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TUNNEL EVIDENCE

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (GRAIN TO TILBURY) COMPULSORY PURCHASE ORDER 2024

STATEMENT OF EVIDENCE

Timothy M. Hyett
Tunnel and Geotech Expert
for National Grid Electricity Transmission plc

1. QUALIFICATIONS AND EXPERIENCE

1.1 My name is Timothy Hyett, and I am a Subject Matter Expert (**"SME"**), Technical Consultant and Expert Witness (**"EW"**) in the fields of Tunnelling, Underground Space and Geotechnics.

1.2 I am a Chartered Engineer (CEng), a Chartered Engineering Geologist (CGeol) and a fellow of the Geological Society. I am also a member of the British Tunnelling Society, the Institute of Engineers (Ireland) and the Chartered Institute of Building, and I hold undergraduate qualifications in civil engineering; degrees in maths and physics, an MSc in engineering geology and an LLM in law.

1.3 I have more than 40 years of experience working in Tunnelling, having entered the industry as a school leaver in 1980. My varied career progression spanning four decades has provided me with direct exposure to many clients, consultants and leading tunnel and civil engineering contractors, where at some point or other I have carried out most if not all the recognised engineering, technical, managerial, contractual and commercial functions associated with modern tunnel building in the UK and abroad.

1.4 My specialist disciplines include Tunnel Boring Machine ("**TBM**") driven segmental tunnels, micro-tunnels and trenchless techniques used for major river/marine crossings and offshore landfalls to support oil & gas distribution and high voltage electricity transmission.

1.5 I am currently working for National Grid Electricity Transmission plc ("**NGET"**) as Tunnel & Geotech SME on the Grain to Tilbury (TKRE) cable tunnel project crossing the Thames ("**the Project**"). I also work in the same capacity on NGET's Snowdonia Visual Impact Provision (**"VIP")** Cable Tunnel project crossing the Dwyryd

Estuary, amongst several other assignments, and prior to this, I worked as Principal Tunnelling Expert for National Grid (Gas) on the Feeder 9 Pipeline Tunnel crossing the Humber Estuary. I have also worked in the tunnelling sector across the UK and abroad in Europe, the Middle East and North America.

2. INTRODUCTION AND SCOPE OF EVIDENCE

2.1 My evidence in respect of the National Grid Electricity Transmission (Grain to Tilbury) Compulsory Purchase Order ("**the Order")** is structured as follows:

Section 3 provides an overview of the Project

Section 4 describes NGET's experience in delivering tunnelling projects.

Section 5 describes NGET's approach to tunnelling on this scale.

Section 6 describes the tunnelling works required for the Project.

Section 7 provides a response to matters raised by objectors to the Order insofar as they are relevant to my area of expertise, and;

Section 8 provides a summary of my evidence and my conclusions.

2.2 References in my evidence to the core documents are made by the abbreviation, for example, **"CD XX".** The evidence of other witnesses is referred to by the name of the author. There is a glossary of key terms used by all the NGET witnesses at **CD:F7 ("the Glossary")** and my evidence adopts the terms defined in the glossary.

3. OVERVIEW OF THE PROJECT

3.1 As set out in the evidence of Lee Driscoll, the Project comprises the boring of a new tunnel under the River Thames, two new sealing end compounds and tunnel headhouses, new overhead line gantry structures, downleads and modifications to the existing OHL to enable the new OHL conductors which will be connected to the existing 400 kilovolt ("**kV**") OHL conductors via new terminal towers.

3.2 Specifically, the scope of work arose following NGET's initial engagement with proposals to upgrade the Grain-Tilbury and Kingsnorth-Tilbury 400 kV high voltage (**"HV"**) electric circuits to meet the Future Energy Scenarios (**"FES"**) and Electricity Ten Year Statement (**"ETYS"**) produced by the National Energy System Operator (**"NESO"**) who forecast a large amount of renewable generation, including offshore wind and nuclear, together with three interconnectors from the continent to connect into the east coast of England.

