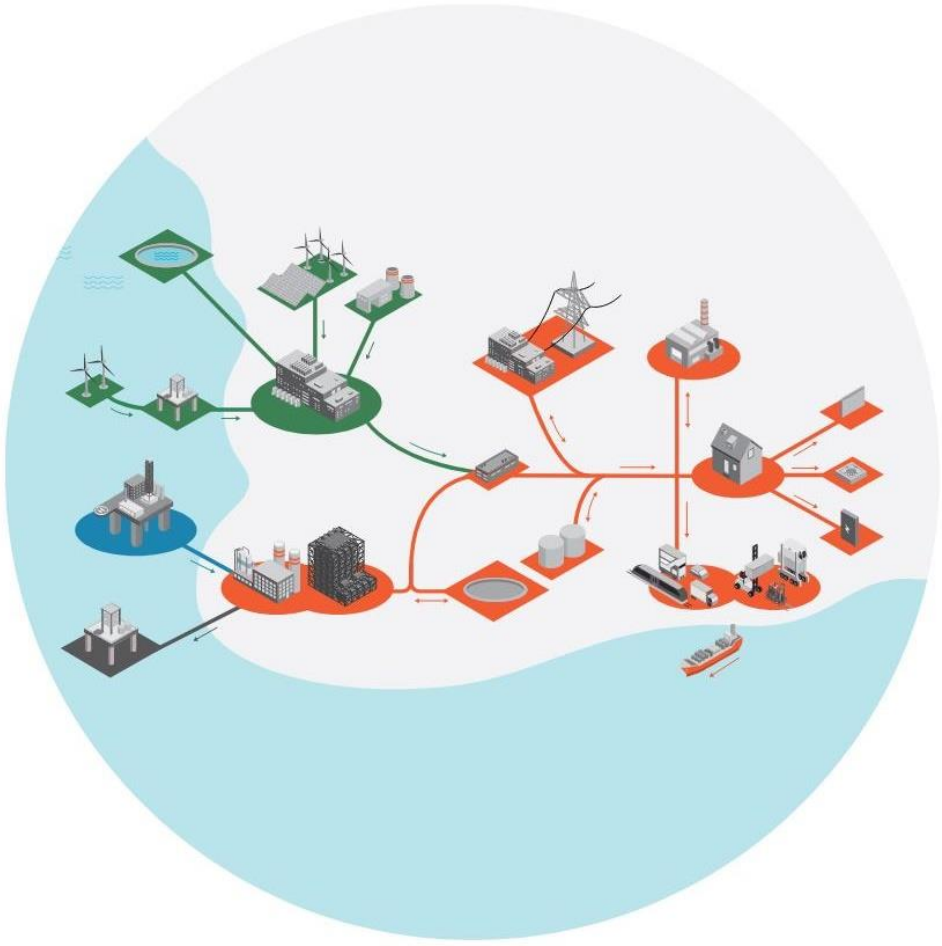
Appendix A16 – Options Design Basis

Northern Gas Networks

East Coast Hydrogen - Pre-FEED Study

Options Design Basis

Reference: 293805-ARUP-ODB
NGN Reference: REP 006
Rev A | 01 June 2023



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1. Introduction

Northern Gas Networks (NGN) are the company responsible for distributing gas to homes and businesses across the north of England, an area covering West, East & North Yorkshire, the North East and Northern Cumbria.

East Coast Hydrogen (ECH) provides a solution to connect these industrial clusters with other supply points, such as the East Midlands Hydrogen Innovation Zone, and export hydrogen production across the North of England enabling the seamless conversion of businesses and homes to 100% hydrogen where it is best deployed.

This collaborative programme between Northern Gas Networks, Cadent Gas and National Grid Gas Transmission (NGGT) represents an opportunity for the Government and the private sector to work together in delivering on our ambitious decarbonisation targets. ECH has the potential to connect over 7GW of hydrogen production by 2030, alone exceeding the UK Government's 10GW by 2030 target in a single region.

ECH can utilise the natural assets of the North of England, including existing and potential hydrogen storage facilities, and build on the hydrogen production in two of the UK's largest industrial clusters in the North East and North West and in turn ensure significant private sector investment in the UK's industrial heartlands.

ECH is a 15-year programme that will be carried out in multiple discrete phases to decarbonise industrial processes and domestic heating in the East Coast region. Proposed phases can be seen below:

Phase 1 - (2022 2026) - Completion of Pre-FEED, FEED Study and development of East Coast Cluster infrastructure

Phase 2 - (2024 2030) - Connection of Humber and Teesside clusters, and growth into Yorkshire and East Midlands

Phase 3 - (2028 2037) - Expansion from the industrial Clusters into Northern urban areas and the Midlands

Phase 4 - (2032+) - Connection of the network into further regions and future growth opportunities

NGN will look to trigger the Net Zero and Small Projects (NZASP) Reopener to undertake the subsequent phase i.e., FEED study.

