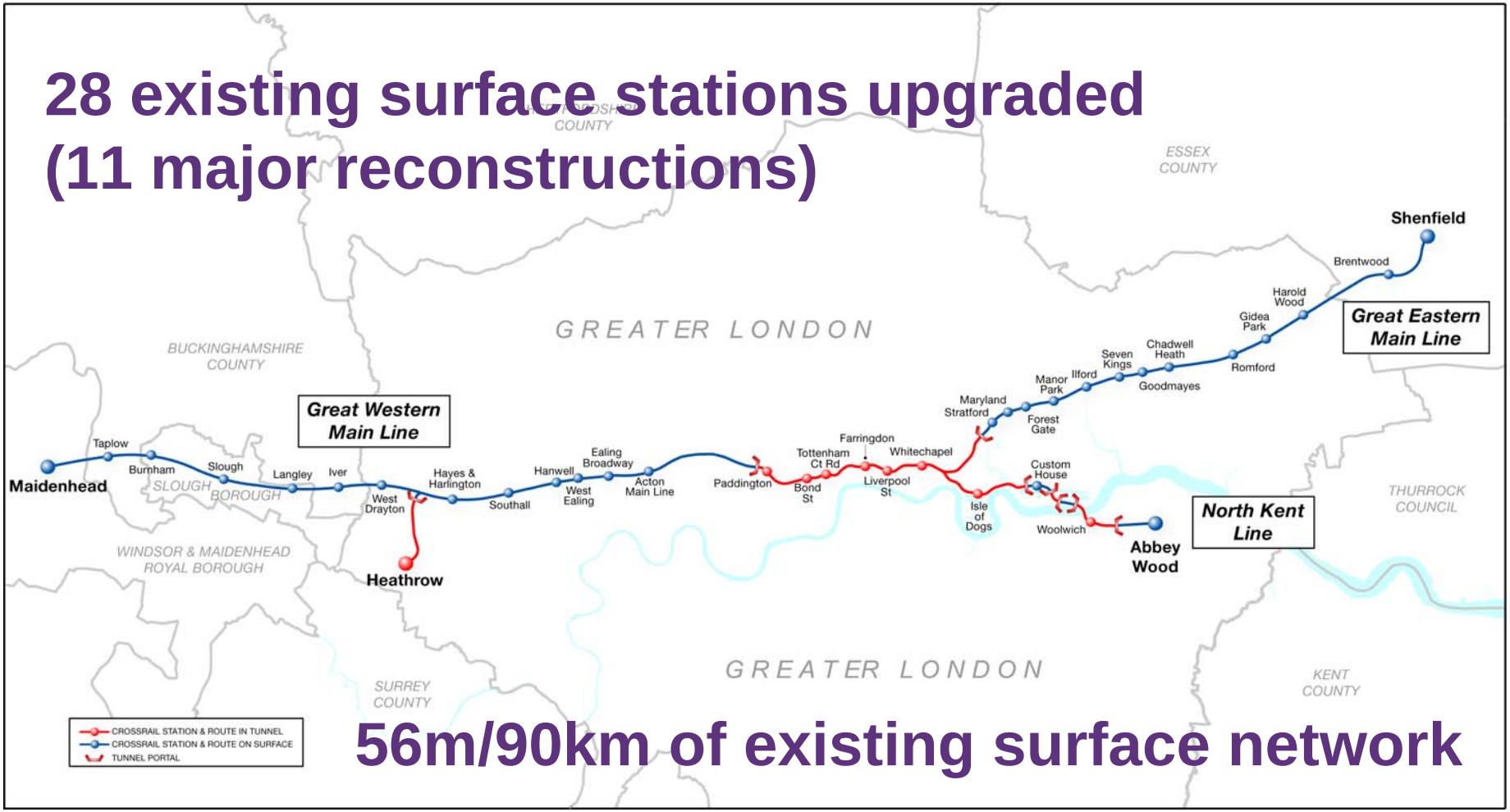
Dr Ursula Lawrence

Soft Ground Tunnelling through London

Contents

- Introduction to Crossrail
- Ground conditions
- Ground Risk
- Excavated material

Crossrail Route



Central Section

13m/21 km of new sub-surface twin-bore railway through London

9 sub-surface stations

GDP benefits of at least £36bn

National tax revenues of at least £14.8bn

Crossrail Benefits

Total outturn 'Cost of the Project' £15.9 Billion

Approximately 200 million journeys generated in first year

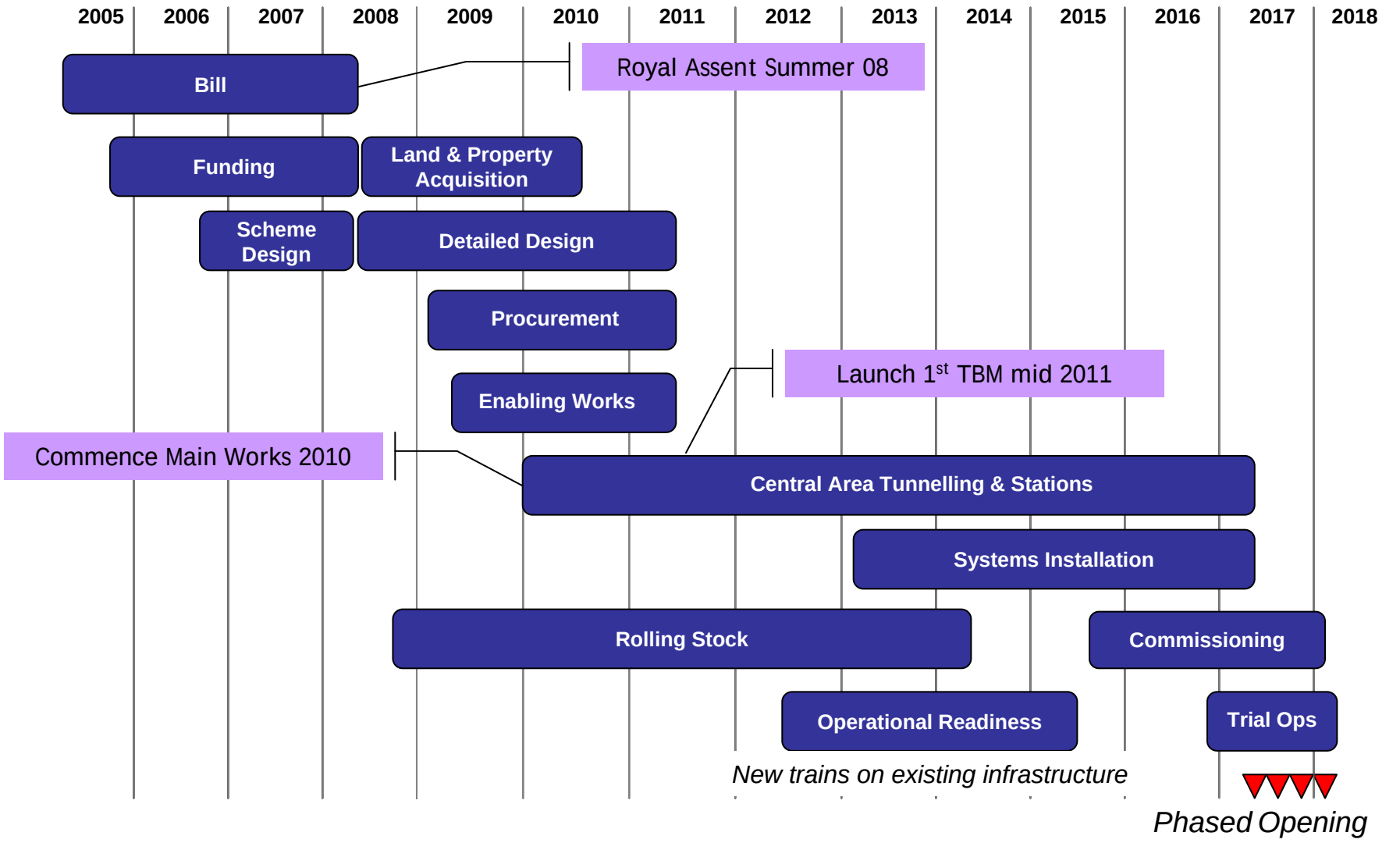
10% added to London's rail-based network capacity

Up to 14,000 people required at peak of construction

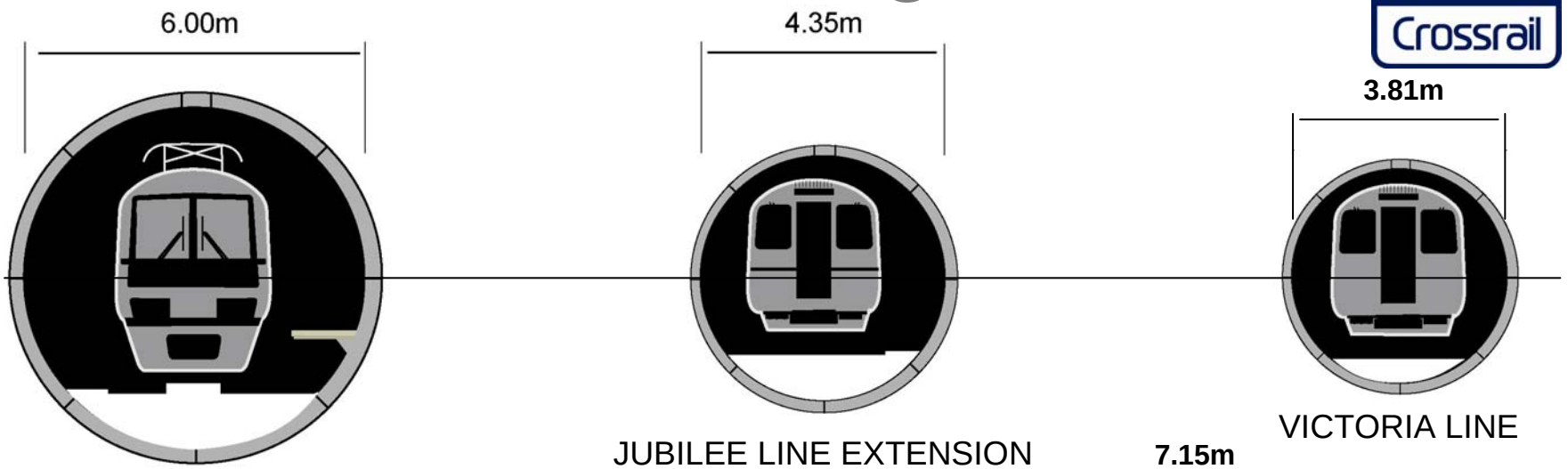
24 trains an hour in peak through central part of route