4. NATIONAL GRID'S EXPERIENCE IN DELIVERING TUNNELLING PROJECTS

4.1 As owner and operator of the UK's NHV electricity transmission network (and the high-pressure gas transmission system) NGET have an established track record building cable tunnels of this type and other complex underground infrastructure. Their talented and diverse engineering teams have delivered some of the most difficult tunnelling projects in the UK in recent years, making them extremely well placed to procure, manage, and supervise the challenging Project. For example:

4.2 The first phase of the London Power Tunnels **("LPT")** project commenced in 2011 with the construction of around 40km of HV Cable Tunnel constructed using state-of-the-art TBMs, triggering the start of a huge investment program spanning 15 years to relocate HV electric cables beneath the streets of the capital at depths ranging from 15m to 60m to ensure there is sufficient transmission infrastructure available to support existing and future energy demands in London and the south-east.

4.3 In 2020, the second phase of LPT began and involved another 30km of tunnel in diameters ranging from 3.0m to 4.0m, constructed using state-of-the-art TBMs over three main sections: from *Wimbledon to New Cross* (12km), *New Cross to Hurst* (18km) and *Hurst to Crayford* (2.5km). There were seven vertical shafts over 30m deep with modifications to existing substations, OHLs and two new substations north of the Thames.

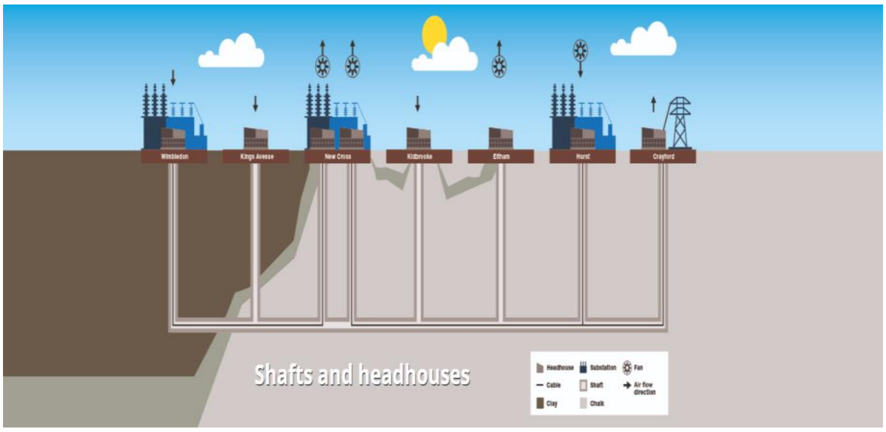

Fig 1 - Schematic of the London Power Tunnels project (LPT1)

4.4 Between 2016 and 2021, National Grid (gas) also delivered the Feeder 9 Gas Pipeline Tunnel project - a 5.5km long 3.65m diameter PCC lined tunnel to beneath the Humber estuary in difficult geology under high water pressure. On completion, the Humber tunnel project was recognised as the longest river / marine pipeline tunnel constructed in the World to date and was credited as such in the Guinness book of records.

4.5 NGET are also currently building the Snowdonia VIP Cable Tunnel in North Wales - a large diameter TBM driven tunnel 3.45km long beneath Dwyryd Estuary in hard rock - to relocate HV OHL cables underground.

4.6 All the above infrastructure projects were built using state-of-the-art TBM tunnelling techniques and involved with deep vertical shafts and cable installations like the current Project. To reflect the engineering challenges on the current Project, NGET assembled key senior project management staff from LPT, Snowdonia VIP and the Humber projects to lead the scheme through detailed design and construction, working alongside recognised SME's and discipline experts in a variety of specialist areas.

5. NATIONAL GRID'S APPROACH TO TUNNELLING

5.1 National Grid is one of the largest investor-owned energy companies in the world, and it plays a vital role in delivering electricity and gas to millions of people across the UK (and the north-eastern US). In terms of position within the tunnelling Industry, NGET are probably the largest single corporate entity in the UK who can demonstrate a proven track record of medium to large diameter tunnel building on such a scale using advanced, state-of-the-art TBM technology and shaft sinking capability.

