

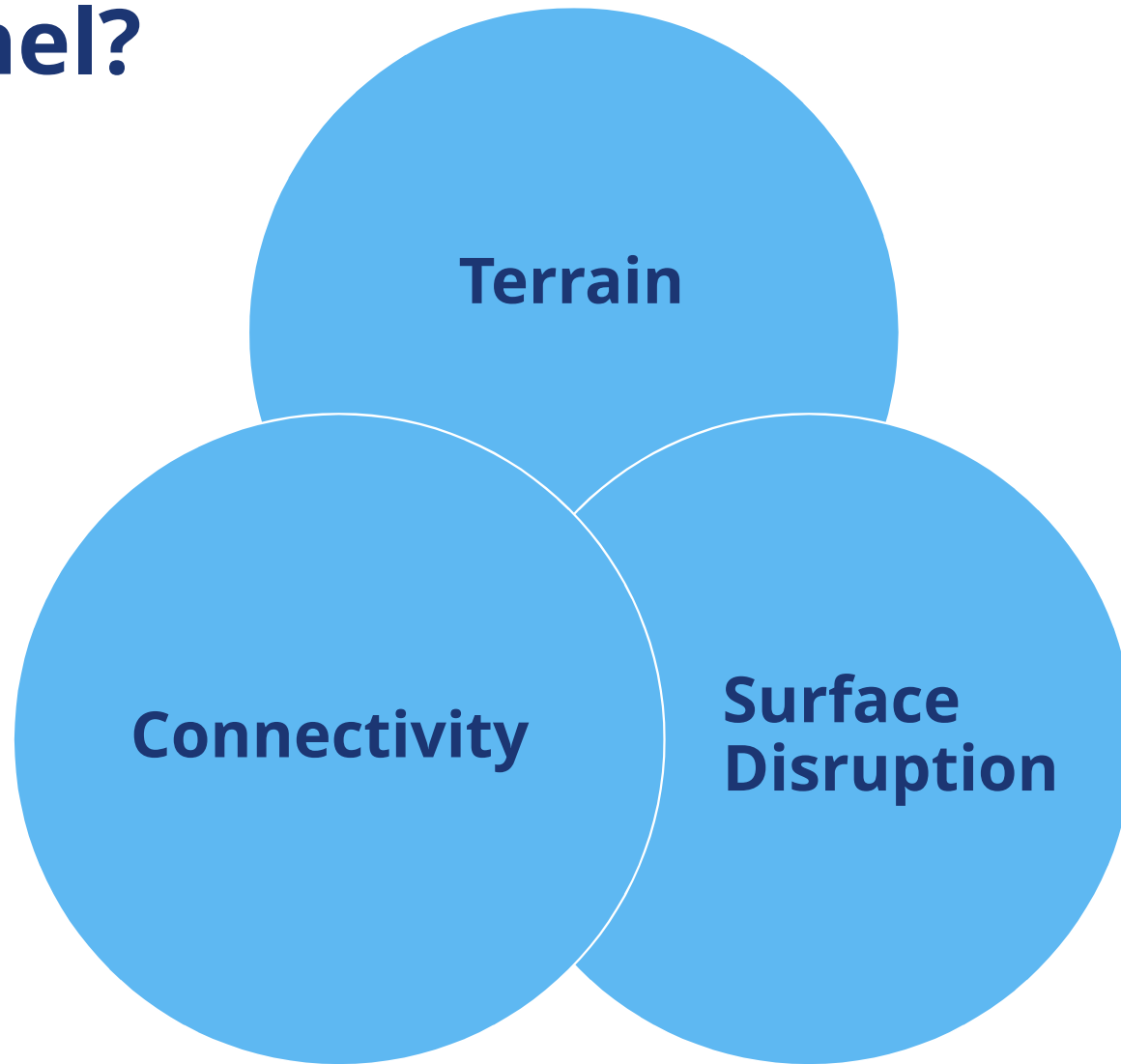
# HS2

## Phase 2a - Tunnels

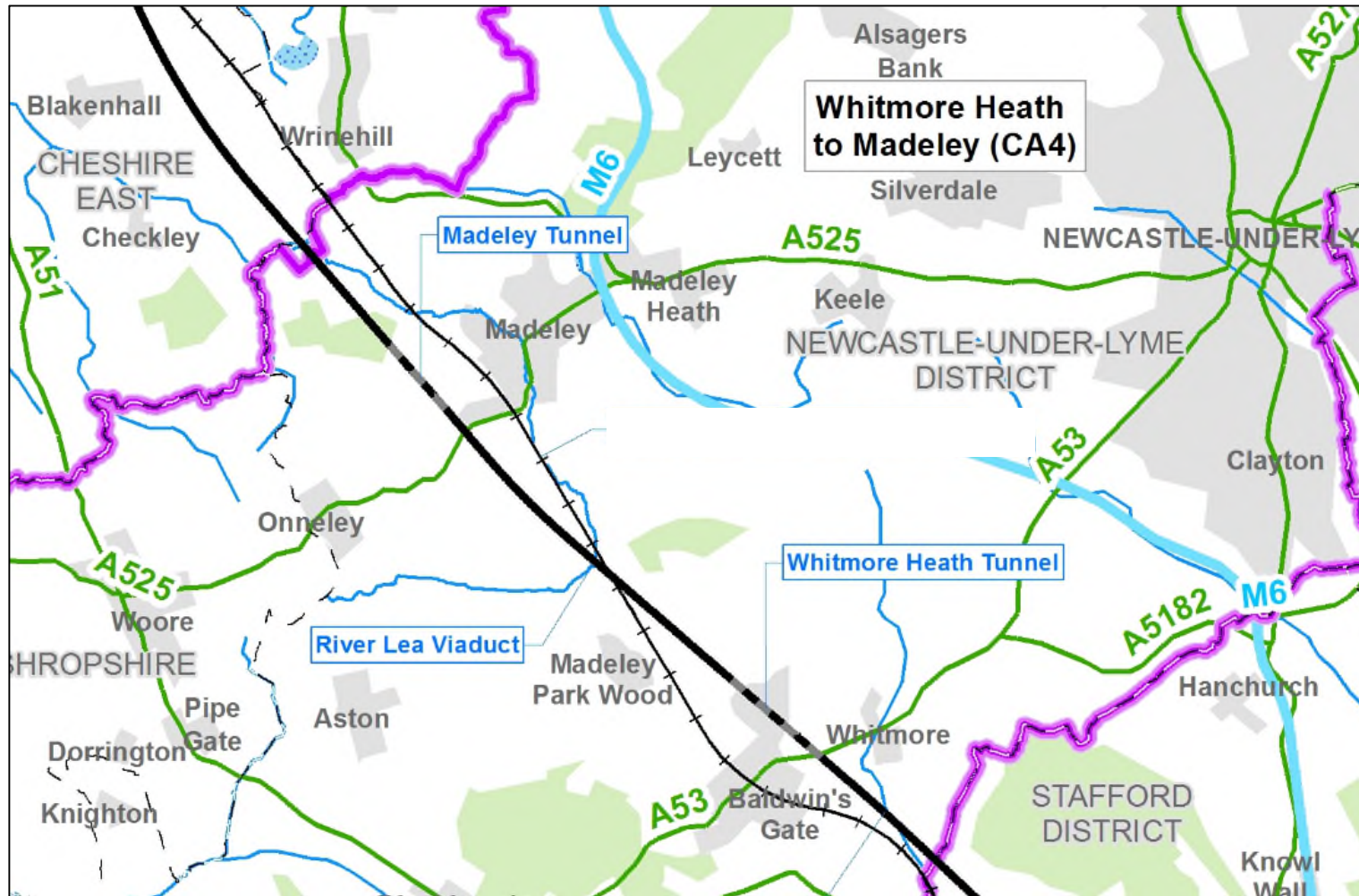
Tim Smart

27 March 2018

# Why Tunnel?



# Tunnel Locations



# Tunnel Briefing Agenda

## Construction

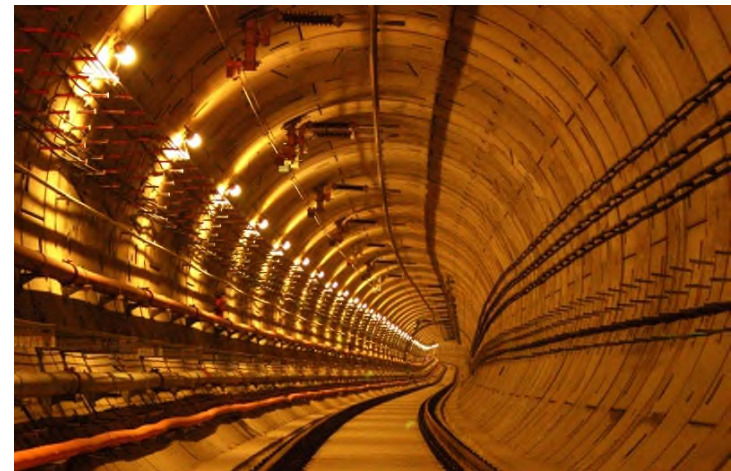
- (1) Tunnelling techniques
- (2) Settlement
- (3) Construction aspects

## Operational Aspects of Tunnelling

- (1) Safety arrangements
- (2) Vibration

## Cost implications

- (1) Costs of tunnelling



# Construction – Tunnelling Techniques

## Bored Tunnels

- Shield type machines with precast segmental tunnel lining
- Used when surface access is very limited at depths typically below one tunnel diameter
- Longer tunnel lengths where economical to use machine

## Cut and Cover Tunnels

- Typically concrete box structures constructed in excavated ground
- Used at shallower depths where there is good surface access

## Mined/Sprayed Concrete Lining Tunnels

- Mechanically excavated with sprayed concrete lining in suitable ground conditions
- Used in shorter drives and cross passages