Arup have been commissioning by NGN to undertake a Pre-FEED study to support the Net Zero and Small Projects (NZASP) Reopener and subsequent project phases e.g., FEED study.

2. Purpose of Document

The purpose of this document is to outline the strategy and approach for the optioneering study of the network. It summarises the base data and assumptions to be used including the demand and supply information. The document also outlines the methodology of optioneering for the new build pipelines based on the outputs from Continuum's Optioneer software and the multi-criteria analysis used in its assessment. It also outlines the multi-criteria analysis used for the options assessment of repurposed line vs. new line options.

3. Optioneering Approach

3.1 Approach Overview

The optioneering will follow a step wise approach to identify and confirm the preferred options for modelling. The focus will be on supplying the top industrial and commercial offtakers and town trials. The approach will consist of the following steps:

- Step 1 – Identify and confirm the East Coast Hydrogen backbone.
- Step 2 – Identify and confirm suitable supply (spurs) and offtake points.
- Step 3 – Identify and confirm suitable hydrogen supply options for agreed supply and offtake points.
- Step 4 – Evaluate hydrogen supply options using multi criteria analysis.
- Step 5 - Confirm preferred option for each supply spur, which may be new build, repurposing/ temporary lines or a combination of these.
- Evaluate options for extending the network to Cumbria.

3.2 Step 1 – East Coast Hydrogen backbone

The first step is to identify and confirm the backbone for transporting hydrogen from the major hydrogen production points to the demand locations. The east coast hydrogen backbone has been identified as consisting of the following pipelines:

- Feeder 6 repurposed for 100% hydrogen from Elton to Cowpen Bewley
- Feeder 7 repurposed for 100% hydrogen from Bishop Auckland to Asselby
- New pipeline between Asselby and Ganstead. (This will follow the NTS Feeder 29 from Asselby to Ganstead)

3.3 Step 2 – Suitable supply (spurs) and offtake points

The next part of the approach is to identify supply and offtake points based on geographical areas. Six key geographical areas were identified in line with the hydrogen backbone, these are illustrated in Appendix A.1 and consist of the following:

- Area A – Teesside
- Area B – Feeder 7 to Pannel
- Area C – Leeds and Bradford
- Area D – Feeder 7 Towton to End
- Area E – North Humberside

- Area F – Newcastle

For each of the areas outlined above, suitable offtake points were identified from the top industrial and commercial loads, based on the predicted hydrogen demand in 2037 as detailed in the Demand Study Report [1]. Industrial sites which are predicted to transition or partially transition to hydrogen by 2037 were considered as potential offtake points.

Consideration was also given to identify clusters of industrial sites, where there are a number of potential hydrogen users in close proximity, which could be supplied using common infrastructure.

For each of the areas, suitable supply points (spurs) were also identified from the existing infrastructure. These include, for example:

- Existing installations (e.g., above ground installations (AGIs)) on the repurposed NTS pipelines, identified in step 1.
- Existing installations on HP pipelines which have the potential for repurposing.
- New installations to replace natural gas assets.

3.4 Step 3 – Suitable hydrogen supply options

For each of the identified supply spurs and demand offtake points, the different potential supply options have been identified. These options include, for example:

- Repurpose existing natural gas asset to supply hydrogen.
- New hydrogen pipelines to replace existing natural gas assets.
- New smaller hydrogen pipeline to provide initial demand to offtakes whilst retaining natural gas asset for required demand to other offtakes. (With a view to re-purpose the natural gas asset to provide 2 off hydrogen pipelines when the remaining natural gas demand transitions to hydrogen.)

3.4.1 New Supply Options Methodology

All new line options are being assessed by Continuum Industry's Optioneer software. Route points for all new lines will be uploaded to the Optioneer software and routing between the route points will be optimised to minimise consent and technical penalties based on the multi criteria analysis (MCA) outlined in Section 3.5.1 and shown in Appendix A.2.1. Each routing option will be scored, and the optimal routes taken forward for further assessment. The following assumptions were used to identify the route points for the new lines.

- Clusters of industrial users were selected based on their proximity to each other and to the repurposed NTS for new routing options.
- Where it will not be possible to repurpose existing AGIs, new line route options will be selected based on proximity to the repurposed NTS.
- Distribution pipelines planned for future hydrogen production to be integrated into the routing options.