5.2 As a matter of policy, NGET are fully committed to the Construction (Design and Management) Regulations 2015 ("**CDM**") on every major tunnelling project. CDM ensures health and safety is prioritised and managed throughout every stage of a construction project to reduce the risk of harm to the workforce, members of the public and the environment.

5.3 From the outset, the NGET delivery team for the Project have embraced key tunnel industry guidelines and looked closely at relevant past projects in an effort to mitigate project risk. The lessons learned include, amongst other things, the importance of carrying out geo-hazard risk assessments early; the importance of accurate geological data collection; correct TBM selection; rigid TBM specification; the importance of a robust Tunnel Lining design; a zero-tolerance approach to leaks and annular grouting; and a commitment to monitoring ground movement and tunnel deformation, along with quality assurance and control. .

5.4 Whilst unforeseen conditions can never be eliminated entirely on major TBM driven tunnels in complex geology, the following standards remain the key guidelines that have been prioritised on the project to minimize risk:

5.4.1 BS 6164:2019 Code of Practice for health and safety in tunnelling in the construction industry.

5.4.2 Specification for tunnelling, Third Edition, published by the British Tunnelling Society and The Institute of Civil Engineers 2010.

5.4.3 Closed-face tunnelling machines and ground stability - a guideline for best practice. Published by the British Tunnelling Society and The Institute of Civil Engineers 2005.

5.4.4 BS EN 16191:2013 Tunnelling machinery – Safety Regulations (which came into force in 2014).

5.4.5 Tunnel lining design guide. Published by the British Tunnelling Society and The Institute of Civil Engineers 2004.

5.4.6 The Joint Code of Practice for Risk Management of Tunnelling Works in the UK, 2003 (**"JCOP"**) published by the British Tunnelling Society and the Association of British Insurers.

5.4.7 The international Tunnelling Code of Practice for Risk Management of Tunnelling Works, 2012 (**"TCOP"**).

5.5 The list is by no means exhaustive, and many further tunnelling industry codes, standards and regulations have been adopted wholesale. In addition, NGET have prepared detailed in-house specifications, including for the TBM, the Tunnel Lining and the Spoil Treatment Plant ("**STP"**) - all of which elevate the national and international standards even higher - in a dedicated effort to ensure, with a high degree of certainty, that the project is delivered safely and with the minimum disturbance to third parties, members of the public and the environment.

5.6 These procedures have influenced the planning and design of the Project and in turn helped NGET minimise site footprints required for construction, including the compound areas either side of the river, access roads and peripheral land subject to the Order.

6. TUNNELLING WORKS REQUIRED FOR THE PROJECT

6.1 A large section of the new infrastructure required on the Grain-Tilbury scheme is in OHL but the existing HV circuits also currently pass beneath the Thames in an existing medium diameter cable tunnel built in the 1960s.

6.2 Early in the Project it was identified that the existing tunnel is not capable of accommodating the cables required to upgrade the network as required to increase capacity and that the only feasible and appropriate solution was to build a new, replacement HV Cable Tunnel beneath the Thames. This new tunnel would have an internal diameter of c.4.0m and a length of approximately 2.2km to house and carry the 12 new cross-linked HV electricity cables needed as part of the upgrade to the network.

6.3 Having identified the preferred option of installing the cables in a new tunnel under the River Thames, NGET considered options for carrying out the tunnel works efficiently, including the use of trenchless techniques, which if feasible would have had a lower-scale impact and a reduced budget cost than a new TBM driven tunnel of this size and scale.