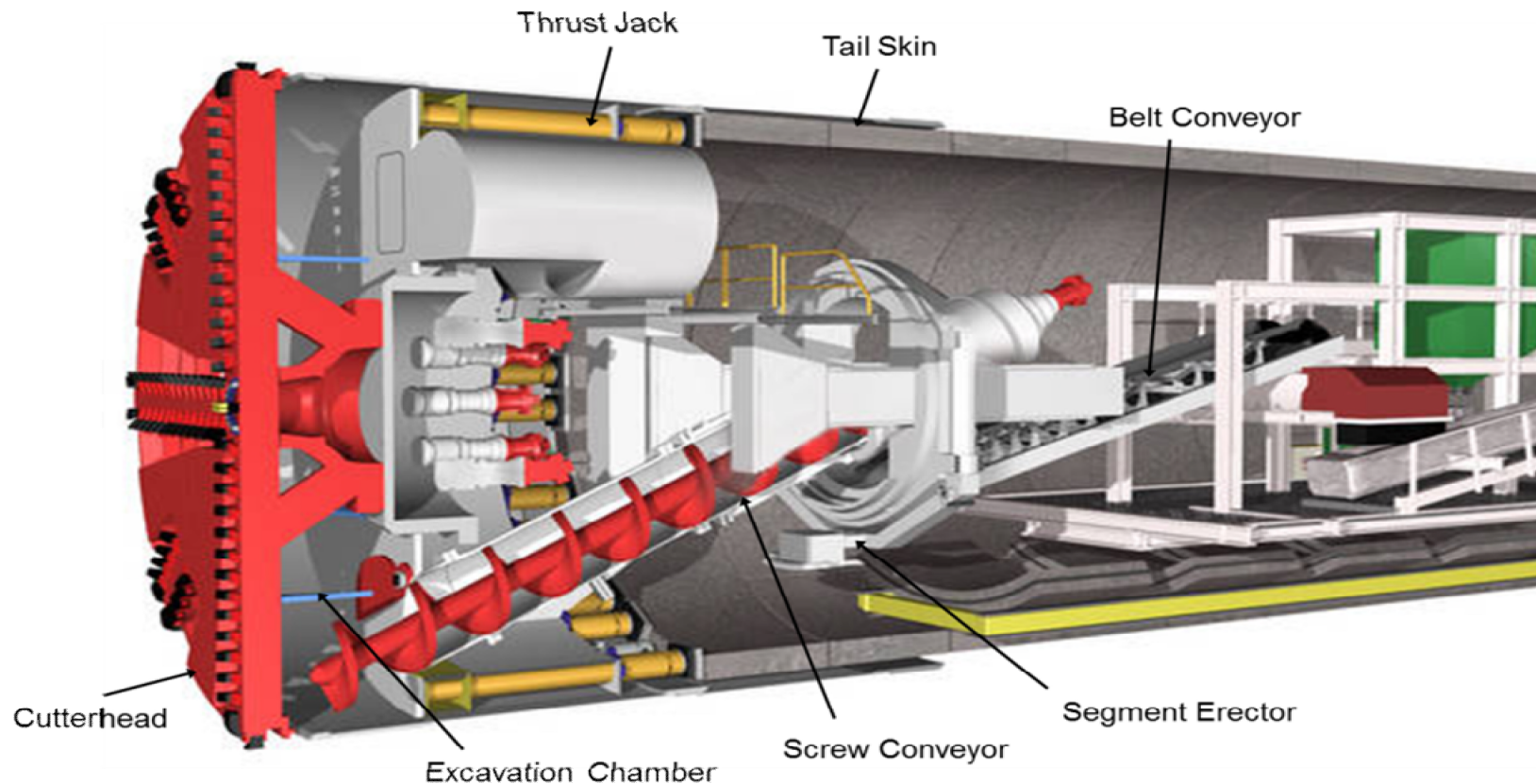
Construction

Operational Aspects of Tunnelling

Cost Implications

# Bored Tunnels

## Earth Pressure Balance Tunnel Boring Machine (EPBM)



Construction

Operational Aspects of Tunnelling

Cost Implications

# Bored Tunnels

HS1 EPBM in factory showing back up arrangements



