National Grid
Cable Tunnel Replacement Project

Environmental Statement
Volume II
Chapter 2 Alternatives

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Quality information

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2.1 Introduction

2.1.1 In accordance with Regulation 18(3)(d) and Schedule 4 part 2 of the Town and Country Planning (Environmental Impact Assessment) Regulations 2017 (2017 Regulations) (Ref 2-1), this chapter will provide a description of the reasonable alternatives considered by National Grid which are relevant to the Proposed Development and its specific characteristics, and the main reasons for the option chosen, taking into account the effects of the Proposed Development on the environment.

2.1.2 This chapter sets out the need for the Proposed Development and describes how the project has been identified; firstly, in response to the need case and secondly, how the Proposed Development has evolved and the alternatives that have been considered taking account of National Grid statutory duties under the Electricity Act 1989.

2.2 Background

2.2.1 The Future Energy Scenarios (FES) (Ref 2-2) and Electricity Ten Year Statement (ETYS) 2020 (Ref 2-3) forecast a large amount of renewable and low carbon generation, including offshore wind and nuclear, together with three interconnectors from the continent connecting into the transmission system in the east coast of England. Through these forecasts, National Grid Electricity System Operator (ESO) has identified that the Tilbury to Grain and Tilbury to Kingsnorth 400 kilovolt (kV) circuits will be significantly overloaded in their current capacity.

2.2.2 The Network Options Assessment (NOA) is undertaken by the ESO each year. This comprises economic analysis to understand the balance between managing power flows across network boundaries by making constraint payments and the cost of asset-based reinforcement options proposed by the Transmission Owners (TOs). In the most recent NOA (2022) (Ref 2-4), the ESO has recommended investment in upgrading these 400 kV circuits giving the project a 'proceed' signal with an Earliest in Service Date (EISD) of 2028. This is reconfirmed in the NOA refresh published July 2022, incorporating the Holistic Network Design (HND) as a key input.

2.2.3 The 400 kV circuits are currently predominantly overhead line, with a cable section installed within a deep tunnel crossing the River Thames. As the Transmission Licence Holder with responsibility for the circuits, National Grid commenced assessing alternative approaches to refurbish or upgrade the existing tunnel section of the 400 kV circuits in 2021.

2.3 Need for the Proposed Development

2.3.1 National Grid owns and operates the national high-voltage electricity transmission system throughout England and Wales. The key role of the transmission system is to connect the electricity generators' power stations with the local distribution networks of the regional electricity companies. National Grid holds the Transmission Licence for England and Wales and is thus obligated to develop and maintain an efficient, co-ordinated and economical system of electricity transmission and to facilitate competition in the generation and supply of electricity, as set out in the Electricity Act 1989.

2.3.2 The Proposed Development is part of the Ofgem's new accelerated strategic transmission investment (ASTI) framework (Ref 2-5) (published December 2022). National Grid is responsible for delivering the extensive onshore transmission system enhancements that are required to achieve the government's 2030 power section decarbonisation target.

2.3.3 National Grid's operations are dictated by the latest Future Energy Scenarios (FES) and Electricity Ten Year Statement (ETYS) reports. In recent years, these reports have begun forecasting a large amount of renewable and low carbon energy generation, connecting into the transmission network

in the east coast of England, together with three interconnectors from the continent. Through these forecasts, National Grid Electricity System Operator (ESO) has identified that the Tilbury to Grain and Tilbury to Kingsnorth (TKRE) 400 kilovolt (kV) circuits will be significantly overloaded in their current capacity and require uprating. National Grid has named this wider project: 'Grain to Tilbury'.

2.3.4 Each year, the ESO undertakes an assessment of the options National Grid has available for meeting forecasted energy demands (the Network Options Assessment, NOA). This assessment comprises economic analysis to understand the balance between managing power flows across network boundaries. In the most recent NOA (2021/22), the ESO has recommended investment in upgrading the 400 kV circuits giving the project a 'proceed' signal with an Earliest in Service Date (EISD) of 2028. This was reconfirmed in the NOA refresh published July 2022.

2.3.5 The 400 kV circuits are currently predominantly overhead line, with a section installed within a deep tunnel beneath the River Thames. As the Transmission Licence Holder with responsibility for the circuits, National Grid are required to upgrade them.

2.4 Approach to developing the Proposed Development

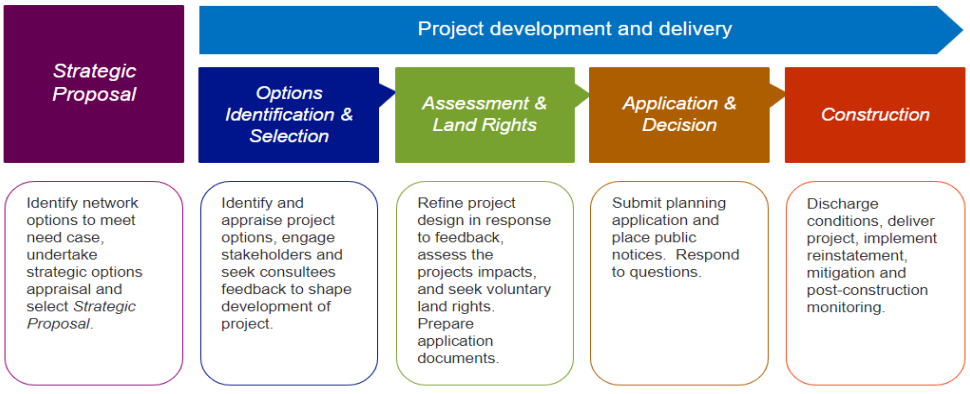
2.4.1 As a transmission licence holder under the Electricity Act 1989 (1989 Act) (Ref 2-6), National Grid has a number of statutory duties which it must comply with when developing and maintaining its network. In accordance with Section 9(2) of the 1989 Act, the holder of a licence authorising the transmission of electricity must develop and maintain an efficient, coordinated and economical electricity transmission system and to facilitate competition in the supply and generation of electricity.

2.4.2 In terms of Schedule 9 of the 1989 Act, National Grid is required in formulating any 'relevant proposals' such as the Proposed Development, to (a) have regard to the desirability of preserving natural beauty, of conserving flora, fauna and geological or physiographical features of special interest and of protecting sites, buildings and objects of architectural, historic or archaeological interest; and (b) do what he reasonably can to mitigate any effect which the proposals would have on the natural beauty of the countryside or on any such flora, fauna, features, sites, buildings or objects.

2.4.3 Taking account of this, National Grid has considered the natural environment, cultural heritage, landscape and visual quality, and also includes the impact of its works on communities, such as the effects on traffic and transport from construction in developing the Proposed Development.

2.4.4 The statutory responsibilities outlined above underpin National Grid's approach to developing new infrastructure projects such as the Proposed Development. This is illustrated below in Plate 2-1. The first three stages (Strategic Proposal, Options Identification and Selection and Assessment and Land Rights) have informed the identification of the Proposed Development. At each of these stages, National Grid has considered a range of engineering, economic, environmental and social factors consistent with its statutory duties. In addition, consultation has been undertaken with stakeholders and members of the public at key stages providing the opportunity to feedback on alternatives and inform the identification of the Proposed Development.

Plate 2-1: National Grid's Approach to Project Development & Delivery



2.5 Strategic Proposal

Strategic Options Appraisal

2.5.1 In 2022, National Grid undertook a Strategic Options Appraisal to inform the selection of a preferred option for the upgrade of the 400kV circuits. The Strategic Options Appraisal Report documented the environmentally led process which identified and balanced technical, socio-economic, environmental and cost considerations to inform the selection of a preferred option for the upgrade of the 400kV circuits that cross the River Thames. The three options initially identified are described below.

Option 1: The installation of new cables within the existing tunnel

This option comprised the removal of the existing fluid filled cables (FFCs) within the existing tunnel and retrofitting of new cross-linked polyethylene (XLPE) cables. This option would also require civil repair work to the existing tunnel, although the full extent of this work was unknown. The existing mechanical ventilation system would require replacement. A new mechanical ventilation system would be required in a building of approximately 20m x 10m as shown on **Plate** 2-2. Mechanical and electrical services (M&E) at Tilbury would also be required with this option.

Source: Mott MacDonald, 2021

Plate 2-2: Option 1, new mechanical ventilation system in a building of approximately 20m x 10m

2.5.2 There were health and safety risks associated with Option 1 which would not meet with health and safety regulations or National Grid technical requirements. For example, the works would be within a confined space where the working area would be extremely limited. Additionally, the work would need to be undertaken adjacent to live equipment, as at least one 400kV circuit would need to remain live to maintain electricity supply.

2.5.3 During cable replacement, each circuit would need to be switched out for a full outage season with an Emergency Return to Service (ERTS) on commissioning. The maximum outage duration that could be facilitated for the refurbishment of the tunnel and shafts would be two, six-month outages, in 2026 and 2028 (noting system access would not be available in 2027). An uninterrupted 18-month outage per circuit would not be possible for the Kingsnorth-Tilbury and Grain-Tilbury circuits with consecutive outages required per year between 2029 and 2033 for the cable replacement. Given the minimum construction programme to replace a single circuit is 13 months, it was not considered

feasible to remove each existing circuit, supporting concrete and install new cables within the outages provided.

Summary of the Appraisal

2.5.4 Following the option appraisal, Option 1 was determined to have the least environmental impact and would be delivered through the consenting phase faster than the other two options. However, Option 1 posed significant health and safety risks which could not be eliminated by design or mitigation. It is thought that specialist control measures would be required to mitigate risk during construction and installation activities. Additionally, the construction programme associated with this option was deemed not to be viable due to the limited maximum outage durations.

Option 2: The installation of new cables within the new tunnel

2.5.5 This option comprised the boring of a new tunnel approximately 1.4km long (from shoreline to shoreline), parallel to the existing tunnel, and installations of new XLPE cables. Two cables per phase would be required. This option also included associated infrastructure including new shaft headhouses and mechanical and electrical services, cable sealing end compounds and modifications to the existing overhead lines. This option is what was taken forward as the preferred option and which forms the basis of the Proposed Development as described in Chapter 3: Project Description and assessed in the technical environmental assessments in Chapters 7 – 15 of this Environmental Statement (ES) and is shown on Plate 2-3 below.

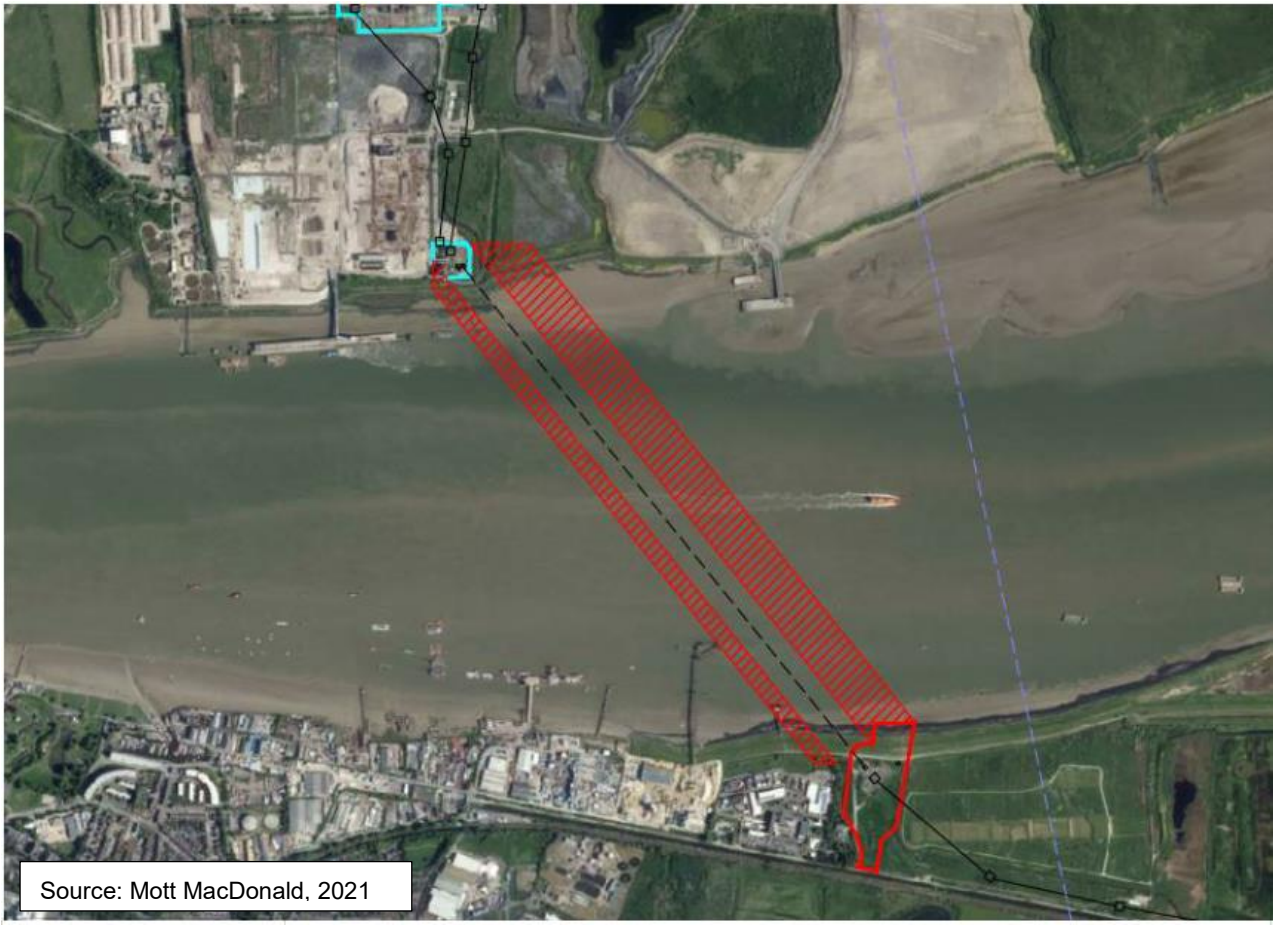


Plate 2-3: Option 2, existing Tunnel (black dashed line) and two indicative corridors for new tunnel (red hatched areas).