6.4 Most utility tunnels (for electricity/gas/telecom) are usually relatively small in diameter, and act as a 'sleeve', the purpose of which is primarily to carry other conduits such as smaller pipelines, cables and services etc., arranged inside the sleeve in a suitable configuration. In these circumstances various techniques are borrowed from the wider tunnelling and civil engineering industry (i.e. micro-tunnelling, pipe-jacking and horizontal directional drilling ("**HDD**") which are also underground disciplines that NGET are particularly familiar with. However, in each case, the technical appraisals proved that these methods were unsuitable for the Project, due to either the span of the Thames, the HV cable requirements and circuit configurations, geology, bathymetry and riverbed geomorphology and/or physical geometry of the riverbanks at Tilbury and Grain. This was the case even when considering the most advanced, state-of-the-art hybrid directional drilling and trenchless techniques available in the current global marketplace.

6.5 The proposed cable tunnel originates from these early conceptual studies. As the Project progressed through *Front End Engineering Design* ("**FEED**"), which included a comprehensive and robust geological assessment, it was determined that a 4.0m internal diameter structurally lined tunnel was required to accommodate the new HV infrastructure. In plain terms, the FEED alignment is a simplistic schematic line on a drawing. However, in order to actually build a tunnel of this scale and complexity, a Design and Build **("D&B")** Contractor needs to delve into the minute detail, and effectively interrogate every meter along the tunnel for spatial orientation, especially through curves to ensure the TBM can navigate the radius, and to ensure the PCC linings can be built through the radius etc, in order to get the actual alignment. Post FEED stage, the project moves into detailed design, which is performed by the D&B Contractor.

6.6 All tunnel and underground space 'design' (irrespective of what it is intended for) comprises three key elements: (i) determination of an alignment (horizontal and vertical), (ii) design / determination of a means of physical support, and (iii) determination or selection of a means to excavate.

6.7 The *horizontal alignment* currently selected for the project represents the optimum route across the Thames, considering the position of the existing 2.8m cable tunnel (upstream) and the route of the proposed Lower Thames Crossing ("**LTC"**) road tunnel (downstream).

6.8 The *vertical alignment* (i.e. tunnel depth) currently selected for the Project represents the optimum and safest position for the tunnel beneath the riverbed, taking account of geology and glaciofluvial geomorphology (i.e. the evolution and movement of sediments in the river). In turn, this set shaft depths at circa 40m at Tilbury and Gravesend and defined a length between the shafts of 2.2km.

6.9 The Tunnel also needs to have a protection zone, which is to protect the built asset against being compromised by any new development in close proximity. If the protection zone was not there, then there would be a risk of new development damaging the tunnel and impairing its design life, which is currently 120 years. Development outside the specified zone will not affect the tunnel, and that is why it is usual for Tunnels to be designed with a suitable ~~a~~ protection zone in mind. The precise location of the tunnel (and its protection zone), may deviate slightly within the extent of the red line boundary established for planning purposes. This is based on minor alterations between the FEED alignment and the actual alignment the Contractor selects at detailed design stage after interrogating the geology and considering other pertinent construction factors.

6.10 The selection of segmental Pre-Cast Concrete (**"PCC"**) linings with an internal dia. of circa 4.0m also represents the optimum and safest means of *physical support* for a tunnel in this geology, and PCC rings are the most robust structural lining for HV cable support, with a 120-year design life.

6.11 Having selected a PCC tunnel lining and taking due cognisance of the critical geology (i.e. chalk) including hydrostatic pressure due to the body of water (i.e. the Thames) a state-of-the-art slurry pressure balance TBM represents the optimum and safest *means of excavation*. In turn, this determined shaft diameters of 15m, as this is the minimum size from which to launch a TBM of this type and size from Tilbury and recover the same at Gravesend.

6.12 The basic aim of the tunnel detailed design discussed above is to determine precisely what construction criteria is required, establish land take requirements and identify what principal structural support materials are required to create as little disturbance as possible during the tunnelling process, and identify what is required to be added in the way of concrete or steel support in the tunnel and shafts to prevent surface movement.

6.13 The extent to which the basic design aim can be met depends on the geological conditions that exist on the job site and the extent to which the design team is aware of them. In consideration of this, NGET carried out an exhaustive review of historic ground information in this location, including research from the 2.8m cable tunnel built in the 1960s, and data from the planned LTC project situated c.500m to the east, as well as relevant Port of London Authority ("**PLA"**) dredging data and bathymetry charts. This enabled the early formulation of a *Conceptual Ground Model*, allowing a preliminary design to be developed and considered for the purposes of local area planning permission.

