October 2012

Number 9 Feeder Replacement Project

Final Strategic Options Report

nationalgrid

nationalgrid

Number 9 Feeder Replacement Project Final Strategic Options Report

Table of Contents

National Grid
National Grid House
Warwick Technology Park
Gallows Hill
Warwick
CV34 6DA

Figures

Tables

October 2012

1 Introduction

This Strategic Optioneering Report is part of the pre-application procedures adopted by National Grid Gas Transmission plc for major infrastructure projects that may require an application to the Infrastructure Planning Commission ("IPC") for development consents.

Under section 31 of the 2008 Planning Act a Development Consent Order is required for development where it is or forms part of a Nationally Significant Infrastructure Project (NSIP). The list of NSIPs are set out in section 14 and under section 14(f) this includes the construction of a pipeline by a Gas Transporter.

Section 20 of the 2008 Act provides that the construction of a gas transporter pipeline is an NSIP if:

(1) The construction of a pipe-line by a gas transporter is within section 14(1)(f) only if (when constructed) each of the conditions in subsections (2) to (5) is expected to be met in relation to the pipe-line.

(2) The pipe-line must be wholly or partly in England.

(3) Either—

(a) the pipe-line must be more than 800 millimetres in diameter and more than 40 kilometres in length, or

(b) the construction of the pipe-line must be likely to have a significant effect on the environment.

(4) The pipe-line must have a design operating pressure of more than 7 bar gauge.

(5) The pipe-line must convey gas for supply (directly or indirectly) to at least 50,000 customers, or potential customers, of one or more gas suppliers.

National Grid is currently investigating options for ensuring the long term security of the No. 9 Feeder where it crosses the Humber Estuary in the East of England. At present the river bed cover over the existing pipeline is being denuded by the erosive action of the river. This feeder carries a high level of importance within the National Transmission System (NTS) as a strategic pipeline carrying significant volumes of natural gas away from the Easington importation terminal south towards the Hatton compressor facility.

Figure 1 Map showing National Grid's Pipeline Crossings

This report provides:

(a) Background to the project;

(b) A summary of the project Need Case;

(c) National Grid's Role and Obligations;

(d) An overview of construction options;

(e) A review of the potential strategic options;

(f) An overview of the Options Appraisal Methodology;

(g) An overall assessment of each option taking into account technical, safety, cost, environmental and socio-economic considerations; and

(h) Summary and identification of the preferred options.

This appraisal was undertaken in 2011 and 2012 and is based on information in the public domain, available at the time of writing. It is essential that future users of this appraisal are fully aware that the information contained within this report will require continual review and amendment, as the data is liable to change over time.

National Grid will continue to regularly review Strategic Options that could meet the identified Need Case in light of changes of circumstances that could materially affect the analysis. Comments on the content and analysis included in this report are welcome and will be taken into account in the on-going development of the project and future reviews.

2 Background

The 5 kilometre (km) long No. 9 Feeder National Transmission System (NTS) pipeline section between Paull and Goxhill Above Ground Installations (AGIs) includes a 3 km crossing of the Humber Estuary and provides a bulk transportation route for gas from the NTS entry points in East Yorkshire into the wider transmission system in Lincolnshire.

Commissioned in 1984, the pipeline crossing was laid in a trench in the boulder clay excavated by a cutter dredger vessel. The trench was allowed to backfill naturally by the tidal flow changes of the river, with some clay backfill close to the Thorngumbald side. The trench width was up to a maximum of 30 metre (m). This was determined by recent soil sample surveys, completed during March 2010.

This short section regularly transports between 70 and 100 million cubic metres per day (mcm/d) of gas making it the most critical pipeline on the NTS.

3 Summary of the Need Case

A Need Case has been produced which explains in detail the current capacity of the No. 9 Feeder and the reasons why a replacement pipeline is required (National Grid, 2011). The following text summarises this document.

As stated previously this short section of the No. 9 Feeder regularly transports between 70 mcm/d and 100 mcm/d and is a critical pipeline on the NTS and remains the highest throughput single pipeline section on the NTS.

Should the Feeder 9 crossing need to be taken out of service, entry capacity from the Easington area (including Norwegian imports and current UK storage) would be reduced to less than 50% of current levels south of the Humber Estuary resulting in the need to curtail supplies in this location across a significant proportion of the year. Alternative supplies would be required in the south to alleviate the north to south capacity constraint imposed. The knock-on effect to downstream pressures is likely to impact on the ability to maintain existing connected loads to the south, with the risk of curtailing demand under winter demand conditions. It is unlikely the ongoing security of the system could be maintained across winter demand levels without the curtailment of demand through third party supplies being turned off.

With the unavailability of the No. 9 Feeder crossing and the associated capacity constraints imposed could subject National Grid to significant commercial liabilities as per National Grid's Gas Transporter Licence; however, National Grid's exposure is limited under the terms of the Licence and the remaining commercial liabilities would be borne across the gas shipper community. Additionally, with the likely constraints imposed on the system with the reduction of the secure gas supply available during high winter demands National Grid would be in breach of its obligation under its Transporter Licence.

The riverbed in the Humber Estuary is extremely mobile with strong tidal currents of up to four knots across the No. 9 Feeder pipeline. The estuary handles 20% of the UK's runoff via the River Trent and River Ouse. With this in mind, the pipeline crossing requires close monitoring by means of a comprehensive survey, including depth of burial and the condition of the sea bed. Annual surveys have been completed as far back as the 1980's.