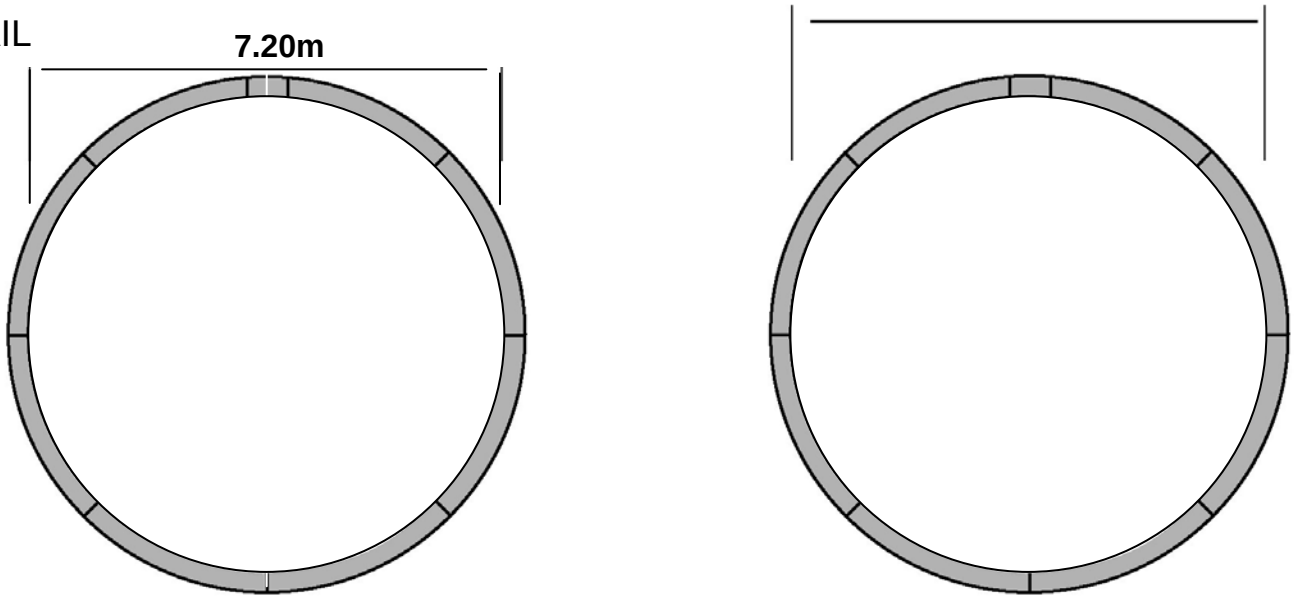
1.5 million people brought within a 60 min commute of central London

Summary Programme



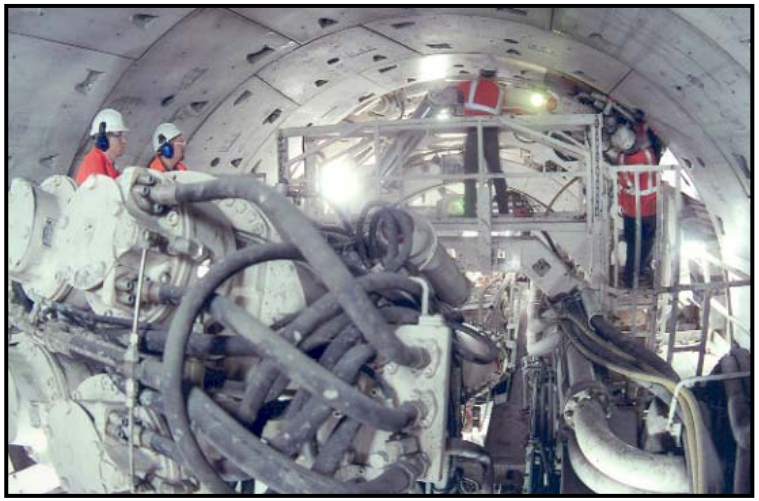
Comparative Running Tunnels





ALL DIMENSIONS REFER TO INTERNAL DIAMETER

Central Tunnels Section Tunnel Boring Machines



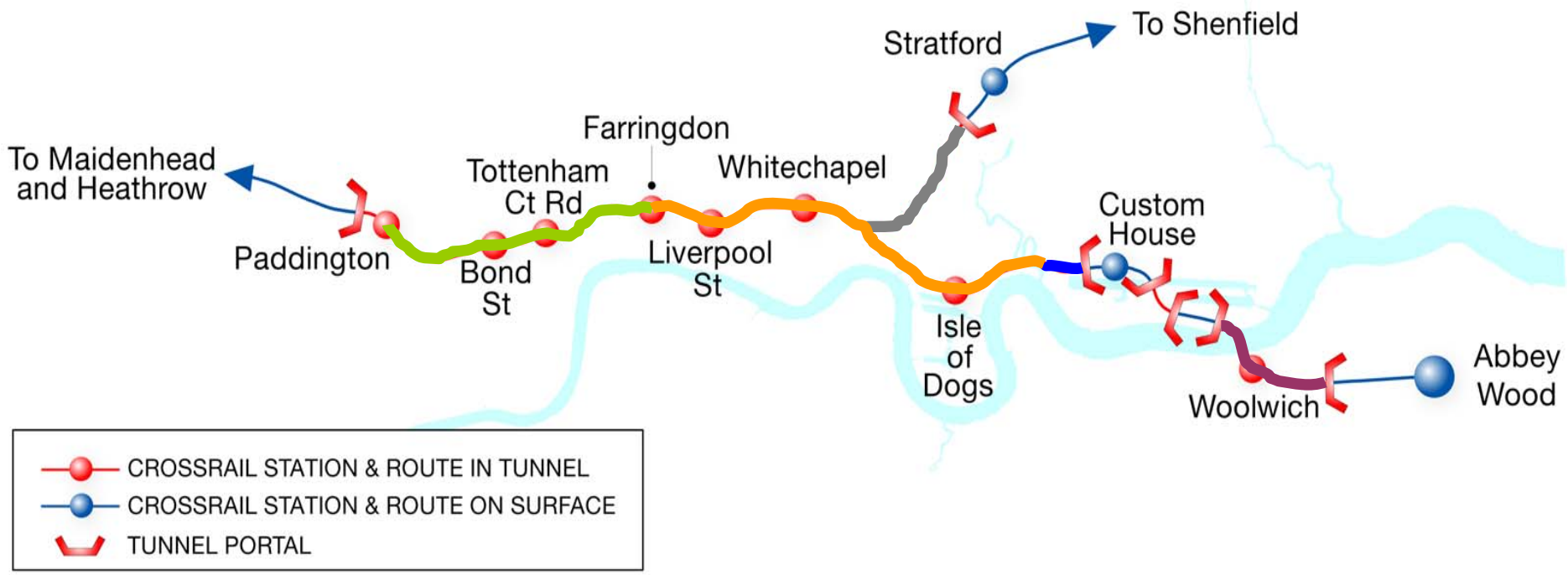
Following recent tunnelling experience in London, CLRL will utilise Earth Pressure Balance TBMs except for the Thames crossing where a Slurry machine will be employed