Construction

Operational Aspects of Tunnelling

Cost Implications

# Precast Tunnel Segments



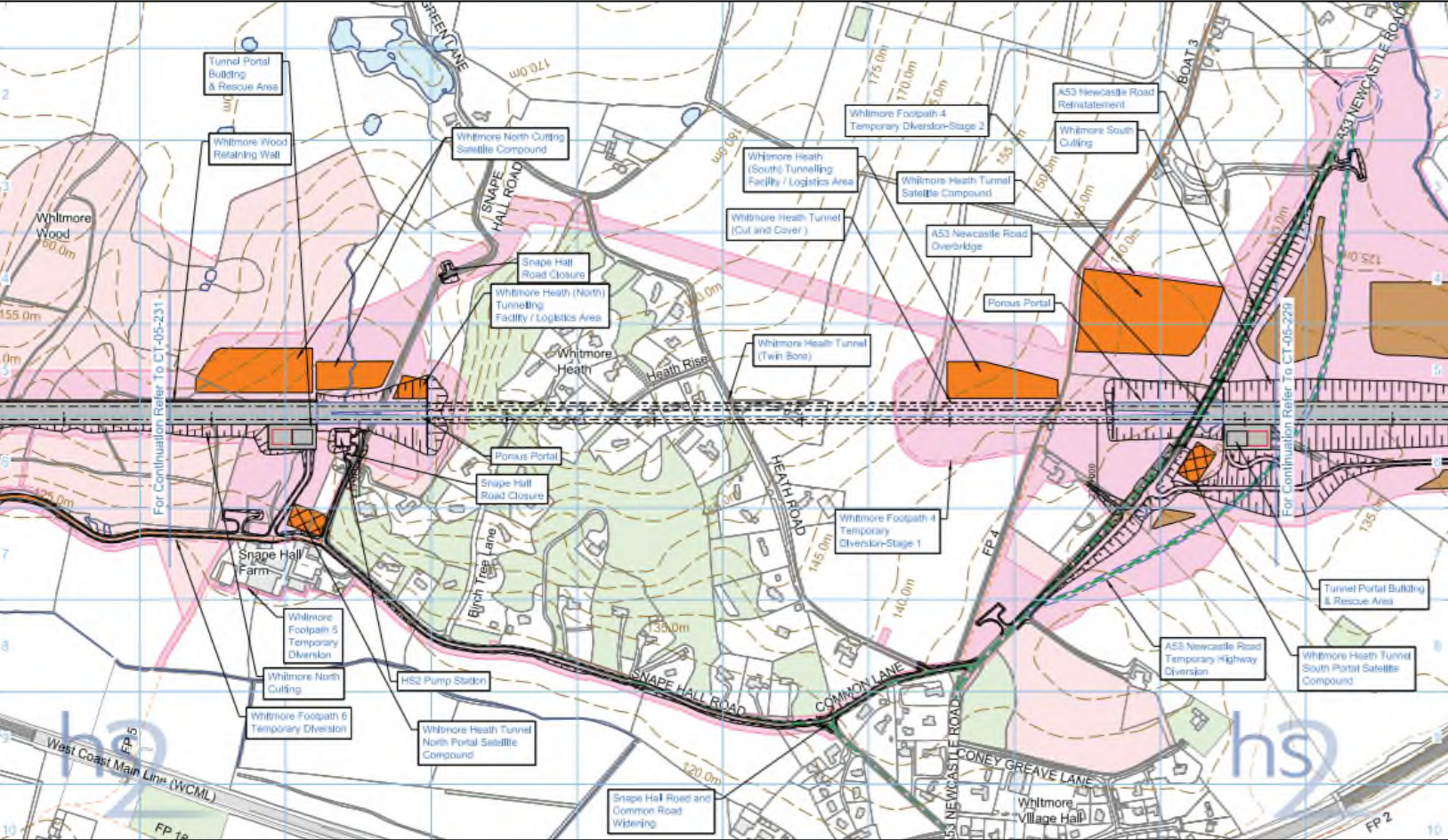
Construction

Operational Aspects of Tunnelling

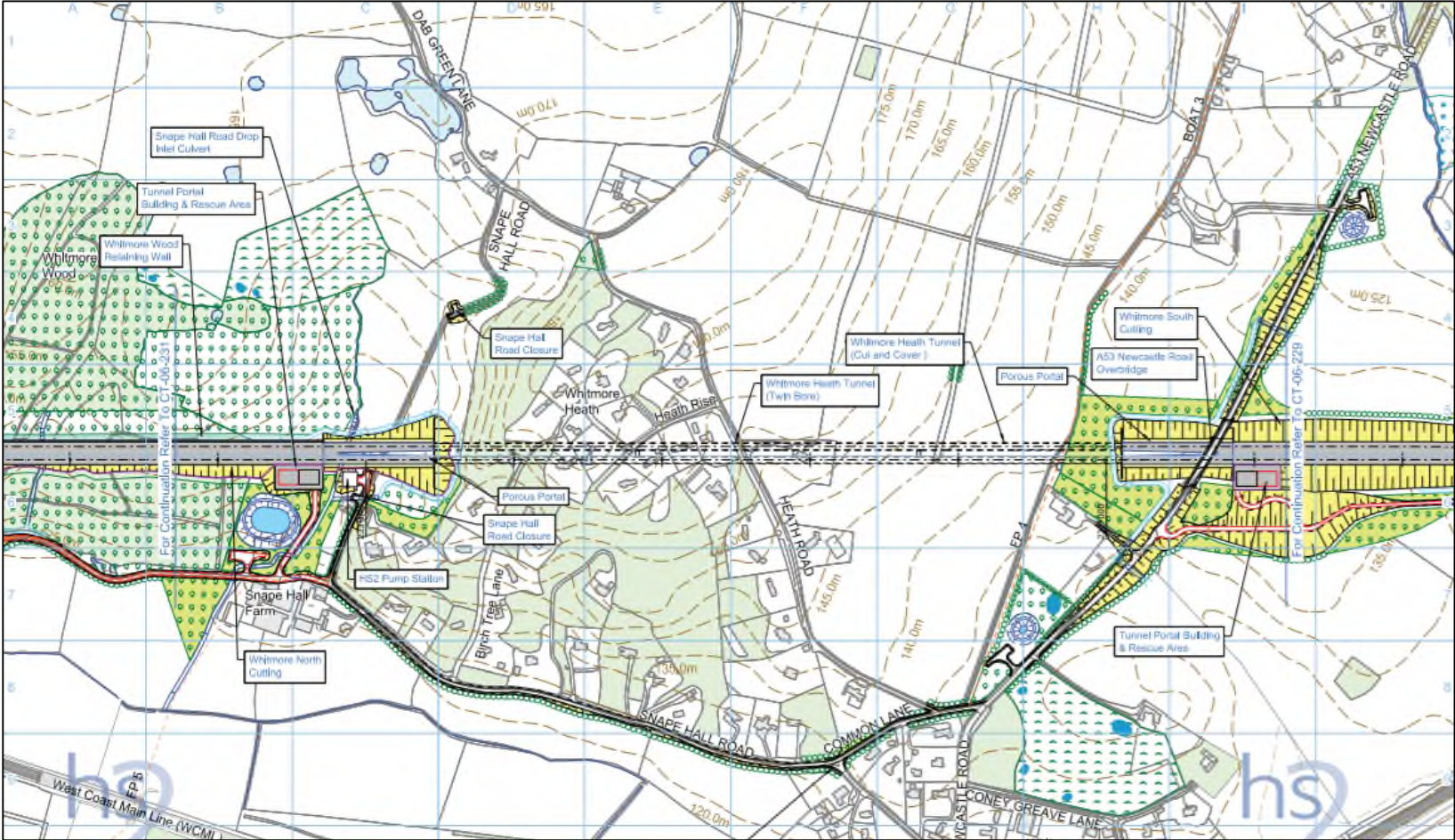
Cost Implications



# Construction Plan - Whitmore Heath



# Operation Plan - Whitmore Heath

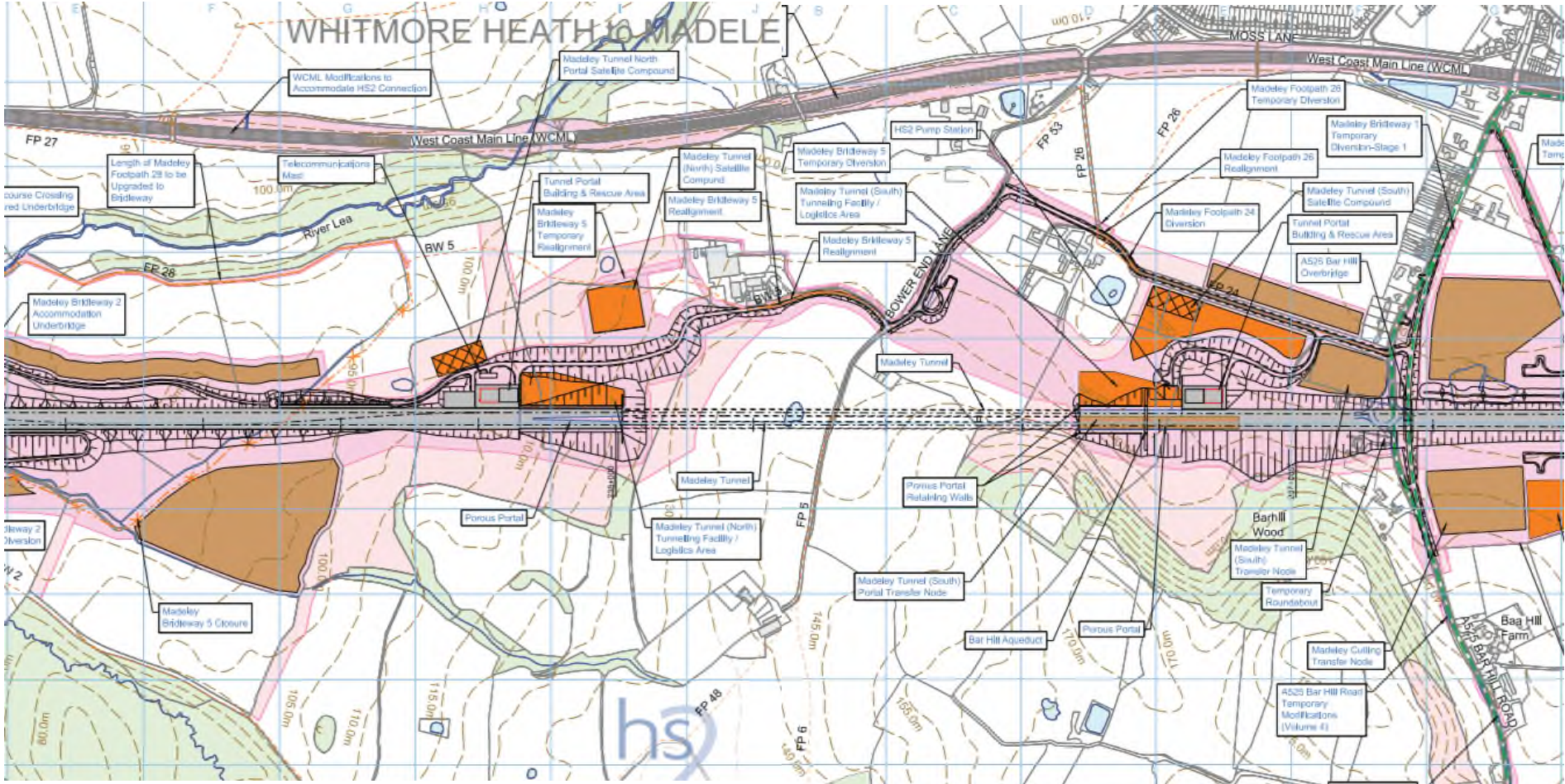


