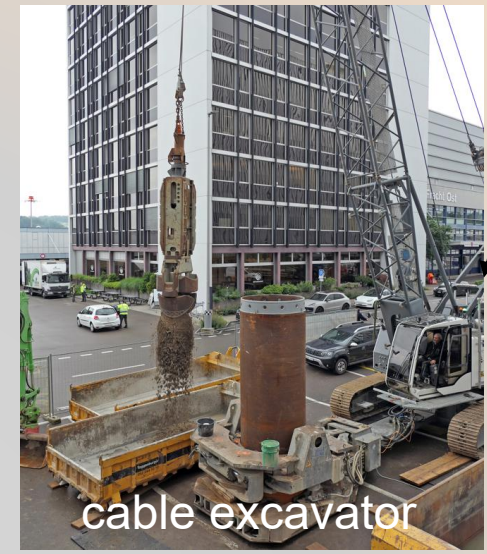
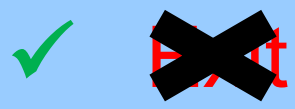
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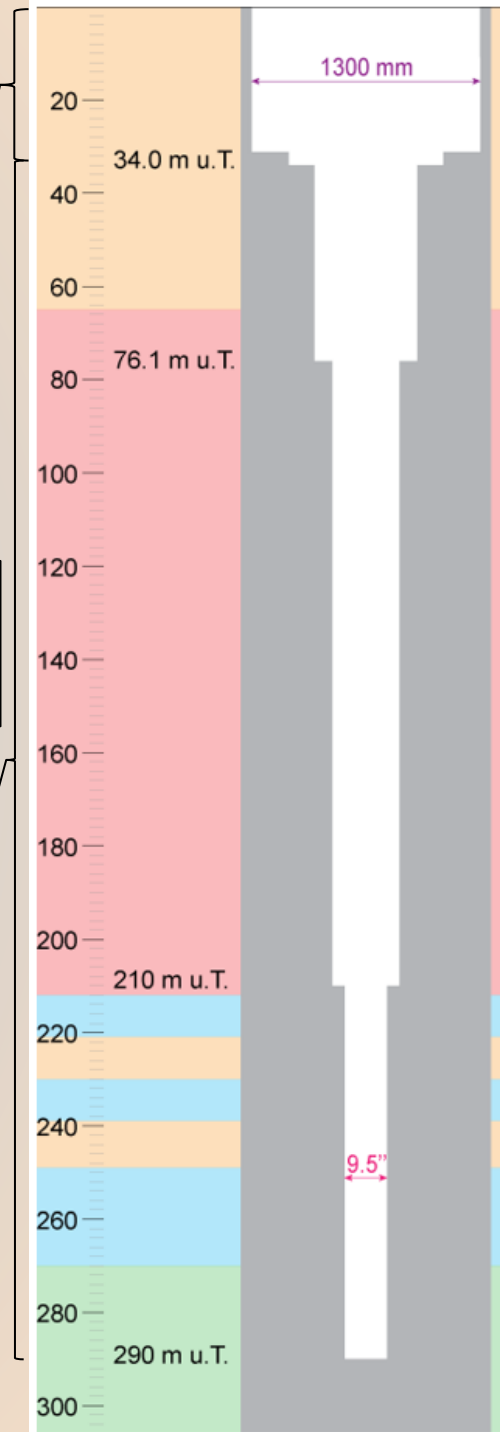


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- moraine & rubble deposits
- slackwater deposits (mainly clay)
- glaciofluvial gravels
- upper marine molasse



Phase 4

test well P18-1 (doublet)
2025



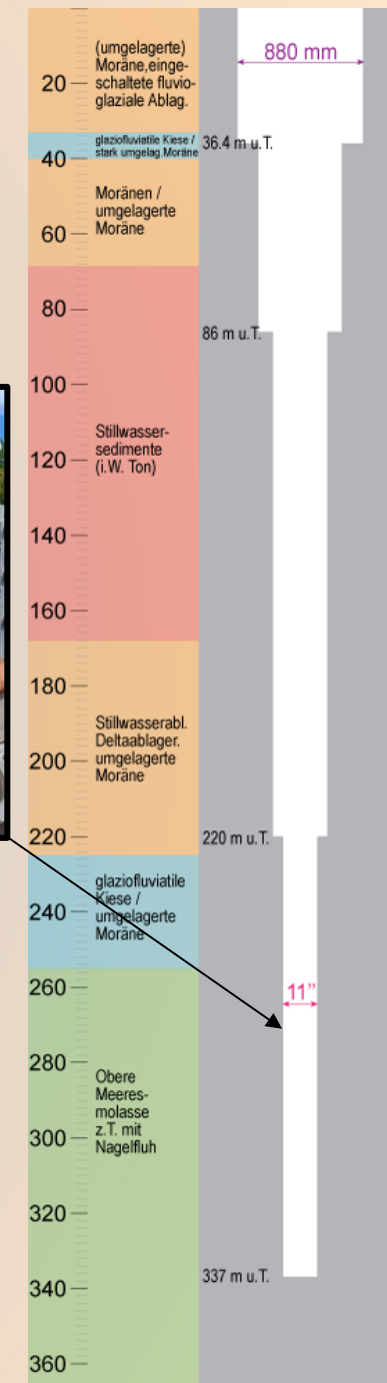
Goals:

- Development of doublet
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- Simulations

- Placement of further wells (doublets or cluster)
- Management concept



stainless steel
slotted bridge filter



Phase 4

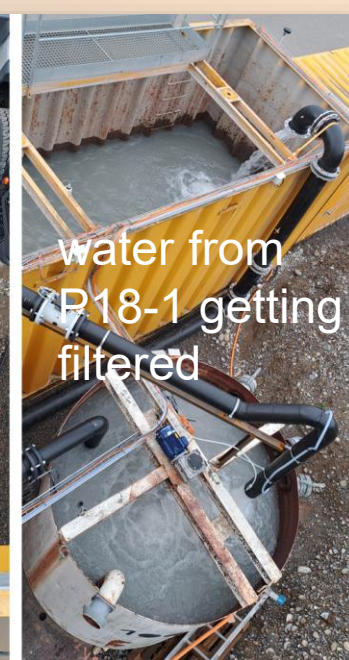
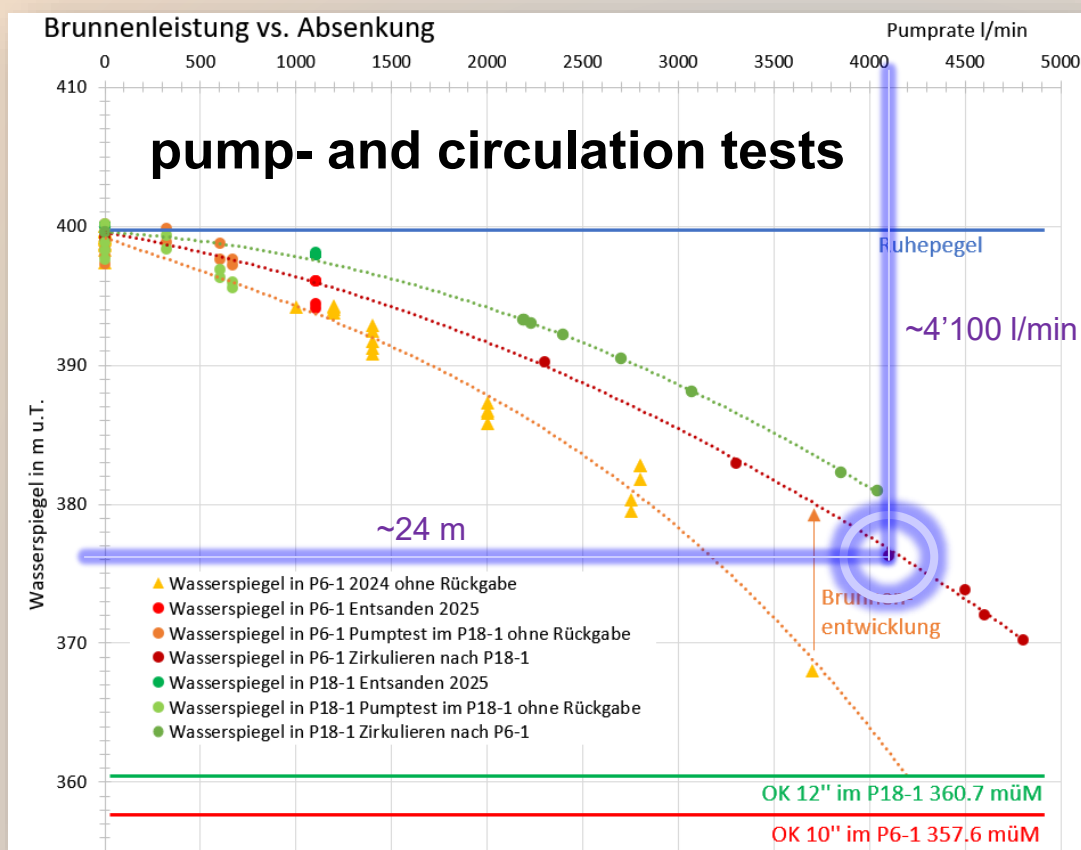
test well P18-1 (doublet) 2025



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- After pumping stop, water levels recover immediately
- Base groundwater level doesn't change → balance preserved
- Filter system is required due to sand content & drilling mud
- Pressure problems with pumps → will likely be solved with a fixed pipe without intermediary pumps
- Proof that >4000 l/min possible