6.14 At the same time NGET commissioned a thorough project-specific geotechnical investigation ("**GI**"), the interpretation of which is an essential prerequisite of the tunnel design process. Boreholes were drilled onshore at Tilbury and Gravesend, and over water from jack-leg pontoons positioned across the span of the river to a depth much greater than the tunnel alignment and at a proportionate separation distance in accordance with *Eurocode 7 (EC7)*. All GI fieldwork was carried out in accordance with best practice as set out in *BS 5930, Code of Practice for ground investigations*.

6.15 This enabled the formulation of the *Observational Ground Model*, allowing the preliminary FEED design of the shafts and tunnel to be progressed. In turn, this also identified the land take areas at

Tilbury and Gravesend required in order to deliver the Project; and informed shaft and tunnel construction methods; TBM selection, headhouse positions and size.

6.16 Drawing upon NGET's past tunnelling experience from projects like LPT, Snowdonia VIP, and the Humber Pipeline Tunnel - all of which were of a similar diameter and involved similar shafts and headhouse configurations - this enabled accurate predictions regarding space proofing, shaft and compound layouts, estimates of vehicle movements as well as enabling reasonable forecasts of volumes of construction traffic, determination of access routes and potential environmental impact.

6.17 Specifically, NGET's knowledge gained from relevant past projects enabled reliable identification of the land take requirements to build the Grain-Tilbury Project, as well as informing how best to safely construct the shafts and tunnel and how best to handle and process excavated material while protecting the environment and minimising disruption to third parties.

Fig 2 - Aerial photograph of London Power Tunnels (LPT2) shaft site like Grain-Tilbury.

Fig 3 – Herrenknecht VSM showing compact site set-up as proposed on Grain-Tilbury.

6.18 In addition, NGET have selected innovative a Vertical Shaft Machines ("**VSM"**) for the Project (see Fig 3 above). This is a 'mechanised' shaft sinking method (not unlike a vertically deployed TBM) that has been in development for several years at Herrenknecht in Germany and which has only seen deployment outside the UK in recent years.

6.19 A major benefit of the VSM system is that it has been designed with a compact jobsite set-up for reliable construction of vertical shafts in restricted space conditions. VSM technology shows its strengths particularly below ground water, in proximity to major rivers and watercourses, and it can be used in all ground conditions, but can function within a minimum surface land take.

6.20 These proposals / considerations demonstrate how NGET have sought to minimise land take generally on the Project, and prioritise health and safety, as well as a maintaining a commitment to third parties and protecting the environment.

7. RESPONSE TO MATTERS RAISED BY OBJECTORS

7.1 I am aware that there are two outstanding objections to the Order. I have responded below to the SGN objection which is the only objection that I consider raises matters relevant to my area of expertise.

SGN (apparatus under the road to be used to transport the tunnel boring machine (TBM))

7.2 SGN states that it has gas mains in the Order Land or the vicinity and that it has concerns that the TBM may adversely affect the integrity of and / or access to these gas mains which form an essential part of the local gas network. NGET needs rights of access down the relevant private road as it may need to use that track for the TBM.

7.3 In response to this, I understand that SGN experienced some issues relating to integrity of some of its buried pipeline assets on the recent Thames Tideway Tunnel project which may have been adversely affected because of incidental surface movements when the colossal TBMs on that project were either delivered or removed from the locality post construction.

7.4 Whilst unusually heavy and abnormal vehicular loads do occasionally have the capacity to impact utilities buried at shallow depth under roads and highways, it is important to note that the TBMs on Thames Tideway were 7.2m in diameter, and considerably larger (and very much heavier) than the 4.0m diameter TBM proposed for the Grain-Tilbury project.