3.4.2 Repurposed Line Supply Options Methodology

For each cluster option, any potential options for repurposing of both AGIs and existing distribution pipework were considered. The repurposed line options will be scored based on an assessment of the capacity of the lines to supply the industrial users and using the MCA outlined in Section 3.5.2. Each option will be scored, and the optimal routes taken forward for consideration against the new supply options. The following assumptions were used to identify the suitable AGIs and lines for repurpose of the existing network.

- High pressure (HP) lines can be repurposed and unmeshed from the intermediate/medium pressure (IP/MP) lines.

- Repurposing strategy will maximise repurposing of HP lines. Feasibility of repurposing will be informed by the results of the existing network study, repurposing study and analysis of the hydrogen demand.
- Existing AGIs can be repurposed for new lines as a preference over new AGIs.
- Distribution pipelines planned for future hydrogen production to be integrated into the routing options.

3.5 Step 4 – Multi Criteria Analysis

To assess the options to supply hydrogen from supply points to off takes, multi criteria analyses have been developed for the new and repurposed line options. The analyses consider commercial factors, environmental factors, constructability, and security of supply.

3.5.1 New Line Initial Assessment

The new line options will be assessed using a multi criteria analysis, which considers a consent and technical penalty for various environmental factors and infrastructure crossings. Each criterion will be scored out of five for a consent and technical penalty (five being the highest penalty). The penalty scoring was based on the ranking shown in Figure 1.

Classification / ranking	Constraint type	Risk-based	Policy wording	Designation type
Class 5	Hard constraint	Likely to preclude development	No development	(depends on the specific objective)
Class 4	Critical importance	Significant risk Significant impact	Avoid as far as reasonably practicable	Internationally and/or nationally designated
Class 3	High importance	Likely risk Significant impact	Avoid where possible	Regionally designated
Class 2	Medium importance	Likely risk Low impact	Reduce effects on	Locally designated
Class 1	Low importance	Insignificant risk Low impact	Avoid where possible whilst avoiding undue diversion	Non-statutory designation
Class 0	None - information only	No risk	Report on	For information only

Figure 1: New line multi criteria analysis ranking descriptors.

The MCA for the new line assessment is shown in Appendix A.2.1.

In addition to the assessment of consenting and technical viability, the new lines will be scored on capital expenditure (CAPEX), which will be based on the construction method for the new pipelines. The CAPEX model is shown in Appendix **Error! Reference source not found.**.

3.5.2 Repurposed vs. New Line Assessment

The best scoring new line options will be taken forward alongside the repurpose line options for further assessment using a separate multi-criteria analysis. The analysis will consider consenting, environmental impact, land interests, public perception, constructability, total installed cost, utilisation factors, and security of supply. The MCA is outlined in Table 1 below.

Table 1: Repurposed vs new line options multi criteria analysis.

Criteria	Weighting	Low-1	Low/Medium-2	Medium-3	Medium/High-4	High-5
Consenting	15%	No new consenting requirements	TCPA for AGI only - requiring engagement with single landowner.	TCPA for pipeline - requiring engagement with multiple landowners (some of whom agreements already exist for existing pipelines).	TCPA for AGI and pipeline - requiring engagement with multiple landowners (none of whom have agreements in place for existing pipelines).	Nationally Significant Infrastructure Project. Development consent order required (3-4 years)
Environmental impact (human health and designated landscape, heritage and nature sites)	20%	No or very low environmental impact, no sensitive area crossings - no environmental impact assessment required (Schedule 2 site not requiring env impact assessment).	Option goes through designated sensitive area(s) of local importance and meets the Schedule 2 thresholds. Limited Environmental impact assessment required.	Option goes through designated sensitive area(s) of regional importance and meets the Schedule 2 thresholds. Environmental impact assessment required.	Option goes through designated sensitive area(s) of national importance and meets the Schedule 2 thresholds. Environmental impact assessment required.	Option goes through designated sensitive area(s) of international importance (e.g. European designated sites or world heritage site and/or meets the Schedule 1 thresholds. Environmental impact assessment required.
Land interests and public perception/ safety considerations	15%	Very low impact on land interests and public perception. Separation distances for safety not constrained.	Low impact on land interests and public perception. Separation distances for safety not constrained.	Medium impact on land interests and public perception. Separation distances for safety minimally constrained.	High impact on land interests and public perception. Separation distances for safety constrained.	Very high impact on land interests and public perception (high pressure pipeline through a town e.g.). Separation distances for safety significantly constrained.
Construct-ability	15%	Minor refurbishment to AGI, no modifications to pipeline	Replacement of existing AGI, no modification to pipeline.	Replacement of existing AGI, refurbishments required to existing pipeline.	Minor refurbishments to AGI, new pipeline required.	Replacement of existing AGI, new pipeline required.
Total installed cost	20%	Total installed cost will be scored based on ranking of options. The utilisation factor of the lines will be factored into the cost and the scoring will be based on the order of magnitude of the cost in terms of £/MWh/annum.				
Security of supply	15%	Hydrogen supply from repurposed NTS (offtake close to repurposed NTS) and natural gas supply as back up for full capacity. No compromise to other users of natural gas (e.g. domestic or non top 200)	Hydrogen supply from repurposed NTS with no natural gas back up supply (offtake far from repurposed NTS), and access to hydrogen production and storage sites allowing for buffer capacity.	Hydrogen supply not directly from repurposed NTS (no natural gas back up supply), with access to hydrogen production and storage allowing for buffer capacity for security of supply.	Hydrogen supply not directly from repurposed NTS but nearby access hydrogen and natural gas storage sites as a buffer.	Hydrogen supply not directly from repurposed NTS, with no buffer capacity from production, linepack, or storage and no natural gas supply as back up supply.