Construction

Operational Aspects of Tunnelling

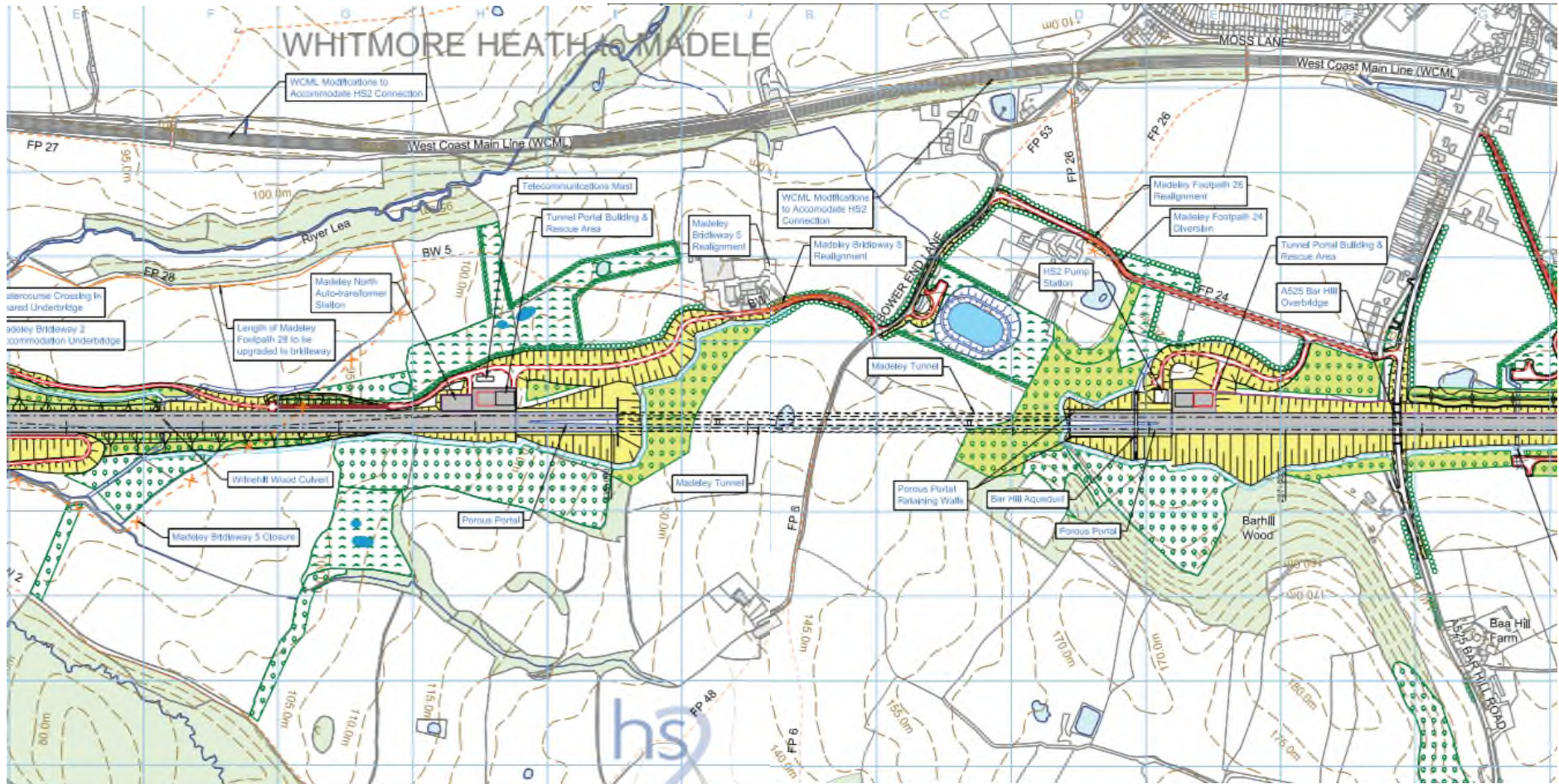
Cost Implications

# Construction Plan - Madeley



Construction	Operational Aspects of Tunnelling	Cost Implications
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# Operation Plan - Madeley