Phase 4

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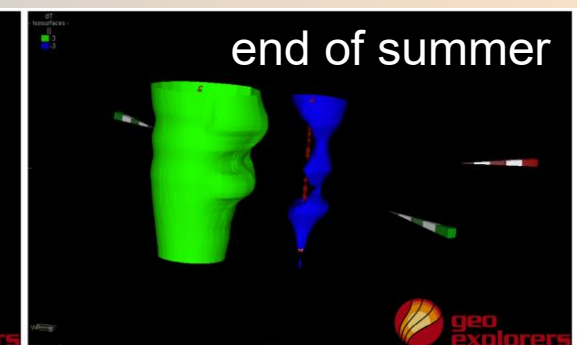
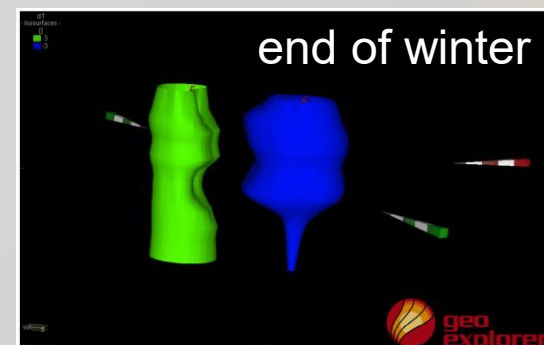
Exit

Further tests carried out:

- Tracer test → thermal short circuit
- Geochemistry → age, mineralisation, oxygen
- DNA samples → microfauna → 3K-rule

Conclusions from simulations:

- A total of six wells allow for approx. 15 GWh/a of energy storage
- To achieve this 2200 l/min of groundwater is needed to be pumped as a weekly average
- The 3K-rule can be complied with (= no more than 3 °C of warming or cooling in 100 m distance from an injection well currently allowed)



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2025



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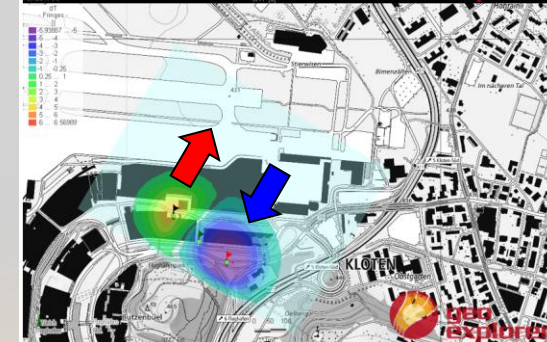
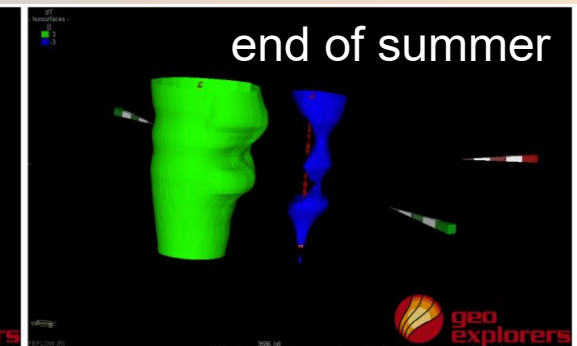
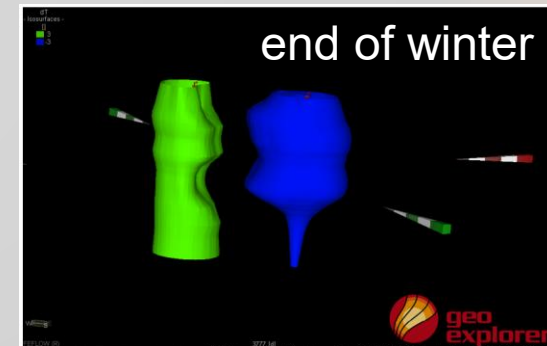


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Phase 5

site development
since 2025/2026

Goals:

- Concession application
 - Site development with line construction
 - Construction of power station
- Operation and monitoring

What's next?

- Installation of fixed pipe between wells P6-1 and P18-1 and second circulation testing.
- Discussion and evaluation of the next steps of development:
 - Placement and sequence of the following wells
 - Optimisations on management- and monitoring concepts



Water's flowing at 4500 l/min

Conclusions

- What started as a one-of-a-kind pilot project idea has successfully run through all phases of exploration and will now be developed to a full-scale aquifer thermal energy storage (ATES).
- A thorough exploration programme with a combination of geophysics and test drillings is essential for the successful placement of the wells.
- The hydrogeological conditions in the underground below Zurich Airport are favourable for energy storage and the reservoir is unrivalled by drinking water use.
- Sand-free extraction of water requires time and several cleaning rounds. The installation of a filter system is essential in production.
- Groundwater balance is important in these systems to avoid quick depletion of the reservoir. Hence, all pumped water must be returned after thermal extraction or charge.
- The water is warm and flowing 🔥 💧



By the way:

a potential of 600 GWh/a

Quaternary glacial channel underneath Zurich Airport

Unconsolidated rock thickness [m]