3.6 Step 5 – Preferred Options

Upon completion of the multi-criteria analysis, the preferred options will be selected. Each option will be technically and economically fit for purpose and shall be:

- Able to receive the relevant consents.
- Able to be safely constructed.
- Safe to operate.

4. References

[1] 293805-ARUP-DMS-Rev-A, East Coast Hydrogen Pre-FEED Study – Demand Study Report, Arup, 2023

A.1 Key Geographical Areas

A.1.1 Area A – Teesside

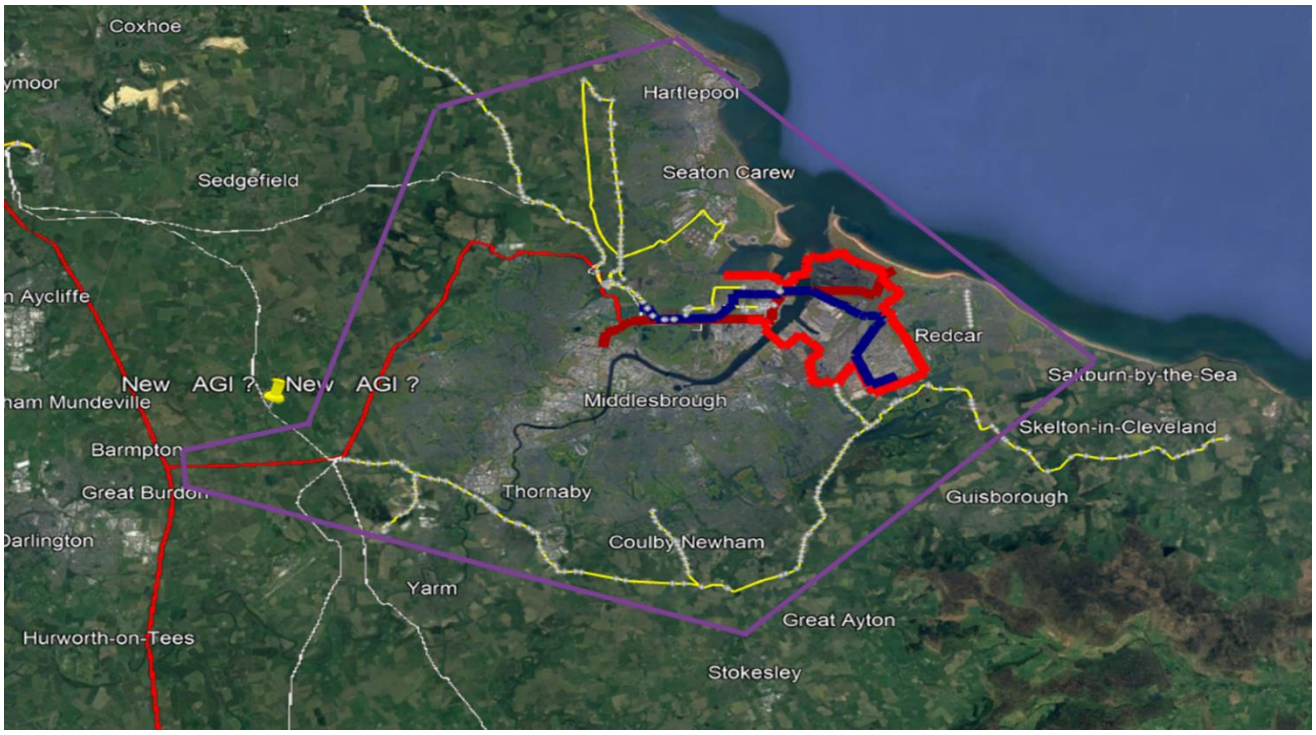

Figure 2: Area A - Teesside

A.1.2 Area B – Feeder 7 to Pannel

Figure 3: Area B - Feeder 7 to Pannel

A.1.3 Area C – Leeds and Bradford

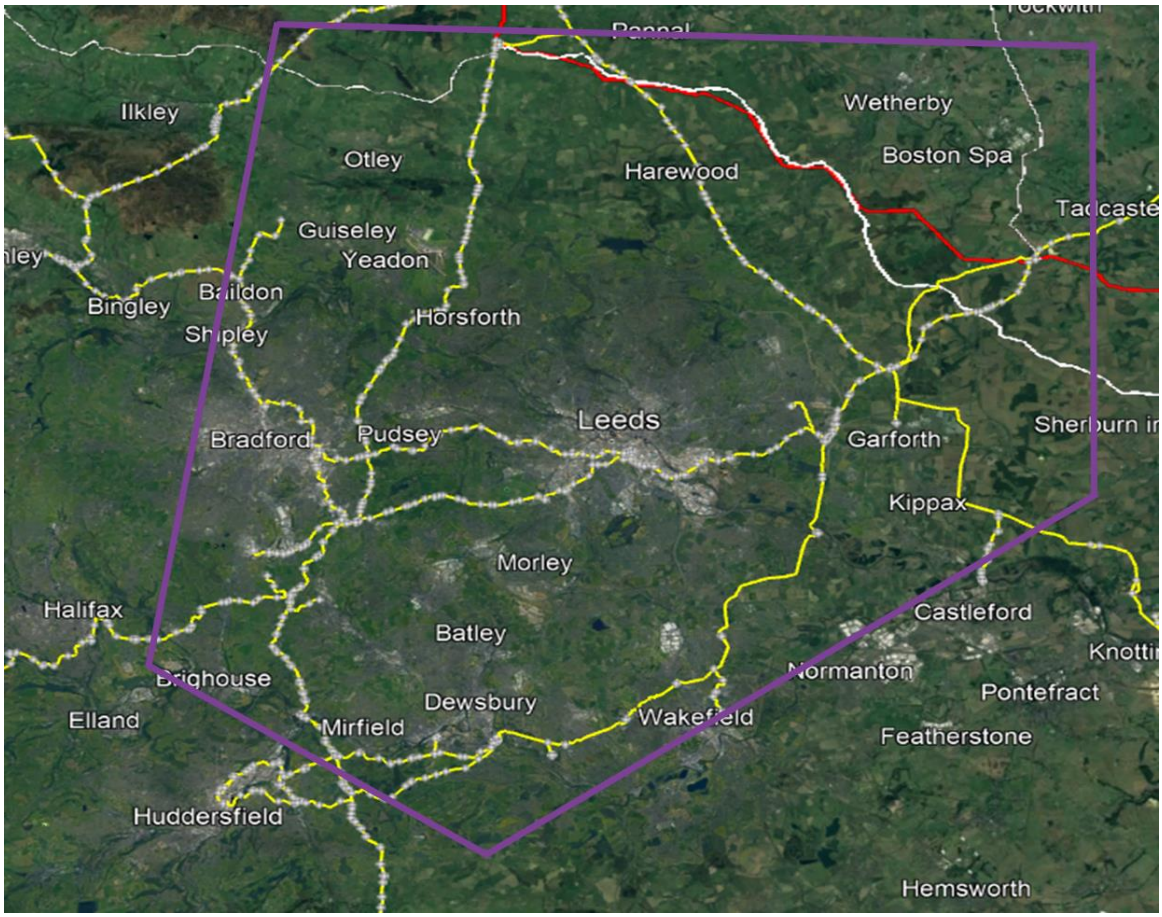

Figure 4: Area C – Leeds and Bradford

A.1.4 Area D – Feeder 7 Towton to end

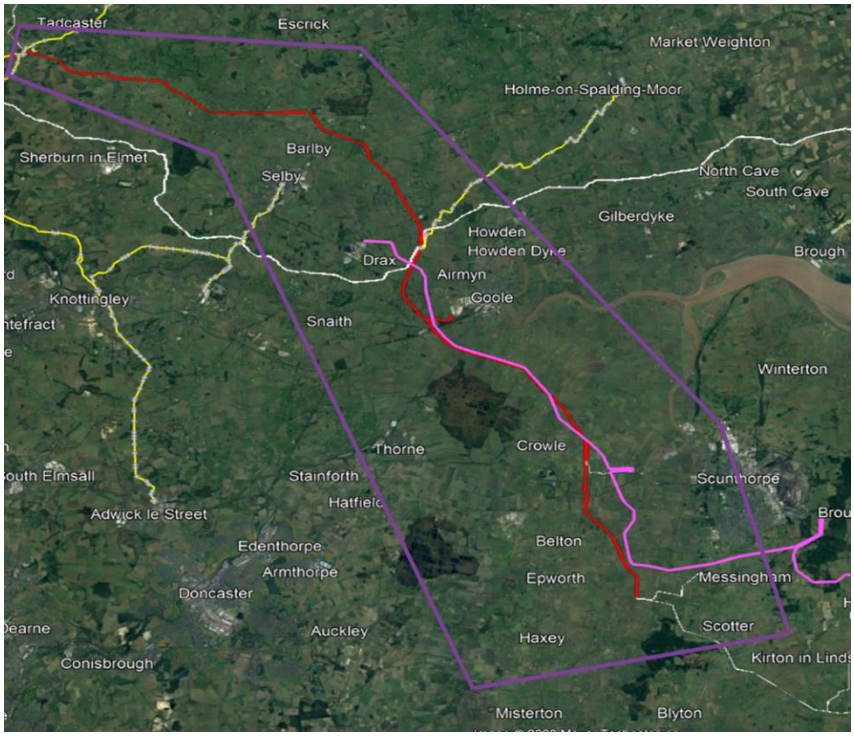

Figure 5: Area D – Feeder 7 Towton to end

A.1.5 Area E – North Humberside