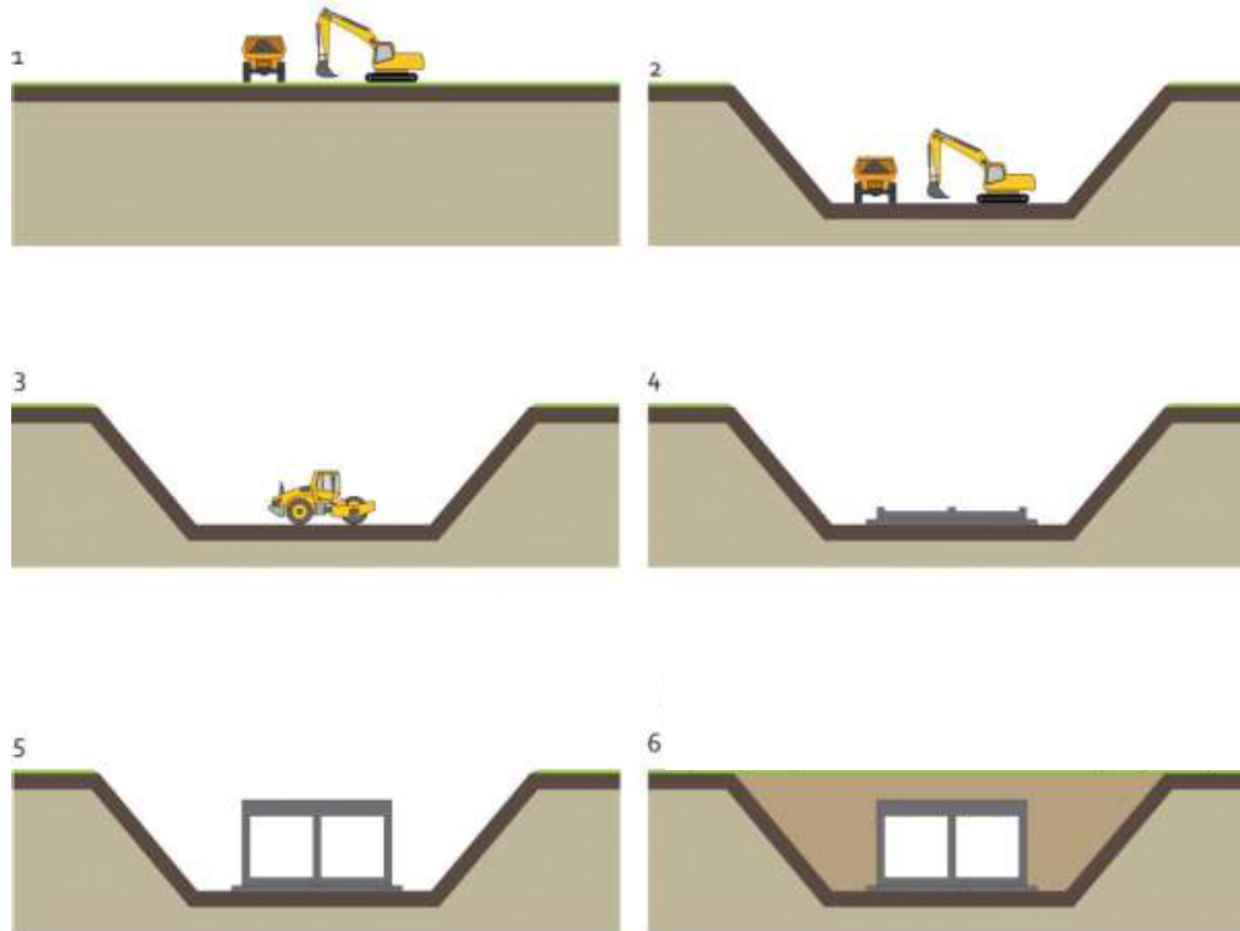


Construction

Operational Aspects of Tunnelling

Cost Implications

# Cut and Cover Construction Methodology 1

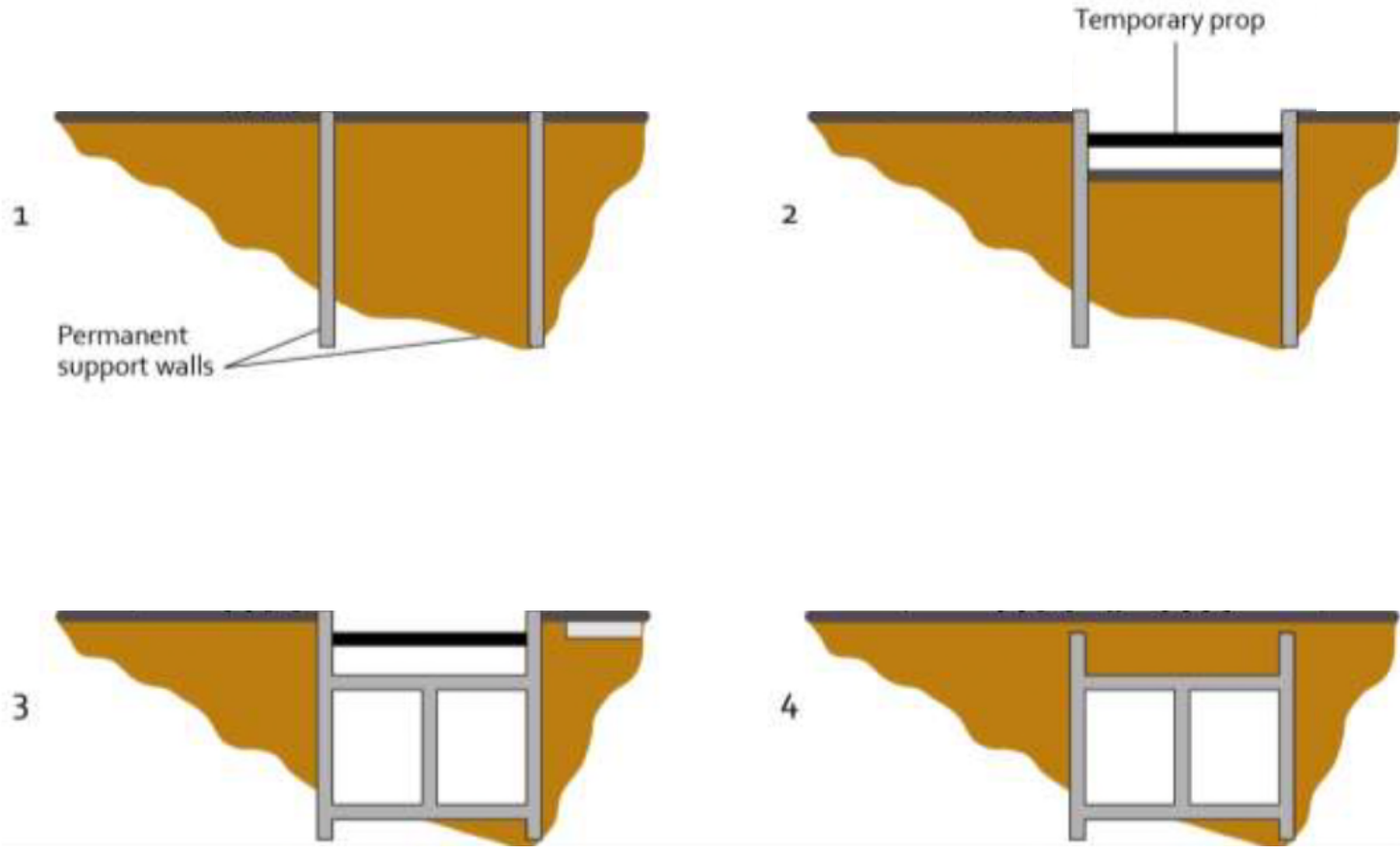


Construction

Operational Aspects of Tunnelling

Cost Implications

# Cut and Cover Construction Methodology 2



# HS1 Cut and Cover Tunnel



Construction

Operational Aspects of Tunnelling

Cost Implications

# Settlement & Rate of Tunnelling

The rate of tunnelling is dependent on ground conditions. It is also important in minimising settlement, which is achieved by operating tunnel boring machines appropriately such as using Earth Pressure Balance machines in “closed” mode.

In order to keep settlement to acceptable limits HS2 has specified maximum of 1% volume loss for bored tunnels. The Promoter’s policy on ground settlement is set out in Information Paper C14.

Continuous 24 hour tunnelling also minimises settlement as it doesn’t allow time for the for the ground to fully relax.

Construction

Operational Aspects of Tunnelling

Cost Implications



# Construction Aspects – Noise from Tunnel Drive Site

Bored tunnelling activities and the associated local site material handling will be operated 24 hours a day.

Noise mitigation is provided by the standard means such as hoarding, muffling, baffles and noise suppression on plant and equipment .

Tunnel sites will be subject to the same HS2 procedures set out under the Code of Construction practice and will be subject to Local Authority Approval under Section 61 of Control of Pollution Act.

Construction

Operational Aspects of Tunnelling

Cost Implications

# Construction Aspects – Noise from Tunnel Boring

Sound and vibration from the tunnel boring machine will be perceptible inside properties for a few days as it passes beneath them.

The effects of ground-borne sound and vibration from the machine on building occupiers will be short-term and is not considered to be significant.