TBMs will be the primary source for controlling ground movements

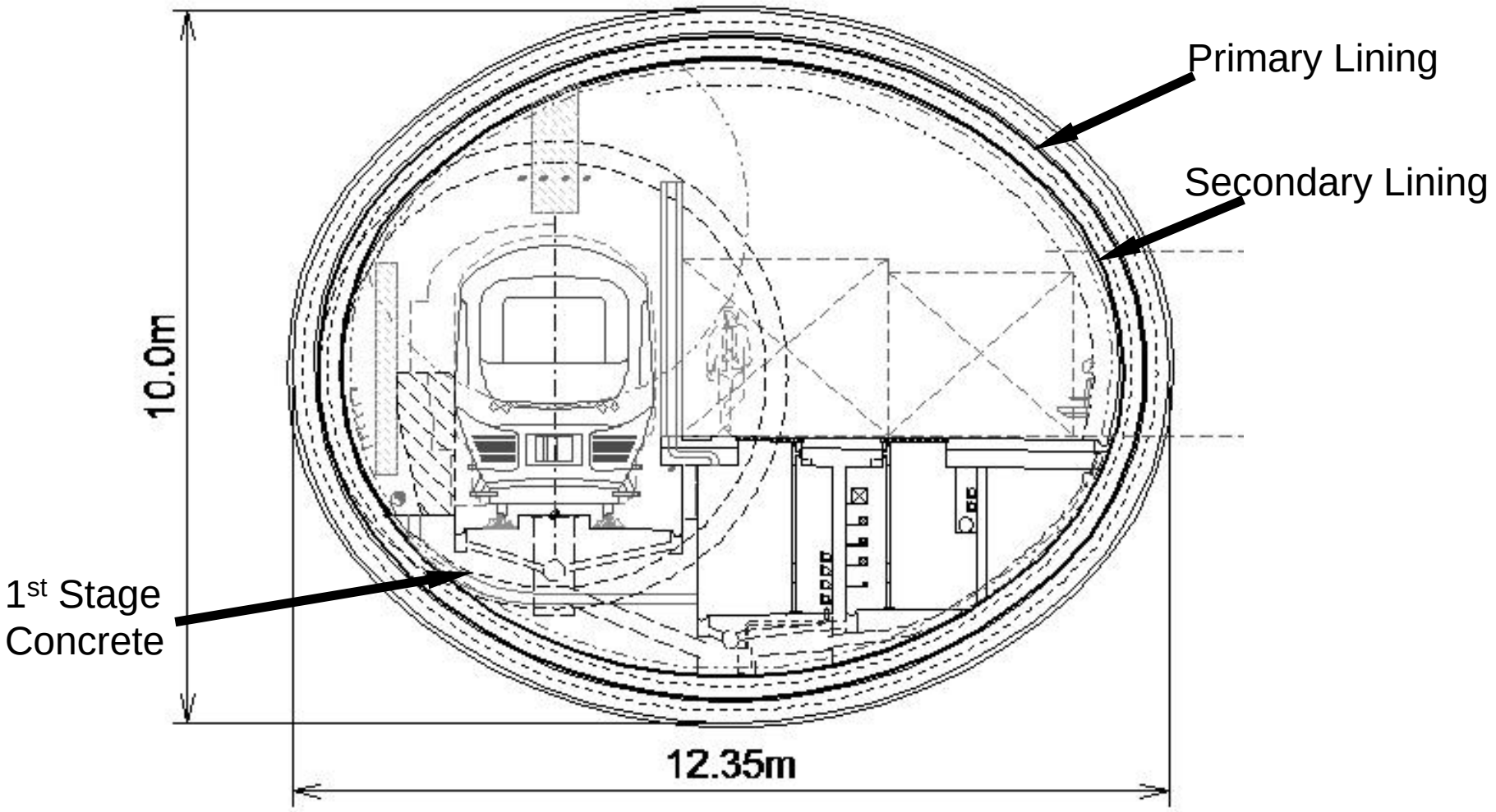
Tunnelling Strategy

Proposed TBM Drives

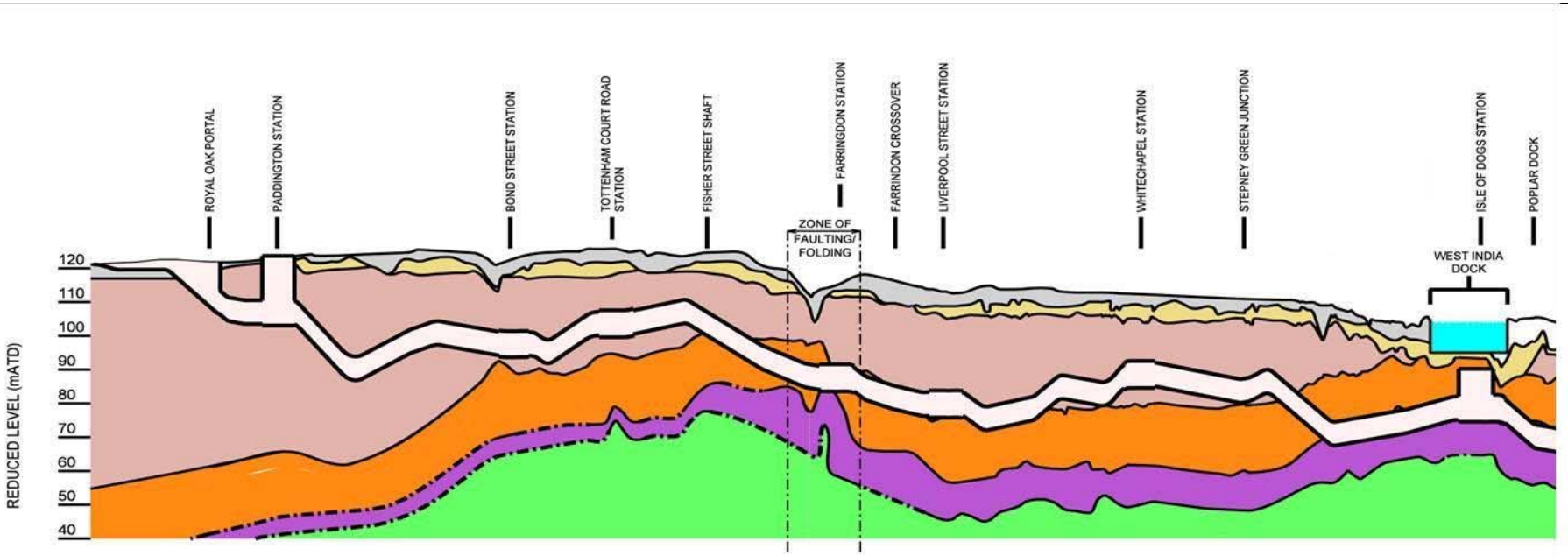
1. Royal Oak to Farringdon
2. Limmo to Farringdon
3. Stepney Green to Pudding Mill Lane
4. Limmo to Victoria Dock Portal
5. Plumstead to North Woolwich



Typical Platform Tunnel Cross Section



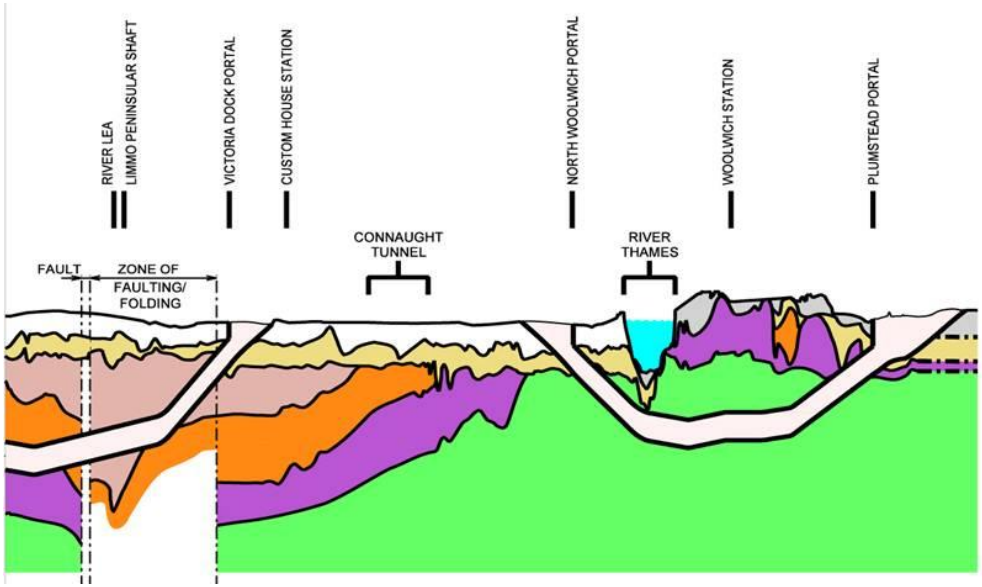
Central Tunnels Geology Long Section 1



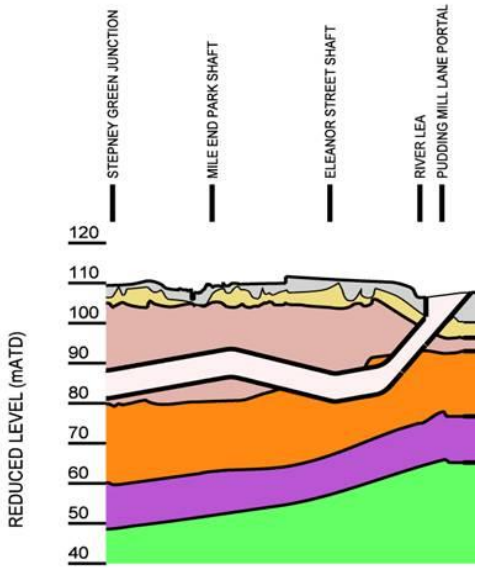
Royal Oak Portal – Isle of Dogs Station

SUPERFICIAL DEPOSITS
RIVER TERRACE DEPOSITS
LONDON CLAY
LAMBETH GROUP
THANET SAND
CHALK
EASTBOUND TUNNEL
UNCERTAIN GEOLOGICAL BOUNDARY

Central Tunnels Geology Long Section 2



Blackwall Way Shaft – Plumstead Portal



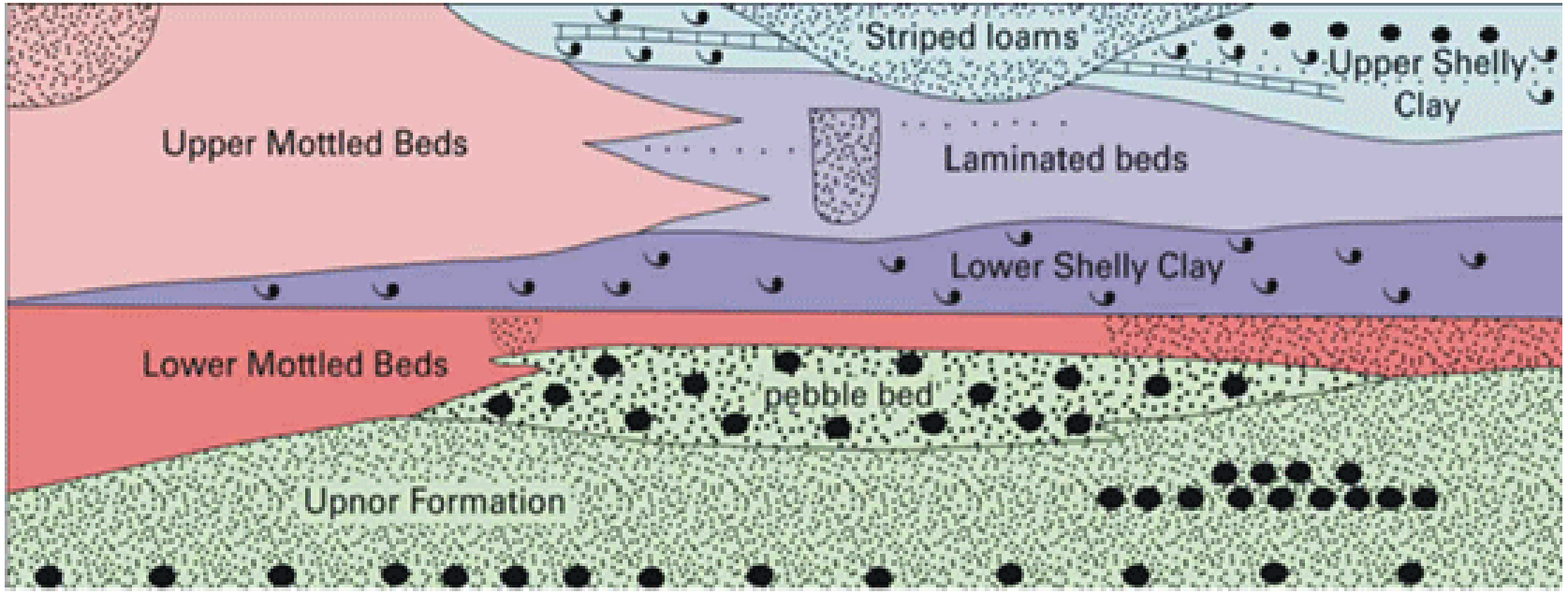
Stepney Green Shaft – Pudding Mill Portal

SUPERFICIAL DEPOSITS
RIVER TERRACE DEPOSITS
LONDON CLAY
LAMBETH GROUP
THANET SAND
CHALK
EASTBOUND TUNNEL
UNCERTAIN GEOLOGICAL BOUNDARY

London Clay

Formation	Unit / Member / Bed	General Description
London Clay Formation (units as King, 1981)	Unit C	Homogeneous, bioturbated, silty clay with dispersed glauconite at its base.
	Unit B	Homogeneous, slightly calcareous silty clay with several thin beds of very silty clay / clayey silt. Basal unit is a sparsely glauconitic sandy clay. Regular succession of semi-continuous claystone bands at 2 to 3m spacing.
	Unit A3	The basal unit is a homogeneous clay containing a number of semi-continuous claystone bands. Above this the remainder of Unit A3 consists of silty clay and very silty clay with thin silt and sand partings. Further thin claystone bands may occur. Pyrite is present throughout.
	Unit A2	Very silty clays and sandy silts on a metric scale, notably pyritic, non-calcareous and containing glauconite. Thin basal unit of glauconitic sandy clay with flint pebbles.