Summary of the Appraisal

2.5.6 Option 2 posed a higher risk of potentially significant adverse environmental effects on the Historic Environment than Option 1. It was also determined that the construction work could be undertaken using Permitted Development rights if the headhouses were to be situated on National Grid's operational land, subject to EIA Screening. Should EIA be screened in, permitted development rights would be lost and an EIA required to support a planning application to the relevant Local Authority, which would result in a longer consenting programme.

2.5.7 The estimated number of two-way traffic movements required for this option during construction were greater than that estimated for Option 3 which as identified as having the potential to cause greater temporary environmental effects on air quality, noise and vibration and traffic and transport than Option 3 in the local area albeit noting that these would be temporary in nature, lasting the duration of the construction phase. It was also assessed that National Grid would explore alternative options to the transport network, specifically the use of river transport and the existing jetties which should reduce direct and indirect effects, along with sensitive routing of road traffic in liaison with stakeholders.

2.5.8 Option 2 was assessed to comply with health and safety, and with all National Grid technical requirements and standards. It would also not impact on the existing circuits for most of the construction phase, with only outages required during the permanent overhead line diversions. The cost and required construction programme of this Option would be greater than that for Option 1.

Option 3: The installation of a new overhead line across the River Thames.

2.5.9 As shown on Plate 2-4, this option comprised the construction of an approximately 2 km span length overhead line across the River Thames, to replace the cables within the existing tunnel. There is limited space for the anchor pylons and diversions to be able to achieve a straight line for tension / loading. The siting of the pylons is also constrained on the south bank of the river due to the Thames and Medway Canal running parallel. The pylons, their foundations and the conductor system would require a bespoke design as well as a complex and extended construction period. The required space to accommodate the anchor pylons in line with the crossing pylons is considerably larger than the other two options.

2.5.10 The crossing overhead line pylons would need to be approximately 245 m in height. This requirement is due to the approximately 130m sag at maximum operating temperature which needs to allow clearance of the frequent numbers of large shipping vessels which use this section of the River Thames. contextualises the height requirement of the pylons in comparison to the existing River Thames crossing pylons, suspension pylon standard height and the Eiffel Tower in Paris, France. Further design engineering work would have been required to confirm whether two crossing pylons either side of the River Thames would be necessary in order to carry the weight of conductors required.

Plate 2-4: Option 3, indicative locations of the crossings, anchor and stringing sites (Source: Mott MacDonald sketch 2022)

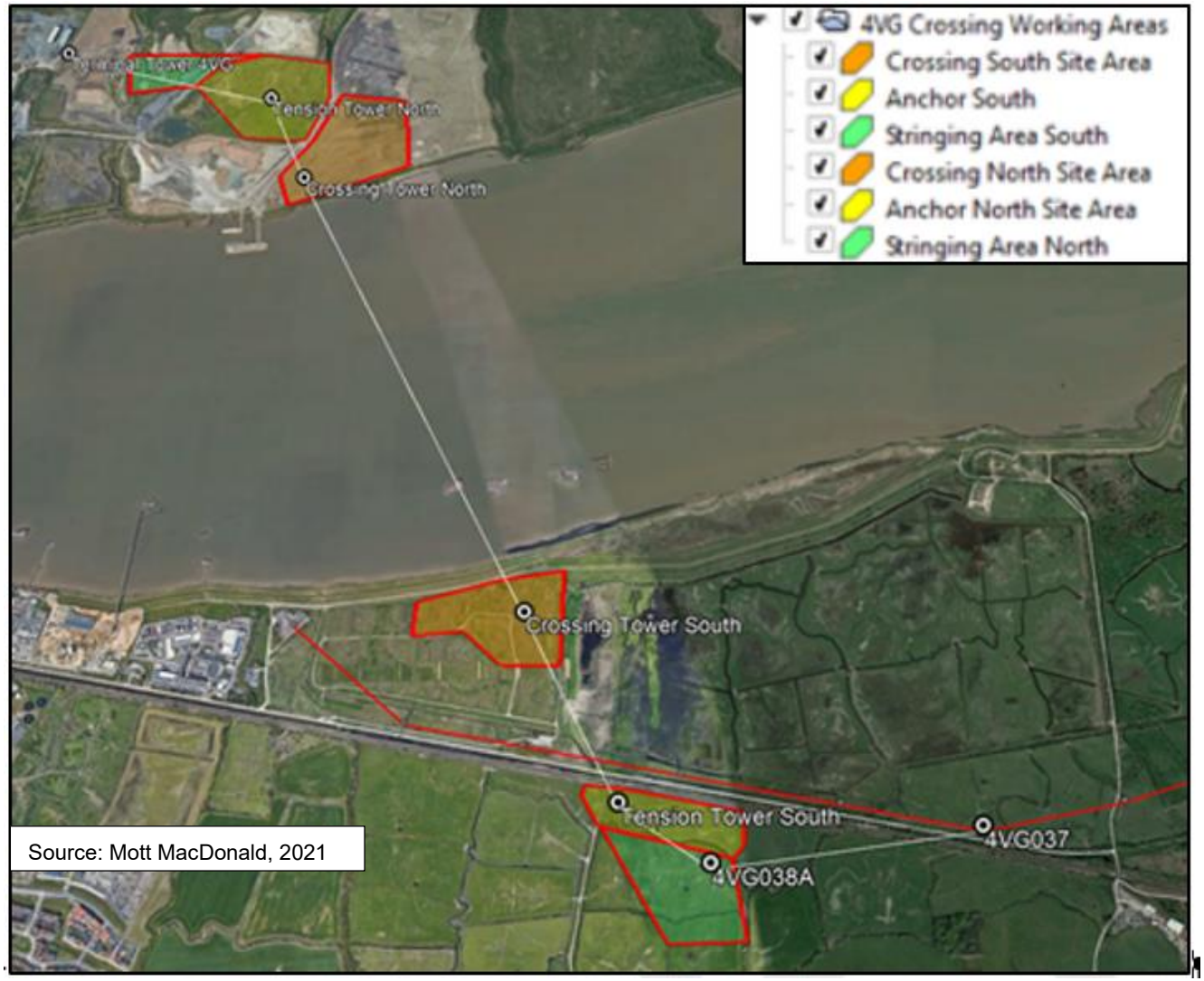
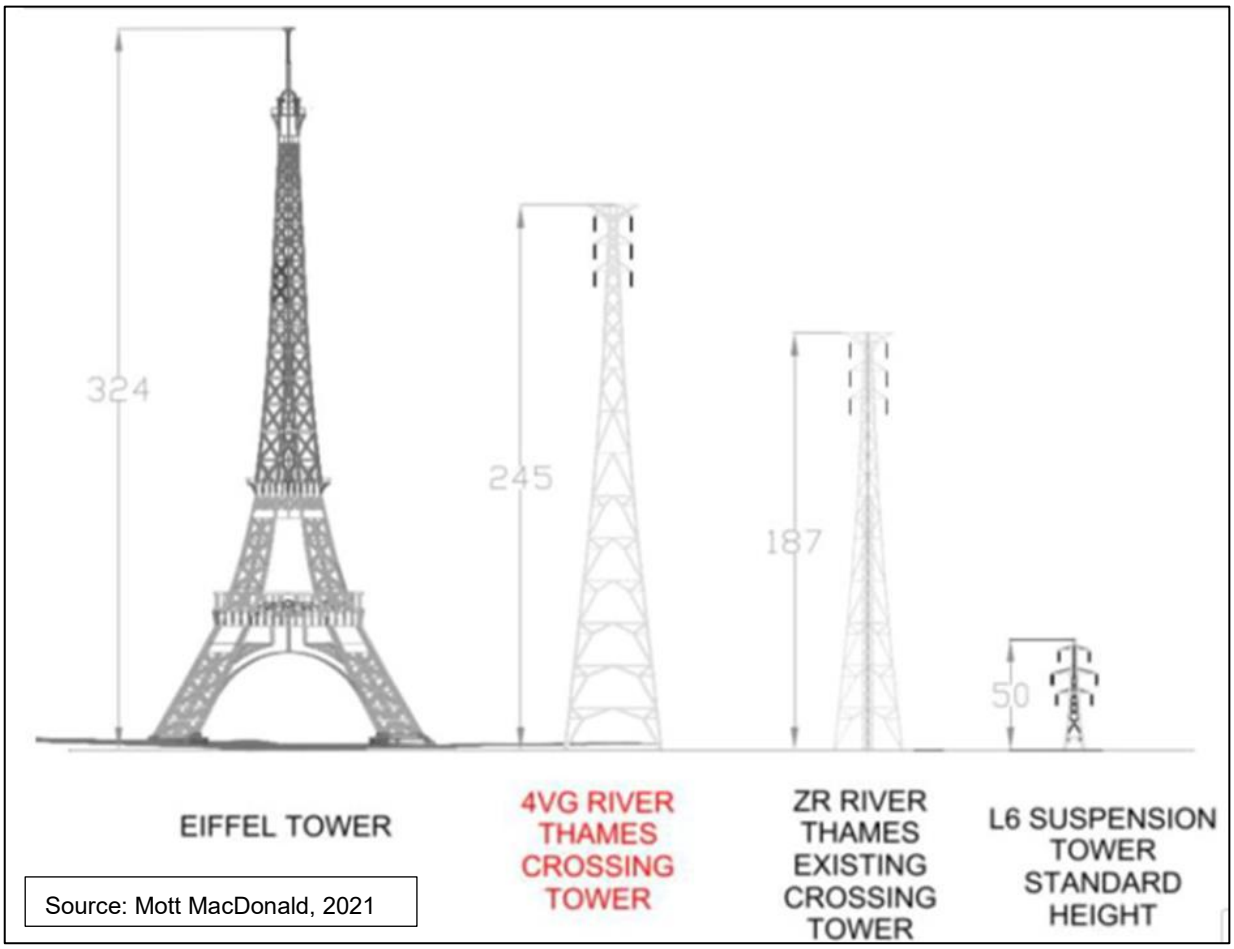


Plate 2-5: Option 3, likely required height of 4VG pylon



Source: Mott MacDonald, 2021

Summary of the Appraisal

2.5.11 Option 3 would have complied with health and safety, and with all National Grid technical requirements and standards. It would also have been cheaper and quicker than Option 2 to construct. The estimated number of two-way traffic movements required for this option during construction are fewer than that estimated for Option 2.

2.5.12 However, Option 3 would fall into the criteria of a Nationally Significant Infrastructure Project (NSIP) under section 16(3)(aa) of the Planning Act 2008 (Ref 2-7) and require a Development Consent Order (DCO) application. Therefore, the consenting programme would be considerably more extensive than Option 1 and 2.

2.5.13 It would also have been likely to receive substantial stakeholder challenge, particularly in regard to the size of 4VG pylons required (see 2.5.11) and there would have likely been long-term significant landscape and visual effects as a result of the required pylon height.

2.5.14 In addition to the above, the indicative proposed alignment of this option passes through sites of international and national importance for ornithological features. Ornithological species susceptible to collision risk are present within this project area and wider zone of influence, including qualifying species of the Thames Estuary and Marshes Special Protection Area / Ramsar. Given the highly migratory nature of many of the species present, significant numbers of species flying at risk heights could not be ruled out. The risk is said to be variable according to the species, but in the worst case could be significant, including for species listed as qualifying features for designated sites. There may also have been habitat loss of functionally linked land used by bird species listed as qualifying species of European designated sites.

Strategic Options Appraisal Recommendation

2.5.15 As Option 1 is not feasible due to the health and safety risks, the choice was limited to Option 2 or Option 3.

2.5.16 It was considered that the environmental impacts of Option 2 would be generally short term (during the construction phase only) with long term impacts being highly localised to the headhouse SEC locations. A differentiating factor between Option 2 and 3 is the estimated construction traffic two-way movements, which for Option 2 are greater than that of Option 3 due to the required tunnel spoil removal. It was recognised at the options stage that it may result in significant environmental effects on local air quality and noise albeit these would be temporary. National Grid were also keen to look at alternatives to removal spoil via the road network to mitigate these potential significant effects.

