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Groundwater impacts of London's new infrastructure

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GQ2019: S02c (192): Threats to groundwater resources from subsurface phenomena.

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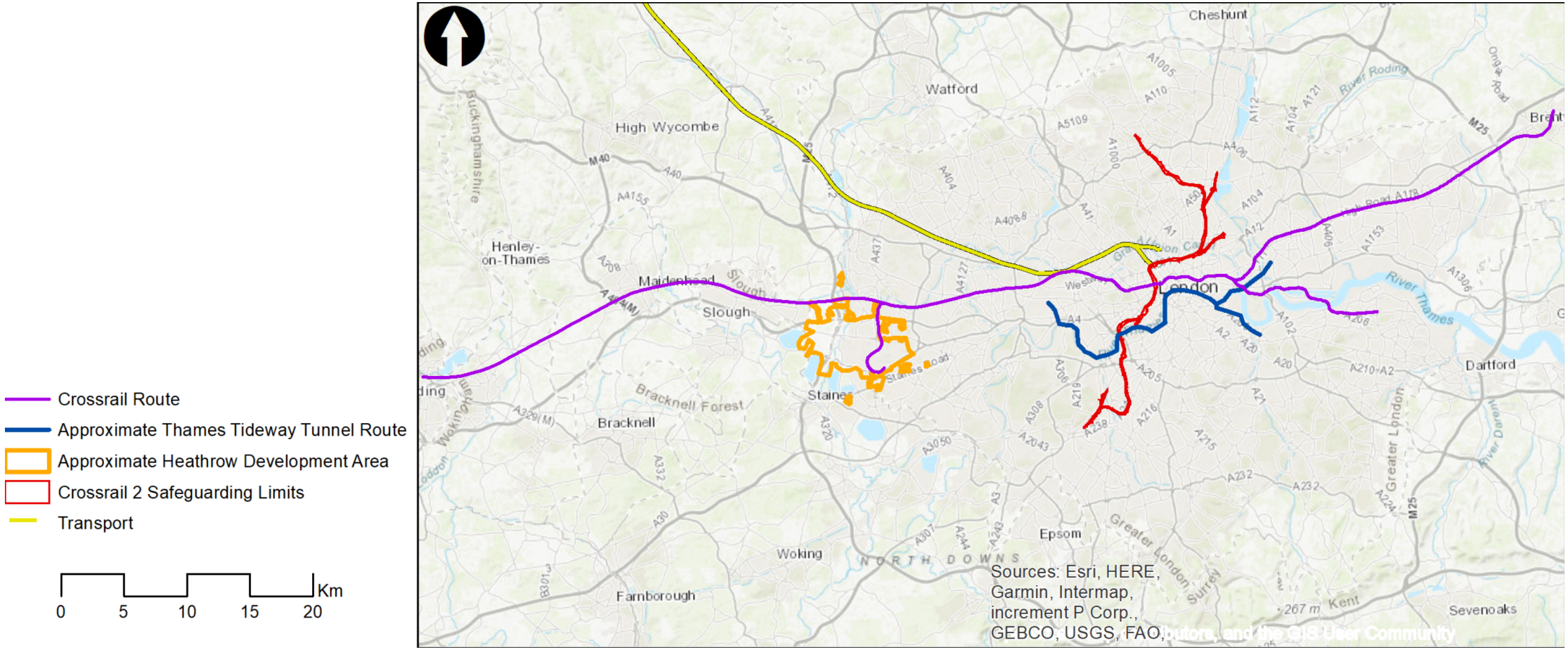
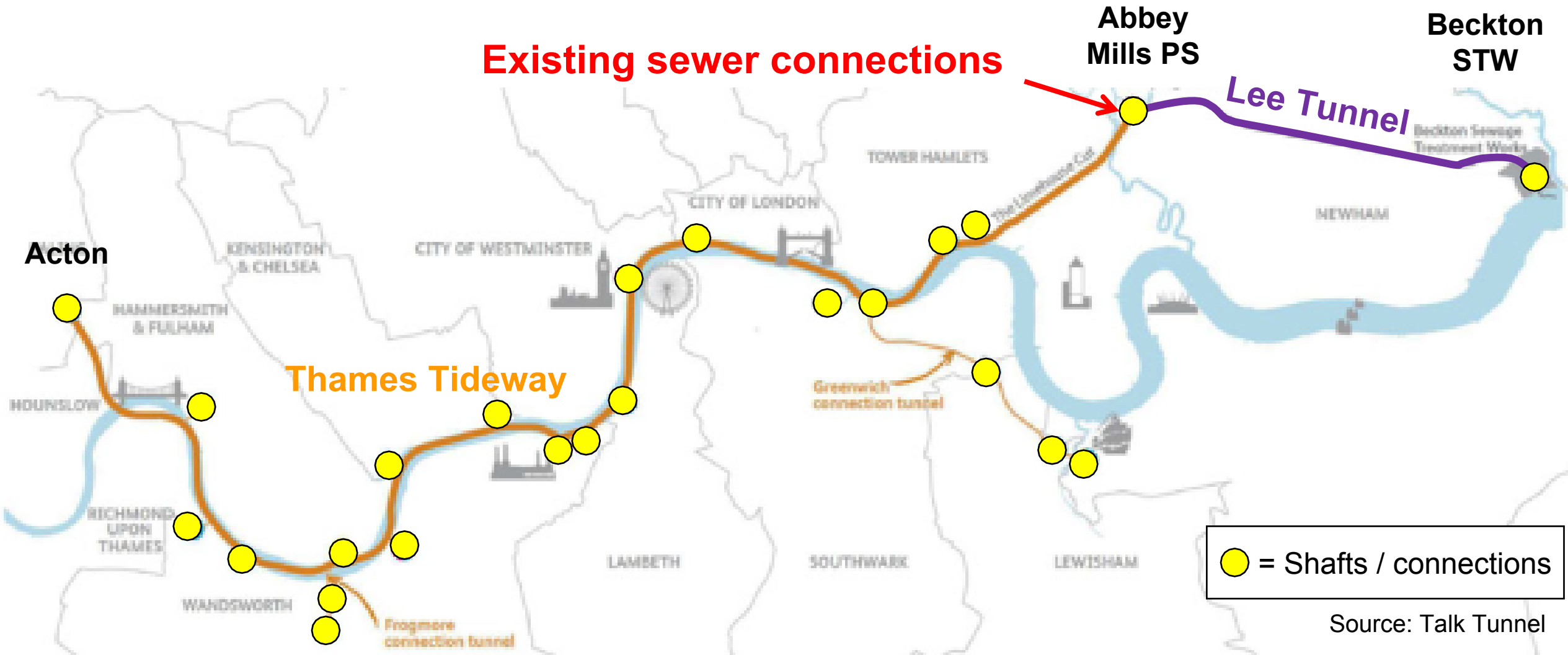
London’s subsurface major infrastructure