National Grid has been aware of seabed erosion in the Humber Estuary since the late 90's and has managed this successfully by remediation work as required over an adjacent pipeline (Feeder 1, approximately 500 m upstream of Feeder 9).

There were no concerns for erosion over Feeder 9 until 2009 when National Grid was advised that there had been an extraordinary amount of seabed erosion in the vicinity of Feeder 1 & 9.

Following analysis of the survey data the Feeder 1 pipeline was isolated by the closure of valves at Paull and Skitter AGI on either side of the Humber Estuary due to potential pipeline failure by fatigue. The impact on the wider NTS was managed with minimal disruption to third party supplies.

The annual surveys have shown that sediment above the Feeder 9 pipeline has deteriorated from a minimum depth of burial of 0.7 m in September 2008 to a 40 m exposed section (crown visible) in December 2009. Considering this the frequency of the surveys was subsequently increased following the December 2009 survey. The survey in June 2010 indicated four exposed sections of 15 m, 21 m, 14.8 m and 40.6 m over No. 9 Feeder.

From November 2010 to December 2011 gravel filled bags and frond mattresses remediation works were carried out to protect the pipeline from further seabed erosion. Current surveys (January 2012) confirm no exposed or free spanning sections of No. 9 Feeder and the remediation work is proving to be very successful with the frond mattresses encouraging sand and silt to settle with indications of up to 0.5 m increase in depth over the pipeline; however, this method of remedial work is only considered to be a relatively short term (up to 10 years) solution as per the report completed by Associated British Ports, Marine Environmental Research (ABP Mer 2010).

Key extracts from the ABP Mer report are shown as follows:

(a) *"The key morphological feature of the direct significance for the stability of the Feeder 1 and 9 pipelines is the main channel where depths have been shown to vary by several metres over time. It would appear that when the pipelines were installed (between 1973 and 1984), bed levels were up to 4 m higher than at present. Over the past 10 years there has been progressively increased exposure of Feeder 1 and more recently Feeder 9."*

(b) *"…..the situation for the pipelines can be expected to improve by 2040 (i.e. over the next 30 years) due to potential for increased accretion within the main channel over this period, although several years of further erosional stress are likely before accretion occurs in the vicinity of the pipelines. To safeguard their structural integrity, Feeder 9 would therefore require ongoing maintenance (remedial works) and monitoring for at least the next 30 years."*

With the current information provided by the ABP Mer report and the experiences with the Feeder 1 pipeline, the need to pursue a replacement pipeline is essential. Solely waiting to see what happens with the completed remedial work is not acceptable due to the national importance of this pipeline for the gas supply industry.

The following sections of this document assess a number of potential Strategic Options that could provide a replacement for this section of the No. 9 Feeder pipeline.

4 National Grid Role and Obligations

All National Grid pipelines are designed in accordance with the Institution of Gas Engineers & Managers standard, IGE/TD/1 (Edition 5) – Steel Pipelines and associated installations for High Pressure Gas Transmission. This standard applies to the design, construction, inspection, testing, operation and maintenance of pipelines and associated installations, designed after the date of publication (2009).

In accordance with the Company's Health, Safety and Environmental Policy, National Grid will comply with the relevant Health, Safety and Environmental legislation in the design, construction and operation of the pipeline.

Considerations taken into account when developing strategic options and subsequent route corridors and route alignments follow the general environmental and engineering principles described below and in National Grid's stakeholder, community and amenity policy[1]:

- Where practicable, statutory and non-statutory designations will be avoided. Where it is not possible to avoid such features, an application will be made to the relevant authorities as appropriate and agreed mitigation measures implemented;
- Potentially difficult construction areas, such as side slopes, solid rock strata, complex river crossings etc. will be avoided wherever possible. Steep slopes will be traversed directly since construction on severe side slopes is undesirable;
- All crossing points such as rivers, major roads and railways will be crossed at right angles as far as is possible;
- Safe access for construction will be a primary consideration during the planning and design of the route; and
- At all locations along the pipeline route the building proximity distance requirements of IGE/TD/1 (Edition 5) will be adhered to.

1 http://www.nationalgrid.com/uk/LandandDevelopment/SC/Responsibilities/sched9/schedule+9.htm

5 Overview of Construction Options

There are a number of different construction options that can be considered as part of the strategic options assessment.

This section provides a brief description of each of construction type, more detail on these methodologies is presented in Appendix 1. The construction methodologies described are intended to illustrate general techniques used in the construction of high pressure gas pipelines.

Trench Excavations

Trench Excavation construction involves digging a trench, placing a pipeline into the trench, replacing the soil over the pipeline and reinstating the working area.

Trenchless Technique Methods

Trenchless construction installs the pipeline below the ground with minimal excavation and includes the following methods:

- Auger boring;
- Pipe-jacking;
- Microtunneling;
- Tunnelling; and
- Horizontal directional drilling (HDD).

Pipeline Testing

Following the installation of the pipeline, it will be cleaned and internally checked using air or water. A test will then be carried out to check the pipe is fit for purpose and after drying, the pipeline will be commissioned with gas.