7.5 On large projects like Thames Tideway one of the most complex engineering tasks is the delivery of the TBM shield to the drive site, and its removal post completion. With smaller diameter TBMs, it is often possible to deliver the shield whole or in sections without severely impacting highway infrastructure. This is not usually possible for larger diameter TBMs, as the size and weight of the various major components (cutterhead, main bearing, erector, shield sections, etc.) can make it impractical or impossible to deliver the shield whole, or even partially assembled.

7.6 The 4.0m diameter TBM proposed for the project is considerably smaller than that used on the Thames Tideway project. We know from past projects like LPT2, the Humber and Snowdonia VIP that TBMs of this diameter can be shipped from Germany and moved by conventional road transport from UK ports to job sites without any impact on general highway infrastructure, subject to a detailed swept path analysis, which identifies obstructions or sensitive buried utilities such as gas pipelines, water mains etc.

7.7 A detailed swept path analysis will be carried out to determine the final route for the TBM during which every sensitive buried asset in proximity will be examined in detail and a structural analysis carried out to ensure abnormal vehicular loading does not interfere or adversely impact the integrity of any utility within the highway.

7.8 Typically, buried utilities and services such as those owned by SGN will remain unaffected by heavy vehicular transport so long as the surface movement (subsidence) of the road pavement is not more than 10mm. This target limit is referenced in Highways England SES Guidance Note: SESGEOGNT00001 '*Geotechnical Certification Process for Third Party Trenchless Installations Under Highways England Strategic Road Network*) (**Appendix 1)** and is generally accepted as a 'benchmark' in the *Design Manual for Roads and Bridges (DMRB)* as outlined in *CD 622 Managing geotechnical risk* **(Appendix 2)** - which applies to road pavements and nearby structures (bridges etc.) across the UK road network.

7.9 Whilst the movement of a 4.0m diameter TBM will usually constitute an 'abnormal load' (i.e. a load that is too large, heavy, or wide to be transported by a standard vehicle) unlike the Thames Tideway TBM, in this case it is not the weight *per se* that presents the primary problem on the Grain-Tilbury project.

7.10 The analysis that will be performed as part of the swept path analysis (and any subsequent *Abnormal Load Impact Assessment*) is the responsibility of the Contractor and will follow procedures like those used for Category 2 underground structures. The TBM will then be broken down in the factory in Germany into suitable sections and specific road trailers will be selected and deployed by the specialist transport company using multiple axle configurations to ensure these limits are not exceeded.

7.11 Movements of this type also require special planning and permits for safe transportation, and the whole process is managed carefully by way of the *Electronic Service Delivery for Abnormal Loads* system ("**ESDL**") operated by Highways England to notify and allow hauliers to plot a suitable route for movements around the road network.

7.12 Permission will not ordinarily be granted where there is a risk of damage to either the highway (or any buried utilities) and whilst the process will be managed and coordinated by the *Contractor*, all transport proposals will need to be accepted by NGET before sanctioning the TBM move.

7.13 The concerns of SGN are duly noted, but the TBM on the Project is a fraction of the size and weight of the Tideway TBMs, and following a detailed swept path analysis to determine the final route, every sensitive buried asset in proximity will be examined in detail and a structural analysis carried out to ensure abnormal vehicular loading does not interfere or adversely impact the integrity of any utility within the highway.

7.14 Where further concerns are highlighted (or arise) from third parties such as SGN (or others) the TBM will simply be transported in smaller sections, as the key components of a 4.0m TBM of this type are readily broken down into more manageable sizes and weights that reduce the risk of damage even further.

8. SUMMARY AND CONCLUSIONS

8.1 I have more than 40 years of experience working in Tunnelling, having entered the industry as a school leaver in 1980.

8.2 I am currently working for National Grid Electricity Transmission plc as Tunnel & Geotech SME on the Project. I also work in the same capacity on NGET's Snowdonia Visual Impact Provision Cable

Tunnel project crossing the Dwyryd Estuary, amongst several other assignments. I have also worked in the sector across the UK and abroad in Europe, the Middle East and North America.