Lambeth Group



Formations

Woolwich Formation

Reading Formation

Upnor Formation

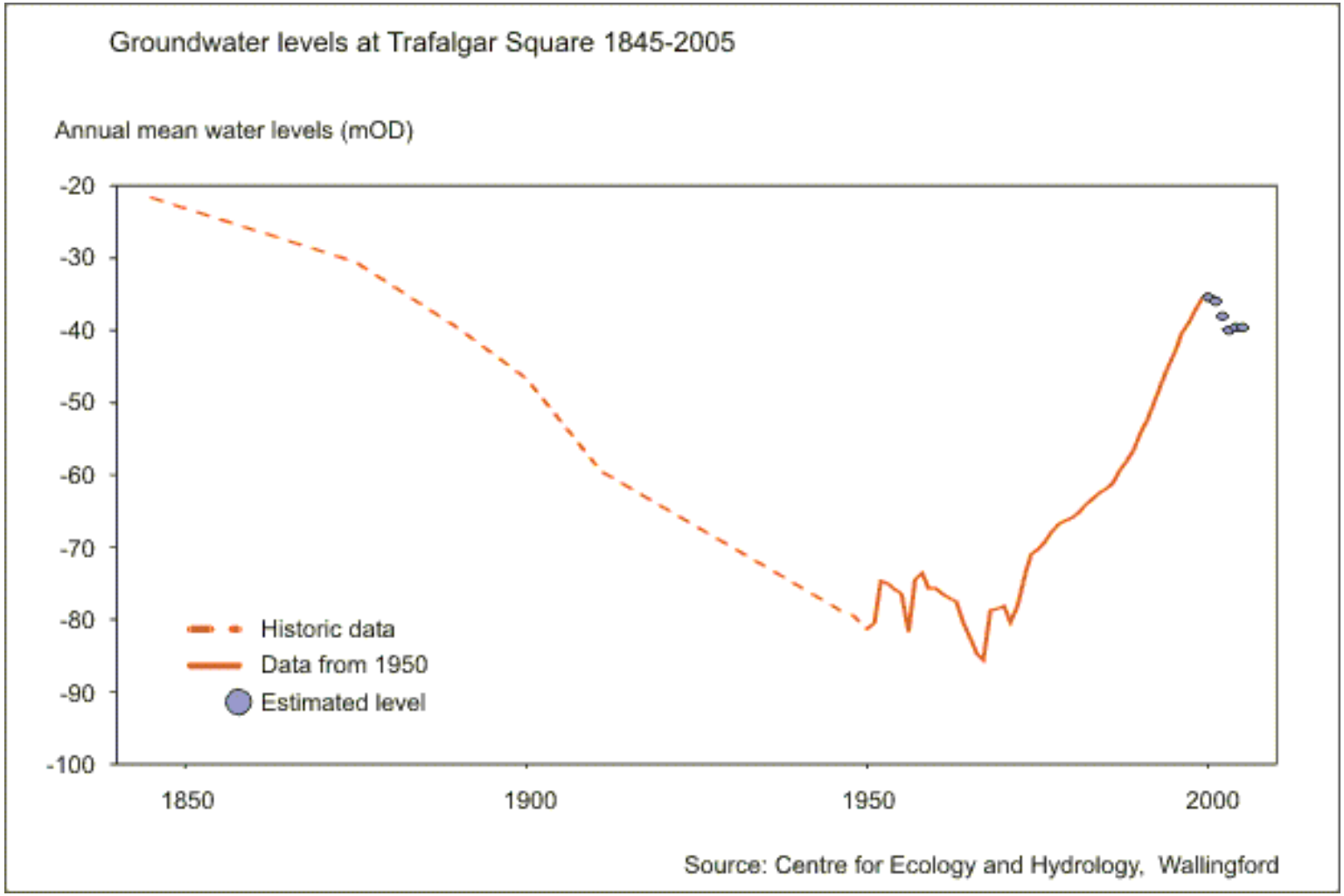
Informal units

- Upper Shelly Clay
- Laminated beds
- Lower Shelly Clay
- Upper Mottled beds
- Lower Mottled beds

Principal lithologies

- Clay
- Sand
- Shell beds
- Gravel beds
- Limestone

Historic groundwater



Stratigraphic Ground risks

- Obstructions –London Clay nodules
- Hazardous gases posing a risk to workforce
- Irregular groundwater flows in Lambeth Group Sand Channels and Harwich Formation
- Aggressive groundwater from oxidation of sulphates in London Clay
- Smectite rich clays in London Clay and Lambeth Group affects material handling and processing

Site Specific Risks in London

- Faulting and fissuring
- Scour features and buried river channels
- UXO
- Obstructions
- Sensitive structures
- Deep Aquifer
- River Thames

faulting

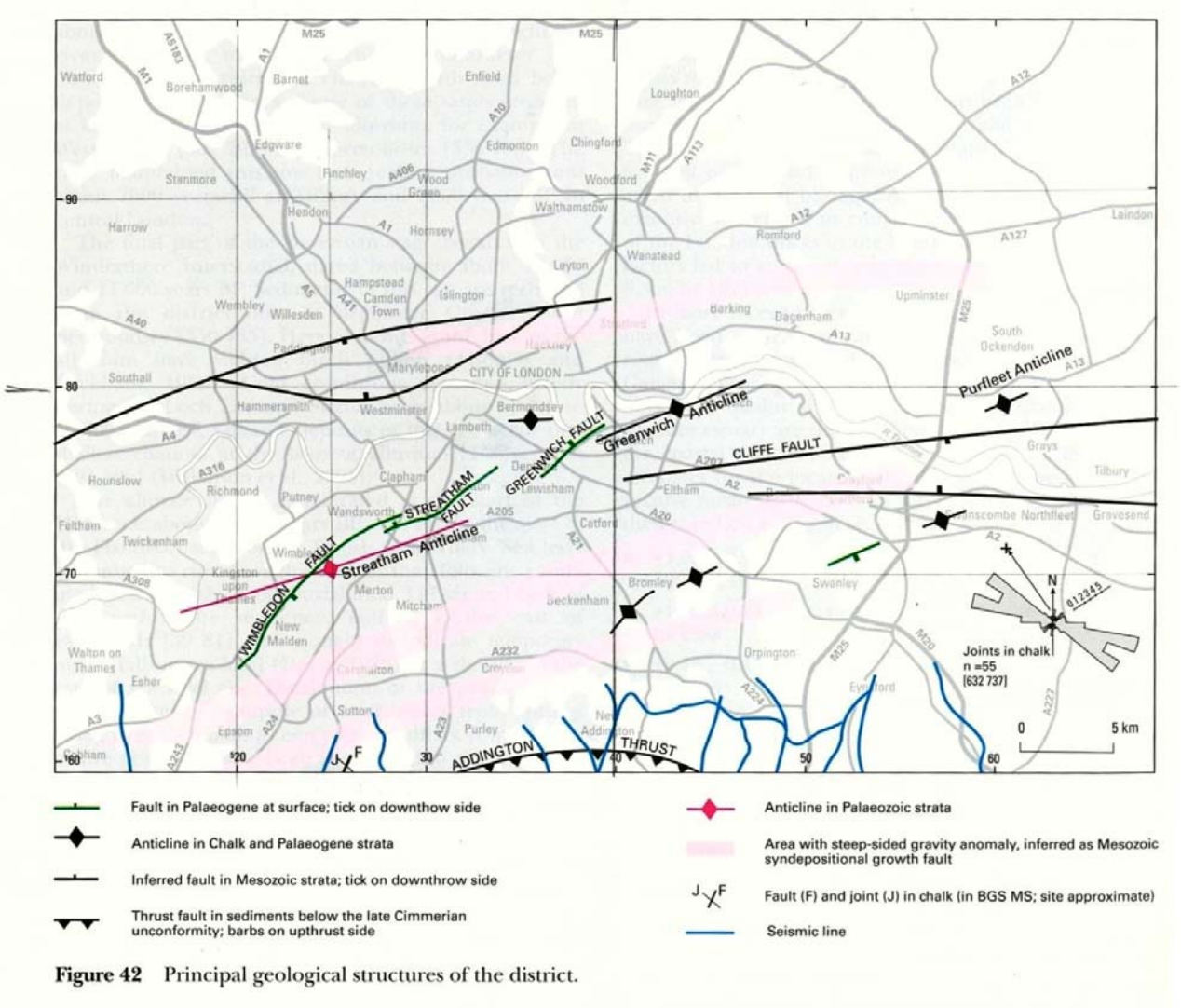
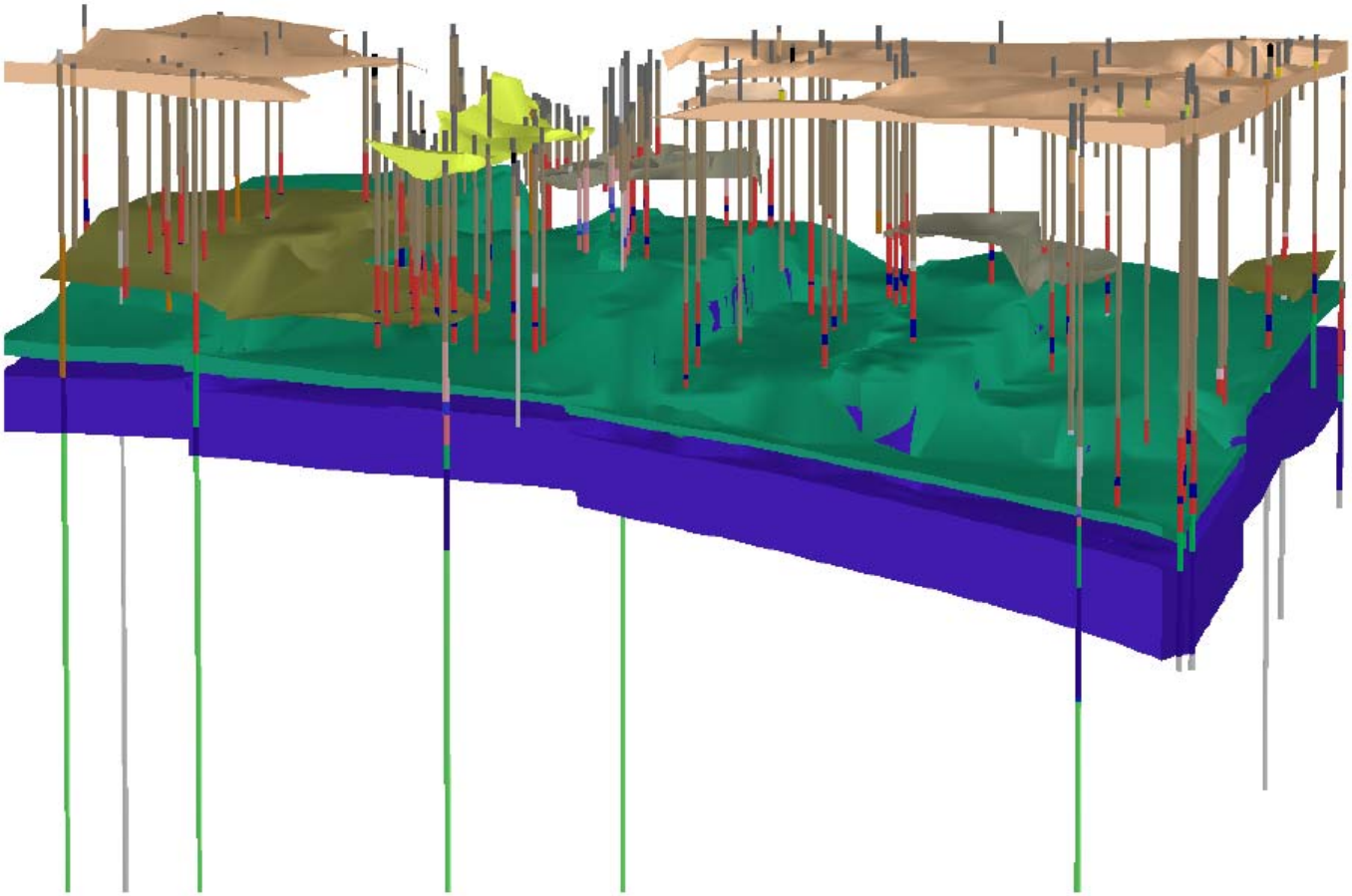
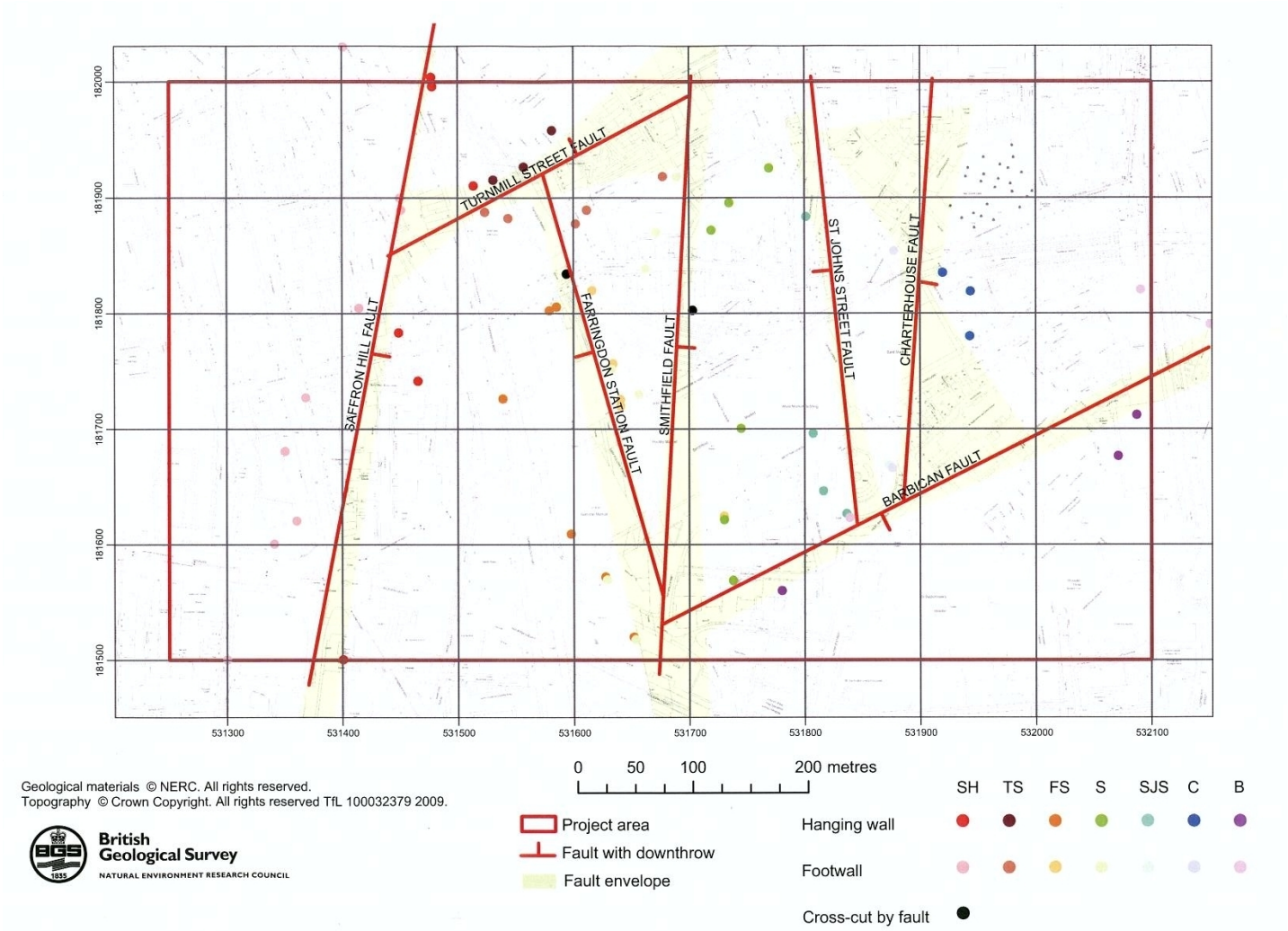