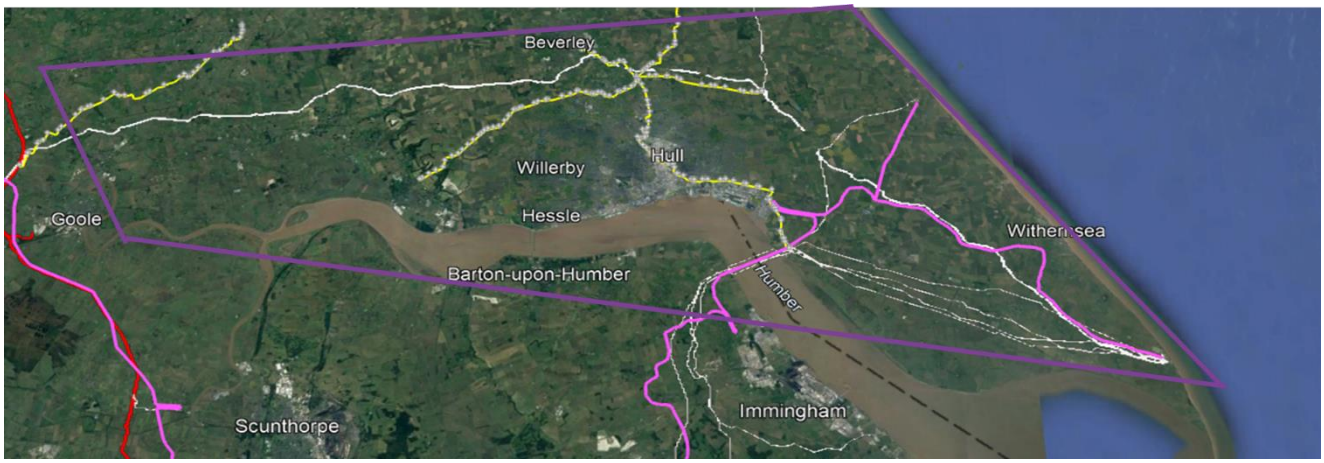

Figure 6: Area E - North Humberside

A.1.6 Area F – Newcastle

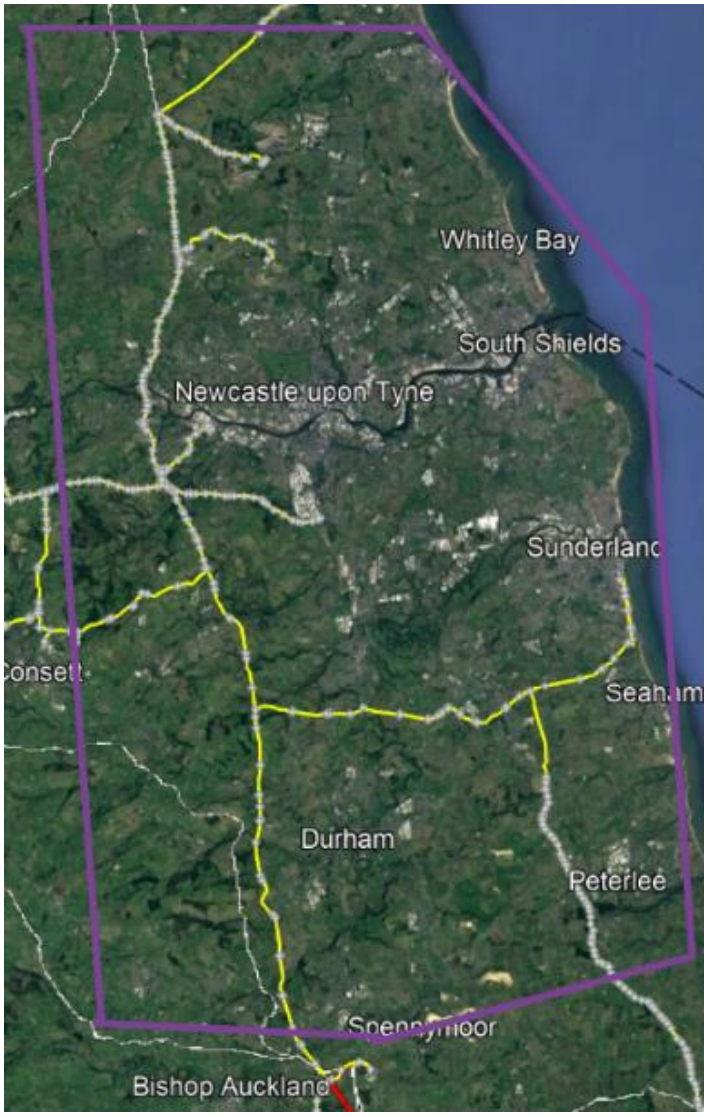

Figure 7: Area F - Newcastle

A.2 New Line Analysis

A.2.1 Multi Criteria Analysis

Table 2: Continuum multi criteria analysis

Optioneer Layer Name	Descriptive Layer Name	Consent Penalty Classification	Technical Penalty Classification
National_Cycle_Network	National Cycle Network	1	1
RSPB_-_Reserves	Reserves - RSPB	4	0
Buildings_All_Local	Buildings - All - Local	0	5
Buildings_All_Local	Buildings - All - Local	0	5
Elevation	Elevation	0	3
Functional_Sites_-_All	Functional Sites - All	1	5
Functional_Sites_-_Education	Functional Sites - Education	1	5
Functional_Sites_-_Education_MedicalCare	Functional Sites - Education MedicalCare	1	5
Functional_Sites_-_MedicalCare	Functional Sites - MedicalCare	1	5