2.5.17 Given the location and scale of Option 3, it was considered that it would have greater significant and permanent environmental effects. Additionally, the indicative alignment of option 3 passed through sites of international and national importance for ornithological features, and species susceptible to collision risk with overhead lines would be present within the vicinity of Option 3, including qualifying species of the Thames Estuary and Marshes SPA / Ramsar site. There is also the potential for displacement of birds from the wider area surrounding this option.

2.5.18 On balance it was considered that Option 2, the installation of new cables within the new tunnel, would be considered preferable overall. While the costs for this option are greater in comparison to the Option 3, the risk of potential significant effects were fewer and temporary in nature.

Environmental Stakeholder Consultation

2.5.19 The Strategic Options Appraisal was shared with key environmental stakeholders, firstly to inform them of the proposals and seek their feedback on the options presented and emerging preference. The engagement and feedback received is summarised below.

Meeting with Environment Agency: 13th October 2022

2.5.20 The purpose of this meeting was to discuss the Proposed Development and the three options outlined above with the Environment Agency. The Strategic Options Appraisal report was shared in advance of the meeting. The conclusions outlined in the report as well as constraints associated with the relevant options were discussed. The following key constraints were noted by the Environment Agency:

- Flood zones 2 and 3 present on both sides of the river;
- Flood defences present on both sides of the river, and National Grid should consider the 16m working distances during construction, where feasible, and residual risk in the preparation of any Flood Risk Assessment;
- Existing and historic landfill sites on the north bank in east and consequent risks to water quality from mobilisation of sediment and contaminants; and
- Wildlife habitat including nearby European designated sites.

2.5.21 The Environment Agency advised their Thames Estuary 2100 Plan[1] (currently undergoing revision) should be considered, especially with regards to depths of shafts and where the defences would be.

2.5.22 The Environment Agency did not have a clear preference on which option should be taken forward but agreed Option 3 would be the more difficult of the three to consent and implement.

Pre-application advice letter from Historic England: 8th November 2022

2.5.23 Historic England provided National Grid with a pre-application advice letter detailing their opinion on the three options outlined above.

[1] https://www.gov.uk/government/collections/thames-estuary-2100-te2100

2.5.24 They stated serious concerns with regards to the Option 3 (the installation of a new overhead line across the River Thames) and the likely impact of this option on a range of heritage receptors which would be significant.

2.5.25 Historic England confirmed that their preferred option at this early stage would be Option 2 (the preferred option).

Meeting with Royal Society for the Protection of Birds (RSPB): 25th November 2022

2.5.26 The RSPB stated that ground nesting birds will be a key consideration during construction phase along with other Schedule 1 birds such as marsh harriers and water voles. The RSPB also recommended Cliffe Pools as being suitable locations for exported spoil, stating that the RSPB are interested in using tunnel spoil from the Proposed Development to provide wildlife benefits at this location, should it be suitable.

2.5.27 During the meeting, details of relevant RSPB contacts were provided to allow continued and meaningful engagement.

Meeting with Royal Society for the Protection of Birds (RSPB): 1st December 2022

2.5.28 This meeting was held following the initial meeting on the 25 November 2022, attendees from the RSPB included the RSPB Area Manager for Kent and Sussex, and the RSPB Rural Surveyor. The meetings' purpose was to request formal opinions on the three options presented in the Strategic Options Report.

2.5.29 National Grid confirmed in the meeting that the tunnel works (driving from the north) will not be in the adjacent national/European designated sites and that the adjacent existing overhead line will require some alterations.

2.5.30 The RSPB explained the importance of the Shorne coast as a designated site for breeding Redshank, and that the area would benefit from improvements to the freshwater supplies. Likewise, the RSPB explained undergrounding of OHL would be a beneficial project for local biodiversity and encouraged National Grid to submit details on potential easements (as appropriate) as early as possible.

2.5.31 National Grid also clarified that any advice or recommendations on survey work from the RSPB would be welcomed.

Meeting with Natural England: 28th November 2022

2.5.32 This meeting was held with the lead advisor in the West Anglia Team (covering Essex), the senior advisor for Thames Estuary and project manager for the Site of Special Scientific Interest (SSSI) Notification Project from Natural England to discuss the Proposed Development and run through the options presented in the Strategic Options Appraisal.

2.5.33 Uncertainties surrounding the extent and location of land required for spoil storage were discussed alongside uncertainties of how the Proposed Development might interact with the Port of Tilbury Freeport proposals, it was however noted that an initial meeting had been held with Port of Tilbury to discuss this interaction.

2.5.34 Natural England enquired about the noise generated from the Tunnel Boring Machine which would be required for Option 2, and also stated that the scope of impacts must consider all functionally linked land to European sites. Natural England explained that the Tilbury area is in the second stage of Natural England's 'Thames Estuary Invertebrates Essex & Kent' SSSI notification project.

2.5.35 Natural England raised the presence of Goshem's Farm, an Ingrebourne Valley site which consists of ash deposits, has undergone 10 years of ecological monitoring and is particularly important for

invertebrates with species of national interest. There are also notable plant, and breeding bird species and ditches of importance to aquatic wildlife.

Letter received from Natural England: 25th April 2023

2.5.36 Natural England provided National Grid with a letter detailing their opinion on the three options outlined above.

2.5.37 Natural England agreed with the view that Option 1 would have least environmental impact, giving rise to no direct effects on nationally and internationally designated sites. However, Health and Safety considerations and the requirement for prolonged outages appear to render this option unfeasible.

2.5.38 In regard to Option 2, Natural England clarified that it will be necessary to undertake a Habitats Regulations Assessment screening and (if required) appropriate assessment. They also advised National Grid that the Tilbury area provides a node for nationally important wildlife interest and is within an 'area of interest' for possible notification as Site of Special Scientific Interest (SSSI) and consequently, great care should be taken to avoid areas of high sensitivity as a matter of best practise, consistent with these considerations, and noting National Grid's status as a public body with legal duties towards the conservation and enhancement of SSSIs.

2.5.39 In relation to Option 3, Natural England assessed that this option would involve a direct loss of habitat used by qualifying features within the Ramsar and SSSI and would also create the potential for displacement of birds from a wider area, both within the designated sites and on functionally linked land. They stated that these potential impacts, together with the bird collision risk presented by the overhead line/structures, represent a more significant ecological risk, with much less scope for mitigation, than that which is associated with Option 2.

Strategic Options Phase – Conclusion

2.5.40 The Environment Agency did not have a clear preference on which option should be taken forward but agreed Option 3 would be the more difficult of the three to consent and implement.

2.5.41 Historic England confirmed that their preferred option at this early stage would be Option 2.

2.5.42 Natural England agreed that Option 1 would have least environmental impact but acknowledged that this option is not feasible due to Health and Safety considerations. They stated that Option 3 represents a more significant ecological risk, with much less scope for mitigation, than that which is associated with Option 2 but that should Option 2 be taken forward, that great care should be taken to avoid areas of high sensitivity as a matter of best practise.

2.5.43 Following the feedback received from consultees, there is an acknowledgement that Option 1, although more favourable from an environmental perspective is not feasible due to health and safety considerations and therefore the justification for ruling this option out is understood. When considering Option 2 and 3 there is consensus that option 2 is preferential over Option 3.

2.6 Siting Options - Identification and Selection

2.6.1 Following the decision to adopt Strategic Option 2 (a new tunnel), further options work was carried out to identify areas that are suitable for the temporary and permanent works required for the new bored tunnel (hereafter the Proposed Development) and associated infrastructure.

2.6.2 It was noted early that it would be preferable, from National Grid's perspective, to site the required infrastructure as close to the existing as possible, so to reduce the amount of construction work required to divert the overhead line i.e. new pylons.

2.6.3 Land adjacent to both existing sealing end compounds at Tilbury and Gravesend was deemed suitable for both the temporary and permanent works, however, it was recognised that environmental and engineering constraints were present on the surrounding land.

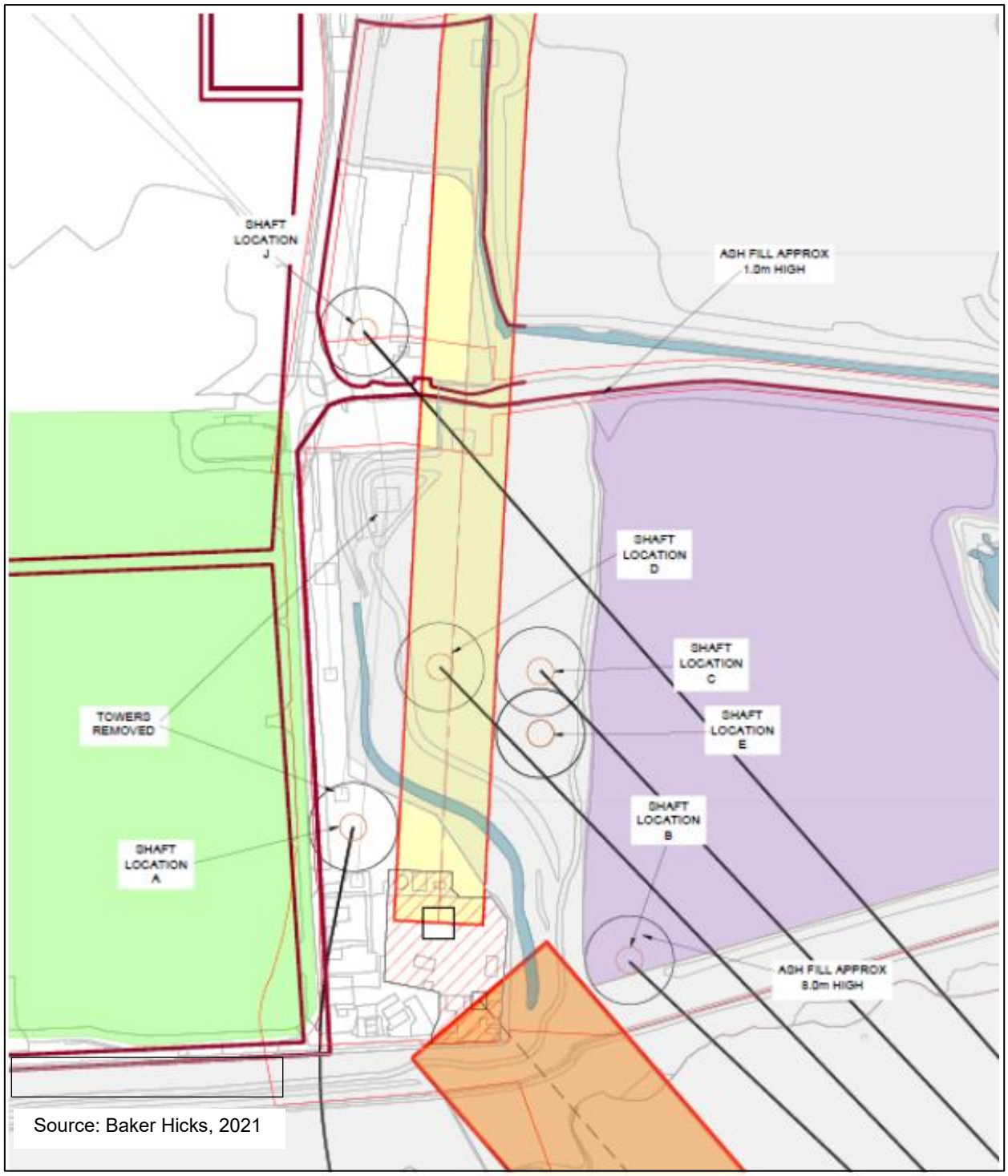
2.6.4 These constraints, such as current and former land use, access to major roads, existing landowner preferences, environmental status and topography have been used to inform the identification of suitable land. The former Tilbury Power Station foundations, in particular, would pose a significant risk to tunnelling and the integrity of the existing cable tunnel in service.

2.6.5 It was also recognised that the proposed Tilbury SEC and overhead line connection options would need to avoid and minimise the impact on Natural England's Thames Estuary Invertebrates Essex & Kent' SSSI notification project. , as highlighted by Natural England in consultation (see paragraph 2.5.34).

Tilbury Site Area

2.6.6 Initially, five preferred tunnel shaft locations were identified at Tilbury as shown in Plate 2-6 and described below.

Plate 2-6: Extract from Tilbury Constraints and Tunnel Route Plan



Source: Baker Hicks, 2021

- **Shaft Location A** was positioned on hardstanding left over from the demolition of the Tilbury Power Station and immediately behind the existing SEC. Whilst a shaft and head house could be constructed in this location it is not possible to have the gantries positioned immediately adjacent to it. It was identified that tunnelling to this point would be constrained by the presence of deep foundations from both the former power station and the jetty/dolphin piles for the Port of Tilbury and was therefore dismissed as a viable option.
- **Shaft Location B** was positioned as close as possible to the River Thames in the Pulverised Fuel Ash (PFA). There is significant land changes in level in that area, which would require considerable removal of PFA to produce the required construction level and would require

reinstatement to the original levels at the end of construction. This location lies within the proposed SSSI.