Figure 42 Principal geological structures of the district.

Farringdon Station 3D geological model

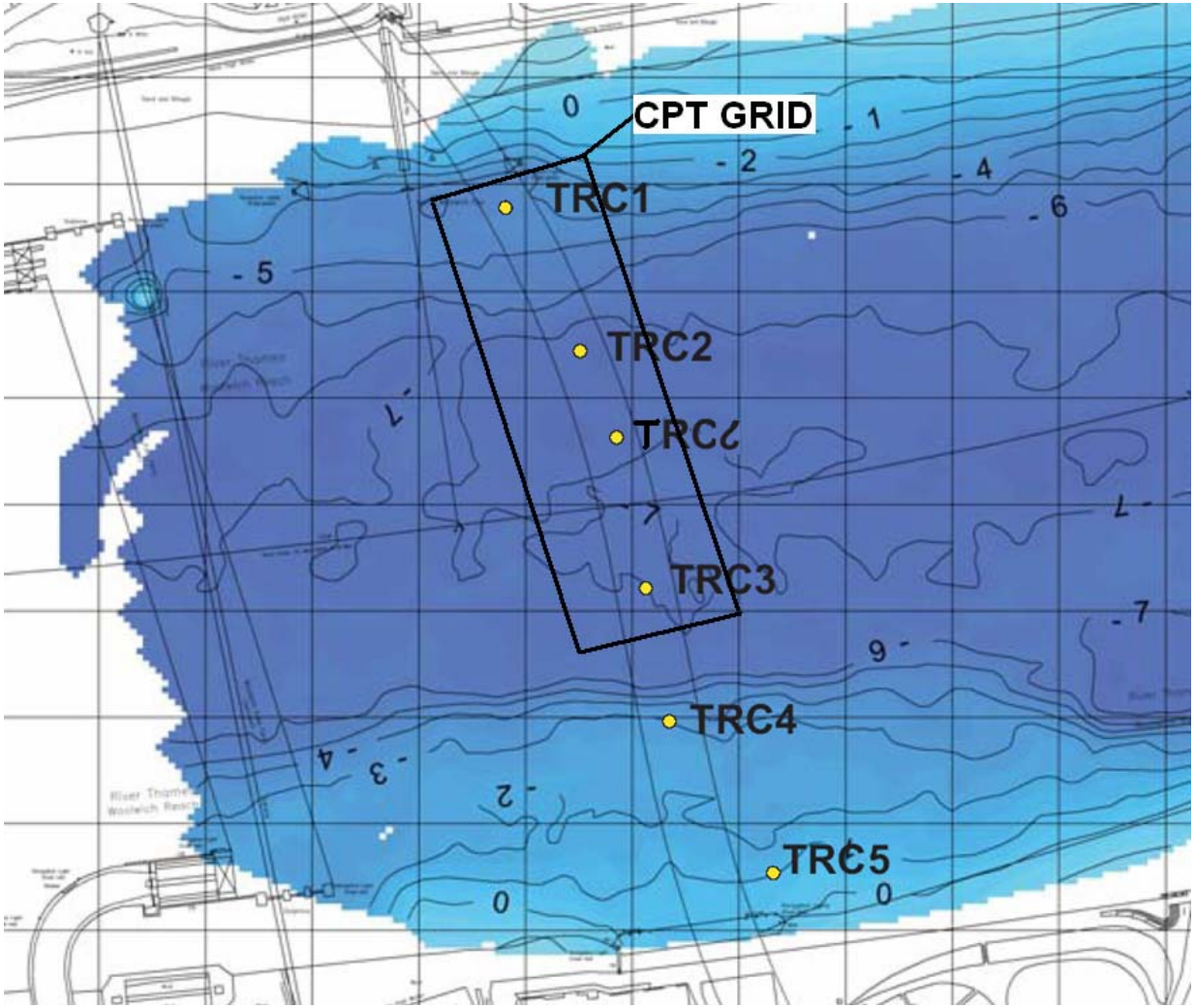


Faulting



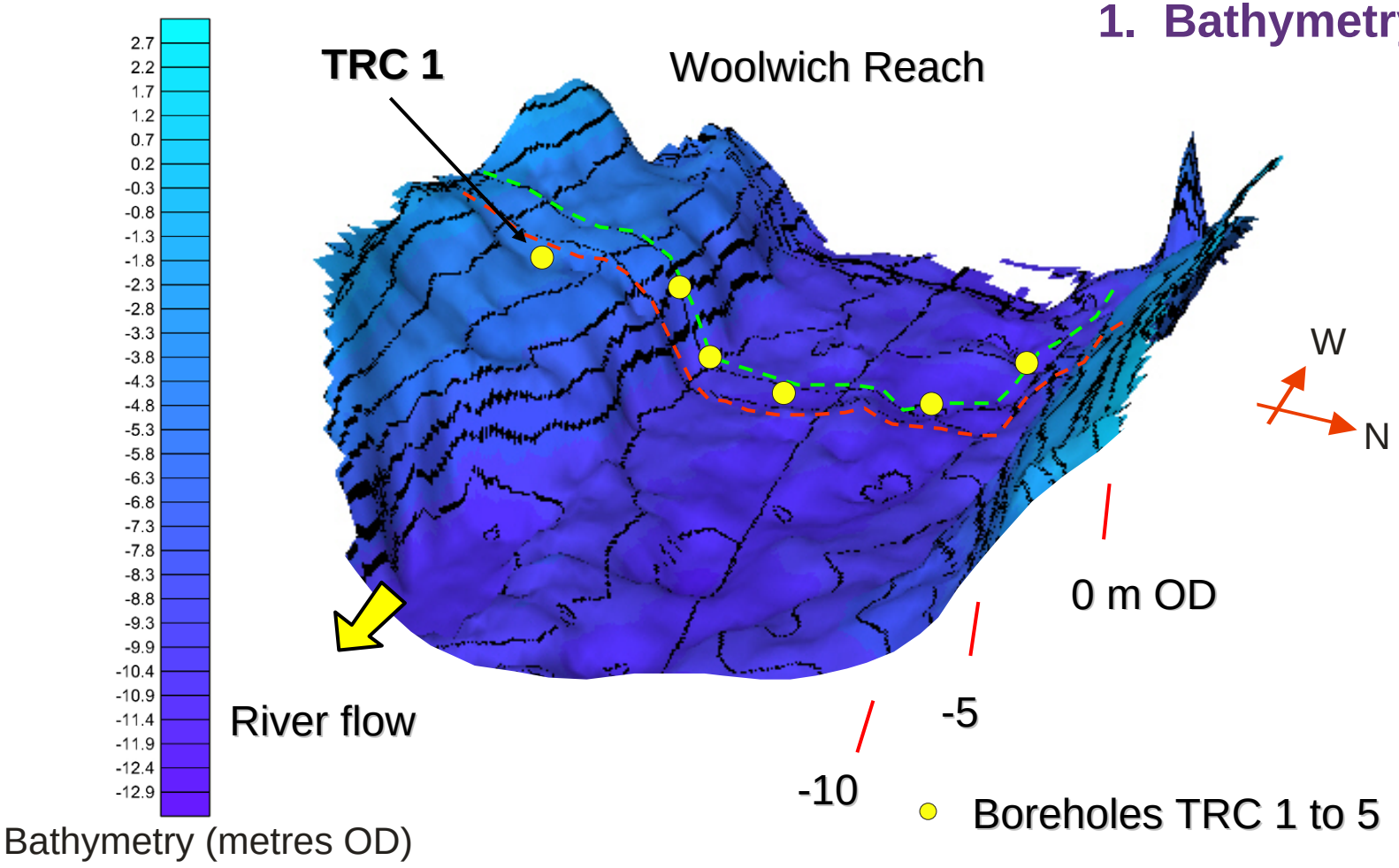
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Scour Features