Compression

As gas is transported through a pipeline, it loses pressure due to friction. Compressor stations increase the pressure of gas within the pipeline to enable the gas to be transported effectively.

6 Review of Potential Strategic Options

Extensive network analysis has been carried out to identify the options to replace the existing Humber Estuary No. 9 Feeder crossing between Paull and Goxhill Above Ground Installations (AGI's).

Technical and Benefit Filter

An initial list of options was refined by using a technical filter. The technical filter discounted options that would not meet the supply forecasting required capacity of 2115 gigawatt hours per day (Gwh/d) (195 mcm/d) for the area. The technical filter also discounted options which were not buildable, achievable within the envisaged project timescale (of up to 10 years) or did not achieve technical or safety specifications.

The options were also assessed against a benefit filter which removed options that satisfied the Need Case but did not offer any material benefit over another option, thereby preventing the need to assess multiple options with potentially greater impacts. Options removed under the benefit filter were to be 'parked' with reasons why they were parked and may be iteratively reviewed and revisited as the project develops.

The output of these two filters was a refined list of potential Strategic Options to be taken forward to the Level 1 Options Appraisal.

Challenge and Review Workshop

A Challenge and Review workshop was held on the 3rd May 2011 to review the potential Strategic Options and to confirm that all options had been considered. The options were reviewed and a refined list of potential Strategic Options to be taken forward to the Level 1 Options Appraisal stage was determined.

Summary of Potential Strategic Options Being Taken Forward for Review in this Report

Seven potential Strategic Options for replacing the existing Humber Estuary No. 9 Feeder pipeline have been considered and are documented in this report. National Grid considers that each of these options is able to meet the Need Case through the construction of single pipelines, twin pipelines or a combination of pipelines and compressor stations and has taken these options forward for review in this report. These options are outlined in more detail in the following sections.

The seven potential Strategic Options that were reviewed are:

Direct Humber Estuary Crossing

- Option 1a – Direct Humber Estuary Crossing – Tunnel (6 km)
- Option 1b – Direct Humber Estuary Crossing - Excavated Trench (6 km); and
- Option 1c – Direct Humber Estuary Crossing - Horizontal Directional Drill (HDD) with cofferdam (6 km).

Onshore Pipeline

- Option 2 - Onshore - Paull to Kirmington including twin pipelines, single pipeline, tie to Feeders 9 and 22 and compression (190 km);
- Option 3 - Onshore (no compression) - Pipelines routed around Hull to Asselby and Keadby and tie to Feeders 9 and 22 (250 km).

Offshore Pipeline

- Option 4 – Offshore - Pipeline between Easington and Theddlethorpe, onshore pipeline between Theddlethorpe to Hatton and Compression (85 km); and
- Option 5 – Offshore - Easington to Bacton with compression, Kings Lynn to Peterborough onshore pipeline, high flow modifications and re-wheels (200 km).

Each of these seven potential Strategic Options and their Areas of Search used to inform the strategic options appraisal, are illustrated on maps contained within Appendix 2.

Description of Potential Strategic Options Including Construction Technology

Option 1a – Direct Humber Estuary Crossing – Tunnel (6 km)

A Tunnel (see construction methodology in Chapter 5 and Appendix 1) under the Humber Estuary between Paull AGI and Goxhill AGI. The total pipeline length would be approximately 6 km (with a 3 km estuary crossing). This Option will restore the existing capability of 2115 GWh/d and will not require any compression.

Option 1b – Direct Humber Estuary Crossing - Excavated Trench (6 km)

Option 1b is a direct estuary crossing laid in an excavated trench (see construction methodology in Chapter 5 and Appendix 1) between Paull AGI and Goxhill AGI. The pipe would be laid deeper in the boulder clay than the existing pipeline with an appropriate engineered infill to reduce the risk of any future seabed erosion. The pipeline would be approximately 6 km in length (3 km estuary crossing) between the Paull AGI and Goxhill AGI. This Option will restore the existing capability of 2115 GWh/d and will not require any compression.

Option 1c – Direct Humber Estuary Crossing - Horizontal Directional Drill (HDD) with cofferdam (6 km)

Option 1c is a direct crossing between the Paull and Goxhill AGI using HDD under the Humber (see construction methodology in Chapter 5 and Appendix 1). The pipeline would be approximately 6 km in length (3 km estuary crossing) would restore the existing capability of 2115 GWh/d and will not require any compression.

Option 2 - Onshore - Paull to Kirmington including twin pipelines, single pipeline, tie to Feeders 9 and 22 and compression (190 km)

This Option involves the construction of a twin pipeline between Paull and a location near Epworth, North Lincolnshire, over a length of approximately 81 km. A single pipeline between a location near Epworth and Kirmington, North Lincolnshire would also be constructed over a length of approximately 30 km. The option would also require a 35 Megawatt (MW) compression station at a location near Epworth and would tie in with Feeder 9 and Feeder 22. Compression is required to maintain pressure along the pipeline to meet capacity. The majority of the construction for the pipelines would be using the 'open cut' technique (see construction methodology in Chapter 5 and Appendix 1). Other techniques like boring, tunnelling or directional drilling are likely to be used for the crossing of features such as roads, railways, watercourses or other services as required. This Option would increase the existing capacity by 33 GWh/d (2148 GWh/d). The total pipeline length is approximately 190 km with total compression of 60 MW.