8.3 The Project involves the construction of two 15m diameter deep shafts to a depth of c.40m at Tilbury and Gravesend, and 2.2km long 4.0m diameter PCC Segmental Tunnel driven beneath the river Thames.

8.4 The scope of work arose following NGET's initial engagement with proposals to upgrade the Grain-Tilbury and Kingsnorth-Tilbury 400 kV high voltage electric circuits to meet the Future Energy Scenarios and Electricity Ten Year Statement produced by the Electricity System Operator who forecast a large amount of renewable generation, including offshore wind and nuclear, together with three interconnectors from the continent to connect into the east coast of England.

8.5 NGET have an established track record building cable tunnels of this type and other complex underground infrastructure including LPT phases 1 and 2, Feeder 9 Gas Tunnel Project beneath the Humber Estuary and Snowdonia VIP. More details are in the main body of my evidence.

8.6 NGET can demonstrate a proven track record of medium to large diameter tunnel building on such a scale using advanced, state-of-the-art TBM technology and shaft sinking capability.

8.7 The NGET delivery team for the Project have embraced CDM and key tunnel industry guidelines and looked closely at relevant past projects in an effort to mitigate project risk. The lessons learned include, amongst other things, the importance of carrying out geo-hazard risk assessments early; the importance of accurate geological data collection; correct TBM selection; rigid TBM specification; the importance of a robust Tunnel Lining design; a zero-tolerance approach to leaks and annular grouting; and a commitment to monitoring ground movement and tunnel deformation, along with quality assurance and control.

8.8 Some of the key tunnelling guidelines and standards prioritised on the Project to minimize risk are listed in the main body of my evidence. Many further tunnelling industry codes, standards and regulations have been adopted wholesale. In addition, NGET have prepared detailed in-house specifications, including for the TBM, the Tunnel Lining and the Spoil Treatment Plant - all of which elevate the national and international standards even higher - in a dedicated effort to ensure, with a high degree of certainty, that the Project is delivered safely and with the minimum disturbance to third parties, members of the public and the environment.

8.9 These procedures have influenced the planning and design of the Project and in turn helped NGET minimise site footprints required for construction, including the compound areas either side of the river, access roads and peripheral land subject to the Order.

8.10 The new tunnel will have an internal diameter of c.4.0m and a length of approximately 2.2km to house and carry the 12 new cross-linked HV electricity cables needed as part of the upgrade to the network. A protection zone around the tunnel is incorporated within the design and is needed to ensure the NGET asset is protected from future development in close proximity.

8.11 Having identified the preferred option of installing the cables in a new tunnel under the River Thames, NGET considered a variety of options for carrying out the tunnel works safely and efficiently.

8.12 Traditional tunnelling methods and current trenchless technologies were unsuitable for the Project, due to either the span of the

Thames, the HV cable requirements and circuit configurations, geology, bathymetry and riverbed geomorphology and/or physical geometry of the riverbanks at Tilbury and Grain.

8.13 As the Project progressed through design, it was determined that a 4.0m internal diameter structurally lined tunnel was required to accommodate the new HV infrastructure.

8.14 The *horizontal alignment* selected for the project represents the optimum route across the Thames, considering the position of the existing 2.8m cable tunnel (upstream) and the route of the proposed Lower Thames Crossing ("**LTC**") road tunnel (downstream).

8.15 The *vertical alignment* (i.e. tunnel depth) selected for the Project represents the optimum and safest position for the tunnel beneath the riverbed, taking account of geology and glaciofluvial geomorphology (i.e. the evolution and movement of sediments in the river). In turn, this set shaft depths at circa 40m at Tilbury and Gravesend and defined a length between the shafts of 2.2km. There is some latitude for the Contractor to adjust the tunnel alignment within the red-line boundary established at FEED stage for planning purposes, but this is expected to be minor during detailed design.

8.16 The selection of segmental Pre-Cast Concrete linings with an internal dia. of circa 4.0m represents the optimum and safest means of *physical support* for a tunnel in this geology, and PCC rings are the most robust structural lining for HV cable support, with a 120-year design life.