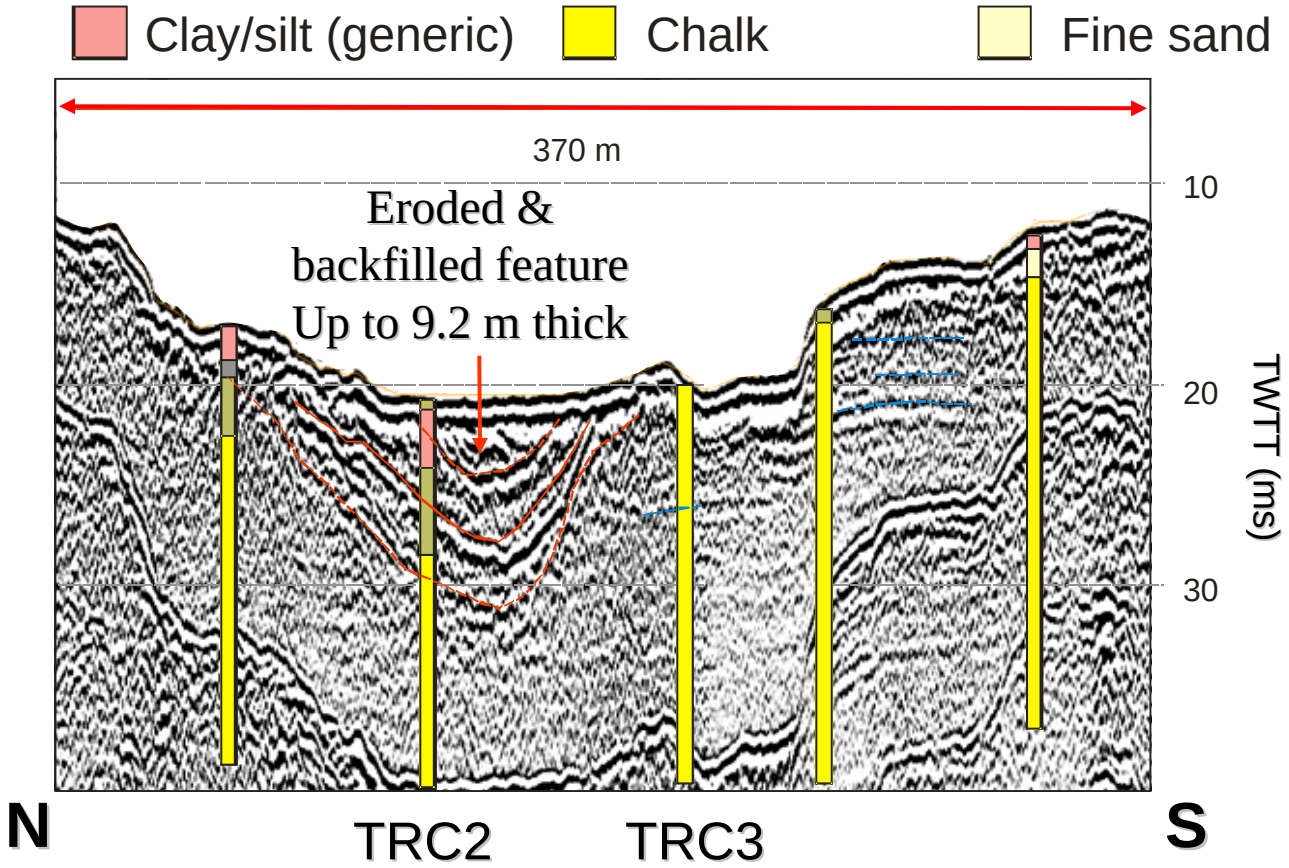


Bathymetry Survey

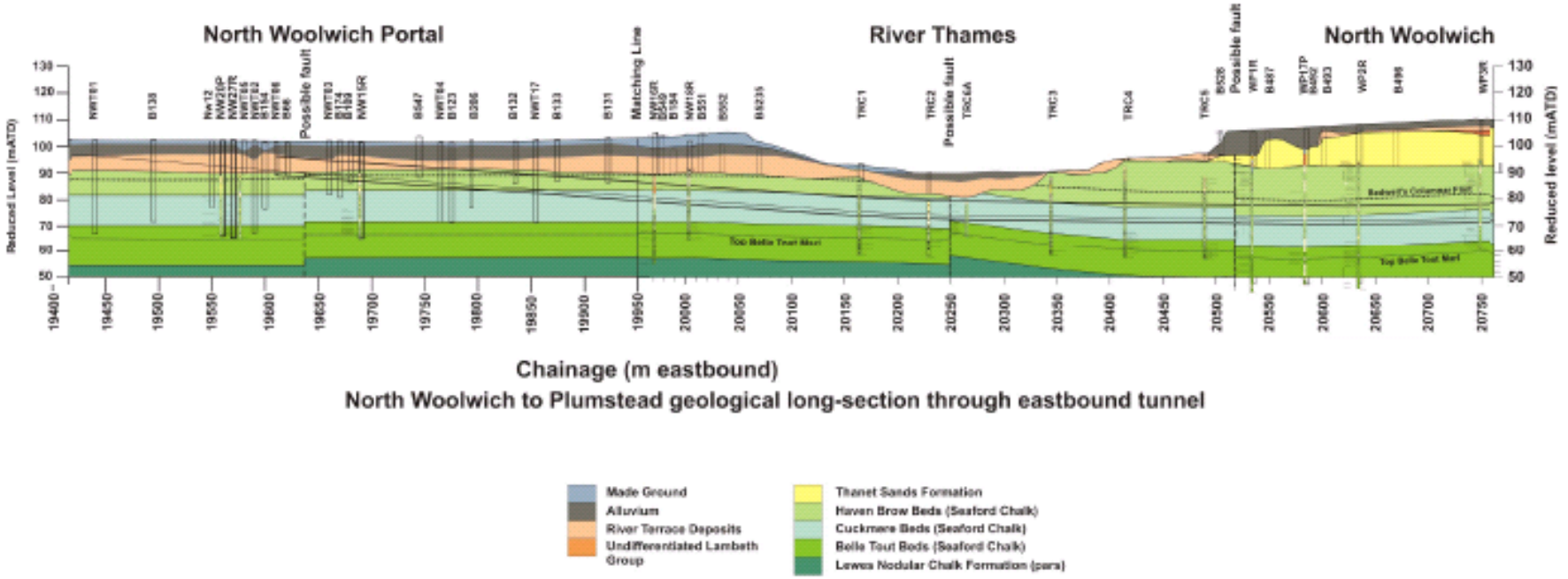
1. Bathymetry



Eroded and backfilled feature in seismic section

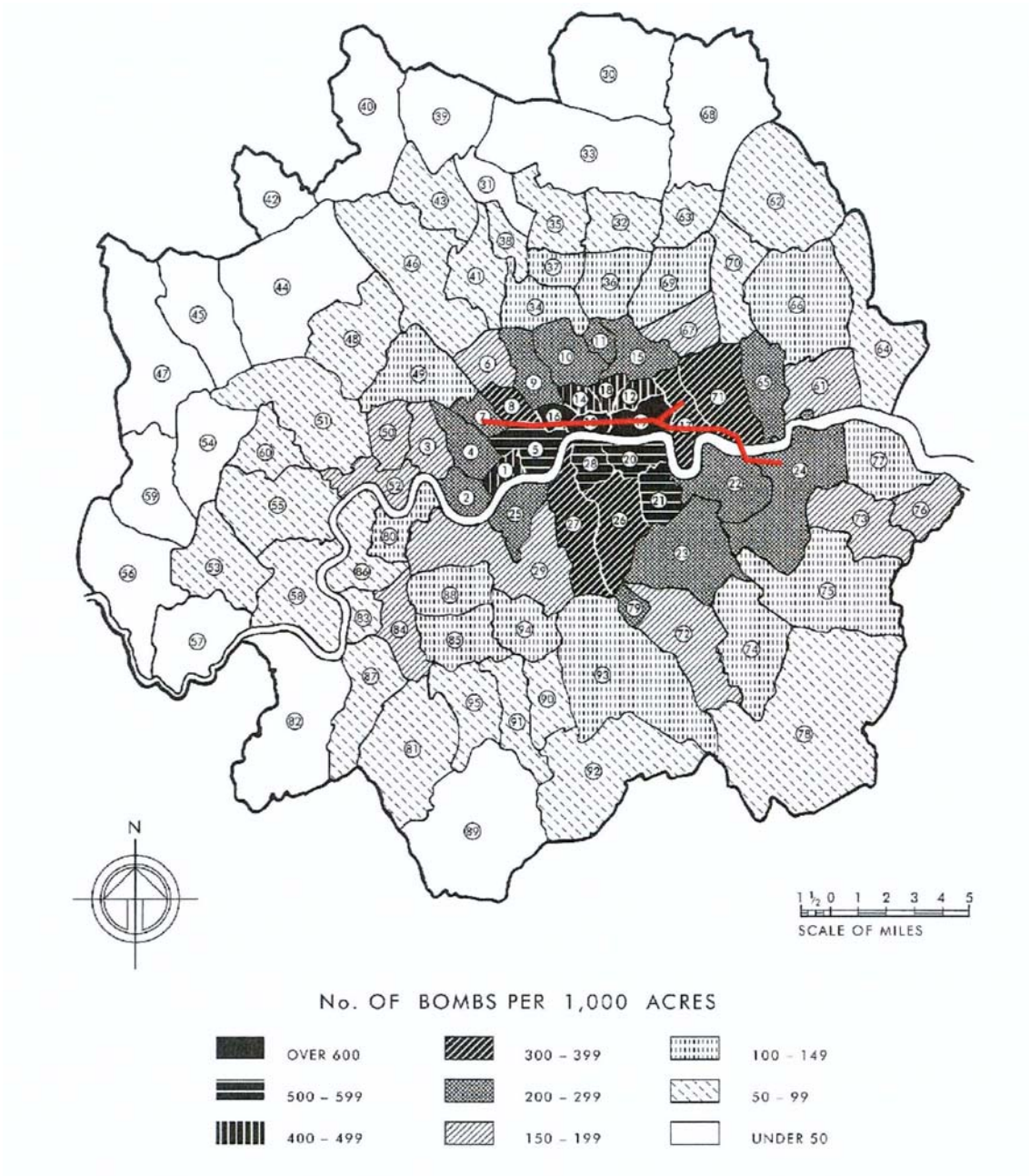


Chalk logging



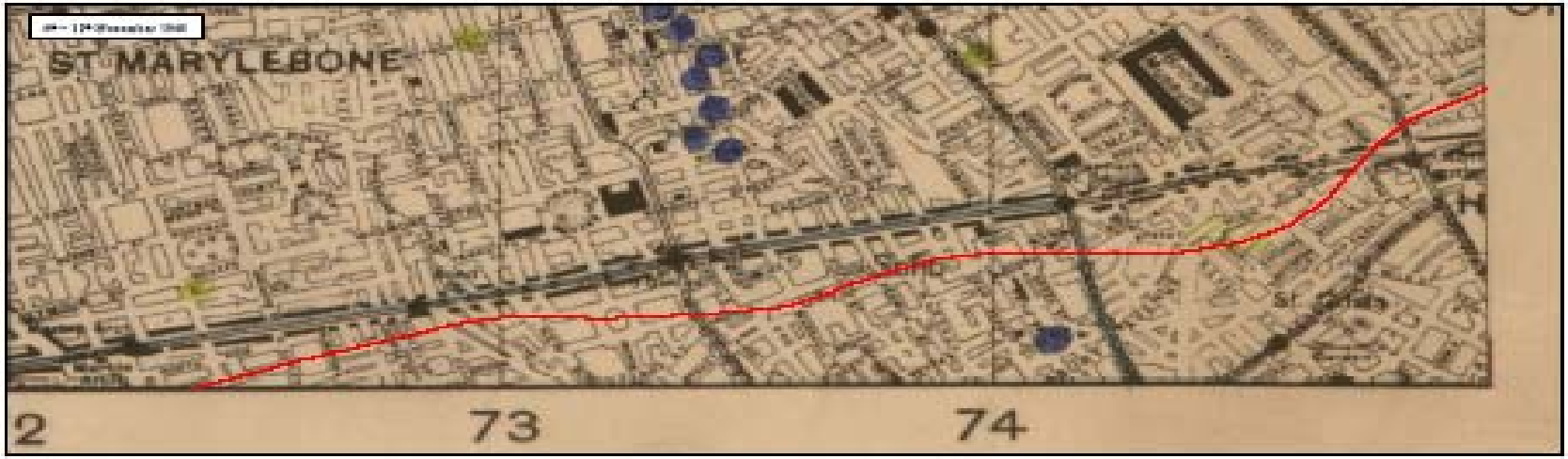
North Woolwich to Plumstead geological long-section through eastbound tunnel

Sensitive Structures



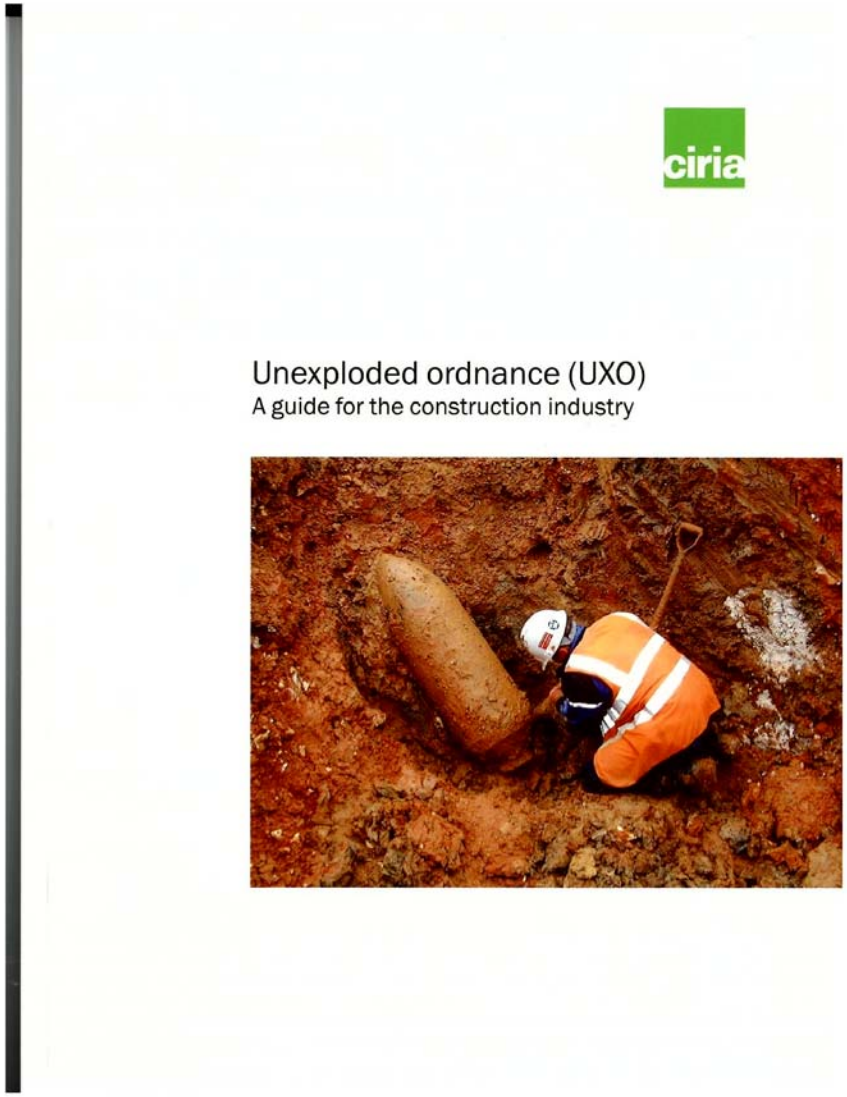