Option 3 - Onshore (no compression) - Pipelines routed around Hull to Asselby and Keadby and tie to Feeders 9 and 22 (250 km)
This Option involves the construction of a twin pipeline between Paull and a location near Epworth, North Lincolnshire, over a length of approximately 81 km. In addition, it also involves the construction of a single pipeline between a location near Epworth and Kirmington of approximately 30 km and a single pipeline between Ganstead to Asselby of approximately 57 km. The majority of the construction for the pipelines would be using the 'open cut' technique (see construction methodology in Chapter 5 and Appendix 1). Other techniques like boring, tunnelling or directional drilling are likely to be used for the crossing of features such as roads, railways, watercourses or other services as required.

This Option would increase the existing capacity by 30 GWh/d (2145 GWh/d). The total pipeline length of approximately 250 km and will not require any compression.

Option 4 – Offshore - Pipeline between Easington and Theddlethorpe, onshore pipeline between Theddlethorpe to Hatton and Compression (85 km)
Option 4 is part offshore and part onshore. The offshore pipeline runs between Easington and Theddlethorpe for a length of approximately 45 km. The onshore pipeline would run between Theddlethorpe and Hatton over a length of approximately 40 km. This Option will require a 35 MW compressor station at Easington. This Option would restore the existing capacity of 2115 GWh/d. The total pipeline length would be approximately 85 km with total compression of 65 MW.

Option 5 – Offshore pipeline Easington to Bacton with compression, Kings Lynn to Peterborough onshore pipeline, high flow modifications and re-wheels (200 km)
Option 5 is part offshore and part onshore option. The offshore pipeline would run between Easington and Bacton over a distance of approximately 130 km and the onshore pipeline would run between Kings Lynn and Peterborough over a distance of approximately 71 km. Compression would be required at Easington (65 MW@ 110 barg) and Kings Lynn would require high flow modifications and re-wheels. This Option would increase the capacity to 2123 GWh/d. The total pipeline length is approximately 200 km with total compression of 125 MW.

7 Overview of Options Appraisal Methodology

Options Appraisal is a multi-criteria analysis tool designed to inform the decision-making process. The aim of Options Appraisal is to provide a robust, consistent and transparent framework for assessing the suitability of different options. It comprises a comparison of the potential effects of alternative options being considered and appraises the performance of the different options within four main topic areas: Environment, socio-economic, technical and cost.

Depending on the scale of project and type of project, Options Appraisal can be applied at different stages of project development:

- Strategic Options (Level 1 options appraisal);
- Outline routeing / siting (Level 2 options appraisal);
- Detailed routeing / siting (Level 3 options appraisal); and
- Final check on project performance (Level 4 options appraisal).

Options Appraisal is an iterative process and can be used to refine options in order to improve their environmental, socio-economic and technical performance.

The design, alignment and location of options can be reviewed and modified at each stage of the process, with the aim of avoiding or minimising the more significant predicted impacts.

Guiding Principles

Options Appraisal is under-pinned by a set of guiding principles which define good performance.

- Using or adapting existing infrastructure is generally preferable to creating new infrastructure;
- Shorter routes are generally preferable to longer ones;
- Financially cheaper options are generally preferable to more expensive ones; and
- Options which avoid, minimise and/or mitigate impacts on environmental or socio-economic constraints are generally preferable to those which do not.

These basic rules are the starting point for the decision-making process, and are designed to ensure compliance with National Grid's various statutory duties, specifically those regarding the minimisation of environmental impacts and the economic and efficient operation of gas transmission systems.

In addition to the general guiding principles, for each sub-topic a set of sub-topic-specific guiding principles for design and routeing ('sub-topic guiding principles') have been established. These are aimed at informing the option selection and scheme design processes so that impacts can be avoided or minimised. These are used both to inform iterative development of more acceptable options and to underpin the appraisal process. The principles have been derived from the relevant legislation and policy guidance and from the statutory duties which set the framework for these considerations.

On some occasions, there will be tensions between the different guiding principles and there is no one solution for these occasions as there is no fixed hierarchy between the principles or the sub-topics. Options Appraisal does not make decisions; it provides information to support the decision-making process. National Grid, taking the advice of our various stakeholders, will make judgements about the option which best balances all duties and obligations. This will ultimately be tested through the planning process, with the final decision made by the Secretary of State.

Level 1 Option Appraisal

The aim of Level 1 Options Appraisal is to help identify a Preferred Strategic Option, based on a full understanding of the issues. The Level 1 Option Appraisal is carried out as part of the Strategic Options stage, the appraisal is carried out at a high, strategic level. The information required to make comparisons between different options generally relates to constraints or issues of national importance or above, which would be of sufficient importance to influence decision-making at such a strategic level. This information is readily obtained through a desk study and a limited consultation exercise.

Topics will be assessed in more detail in further stages of the appraisal process.

The four Topic Areas in Options Appraisal are Environment, Socio-economics, Technical and Cost. These have been identified specifically to ensure that decision-making is based on a broad understanding of the implications of National Grid's projects.

Environmental Appraisal

This Level 1 Options Appraisal has assessed the following sub-topics:

- Landscape and Visual;
- Ecology;
- Historic Environmental; and
- Other Environmental Issues (includes air quality, noise etc.).