8.17 Taking account of the above, a state-of-the-art slurry pressure balance TBM represents the optimum and safest *means of excavation*. In turn, this determined shaft diameters of 15m, as this is the minimum size from which to launch a TBM of this type and size from Tilbury and recover the same at Gravesend.

8.18 The basic aim of the tunnel design discussed above is to determine precisely what construction criteria is required, establish land take requirements and identify what principal structural support materials are required to create as little disturbance as possible during the tunnelling process, and identify what is required to be added in the way of concrete or steel support in the tunnel and shafts to prevent surface movement.

8.19 NGET carried out an exhaustive review of historic ground information in this location, including research from the 2.8m cable tunnel built in the 1960s, and data from the planned LTC project situated c.500m to the east, as well as relevant Port of London Authority dredging data and bathymetry charts.

8.20 At the same time NGET commissioned a thorough project-specific geotechnical investigation the interpretation of which is an essential prerequisite of the tunnel design process.

8.21 This enabled the formulation of the *Observational Ground Model*, allowing the preliminary FEED design of the shafts and tunnel to be progressed. In turn, this also identified the land take areas at Tilbury and Gravesend required in order to deliver the Project; and informed shaft and tunnel construction methods; TBM selection, headhouse positions and size.

8.22 Drawing upon NGET's past tunnelling experience from similar projects like LPT, Snowdonia VIP, and the Humber Pipeline Tunnel - this enabled accurate predictions regarding space proofing, shaft and compound layouts, estimates of vehicle movements as well as enabling reasonable forecasts of volumes of construction traffic, determination of access routes and potential environmental impact.

It also enabled reliable identification of the land take requirements to build the Project, as well as informing how best to safely construct the shafts and tunnel and how best to handle and process excavated material while protecting the environment and minimising disruption to third parties.

8.23 In addition, NGET have selected innovative Vertical Shaft Machines for the Project. This system has been designed with a compact jobsite set-up in mind for reliable construction of vertical shafts in restricted space conditions. VSM technology can function effectively within a minimum surface footprint.

8.24 These proposals / considerations demonstrate how NGET have sought to minimise land take and prioritise health and safety and protecting the environment.

8.25 It is understood that SGN experienced some issues relating to integrity of some of its buried pipeline assets on the recent Thames Tideway Tunnel project

8.26 The 4.0m diameter TBM proposed for the project is considerably smaller than that used on the Thames Tideway project. We know from past similar projects that TBMs of this diameter can be shipped and moved by conventional road transport from UK ports to job sites without any impact on general highway infrastructure, subject to a detailed swept path analysis, which identifies obstructions or sensitive buried utilities such as gas pipelines, water mains etc.

8.27 The TBM will be broken down in the factory in Germany into suitable sections and specific road trailers will be selected and deployed by the specialist transport company using multiple axle configurations to ensure abnormal load limits are not exceeded.

8.28 8.28 Movements of this type also require special planning and permits for safe transportation, operated by Highways England. Permission will not ordinarily be granted where there is a risk of damage to either the highway (or any buried utilities).

8.29 The concerns of SGN are duly noted, but the TBM on the Project is a fraction of the size and weight of the Tideway TBMs, and following a detailed swept path analysis, buried pipelines in proximity will be examined in detail and a structural analysis carried out to ensure abnormal vehicular loading does not interfere or adversely impact the integrity of any utility within the highway.

8.30 Whilst SGN's objections to the Order are noted, they are not fully justified, as every possible effort has been taken by NGET to minimise land take, consider third party needs, prioritise safety and protect the environment.

8.31 On this basis, in my opinion, the objection should not be upheld.

9. DECLARATION

9.1 I confirm that the evidence prepared for this Inquiry and contained within this statement of evidence are my true and professional opinions. I confirm that I have understood and complied with my duty to the Inquiry as an Expert Witness and have provided my evidence impartially and objectively. I confirm that I have no conflicts of interest.

Timothy M Hyett

12th May 2025