- **Shaft Locations C & E** was positioned within a zone between the exclusion zone for the overhead cables and the PFA area. Some ash material would need to be removed to give sufficient working area. This location would require additional length of tunnelling over option B. This location lies within the proposed SSSI.
- **Shaft Location D** was positioned in the north west corner of the area but underneath the existing overhead lines. This option would require a line diversion to enable suitable plant and equipment to construct the shaft and subsequent headhouse and sealing end compound. This location lies within the proposed SSSI.
- **Shaft Location J** was the most northerly of the shaft locations and is midway between the existing sealing end compound and the main substation. The location does not lie within the proposed SSSI. This location would result in the longest tunnelling drive. The location is constrained by the existing overhead lines to the east, roads to the south and west and any movement north is constrained by the need for the sealing end compound and gantries to tie into the existing network.

2.6.7 As the Tilbury side was particularly constrained by its ecological potential and so a wider area of land was appraised. The areas of land available for the Proposed Development were divided in eight areas (T1 – T8) as shown in Plate 2-7. An exercise was undertaken to rank T1-T8 where the tunnel shaft and headhouse, and SEC could be most collectively located with least impact from an ecological perspective.

Plate 2-7: Sub-area locations for the Proposed Development at Tilbury

Source: Baker Hicks, 2021

2.6.8 Table 2-1 below provides a summary of the high-level appraisal of sub areas T1-T8 for the location of the Tilbury site from an ecological perspective and ranks them in order of preference (with 1 being most preferable from an ecological perspective).

Table 2-1:Tilbury Site Sub-Area Ecological Ranking

Sub Area Ref.	Positive Ecological Factors	Negative Ecological Factors	Overall Rank 1-8 (1 being the most ecologically favourable)
T1	• Habitats present are scrub / grassland / ruderal common of unmanaged ground, therefore can be recreated. • Sufficient room to avoid impacts to ditches. • While foreshore adjoining the site is potentially suitable for SPA/Ramsar species the site is well shielded by existing sea wall which will act to limit visual disturbance.	• Within non-statutory wildlife site. • Within area Natural England are considering for SSSI designation. • Range of likely potential species constraints including known populations of all 4 species of common reptile, water vole and habitat suitable for range of birds. • In close proximity to areas of sensitive PFA and some potential for disturbance of these areas. • Potentially extensive species translocation works (in particular reptiles) required prior to works. • These activities are seasonally dependant and may impact project programme.	6
T2	None.	• Highly sensitive area of low nutrient habitat supporting diverse invertebrate assemblage. This area is within the proposed SSSI designation and will almost certainly be highest priority for inclusion. • Any works in this area would lead to strong objection from Natural England and other local nature conservation stakeholders. • Habitat is slow to develop and difficult to recreate therefore mitigation/compensation would be costly and complex.	7
T3	• No established habitat so negligible value for protected/notable species. • Outside of the proposed SSSI designation. • Good potential for ecological enhancement and achieving Biodiversity Net Gain (as low starting point).	• Area in closer proximity to SPA/Ramsar therefore increased risk of bird disturbance and need to repeat/update Habitats Regulations Assessment.	3

Sub Area Ref.	Positive Ecological Factors	Negative Ecological Factors	Overall Rank 1-8 (1 being the most ecologically favourable)
	• Likely less requirement for further surveys and mitigation thus reducing costs and reducing impacts to programme.		
T4	• Majority of site is hardstanding and of negligible ecological value. • Likely less requirement for further surveys and mitigation thus reducing costs and reducing impacts to programme.	• Opportunities for achieving biodiversity net gain may be more limited due to space constraints.	2
T5	• Habitats present are scrub/grassland/ruderal common of unmanaged ground, therefore can be recreated. • Further from the SPA/Ramsar therefore bird disturbance less of an issue.	• Within non-statutory wildlife site. • Within area Natural England are considering for SSSI designation. • Range of likely potential species constraints including known populations of all 4 species of common reptile, water vole and habitat suitable for range of birds. • Potentially extensive species translocation works (in particular reptiles) required prior to works. These activities are seasonally dependent and may impact project programme.	5
T6	• Habitat yet to establish or in very early stages of establishment so limited value for protected/notable species. • Outside of the proposed SSSI designation. • Good potential for ecological enhancement and achieving Biodiversity Net Gain (as low starting point). • Likely less requirement for further surveys and mitigation thus reducing costs and reducing impacts to programme.	• Access to the area may be difficult and may impact habitats to the south in order to allow construction access.	4
T7	• With exception of small areas of disturbed ground in the north consists of hard standing slab of negligible value for biodiversity.	None	1
T8	• Hardstanding but areas deemed too small to be viable for required works.	None	N/A – Too small to be viable for works.

2.6.9 At the Tilbury site, the same consideration of sub-area options T1 to T8 was carried out from an engineering perspective, as shown in Table 2-2 below.

Table 2-2: Tilbury Site Sub-area Engineering Ranking

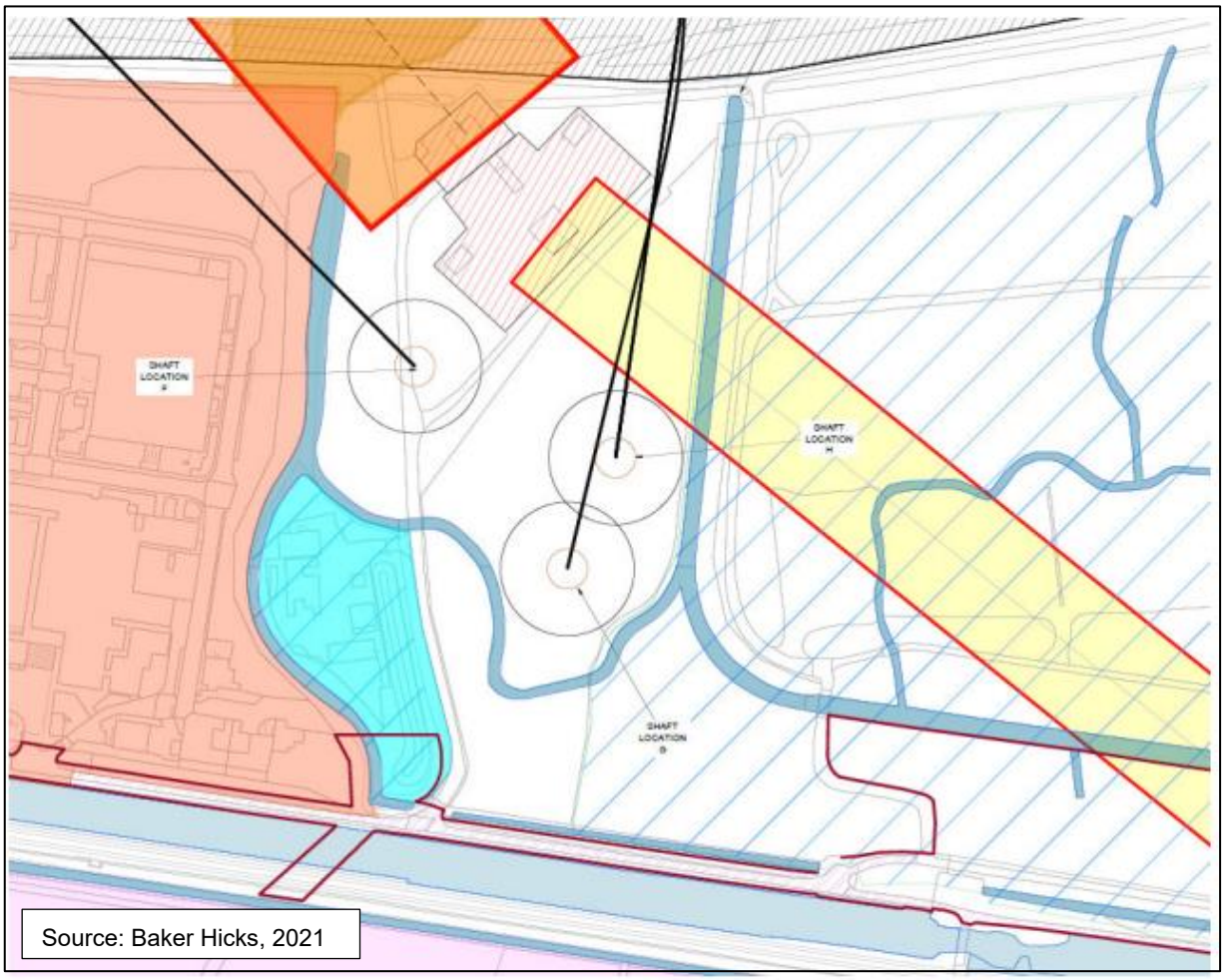
Sub Area Ref.	Positive Tunnel, Shaft, Headhouse and SEC Engineering Factors	Negative Tunnel, Shaft, Headhouse and SEC Engineering Factors	Overall Rank 1-8 (1 being the most favourable from an engineering perspective)
T1	• Close to existing infrastructure, allows effective connection to the existing Overhead Line (OHL). • Most new assets could be constructed outside of outages. • Good compromise between tunnel length, alignment and vicinity to existing OHL asset for connection. • Area clear of underground services / obstructions. • Good existing access ways to the new construction site and temporary working areas.	• Some shaft locations within area would require additional outages and/or additional temporary pylons. • PFA fill to an unknown depth	1
T2	• Short tunnelling route.	• Significant depth of PFA and would potentially require stabilisation prior to construction, plus significant cut and fill works over a large area. • Shaft depths greater due to higher elevation 4 No Layout option of ground profile. • Far from existing OHL asset, would likely require additional OHL pylons or extended length of cables for connection.	4
T3	• Shortest tunnelling route.	• Great distance from the existing infrastructure, would require additional OHL pylons and/or extensive length of underground cables for connection. • Poor ground conditions (described as very soft deposits). • Poor existing access to temporary working areas.	6
T4	• Potentially thinner band of PFA. • Close to existing infrastructure, depending on final connection option no additional pylons would be required; allows viable connection to the existing OHL asset.	• Small site area for permanent assets like compound, headhouse and shaft. • Increased tunnel drive / length compared to T1, T2 and T3. • Small site area for temporary works / laydown areas. • Requires diversion of existing road through the PoT site to facilitate construction access. • Existing underground services on west part of site will require diversion to facilitate new assets.	3
T5	• Likely no additional pylons would be required; allows viable connection to the existing assets.	• Increased tunnel drive / length. • PFA fill to an unknown depth.	2

Sub Area Ref.	Positive Tunnel, Shaft, Headhouse and SEC Engineering Factors	Negative Tunnel, Shaft, Headhouse and SEC Engineering Factors	Overall Rank 1-8 (1 being the most favourable from an engineering perspective)
		• Site relatively small and orientation difficult, but workable.	
T6	• Large size area so headhouse and sealing end compound could be placed comfortably.	• Longest tunnel drive / length. • Would require temporary diversion of overhead lines. • Recently placed materials are subject to long term consolidation leading to settlement of the ground surface.	5
T7	• Large flat working area for temporary construction works. • Good existing access ways to the new construction site and temporary working areas.	• Deep foundations will cause construction difficulties for the shaft and SEC, particularly foundations for gantries and High Voltage (HV) equipment. • Deep foundations will cause construction difficulties for tunnelling; likely extensive asbestos deposits in ground. • Deep foundations likely to cause issues with long term durability of tunnel. • Existing underground services throughout site will require identification / diversion to facilitate new buried assets. • Tunnel route would pass to the west of the existing tunnel (likely crossing would be required) and under the jetty for Port of Tilbury with dolphin foundations - construction risk.	7
T8	Hardstanding, close to existing SEC and good existing access routes towards area.	Area too small to be viable for required headhouse and SEC. Tunnel drive alignment would be within the protection / exclusion zone of the existing tunnel; no viable bend radius can be accommodated to avoid.	8

Gravesend Site Area

2.6.10 Plate 2-8 below shows the three identified shaft location options at Gravesend.

Plate 2-8: Extract from Gravesend Constraints and Tunnel Route Plan



2.6.11 The land immediately south of the existing SEC was identified as having the least constraints for the permanent location of the head house and sealing end compound. The land is within the ownership of National Grid and has no past land use that could technically constrain its development.

2.6.12 The major constraint in this location ,however, is the existing overhead lines passing into the existing sealing end compound.

2.6.13 The land to the east is an RSPB nature reserve and the Metropolitan Police Firing Range. The use of this land was not considered as environmentally favourable as the land to the south of the existing sealing end compound.

2.6.14 **Shaft Location F** to the west would be restricted to a tunnel passing to the west of the existing tunnel under the existing sealing end compound. It would also require access to the flood defences along the River Thames.

2.6.15 **Shaft Location G and H** are along a line on the boundary of the existing site positioned to allow sufficient working room with the constraint of the height restriction of the existing overhead lines. Tunnels from both these shafts would run to the east of the existing tunnel.

Tunnel Constraints

2.6.16 Due to the positioning of the land available it is considered that the proposed tunnel alignment will be to the east of the existing tunnel, ensuring it does not cross the boundary laid out by National Highway's Lower Thames Crossing project, whilst also considering the deep foundations of the former Tilbury Power Station that exist to the west of the existing tunnel on the Tilbury side.

Main Compound and Drive Site

2.6.17 An initial appraisal of the sites based on access, current land use and environmental constraints suggested that the main construction compound site and the tunnel boring drive shaft would be better suited at the Tilbury Site. It was recognised that the land at Gravesend is within a Local Wildlife Site and that vehicle access to the site is limited along the Thames and Medway Canal Road.