The environmental appraisal for each of the potential Strategic Options has considered environmental constraints of international and national importance. Features considered as potential environmental constraints to each Strategic Option are presented in Table 1. The table also summarises the legislation under which protection is conferred and the data sources from which information (where applicable) was taken.

Table 1: Environmental Constraints and Data Sources

Feature	Legislation	Routeing Response (and Reference)	Data Sources
Agricultural Land Classification (Grades 1 to 3)	n/a	-	Natural England - www.gis.naturalengland.org.uk/
Area of Outstanding Natural Beauty (AONB)	National Parks and Access to the Countryside Act 1949/ Countryside and Rights of Way Act 2000	Seek to avoid/consider undergrounding	Natural England - www.gis.naturalengland.org.uk/
Areas Benefitting from Defences		-	By request - Environment Agency (Commercial Services Department)
Country Parks	n/a	Seek to avoid	Natural England - www.gis.naturalengland.org.uk/
Flood Storage Areas			By request - Environment Agency (Commercial Services Department)
Grade I and II* Listed Buildings	Planning (Listed Buildings and Conservation Areas) Act 1990	Seek to avoid/consider effect on setting	English Heritage - http://services.english-heritage.org.uk/NMRDataDownload/
Heritage Coast	n/a	Seek to avoid	Natural England - www.gis.naturalengland.org.uk/
Important Bird Area	n/a	Seek to avoid	RSPB - http://www.rspb.org.uk/ourwork/science/datazone/index.aspx
National Character Areas	n/a	-	Natural England - www.gis.naturalengland.org.uk/
National Flood Defences	n/a	-	By request - Environment Agency (Commercial Services Department)
National Flood Zone 2	n/a	-	By request - Environment Agency (Commercial Services Department)
National Flood Zone 3	n/a	-	By request - Environment Agency (Commercial Services Department)
National Nature Reserves (NNR)	National Parks and Access to the Countryside Act 1949	Seek to avoid/verify potential effects	gis.naturalengland.org.uk
New Candidate Marine Special Areas of Conservation (cSAC) (2010)	n/a	Seek to avoid	Sea Zone Ltd. - http://www.seazone.com
RAMSAR Sites	The Conservation of Habitats and Species Regulations 2010	Seek to avoid (birds interest)	Natural England - www.gis.naturalengland.org.uk/
Registered Parks & Gardens	n/a	Seek to avoid	English Heritage - http://services.english-heritage.org.uk/NMRDataDownload/
Royal Society for the Protection of Birds (RSPB) Reserve	n/a	Seek to avoid	RSPB - http://www.rspb.org.uk/ourwork/science/datazone/index.aspx
Scheduled Monument	Ancient Monuments and Archaeological Areas Act 1979	Seek to avoid/consider effect on setting	English Heritage - http://services.english-heritage.org.uk/NMRDataDownload/
Settlements	n/a	Seek to avoid	Digitised from Ordnance Survey
Sites of Special Scientific Interest (SSSI)	Wildlife and Countryside Act 1981 Countryside and Rights of Way Act 2000	Seek to avoid/verify potential effects	Natural England - www.gis.naturalengland.org.uk/
Special Area of Conservation (SAC)	The Conservation of Habitats and Species Regulations 2010	Seek to avoid (birds interest)	Natural England - www.gis.naturalengland.org.uk/
Special Protection Area (SPA)	The Conservation of Habitats and Species Regulations 2010	Seek to avoid (birds interest)	Natural England - www.gis.naturalengland.org.uk/
UK Biodiversity Action Plan (BAP) Priority Habitat	n/a	Seek to avoid	Natural England - www.gis.naturalengland.org.uk/

Socio-Economic Appraisal

This Level 1 Options Appraisal has assessed Socio-Economic issues. A high-level desk study to identify the key socio-economic issues has been undertaken and the Strategic Options impact on socio-economic constraints assessed. Features considered as potential socio-economic constraints to each Strategic Option are presented in Table 2 which also summarises the data sources from which information was taken.

Table 2: Socio-Economic Constraints and Data Sources

Feature	Data Sources
Airports and Airfields (in use and disused)	UK General Aviation - http://ukga.com
Anchorage Area	Sea Zone Ltd. - http://www.seazone.com
Bathymetry	Sea Zone Ltd. - http://www.seazone.com
Cable Area, Power Line	Sea Zone Ltd. - http://www.seazone.com
Cable, submarine	Sea Zone Ltd. - http://www.seazone.com
Dredging Licensing	Sea Zone Ltd. - http://www.seazone.com
Dumping Ground	Sea Zone Ltd. - http://www.seazone.com
Gas Pipelines	Dataset provided by National Grid.
Harbour Area	Sea Zone Ltd. - http://www.seazone.com
Licensed Area, Wind Farm	Sea Zone Ltd. - http://www.seazone.com
Major Roads (Classified A roads)	Digitised from OS Mapping
Military Practice Area	Sea Zone Ltd. - http://www.seazone.com
Military Site	Digitised from OS Mapping
Mooring facility	Sea Zone Ltd. - http://www.seazone.com
Motorways	Digitised from OS Mapping
National cycle routes	Digitised from Sustrans website - www.sustrans.org.uk/
National Trails	Natural England - www.gis.naturalengland.org.uk/
Offshore Installation, Fixed platform/ structure	Sea Zone Ltd. - http://www.seazone.com
Offshore Platform	Sea Zone Ltd. - http://www.seazone.com
Overhead Power Lines	Dataset provided by National Grid.
Pile, post	Sea Zone Ltd. - http://www.seazone.com
Pipeline, submarine/ on land	Sea Zone Ltd. - http://www.seazone.com
Ports	Digitised from Regional Plan
Power Stations	National Grid - www.ccshumber.co.uk
Small Craft Facility (Camp site)	Sea Zone Ltd. - http://www.seazone.com
Small Craft Facility (Caravan site)	Sea Zone Ltd. - http://www.seazone.com
Small Craft Facility (Nautical club)	Sea Zone Ltd. - http://www.seazone.com
Traffic Separation Scheme Lane (part)	Sea Zone Ltd. - http://www.seazone.com
Urban Areas (from Agricultural Land Classification dataset)	Natural England - www.gis.naturalengland.org.uk/
Wind Farm Locations	Restats - restats.decc.gov.uk