WW2 bomb density map

Bomb census maps



Bomb Damage Maps

CIRIA UXO



Unexploded Ordnance (UXO) - A Guide for the Construction Industry
K. Stone, A. Murray & S. Cooke

Excavated Material

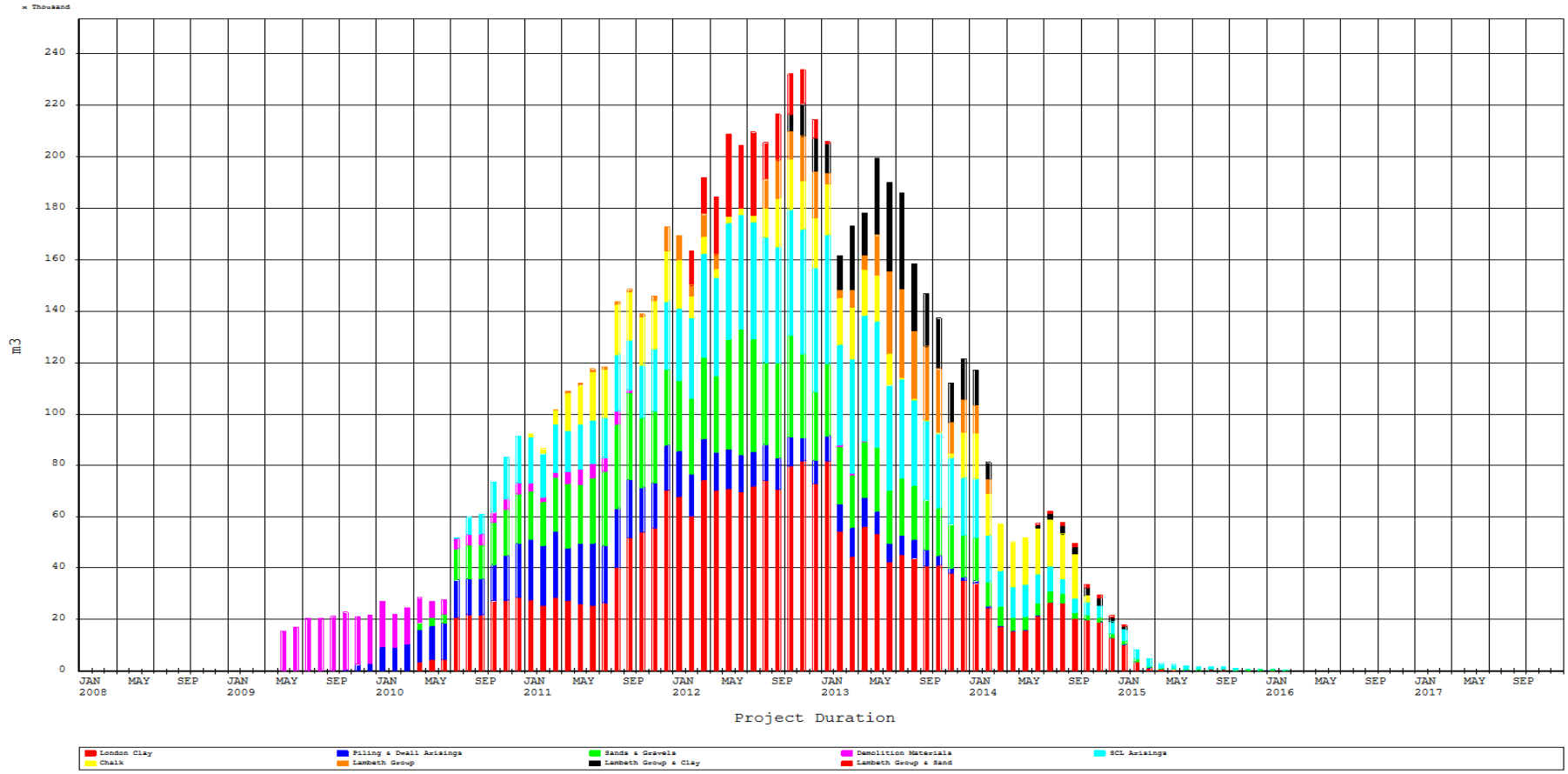
- Clay 2.3M m^3
- Piling & Diaphragm Walling Arisings 0.68M m^3
- Sprayed Concrete Lining 1.4M m^3
- Sand & Gravels 1.15M m^3
- Chalk 0.6M m^3
- Lambeth Group 0.9M m^3
- Demolition arisings 0.27M m^3