2.6.18 The access to Gravesend site is through Gravesend town centre and a narrow single carriageway road would present problems for the extended construction period of tunnelling. Whilst materials could be delivered and removed via a jetty on the River Thames, the personnel requirements arriving on a shift for a drive site would still present a significant number of vehicle movements. The widening of the carriageway is not possible due to the presence of the canal.

2.6.19 The area available at Tilbury is sufficient for the permanent and temporary works requirements. The desk study identification of the deposition of ash from the power station would lead to positioning the permanent works in an area where the land was not infilled, but this is constrained by the overhead line to the existing compound which can't be disrupted during construction.

2.6.20 It was determined that there would be sufficient land adjacent to the existing sealing end compound for it to be considered for either the drive or reception shaft for the tunnel boring.

Sealing End Compound and Overhead Line Connection Options

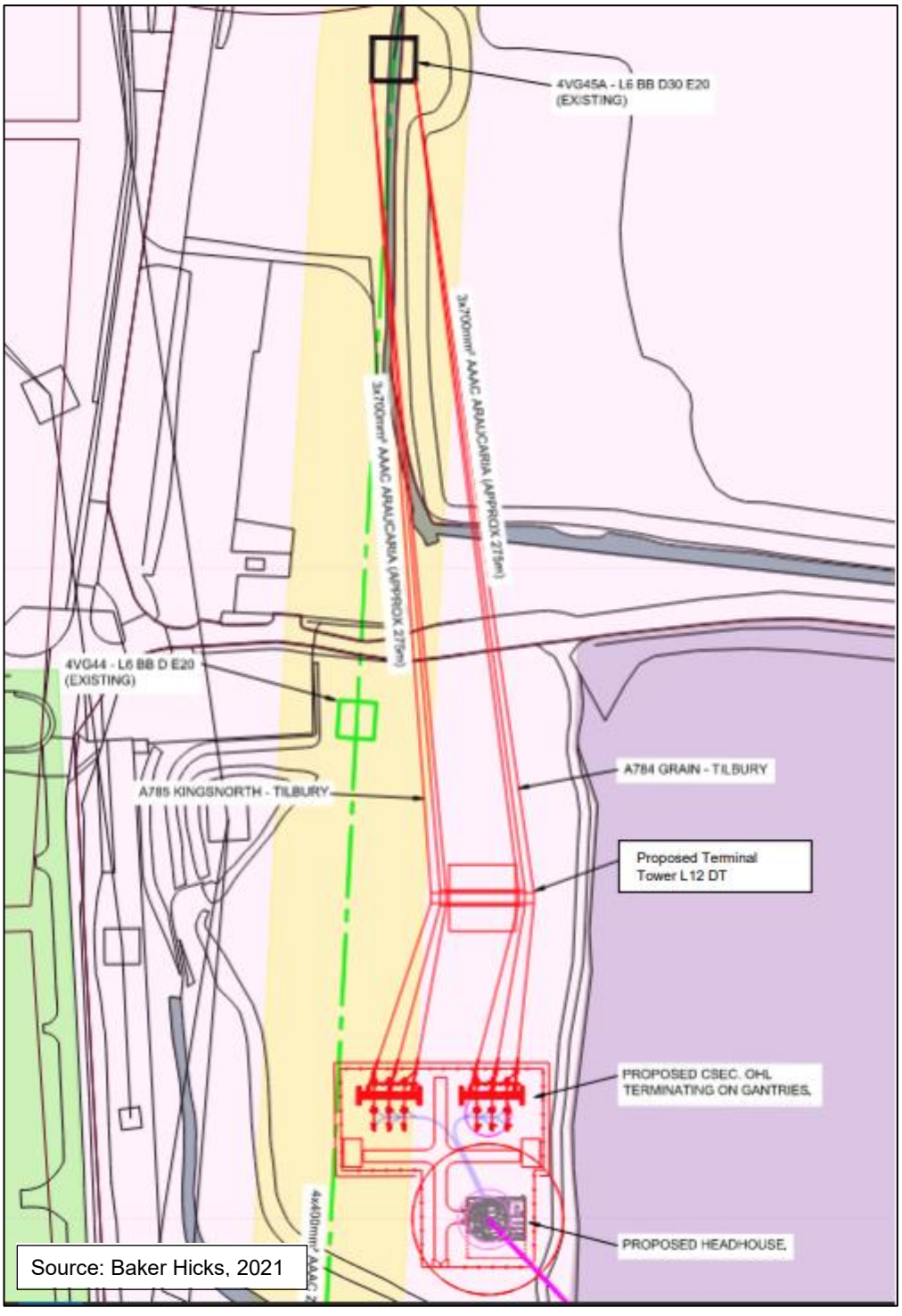
Tilbury

2.6.21 Following the appraisal of the sub-areas and the shaft locations, seven Sealing End Compound (SEC) and Overhead Line (OHL) connection options were assessed at Tilbury. Each option has briefly been described below and a comparison (see Table 2-3 below) has been made between the options.

Tilbury Option 1

2.6.22 This option is based on the Shaft Location E. A new terminal pylon would need to be constructed offline to terminate the circuits onto new proposed SEC.

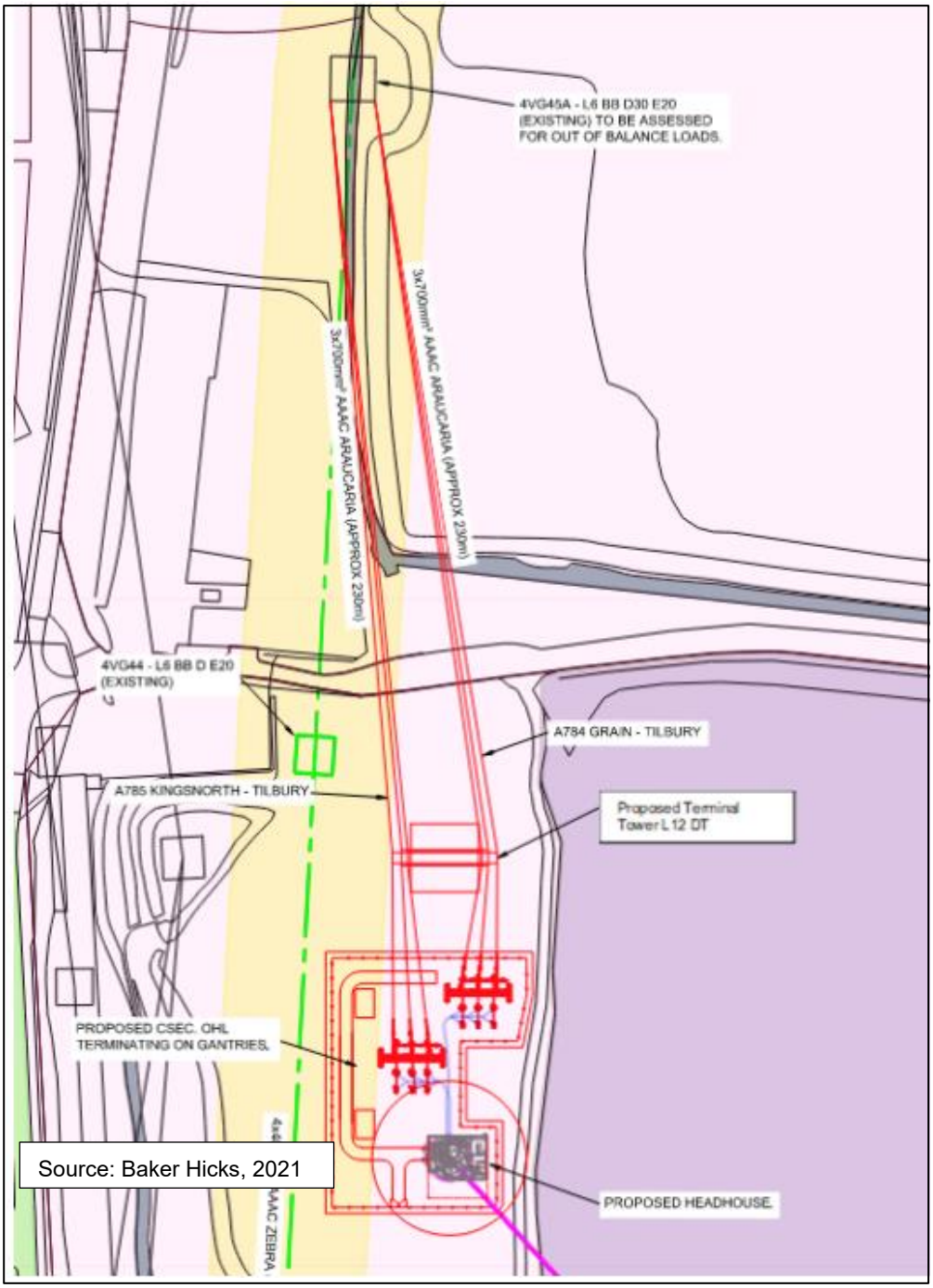
Plate 2-9: Tilbury Option 1



Tilbury Option 2

2.6.23 This option is based on the Shaft Location C. A new terminal pylon would need to be constructed offline to terminate the circuits onto the new proposed SEC. The SEC footprint is larger than option 1 due to staggered arrangement of circuit bays.

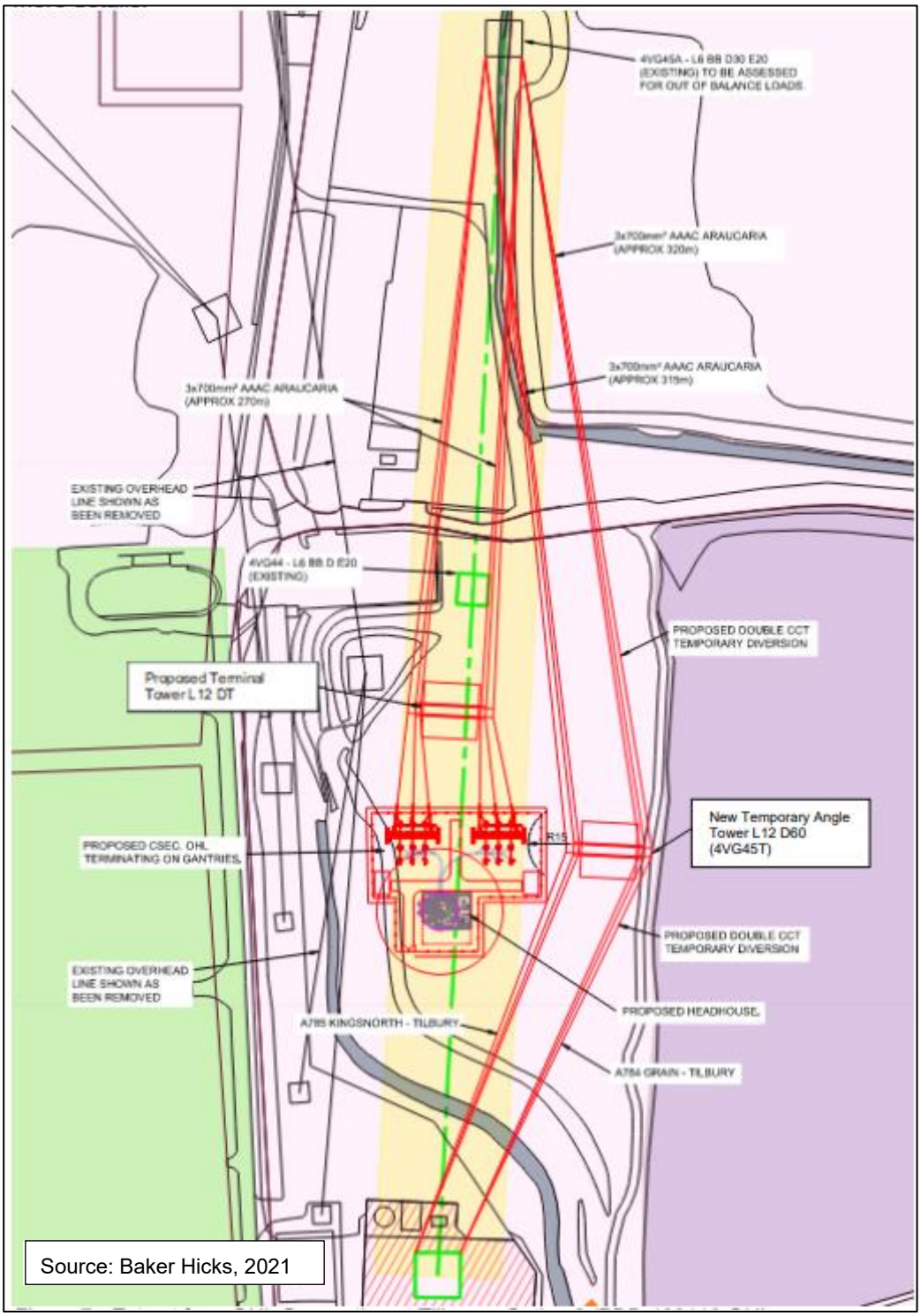
Plate 2-10: Tilbury Option 2



Tilbury Option 3

2.6.24 This option is based on the Shaft Location D. A new terminal pylon would need to be constructed inline to replace exiting pylon at 4VG44 and terminate the circuits onto new proposed SEC. To facilitate the construction of the new terminal pylon, SEC, head house and tunnelling work, a temporary diversion of both circuits will be required. Temporary diversion will be constructed between 4VG43 - 4VG45A via temporary pylon at 4VG45T.