Technical Appraisal

Chapter 6 explains that each potential Strategic Option has been assessed initially using the technical and benefits filter to ensure that it meets the Need Case and that the Strategic Option is technically possible. Strategic Options which do not meet the Need Case or would not meet National Grid standards and specifications have not been considered for further analysis.

The Level 1 Options Appraisal describes the high-level issues associated with each option taking into account the technical complexity of the option, construction/delivery issues, technology issues, capacity issues and any network efficiencies/benefits.

Cost Appraisal

Once an indicative scope of works associated with each strategic option was identified, an estimate of the capital cost of construction and life-time costs including the costs associated with operation, maintenance has been estimated. As options have been refined through the appraisal process, these costs have been refined to ensure that options are being compared on a fair basis.

Capital cost is an estimate of the cost of equipment and installation costs. These costs are estimated using current financial year prices applicable at the time of publication of this report. For the purposes of reviewing Strategic Options, the cost estimates are based on generalised unit costs for the key elements of the option, reflecting recent contract values or manufacturers' or consultants' budget estimates. This is sufficient to allow a broad order of consistent costs to be established for the options, as necessary at the strategic level, and is not intended to provide a detailed cost for each option which can only be obtained at the detailed design stage.

The lifetime cost is an estimate of the cost of maintaining a gas pipeline per km, the operating and maintenance costs of a compressor station, aerial surveillance costs, In Line Inspection (ILI) and the cost of overhaul/incident costs for compressor stations over a 40 year life.

Although costs have been estimated for each option they are not shown in this report as they are commercially sensitive and could influence the construction tender process. The costs will be presented as a multiple of the cheapest option.

Strategic Optioneering Workshop

A Strategic Optioneering workshop was undertaken to review and challenge the initial Level 1 Appraisal findings in order to determine the Strategic Options to be taken forward to the outline routeing/siting stage of the project. The assessment presented in this report is the updated appraisal following the Strategic Optioneering Workshop.

8 Level 1 Options Appraisal

Constraints Maps

Constraints maps have been produced highlighting the constraints across the Environmental and Socio-economic sub-topics. These maps have been used to identify whether a particular option is likely to be viable. These are displayed in Appendix 3.

Options Appraisal Summary

An Option Appraisal Summary Table (OAST) has been prepared for each strategic option, summarising the implications of that option with regard to all sub-topics considered and providing a summary of the pros and cons of each strategic option. The OASTs are presented in Appendix 4.

The appraisal assumes that standard mitigation measure and the application of good construction practices will be implemented. Therefore at this stage of the process only issues which would require more that standard mitigation and which would result in impacts that could differentiate factors between the options have been considered.

The following sections provide a summary of the options appraisal for each Strategic Option. This includes a summary of the potential effects, mitigation and residual effects and implications and outcomes of that option with regard to all sub-topics considered.

Option 1a – Direct Humber Estuary Crossing – Tunnel (6 km)

Technical

Option 1a utilises tunnelling construction techniques which is a proven technology considered as having a medium to high risk in terms of technical complexity. As the method is well established it is not expected that there would be any significant programme or technical issues at this stage. This option would deliver the existing capacity of the No. 9 Feeder.

Cost

The capital cost of this option is estimated to be 1.2 times more expensive than Option 1b (excavated trench). The lifetime cost for this option is estimated to be £45 million over a 40 year life. This is based upon 6 km of pipeline requiring pipeline inspection gauge (PIG) trap facilities on the north and south banks of the estuary. 'PIG' traps enable in-line inspection of the pipeline to be carried out across the estuary.

Environment

Landscape & Visual

It is likely that there will be some temporary, localised adverse landscape and visual effects during the construction period. Adverse effects upon the landscape and visual receptors can be limited if key landscape features are avoided through appropriate siting of the tunnel launch and reception shafts. Landscape would not be material in the consideration of this option as the Preferred Strategic Option at this stage. This option **'complies with the guiding principles with no substantive concern'**.

Ecology

Option 1a has the potential to impact upon the River Humber Estuary which is designated as a Special Protection Area (SPA), Special Area of Conservation (SAC), Ramsar site, Important Bird Area (IBA) and Site of Special Scientific Interest (SSSI). There is the potential for impacts during the construction phase due to noise and vibration, pollution and general disturbance to flora and fauna. Given the international importance of the habitat, it will be necessary to demonstrate that any scheme does not have an adverse effect on the integrity of the constituent qualifying habitats and populations (most notably birds and fish).