TOTAL 9.5m cu yds (**7.3M $m^{3)}$**

- Recovery/Recycling Aggregate & hardcore -2.0M m^3

FOR BENEFICIAL REUSE 6.9M cu yds 5.3M m^3

Excavated Material Histogram



Project Start	22APR02	MUCK	Sheet 1 of 1
Project Finish	27FEB18	CrossRail	
Data Date	6OCT06	Construction Programme	
Plot Date	1NOV07	Spoil Histogram-All	

Date	Revision	Checked	Approved

Excavated Material

- Over 200k m^3 per month at peak
- Material generated 2010 – 2015
- Initial transport
  - 14% by rail – 1M m^3 1.3M cu.yds
  - 39% by barge – 2.9M m^3 3.8M cu.yds
  - 47% by road – 3.4M m^3 4.4M cu yds
- Overall 85% of transport is by water and rail on a volume/mileage basis

Movement of Excavated Material

1 M m³

Stations + Shafts

3.1 M m³

Wallasea Island – 4.1 M m³

Westbourne Park - Western Tunnelling Site

Limmo - Eastern Tunnelling Site

2 M m³ Recycled

East London Wharf

4.1 M m³

2.3 M m³

3.2 M m³

0.9 M m³

Plumstead Portal/Woolwich Station

Manor Wharf

0.3 M m³

0.1 M m³

1.0 M m³

Northfleet Embankment/ Queenborough – 1.2 M m³

Transport

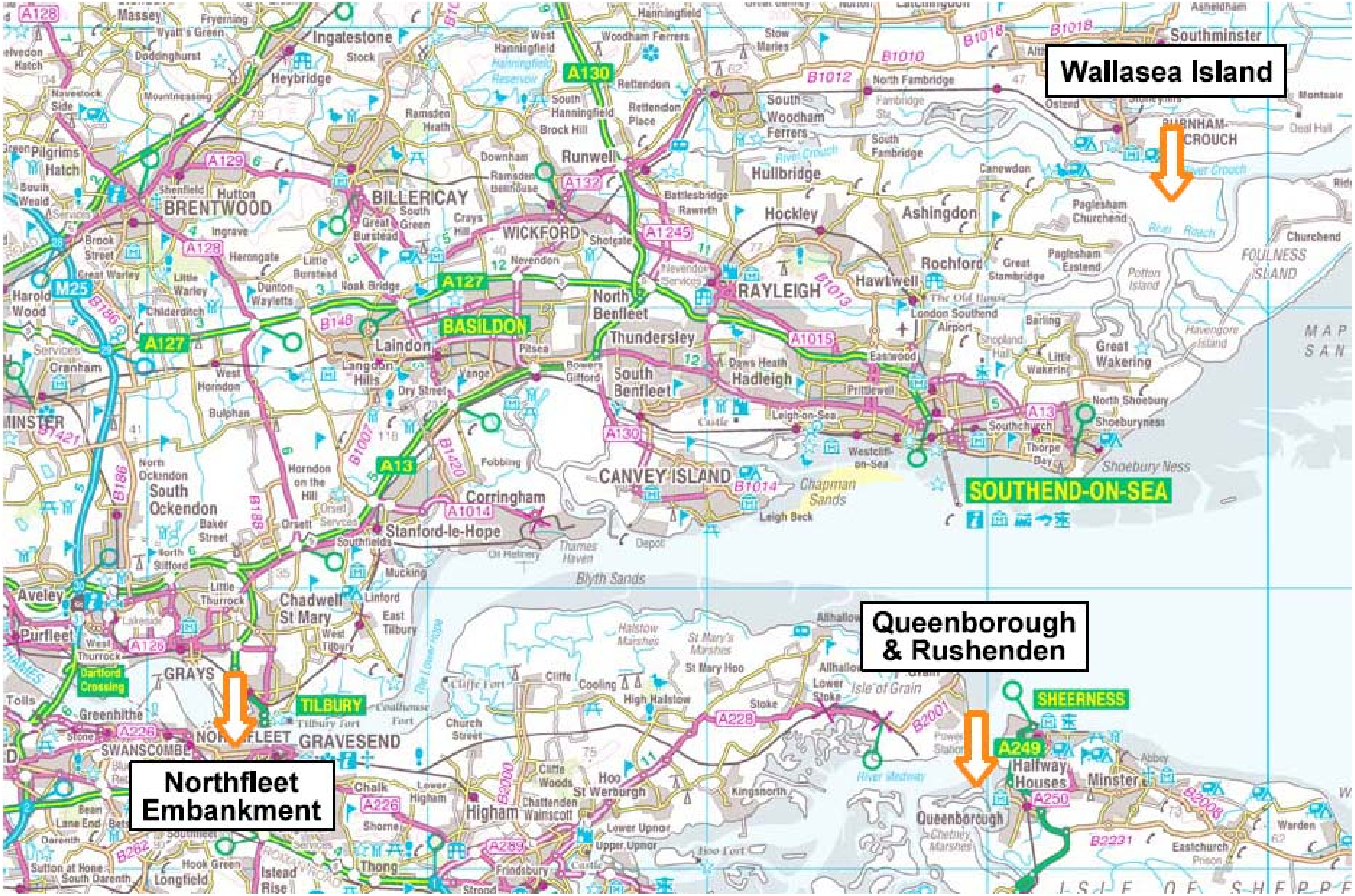
Generally 300 loads per day in Central London

Peak:150-200 lorries moving c600 loads per day Crossrail wide

4 trains of 20 wagons per day

5x 2000 tonne ships per day plus barges

Location of Sites

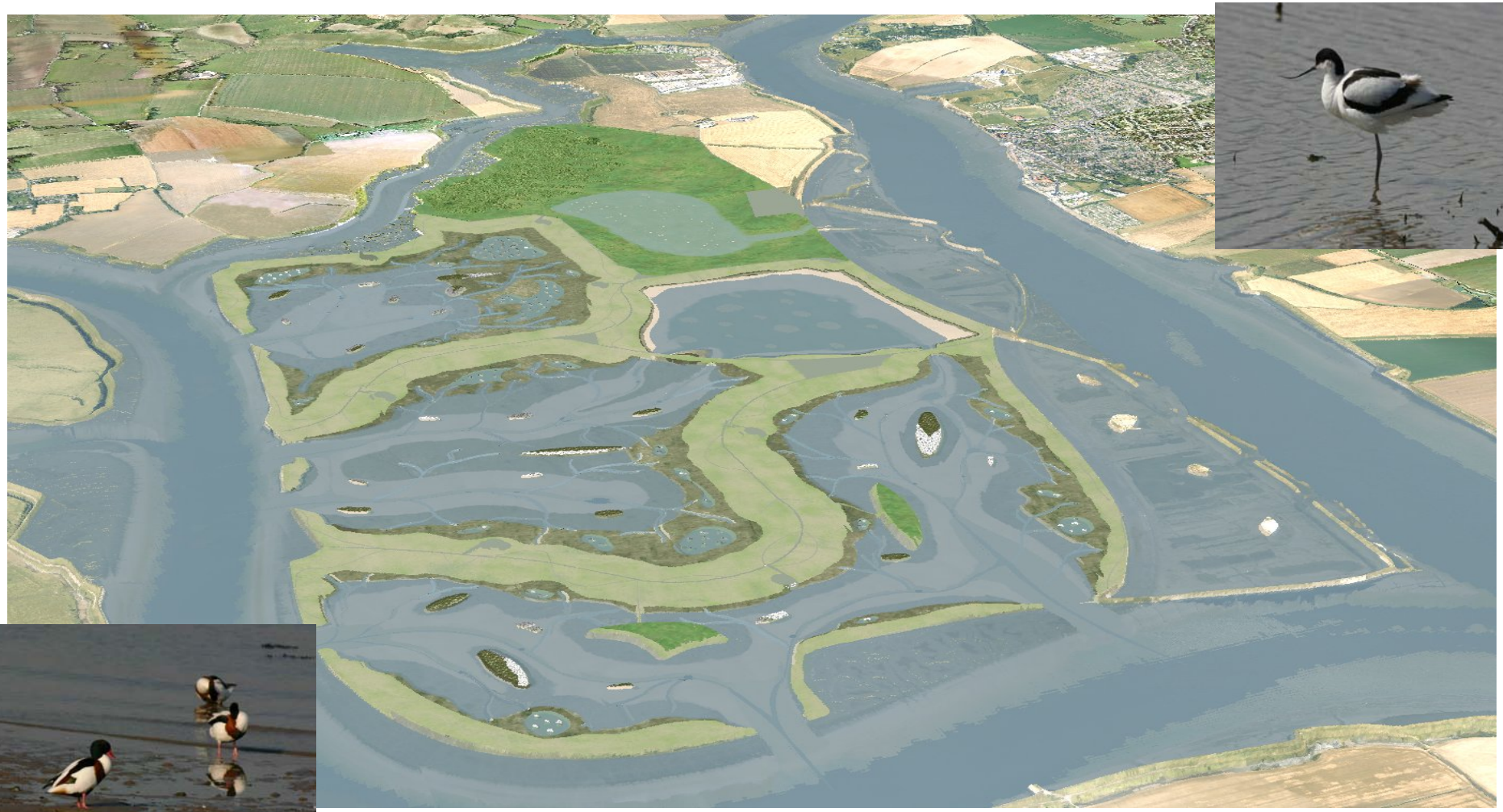


Wallasea Island

- RSPB scheme to transform, in a phased and managed way, 620 hectares of arable farmland into the coastal marshland it once was.
- The newly restored landscape will be a wetland mosaic of mudflats and saltmarsh, shallow lagoons and pastures.
- Criss-crossed by higher level bunds to provide access.
- Capacity to take approximately 10M m^3 bulked.
- All excavated material delivered by water.
- Planning application submitted

Wallasea Island

Wallasea Island



Delivering a world-class affordable railway safely through effective partnerships