- London underground – 1863
  - 11 lines, 270 stations
  - 250 miles
- Crossrail (1 and 2) – approved in 2007 (completion 2020/21)
  - Crossrail 1: 73 miles, crosses east to west
  - Crossrail 2: (construction 2023) runs north to south
- Lee Tunnel (part of Tideway): super sewer
  - 4.3 miles long, East London
  - Completed Jan 2016
- Tideway: super sewer
  - 25km long (west to east)
  - Completion 2024
- HS2
  - Starts at Euston station and heads west
  - Completion 2026 (Phase 1)

London’s recent / future major infrastructure

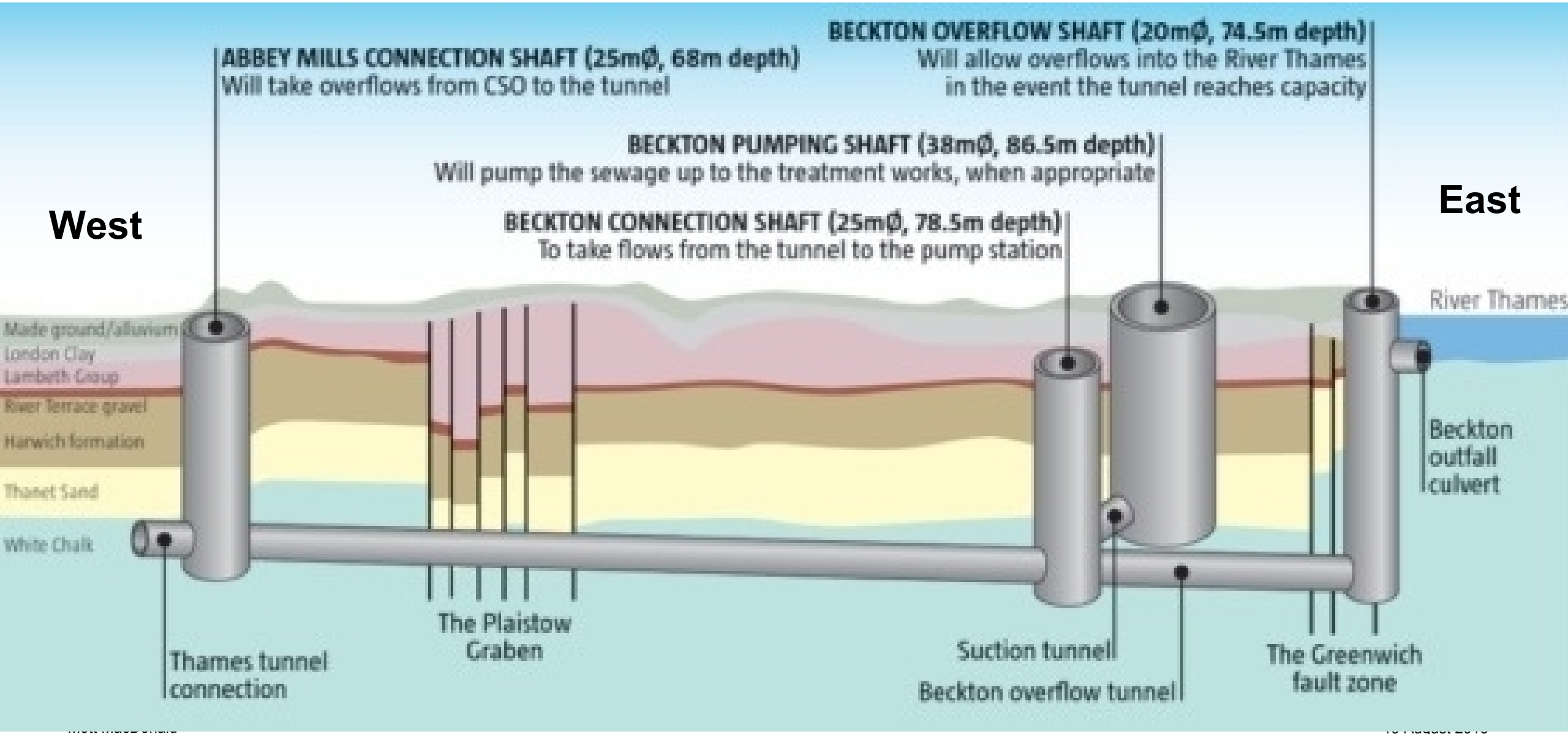


Thames Tideway and the Lee Tunnel



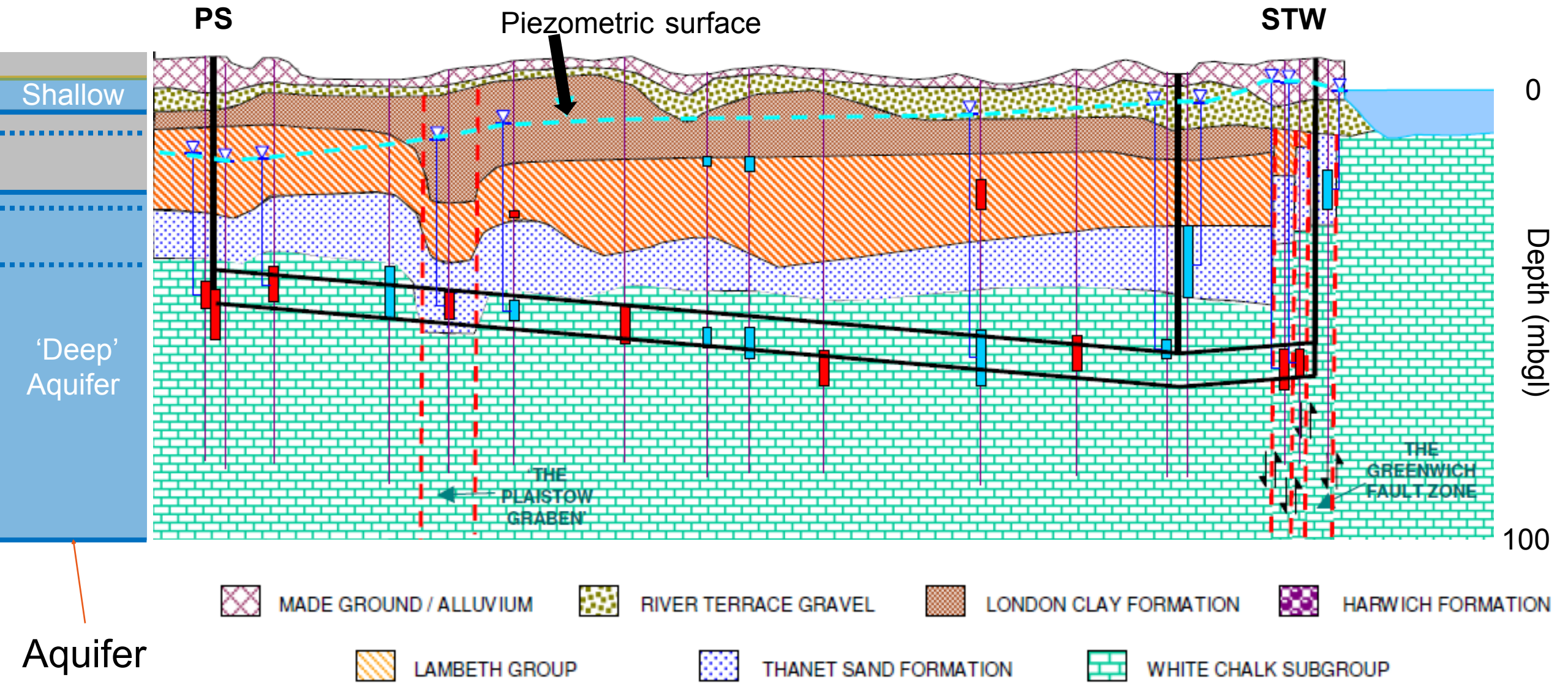
Source: Talk Tunnel

Example of Tunnels: shafts and geological features



Source: New Civil Engineer

Potentially affected aquifers



Dewatering

Lee Tunnel Groundwater monitoring network

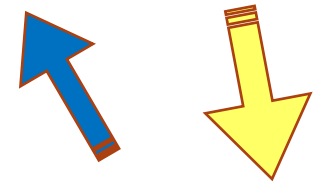
52 boreholes

- Lambeth Group
- River Terrace Gravels
- Harwich Formation
- Thanet Sand
- Chalk

- Crossrail

Groundwater flow in:

Chalk Shallow



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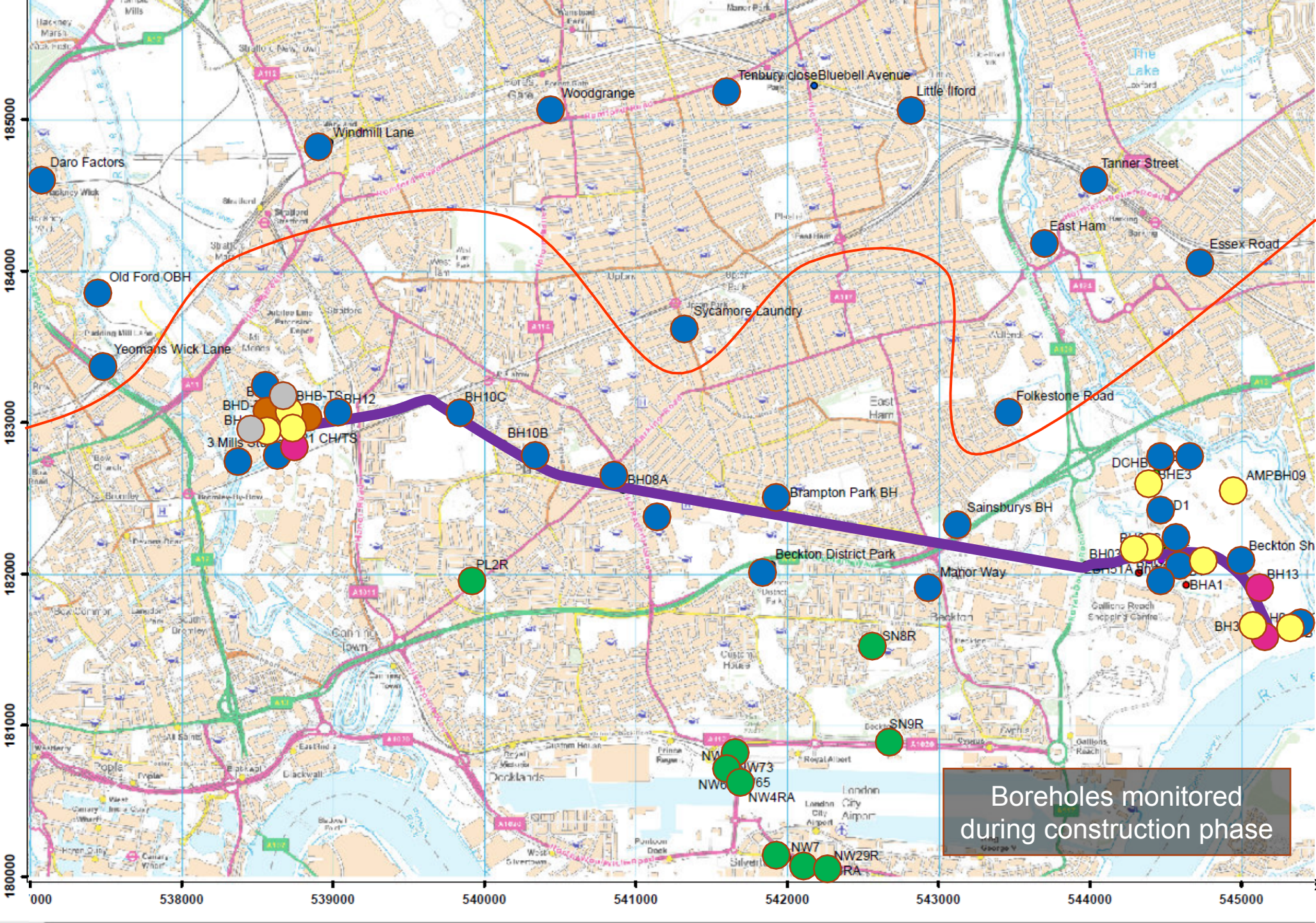


Dewatering at connection & pumping shafts - construction

1. Pumping rates: 50 – 60 l/s
2. 82m drawdown
3. Deterioration of water quality – former industrial contamination on nearby site
4. Significant monitoring / Hydrocarbon forensics

Modelling / controls

Internal dewatering

Shaft construction at pumping station

- East London
- Surrounded by residential properties
- <1ha
- Legacy contamination