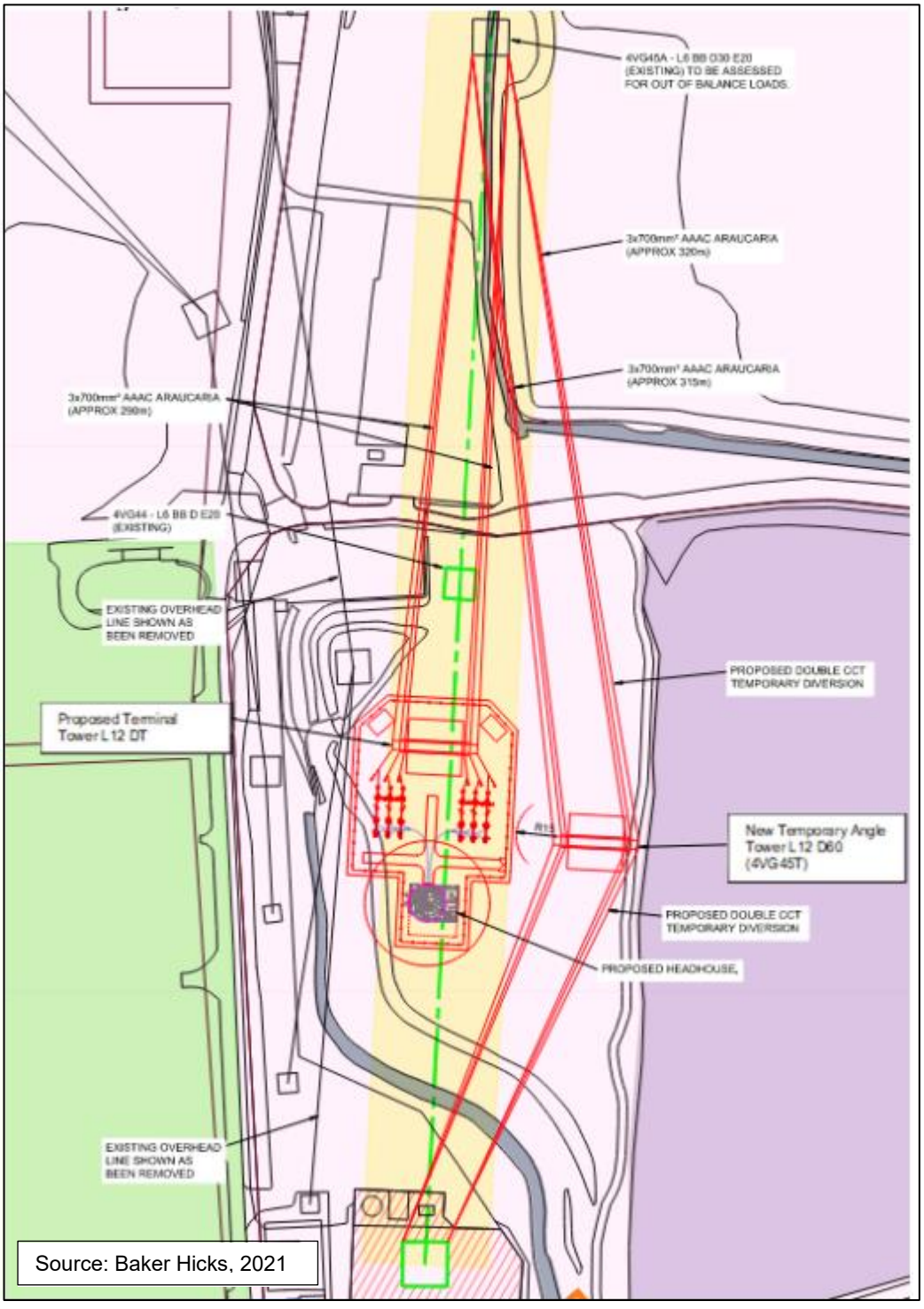
Plate 2-11: Tilbury Option 3



Tilbury Option 4

2.6.25 This option is based on the Shaft Location D. A new terminal pylon would need to be constructed inline to replace the existing pylon at 4VG44 and terminate the circuits onto new proposed SEC. To facilitate the construction of the new terminal pylon, SEC, head house and tunnelling work, a temporary diversion of both circuits will be required. Temporary diversion will be constructed between 4VG43 - 4VG45A via a temporary pylon at 4VG45T. Both circuits will be terminated on anchor blocks. As such, footprint of the SEC would be greater to accommodate the new terminal pylon and the anchor blocks.

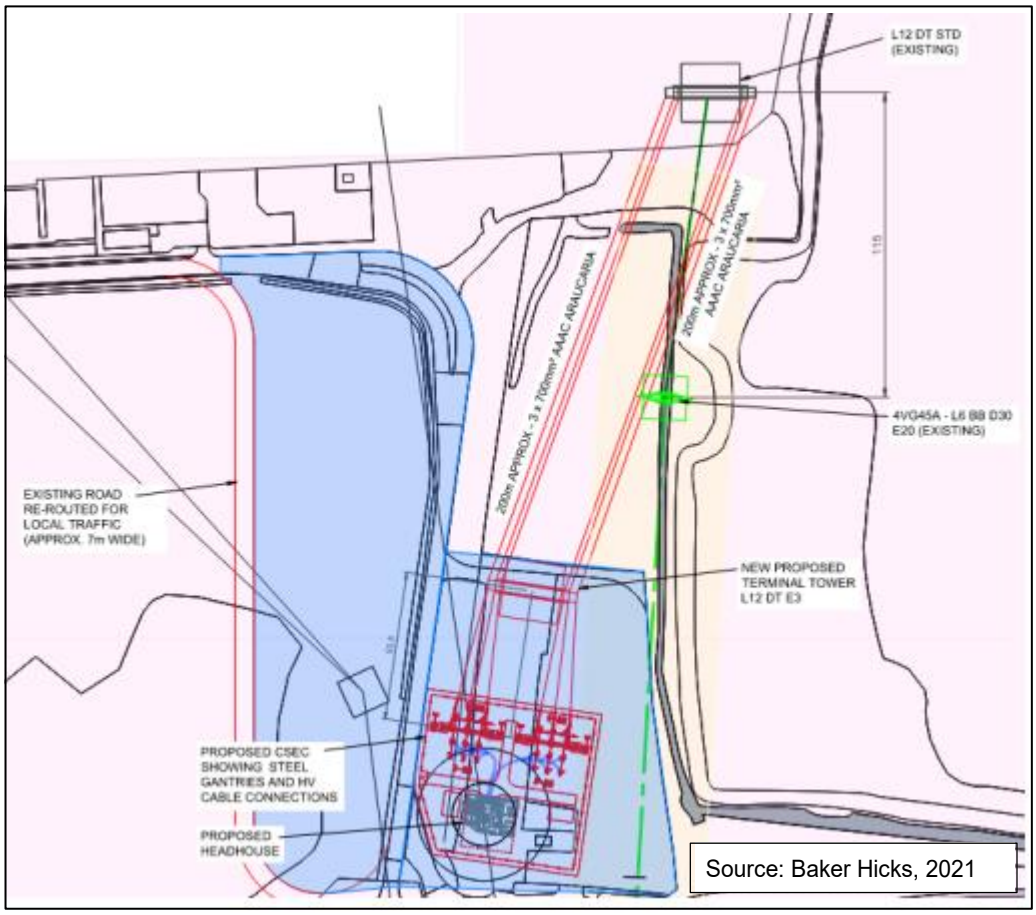
Plate 2-12: Tilbury Option 4



Tilbury Option 5

2.6.26 This option is based on the Shaft Location J. A new terminal pylon would be constructed offline to replace existing pylon at 4VG45A. Both circuit bays can be built offline.

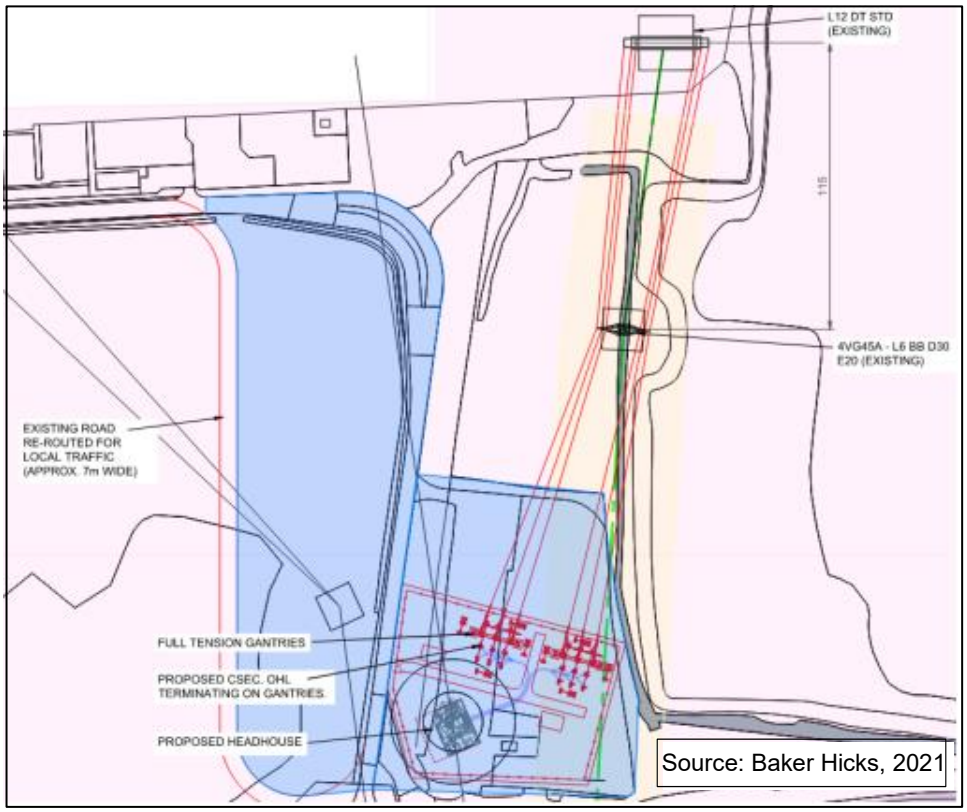
Plate 2-13: Tilbury Option 5



Tilbury Option 6

2.6.27 This option is based on the Shaft Location J. The existing pylon at 4VG45A would be used to terminate both circuits onto full tension gantries at new proposed SEC. Construction of Kingsnorth - Tilbury circuit bay was noted can be achieved offline.

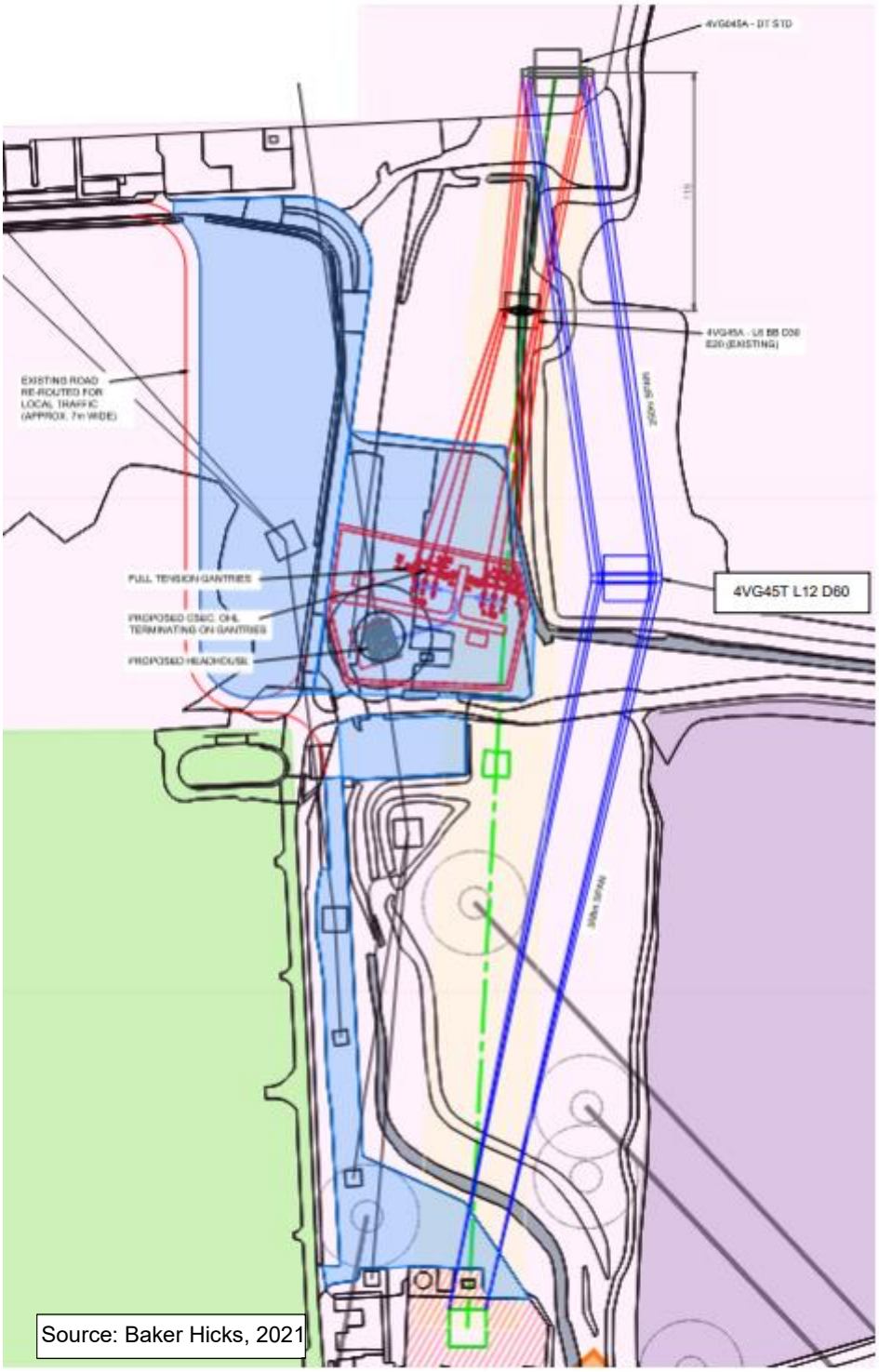
Plate 2-14: Tilbury Option 6



Tilbury Option 7

2.6.28 This option is based on the Shaft Location J. Existing pylon at 4VG45A would be used to terminate both circuits onto full tension gantries at new proposed SEC. To facilitate the construction of both circuit bays offline, a temporary diversion of both circuits will be required.