Functional_Sites_-_Transport	Functional Sites - Transport	1	5
Functional_Sites_-_Transport_Air	Functional Sites - Transport Air	2	5
Functional_Sites_-_Transport_Road	Functional Sites - Transport Road	1	5
Functional_Sites_-_Transport_Water	Functional Sites - Transport Water	1	5
Greenspace_-_All	Greenspace - All	1	0
Greenspace_-_Allotments	Greenspace - Allotments	3	0
Greenspace_-_Cemeteries	Greenspace - Cemeteries	3	0
Greenspace_-_GolfCourses	Greenspace - GolfCourses	3	0
Greenspace_-_Public_Parks_and_Gardens	Greenspace - Public Parks and Gardens	3	0
Greenspace_-_Religious_Grounds	Greenspace - Religious Grounds	3	0
Greenspace_-_Sports_Grounds	Greenspace - Sports Grounds	3	0

National_Parks	National Parks	4	1
Rail_-_Multi_Track	Rail - Multi Track	1	3
Rail_-_Narrow_Gauge	Rail - Narrow Gauge	1	3
Rail_-_Single_Track	Rail - Single Track	1	3
Rail_-_Stations	Rail - Stations	1	5
Rail_-_Tunnel	Rail - Tunnel	1	5
Rivers	Rivers	1	4
Rivers	Rivers	1	4
Road_-_A_Road	Road - A Road	1	3
Road_-_B_Road	Road - B Road	1	2
Road_-_Classified_Unnumbered_Road	Road - Classified Unnumbered Road	1	1
Road_-_Local_Road	Road - Local Road	1	1
Road_-_Minor_Road	Road - Minor Road	1	1
Road_-_Motorway	Road - Motorway	1	3
Road_-_Other_Roads	Road - Other Roads	1	1
Road_-_Restricted_Local_Access_Road	Road - Restricted Local Access Road	1	1
Road_-_Secondary_Access_Road	Road - Secondary Access Road	1	1
Road_-_Unclassified_Road	Road - Unclassified Road	1	1
Slope	Slope	0	3
Surface_Water	Surface Water	2	4
Surface_Water	Surface Water	2	4
Urban_Areas	Urban Areas	0	0
Woodland_Miscellaneous_OS	Woodland Miscellaneous OS	2	1
275kV_OverheadLines		0	0
400kV_OverheadLines		0	0
Gas_Pipeline	Gas Pipeline	1	5
Gas_Pipeline	Gas Pipeline	1	5
Gas_Sites	Gas Sites	1	5
SubstationSites		0	5