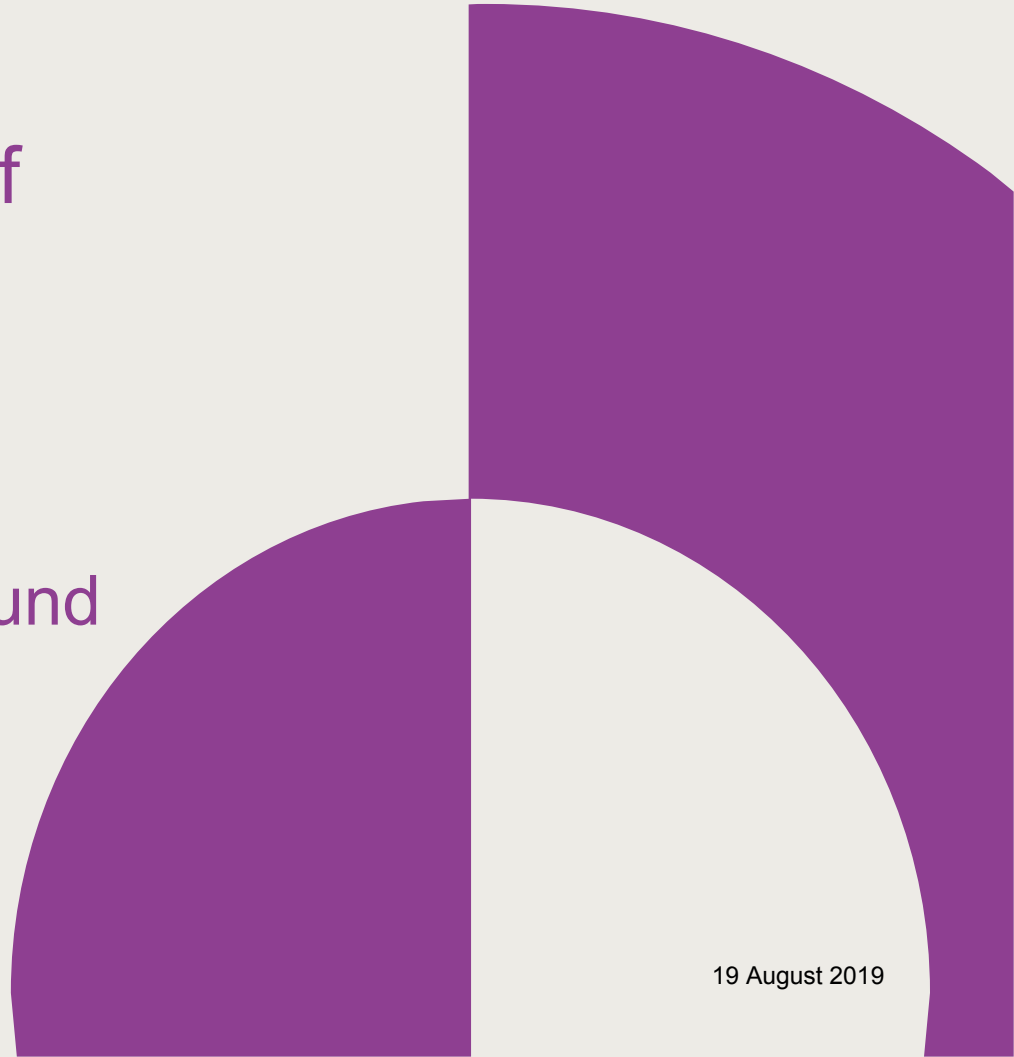
CSM

- Surrounded by former industry (tar, pitch, naphtha and creosote works

- Geology:
  - Made ground
  - RTD
  - TSF
  - CHK

Groundwater quality

- Hydrocarbons: PAH, BTEX, TPH
- High in RTD in south (down-gradient of former industrial source)
- High in TSF in NW corner, including DNAPL
  - Historical drawdown of previous below ground works



Mitigation

- RTD remediation disproportionate
- Deeper free phase in NW – reduce to as low as practicable
  - Physical removal was the preferred choice
- Shaft installation; telescoped in two rings
- Install secant piles using CFA
- Internal dewatering
- GW decontamination prior to discharge

DNAPL Recovery being undertaken

Tunnel leakage

Assessment of surcharge

- Normally operates at pressures below Chalk
- Surcharge events, P’s > Chalk (6-8 times/yr)
- Leakage into aquifer (sewage)

Assessment

NH_4 as an indicator

Baseline: 0.18 – 1.8 mg/l (average 0.75 mg/l)

Assumed cracks

0.2mm circumference cracks every 5mm

3mm circumference cracks every 30m

Receptors

50m
100m
Local abstractions
PWS

Modelling

1D modelling approach

Darcy's law (flow in Chalk aquifer)

Cubic law (discharge through cracks)

$$Q = -\frac{wh^2}{12\mu}\nabla p$$

Q = leakage through tunnel wall (m^2/s)

w = width of crack (m)

h = aperture of crack (m)

μ = *viscosity of fluid (Ns/m^2)*

p = pressure (N/m^3)

K of aquifer limits amount of leakage

T crack in tunnel >>T Chalk

Worst case

Leakage could occur but max increase would be 0.18 mg/l NH_4 50m from tunnel

WFD status

No change (poor – deteriorating)

Impacts

0.18 mg/l at 50m CP

0.0073 mg/l at private abstraction

0.0041 mg/l at PWS

Negligible

Conclusion

Final Thoughts

- Detailed monitoring

- Database GW quality / impacts to GW

- External dewatering - consider former industry / aquifer impacts (shallow and deep)

- Tighter controls on dewatering - modelling / internal dewatering / shaft construction

- Modelling of operational impacts - i.e. surcharge

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Thank you