Plate 2-15: Tilbury Option 7



Source: Baker Hicks, 2021

Tilbury Site OHL termination and SEC Location Option Comparison and Preferred option

2.6.29 Following the identification of the seven options for the Tilbury Overhead Line and SEC locations, a comparison was undertaken to determine the most suitable of the option that should be taken forward for further design consideration, the outcome is outlined in Table 2-3 below.

Table 2-3: Tilbury Siting Options Appraisal

Option	Positive outcomes	Negative outcomes	Selected for further design development
Option 1	• Shorter tunnel length. • New terminal pylon. • Grain – Tilbury circuit bay at SEC can be constructed offline. • Single circuit outage will be required to build the Kingsnorth. • Tilbury circuit bay.	• Possibility of contaminated land (Ground Investigations (GI) to confirm). • Proposed site area is within the potential SSSI site.	No – proposed site area is within the potential SSSI site
Option 2	• Shorter tunnel length. • Offline construction of new terminal pylon and both circuit bays onto SEC. • Non-standard layout of SEC.	• Possibility of contaminated land (GI to confirm). • Proposed site area is within the potential SSSI site.	No – proposed site area is within the potential SSSI site
Option 3	• Offline construction of tunnelling work, SEC, terminal pylon.	• Longer tunnel length. • Temporary diversion of both circuits.	No – proposed site area is within the potential SSSI site
Option 4	• Offline construction of tunnelling work, SEC, terminal pylon.	• Longer tunnel length • Temporary diversion of both circuits.	No – proposed site area is within the potential SSSI site.
Option 5	• New terminal pylon, SEC and head house are outside potential SSSI area. • Removing the existing pylon from potential SSSI area. • All the construction work can be done offline.	• Diversion of existing road will be required to accommodate the laydown area. • SEC is very close to existing road. SEC gate will be constructed inside to allow appropriate curvature of entrance road.	Yes – Selected for further development.
Option 6	• Re-utilisation of existing pylon at 4VG45A. • Overall footprint of the new installation is much less comparing with other options. • Kingsnorth bay can be installed offline. • Single circuit outage may be required for Grain-Tilbury Bay construction. • SEC is away from existing road. SEC gate can be installed in usual place.	• Existing pylon 4VG45A is within potential SSSI area. • Diversion of existing road will be required to accommodate the laydown area	No – proposed site area is within the potential SSSI site.
Option 7	• Re-utilisation of existing pylon at 4VG45A • Both circuit bays can be constructed offline. • SEC is away from existing road. SEC gate can be installed in usual place	• Existing pylon 4VG45A is within potential SSSI area. • Diversion of existing road will be required to accommodate the laydown area. • Need double circuit diversion.	No – proposed site area is within the potential SSSI site.

Option	Positive outcomes	Negative outcomes	Selected for further design development
		• Need more outage for temporary diversion. • Larger construction footprint.	

2.6.30 Option 5 was determined to be the most appropriate option and was taken forward for further design development as the option outside of the proposed SSSI and would remove existing pylons within the proposed SSSI as well.

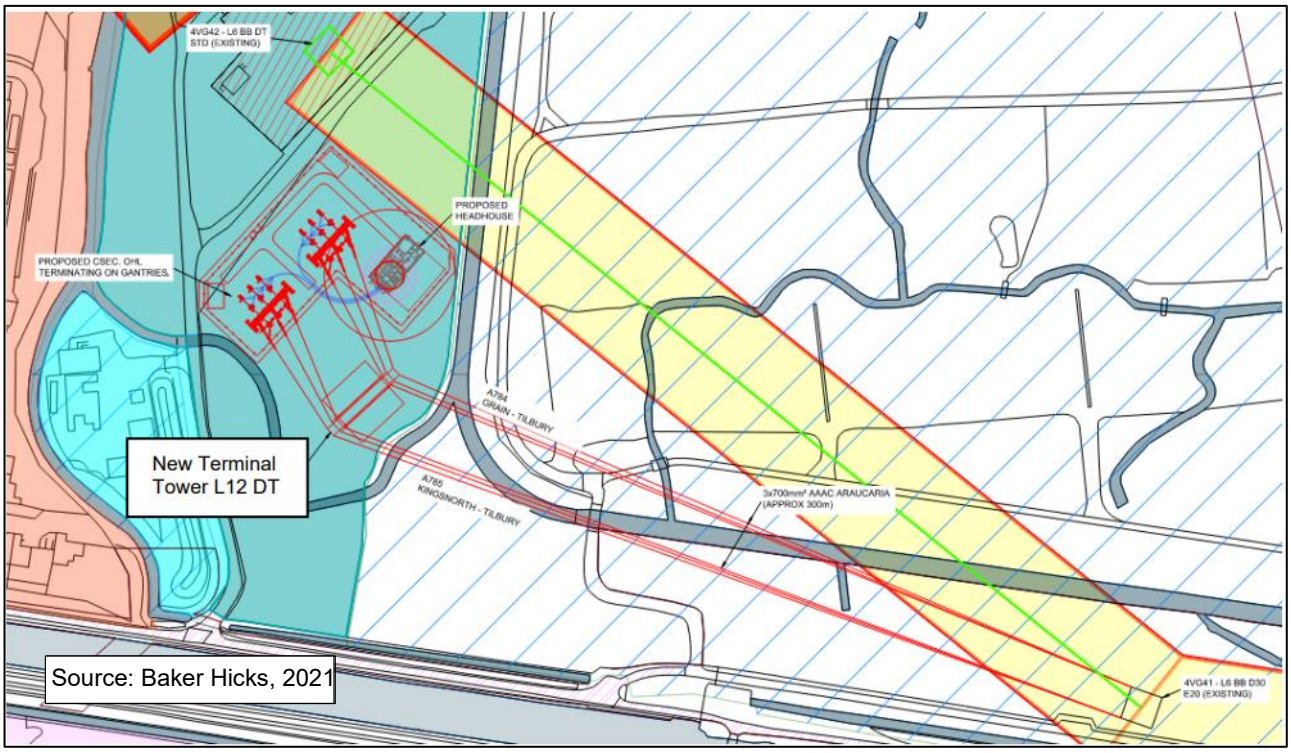
Gravesend

2.6.31 Following the appraisal of the shaft locations, six SEC and OHL connection options were assessed. Each option has briefly been described below and a comparison (see Table 2-4 below) has been made between the options.

Gravesend Option 1

2.6.32 This option is based on the shaft location H. A new terminal pylon would be constructed offline at 4VG42 to terminate the circuits onto new proposed SEC. Both circuit bay can be built offline.

Plate 2-16: Gravesend Option 1



Gravesend Option 2

2.6.33 This option is based on the Shaft Location G. A new terminal pylon would be constructed offline at 4VG42 to terminate the circuits onto new proposed SEC. Both circuit bay can be built offline.

Plate 2-17: Gravesend Option 2

Gravesend Option 3

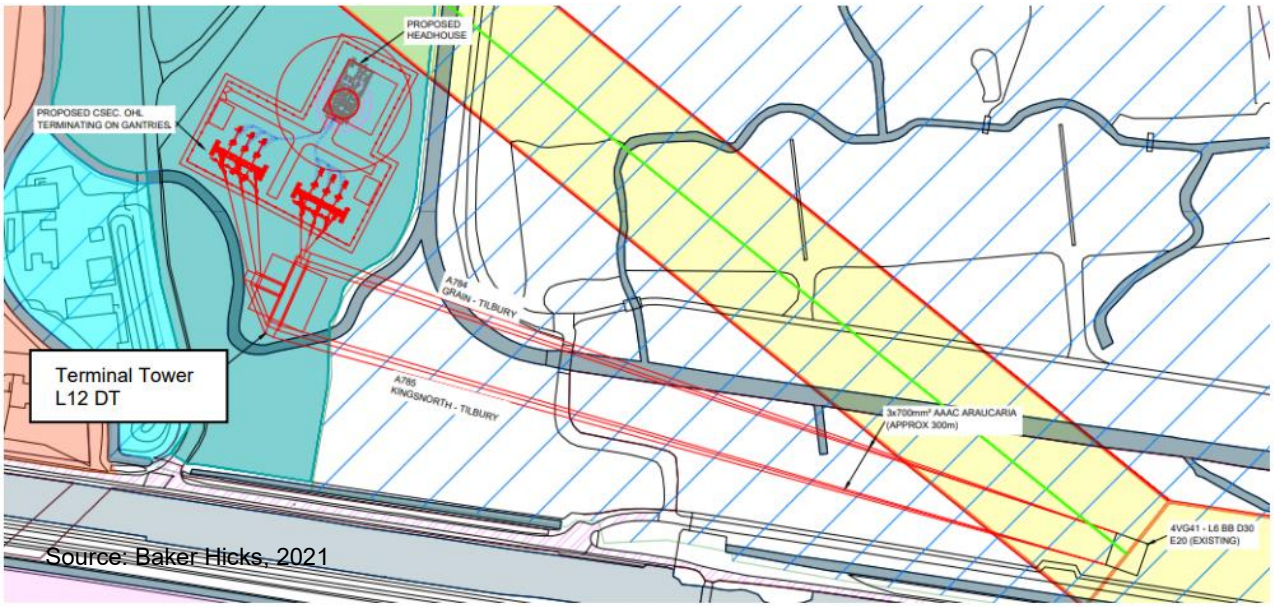
2.6.34 This option is based on the shaft location G. A new terminal tower would be constructed offline at 4VG42 to terminate the circuits to anchor blocks at new proposed SEC. Both circuit bay can be built offline. SEC footprint is larger than other options to accommodate the terminal tower and anchor blocks within the compound.

Plate 2-18: Gravesend Option 3

Gravesend Option 4

2.6.35 This option is based on the shaft location H. A new terminal tower with auxiliary crossarm would be constructed offline near 4VG42 to terminate the circuits onto new proposed SEC. Both circuit bay can be built offline.