# Minimum Safety Requirements

For tunnels under 1km in length

## Place of Relative Safety

- To adjacent independent tunnel tube every 500m

## Fire Fighting Point defined as

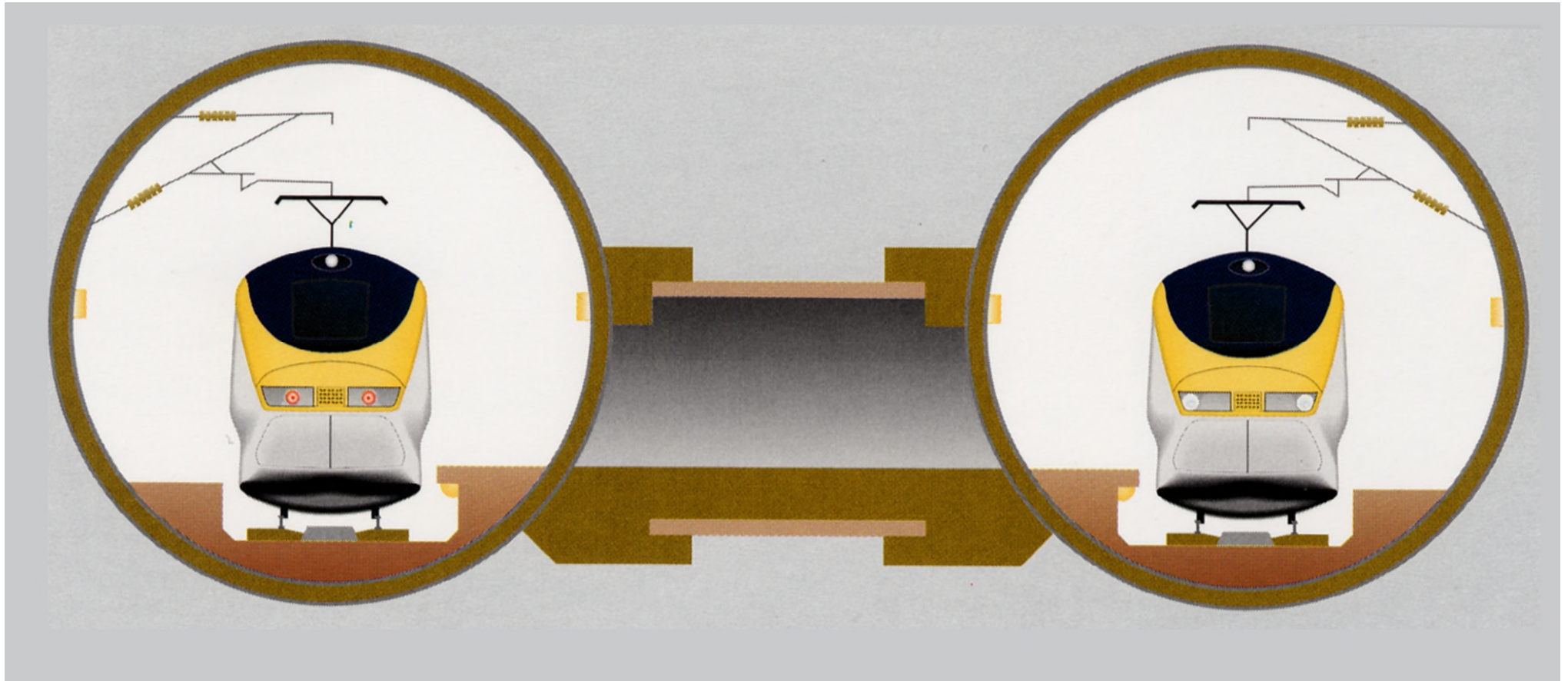
- Location inside or outside tunnel where fire fighting equipment can be used and passengers can evacuate
- Water supply capacity is a minimum of 800 l/min for 2 hours

Construction

Operational Aspects of Tunnelling

Cost Implications

# Tunnel Cross Passage



Construction

Operational Aspects of Tunnelling

Cost Implications

# Evacuation Walkway & Tunnel Cross Passage Opening HS1

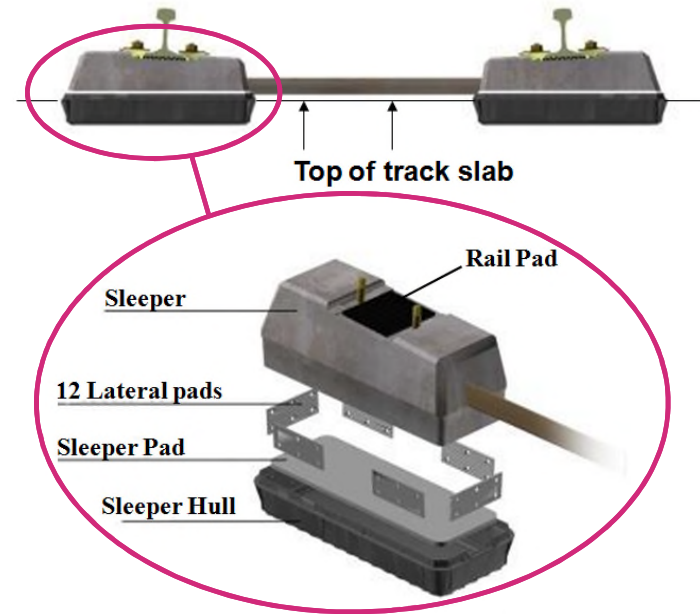


Construction

Operational Aspects of Tunnelling

Cost Implications

# Vibration Mitigation via “booted sleeper” track



Construction

Operational Aspects of Tunnelling

Cost Implications

# Costs of Tunnelling

## Fixed Costs

Tunnel Boring Machine typically  
£15m to £25m

Back up material handling  
similar cost order

Power supply

Mechanical and Electrical  
systems

## Linear Costs

Labour

Lining materials

Excavated material disposal

Ground monitoring

Ground treatment

Tunnel logistics

## Incremental Cost increases

Surface arrangements for drive  
sites, reception sites, tunnel  
logistics

Introduction of shafts

Increase in number of cross  
passages

Introduction of shafts and  
increase in tunnel Mechanical  
and Electrical systems.

Operational Aspects of Tunnelling

Construction

Cost Implications

# Cost vs. Length (Indicative)