As this construction method has a relatively restricted development footprint associated with the tunnel launch/ reception shaft locations it should be possible to avoid direct impacts upon the statutory designated sites through careful route alignment and shaft positioning. Implementation of a buffer area between the tunnel launch/ reception shaft and the designated Estuary should be implemented to mitigate disturbance effects. This buffer area should be as wide as possible. At this stage it is assumed that direct impacts on statutory designated sites can be avoided, and that ecological constraints can be avoided and therefore ecological constraints would not be material in the selection of this option as the Preferred Strategic Option at this stage. This option **'complies with guiding principles and is of no substantive concern'**.

Historic Environment

This option has the potential to impact upon designated heritage assets (schedule monument and listed buildings). At this stage it is assumed that any high value designated heritage assets can be avoided through careful route alignment. Therefore the Historic Environment would not be material in the consideration of this option as the Preferred Strategic Option at this stage. This option **'complies with guiding principles and is of no substantive concern'**.

Other Environmental Issues

There is the potential for short term temporary impacts on the Humber Estuary during construction and impacts to flood defences; however, tunnelling construction techniques and careful siting of the launch/ reception shafts should minimise impacts. Therefore water constraints would be less likely to be material in the selection of this option as the Preferred Strategic Option at this stage. This option **'complies with the guiding principles with no substantive concern'**.

Option 1a is likely to generate a significant amount of spoil and other waste including non-recyclable waste during construction. Waste management practices will be implemented to minimise the impact where possible. However, as this option is relatively waste-intensive compared with the other options. The option has been recorded as **'complies with guiding principles, but is relatively resource- and/or waste-intensive compared with other options'**.

Socio-economics

Option 1a has the potential to impact upon shipping and other activities associated with the Port of Hull as well as existing onshore and offshore pipelines. However the tunnelling construction techniques will mean that the impacts to shipping could be avoided and careful routeing of the pipeline should avoid potential impacts on the existing pipelines. At this stage it is assumed that impacts could be avoided therefore it is no not considered that socio-economic factors would be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as **'complies with the guiding principles with no substantive concern'**.

Summary

Option 1a compares relatively favourably with the other options in terms of technical issues, although not sufficiently so to be a major consideration in decision-making. Considerations in the decision-making are considered to be cost as this option compares favourably with the other options in terms of both capital and lifetime costs and the spoil generated by the tunnel construction as this option is relatively waste-intensive compared with the other options. It is considered at this stage that other environmental and socio economic issues can be adequately managed.

Option 1b – Direct Humber Estuary Crossing - Excavated Trench (6 km)

Technical

Excavated Trench construction methodology is well established and is considered to be medium risk in terms of technical complexity due to the challenging estuary conditions. The method is well established; however, the challenging estuary conditions and the uncertainty over gaining approval for this method (due to the length of construction period) may have significant implications with regard to programme and technical issues. This option would deliver the existing capacity of the No. 9 Feeder.

Cost

The capital cost of this option is estimated to be the lowest of all the options. The lifetime cost for this option is estimated to be £45 million over a 40 year life. This is based upon 6 km of pipeline PIG trap facilities on the north and south banks of the estuary. 'PIG' traps enable in-line inspection of the pipeline to be carried out across the estuary.

Environment

Landscape & Visual

It is likely that there will be some temporary, localised adverse landscape and visual effects during the construction period. Adverse effects upon the landscape and visual receptors can be limited if key landscape features are avoided through appropriate routeing of the pipeline. Landscape would not be material in the consideration of this option as the Preferred Strategic Option at this stage. This option **'complies with guiding principles and is of no substantive concern'**.

Ecology

Option 1b has the potential to impact upon the River Humber Estuary which is designated as an SPA, SAC, Ramsar, IBA and SSSI. Given the international importance of the habitat, it will be necessary to demonstrate that any scheme does not have an adverse effect on the integrity of the constituent qualifying habitats and populations (most notably birds and fish). Excavating a trench across the Humber has the potential to cause construction phase impacts due to noise and vibration effects, risk of pollution and disturbance to flora and fauna.

With an excavated trench, it would not be possible to avoid direct impacts to these statutory designated sites. Ecological constraints are therefore considered to be material in the consideration of this option as the Preferred Strategic Option. This option **'complies with guiding principles, but only after substantive mitigation'**.

Historic Environment

In terms of the Historic Environment, it is assumed that any high value designated heritage assets can be avoided through careful route alignment. Therefore the Historic Environment would not be material in the consideration of this option as the Preferred Strategic Option at this stage. This option **'complies with guiding principles and is of no substantive concern'**.

Other Environmental Issues

Excavating a trench through the Humber Estuary has the potential to cause short term temporary impacts on the Humber Estuary and impacts to flood defences. Direct impacts on the Humber Estuary cannot be avoided however, careful routeing of the pipeline should minimise impacts on the flood defences. Water constraints are therefore considered to be material in the selection of the Preferred Strategic Option and this option has been recorded as **'complies with guiding principles, but only after substantive mitigation'**.