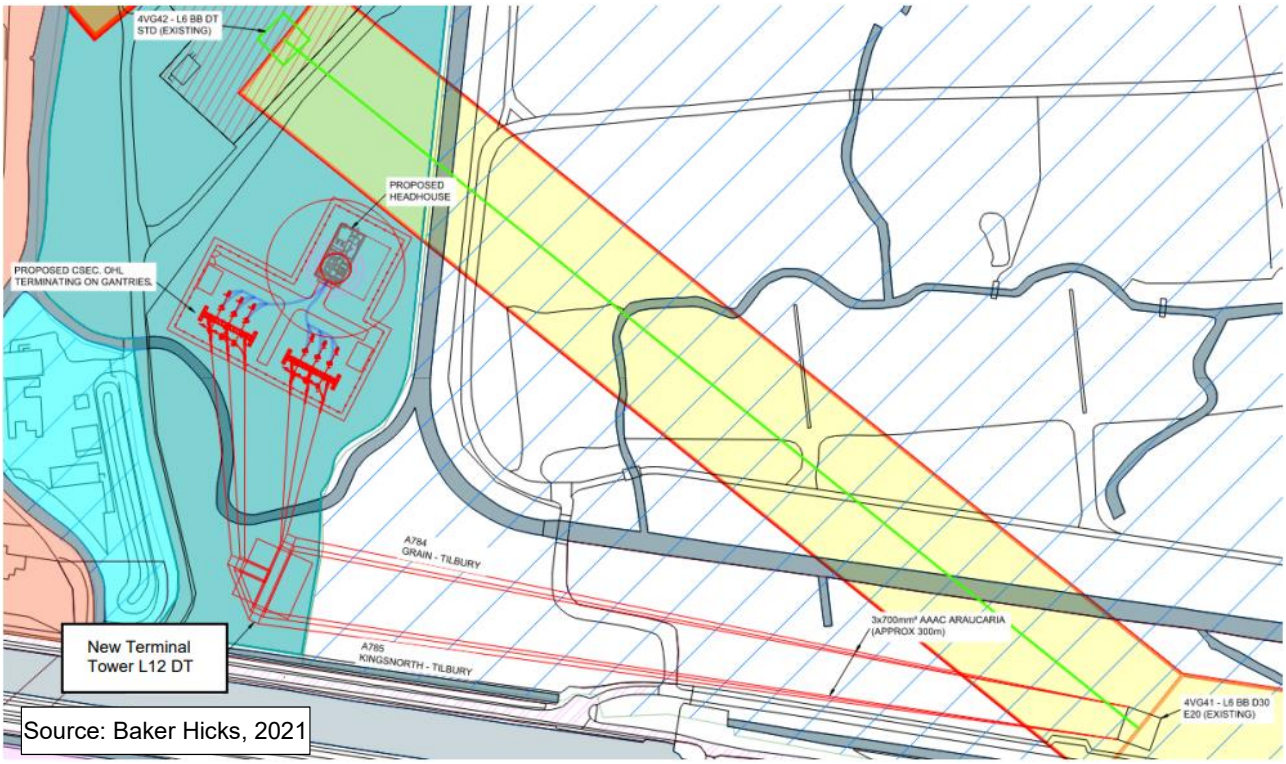
Plate 2-19: Gravesend Option 4



Gravesend Option 5

2.6.36 This option is based on the shaft location H. A new terminal tower with auxiliary crossarm would be constructed offline at 4VG42 to terminate the circuits onto new proposed SEC. Both circuit bay can be built offline. Proposed location of the new terminal tower is further away from the existing line.

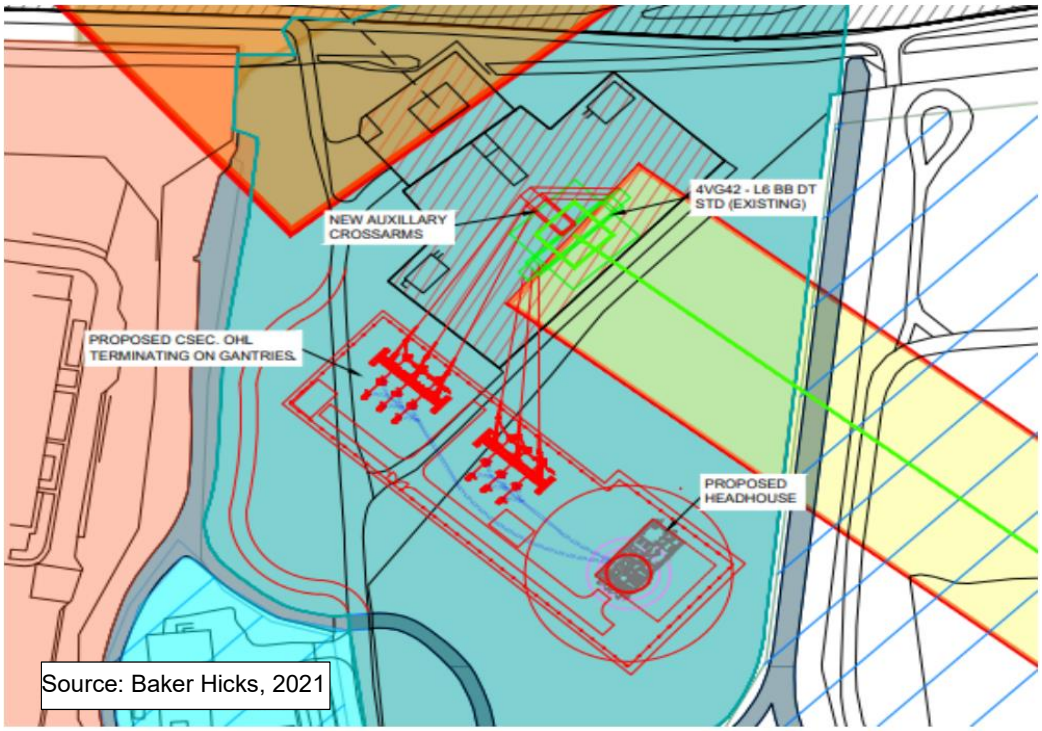
Plate 2-20: Gravesend Option 5



Gravesend Option 6

2.6.37 This option is based on the shaft location H. Existing terminal tower 4VG42 would be used. Auxiliary crossarm would be installed to existing terminal tower to terminate the circuits onto new proposed SEC. Both circuit bay can be built offline.

Plate 2-21: Gravesend Option 6



Gravesend Site OHL termination and SEC Location Option Comparison and Preferred option

2.6.38 Following the identification of the six options for the Gravesend OHL and SEC locations a comparison was undertaken to determine the most suitable of the options that should be taken forward for further design consideration, the outcome is outlined in Table 2-4 below.

Table 2-4: Gravesend Option

Option	Positive outcomes	Negative outcomes	Selected for further design development
Option 1	• Shorter tunnel length -new terminal tower, SEC, head house can be built offline. • Existing road can be utilised for the access to SEC.	• Sharp bends are required for HV cable. • Head house is in close proximity of new Grain. • Tilbury downleads.	No
Option 2	• New terminal tower, SEC, head house can be built offline. -Existing road can be utilised for the access to SEC. • Change in angle of deviation for existing tower 4VG41 is minimum.	• Longer tunnel length in compare with option 1. • Sharp bends are required for HV cable.	Yes – Selected for further development.

Option	Positive outcomes	Negative outcomes	Selected for further design development
Option 3	• New terminal tower, SEC, head house can be built offline. • Existing road can be utilised for the access to SEC. • Change in angle of deviation for existing tower 4VG41 is minimum.	• Longer tunnel length in compare with option 1. • Sharp bends are required for HV cable. • SEC footprints is larger to accommodate the new terminal tower and anchor block.	No
Option 4	• Shorter tunnel length -new terminal tower, SEC, head house can be built offline. • Existing road can be utilised for the access to SEC. • HV cable termination to SEC is easier than other options.	• Auxiliary crossarm will be required on Terminal tower • Terminal tower positioned very close to ditch- Grain - Tilbury gantry is very close to terminal tower. • Required phase to phase and phase to earth clearance will be difficult to achieve. • Change in angle of deviation for existing tower 4VG41 is large. Steelwork and foundation upgrade may be required at tower 4VG41. • Temporary bridge may be required to facilitate the installation of new terminal tower.	No
Option 5	• Shorter tunnel length -New terminal tower, SEC, head house can be built offline. • Existing road can be utilised for the access to SEC. • HV cable termination to SEC is easier than other options.	• Terminal tower required auxiliary crossarm • Terminal tower positioned very close to ditch -Grain - Tilbury gantry is very close to terminal tower. Required phase to phase and phase to earth clearance will be difficult to achieve. • Change in angle of deviation for existing tower 4VG41 is large. Steelwork and foundation upgrade may be required at tower 4VG41.	No
Option 6	• Re-utilising the existing terminal tower 4VG42. • HV cable termination to SEC is easier.	• Installation of new auxiliary crossarm may be required double circuit outage. • Larger footprint of SEC • More challenging construction. • De-commission and dismantling of existing Kingsnorth-Tilbury Bay will require prior to energise the Grain - Tilbury circuit. • Existing road need to be diverted to facilitate access to river bank.	• No

2.6.39 Option 2 was determined to be the most appropriate option and was taken forward for further design development because it has the best balance of positives to negatives.

Horizontal Directional Drilling Feasibility

2.6.40 The use of Horizontal Directional Drilling (HDD) as a construction method for the tunnel was initially reviewed. The ground profile contains a gravel layer which would present a significant challenge with horizontal penetration for any appreciable distance. The number and length of bores required would be significant resulting in larger launch and reception pits which would result in shafts within the RSPB nature reserve at Gravesend and the PFA area at Tilbury.

2.6.41 HDD was therefore considered high risk, high cost and without significant benefits when compared to tunnel boring, and therefore this tunnelling option would not be taken further forward in the design of the Proposed Development.

2.7 The Preferred Option

2.7.1 The preferred option consists of a new tunnel to the east of the existing tunnel, described in the Strategic Options Appraisal as Option 2.

2.7.2 For the Tilbury side, Option 5 with Shaft Location J (within sub-area T4) was selected. This option consists of a new terminal pylon that would be constructed offline in order to replace an existing pylon (4VG45A). The new terminal pylons and headhouses are located outside of the potential SSSI (the old pylon that is to be removed is located within the potential SSSI area). Shaft Location J is the most northerly of the shaft locations and is located midway between the existing sealing end compound and the main substation. The location is constrained by the existing overhead lines to the east, roads to the south and west and any movement north is constrained by the need for the sealing end compound and gantries to tie into the existing network.

2.7.3 For the Gravesend side, Option 2 with Shaft Location G was selected. This option consists of a new terminal pylon, sealing end compound and headhouse which would be constructed offline. Shaft location G is along the boundary line of the existing site and has been positioned to allow sufficient working room with the constraint of the height restriction of the existing overhead lines.

2.7.4 Refer to Chapter 3: Project Description for more details on the Proposed Development.

2.8 Summary and Conclusions

2.8.1 The Strategic Options Appraisal identified and assessed that installation of new cables within a new tunnel beneath the River Thames was preferable compared with installing new cables within the existing tunnel or opting for an overhead line crossing the River Thames due to health and safety concerns associated with the existing tunnel, and the environmental impact was considered to be lower and temporary in nature compared to that of a new overhead line. The strategic options were discussed with relevant consultees in order to receive their feedback on the 3 options, the appraisal, and the emerging preference of a new tunnel. No objections to a new tunnel were received from relevant consultees.

2.8.2 Once the decision to adopt the new tunnel as outlined in the Strategic Options Appraisal was taken, further siting work was carried out to identify areas that were suitable for the temporary and permanent infrastructure required for the Proposed Development in Tilbury and Gravesend. A range of considerations including, former land use, access to a major road, environmental constraints, topography, engineering design and cost were factored into the decision to determine the approach and location for the cable sealing end compounds, headhouses, overhead line connection and tunnel location.

2.8.3 The preferred option taken forward for planning and Environmental Impact Assessment (EIA) is Option 5 for Tilbury with Shaft Location J (within sub-area T4 – see Plate 2-13) and is the most northerly of the shaft locations. For Gravesend, Option 2 with Shaft Location G along the boundary of the existing site was selected.

2.9 References

Ref 2-1 Town and Country Planning (Environmental Impact Assessment) Regulations 2017 (2017 Regulations), Available at: https://www.legislation.gov.uk/uksi/2017/571/contents/made (Accessed: 29/08/2023).

Ref 2-2 National Grid ESO, Future Energy Scenarios, Available at: https://www.nationalgrideso.com/future-energy/future-energy-scenarios (Accessed: 29/08/2023).

Ref 2-3 National Grid ESO, Electricity Ten Year Statement (2023) Available at: https://www.nationalgrideso.com/research-and-publications/electricity-ten-year-statement-etys (Accessed: 29/08/2023).

Ref 2-4 National Grid ESO, Network Options Assessment 2021/22 Refresh (July 2022), Available at: https://www.nationalgrideso.com/research-and-publications/network-options-assessment-noa (Accessed: 29/08/2023).

Ref 2-5 Ofgem, Decision on accelerating onshore electricity transmission investment (15 December 2022). Available at: https://www.ofgem.gov.uk/publications/decision-accelerating-onshore-electricity-transmission-investment (Accessed: 29/08/2023).

Ref 2-6 Electricity Act (1989), Available at: https://www.legislation.gov.uk/ukpga/1989/29/contents (Accessed: 29/08/2023).

Ref 2-7 Planning Act (2008), Available at: https://www.legislation.gov.uk/ukpga/2008/29/contents (Accessed: 29/08/2023).

2.10 Abbreviations

Abbreviation	Definition
ASTI	Accelerated Strategic Transmission Investment
DCO	Development Consent Order
EIA	Environmental Impact Assessment
EISD	Earliest in Service Date
ERTS	Emergency Return to Service
ES	Environmental Statement
ESO	Electricity System Operator
ETYS	Electricity Ten Year Statement
FES	Future Energy Scenarios
FFC	fluid filled cables
GI	Ground investigation
HDD	Horizontal Directional Drilling
HND	Holistic Network Design
HV	High Voltage
kV	Kilovolt
M&E	Mechanical and electrical
NOA	Network Options Assessment
NSIPs	Nationally Significant Infrastructure Projects
OHL	Overhead Line
PFA	Pulverised Fuel Ash
RSPB	Royal Society for the Protection of Birds
SEC	Sealing End Compound
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
TKRE	Tilbury to Grain and Tilbury to Kingsnorth
TO	Transmission Owners
XLPE	Cross Linked Polyethylene

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