Transmission_Tower	Major utilities and other installations	0	5
Underground_Cable	Major utilities and other installations	0	5
AncientWoodland	Ancient Woodland	4	1
Biosphere	Biosphere Reserve	4	1
ALC Grade 1	Provisional Agricultural Land Classification	2	0
ALC Grade 2	Provisional Agricultural Land Classification	2	0
CountryParks	Country Parks	3	0
CRoW	Countryside and Rights of Way (CRoW) Act 2000 - Open Access Land	2	0
Heritage Coast	Heritage Coast	4	0
NationalParks	National Parks	4	1
NationalTrail	National Trail	2	0
NNR	National Nature Reserve	4	1
PriorityHabitat	Priority Habitat	4	0
RAMSAR_All	RAMSAR Site	4	0
SAC_All	Special Area of Conservation	4	0
SPA_All	Special Protection Area	4	0
SSSI	Site of Special Scientific Interest	4	0
SSSI_IRZ_Pipeline	SSSI Impact Risk Zones	3	0
Great_Crested_Newt_-_Observations_-_NBN	Great Crested Newt - Observations - NBN	3	0
NATS_Danger_Area_AIP	NATS Danger Area AIP	0	0
NATS_Prohibited_Area_AIP	NATS Prohibited Area AIP	0	0
NATS_Restricted_Area_AIP	NATS Restricted Area AIP	0	0
Battlefield	Registered Battlefields	4	0
Conservation Areas	Conservation Areas	4	0
ListedBuildings_Grade2	Listed Buildings	4	5
ListedBuildings_TopGrade	Listed Buildings	4	5
ParksAndGardens	Registered Parks and Gardens	4	0
ScheduledMonuments	Scheduled Monuments	4	0

WorldHeritage	World Heritage Site	4	0
NFI_Woodland_-_Broadleaved_-_Forestry_Commission	Woodland NFI Broadleaved	2	1
NFI_Woodland_-_Broadleaved_-_Forestry_Commission	Woodland NFI Broadleaved	2	1
NFI_Woodland_-_Coniferous_-_Forestry_Commission	Woodland NFI Coniferous	2	1
NFI_Woodland_-_Coniferous_-_Forestry_Commission	Woodland NFI Coniferous	2	1
NFI_Woodland_-_Not_Woodland_-_Forestry_Commission	Woodland NFI Not Woodland	0	0
FloodDefences	National Flood Zones/Areas Benefiting from Defences	1	3
FloodStorage	National Flood Zones/Areas Benefiting from Defences	3	3
FloodZone2	National Flood Zones/Areas Benefiting from Defences	3	3
FloodZone3	National Flood Zones/Areas Benefiting from Defences	3	3
Historic_Landfills	Historic Landfills	1	4
Permitted_Waste_Sites	Permitted Waste Sites	3	4
SPZ	Source Protection Zone	2	0
NIA	Noise Important Areas	1	0
Aeroways	Aeroways	2	2
Bars	Bars	0	5
Cafes	Cafes	0	5
Campsites	Campsites	0	5
Fuel_stations	Fuel stations	0	5
Hotels_and_Guest_houses	Guest houses	0	5
Industrial_sites	Industrial sites	0	5
Kindergartens	Kindergartens	0	5
Marketplaces	Marketplaces	0	5
Military_sites	Military Sites	2	5

Military_sites	Military Sites	2	5
Military_Sites	Military Sites	2	5
Nursing_homes	Nursing homes	0	5
Prisons	Prisons	0	5
Public_Rights_of_Way	Public Rights of Way	2	0
Pubs	Pubs	0	5
ResourceAreas_100mBufferNonPoly	ResourceAreas 100mBufferNonPoly	0	0
Restaurants	Restaurants	0	5
Schools	Schools	0	5
SolarPlant	SolarPlant	0	5
Stadiums	Stadiums	0	5
Substations	Substations	0	5
Theme_parks	Theme parks	0	5
Tourist_Attractions	Tourist Attractions	0	5
Tourist_Attractions	Tourist Attractions	0	5
Wind_Plant	Wind Plant	1	5
Type_R_Land_Area	Type R Land use in accordance with IGEM TD/1	0	5
Type_S_Land_Area	Type S Land use in accordance with IGEM TD/1	0	5
Type_T_Land_Area	Type T Land use in accordance with IGEM TD/1	0	5
Type_H_Land_Area	Type H Land use in accordance with IGEM TD/1	0	5