Socio-economics

Option 1b has the potential to impact upon shipping and other activities associated with the Port of Hull as well as existing onshore and offshore pipelines. Potential impacts on the existing pipelines would be avoided with careful routeing but the excavated trench method would mean that impacts on shipping would not be avoided and are likely to be significant given the length of the construction period, shipping constraints would therefore be material in the selection of this Preferred Strategic Option and the option has been recorded as **'complies with guiding principles, but only after substantive mitigation'**.

Summary

Option 1b compares relatively favourably with the other options in terms of technical issues, although not sufficiently so to be a major consideration in decision-making. Considerations in the decision-making are considered to be cost as this option has the lowest capital cost, impacts on the Humber Estuary, flood defences and shipping as these issues could either make the option difficult to obtain consent and/or that mitigation could increase the cost of the option. However, it is recognised that an alternative longer pipeline may result in a greater risk in terms of construction period and land take, and the likelihood of affecting more environmental features will increase.

Option 1c – Direct Humber Estuary Crossing - Horizontal Directional Drill (HDD) with cofferdam (6 km)

Technical

HDD as a construction method for the direct Humber Estuary crossing is considered to be high risk in terms of technical complexity as the method has not been proven over this length. The method would require a cofferdam to be constructed in the estuary. This would enable the HDD to be carried out in two drills from the cofferdam; however, the risk of failure would still be high. The technology has a high risk of failure due to it being unproven over this length and dependent upon strata encountered. The construction of a cofferdam in the estuary for the construction period of approximately one year would reduce the risk of failure, however there is uncertainty over gaining approval for the method due to this structure in the navigable channel. Therefore this construction method could have significant implications with regard to technical issues and programme delivery. This option would deliver the existing capacity of the No. 9 Feeder.

Cost

The capital cost of this option is estimated to be the lowest. However, because of the significant possibility of failure with HDD methods the costs of the excavated trench option have also been included. Consequently, it would be 1.5 times more expensive than option 1b. The lifetime cost for this option is estimated to be £45 million over a 40 year life. This is based upon 6 km of pipeline PIG trap facilities on the north and south banks of the estuary. 'PIG' traps enable in-line inspection of the pipeline to be carried out across the estuary.

Environment

Landscape & Visual

It is likely that there will be some temporary, localised adverse landscape and visual effects during the construction period. Adverse effects upon the landscape and visual receptors can be limited if key landscape features are avoided through appropriate routeing of the pipeline. Landscape would not be material in the consideration of this option as the Preferred Strategic Option at this stage. This option **'complies with guiding principles and is of no substantive concern'**.

Ecology

Option 1c has the potential to impact upon the River Humber Estuary which is designated as an SPA, SAC, Ramsar, IBA and SSSI. There is the potential for impacts during the construction phase in terms of noise and vibration effects, risk of pollution and general disturbance to flora and fauna and general disturbance to flora and fauna.

With HDD, it would not be possible to avoid direct impacts to these statutory designated sites as a permanent structure (cofferdam) would be required in the estuary. Ecological constraints are therefore highly likely to be material in the consideration of this Option as the Preferred Strategic Option. This Option **'complies with guiding principles, but only after substantive mitigation'**.

Cultural Heritage

HDD under the Humber Estuary has the potential to impact upon designated heritage assets (a schedule monument and listed buildings) due to the HDD rig set up and entry/exit points. It is assumed that any high value designated heritage assets can be avoided through careful route alignment. Therefore the Historic Environment is not considered to be material in the consideration of this option as the Preferred Strategic Option at this stage. This option **'complies with guiding principles and is of no substantive concern'**.

Other Environmental Issues

There is the potential for significant impacts on the Humber Estuary during construction due to the cofferdam. With horizontal directional drill construction techniques, it should be possible to avoid impacts on flood defences and some but not all impacts to the marine environment. Water constraints are therefore considered to be material in the consideration of this option as the Preferred Strategic Option. This option **'complies with guiding principles, but only after substantive mitigation'**.

Socio-economics

Option 1C has the potential to impact upon shipping and other activities associated with the Port of Hull as well as existing onshore and offshore pipelines. Potential impacts on the existing pipelines would be avoided with careful routeing but the construction of the cofferdam in the estuary would mean that impacts on shipping would not be avoided and are likely to be significant given the length of the construction period, shipping constraints would therefore be material in the selection of this Preferred Strategic Option and the option has been recorded as **'complies with guiding principles, but only after substantive mitigation'**.

Summary

The considerations in the decision-making for Option 1c include technical issues due to the high risk of method failure, cost as high risk of failure would increase the capital cost, impacts on the Humber Estuary, flood defences and shipping as these issues could either make the option difficult to obtain consent and/or that mitigation could increase the cost of the option. However, it is recognised that an alternative longer pipeline may result in a greater risk in terms of construction period and land take, and the likelihood of affecting more environmental features will increase.

Option 2 - Onshore - Paull to Kirmington including twin pipelines, single pipeline, tie to Feeders 9 and 22 and compression (190 km)

Technical

The construction method to be utilised for Option 2 are well founded and are considered as having a low risk in terms of technical complexity. As the method is well established, straightforward to install and maintain it is not expected that there would be any significant programme issues however, the compressor station will require on-going maintenance throughout its lifetime. This option would increase the existing capacity of the No. 9 Feeder.

Cost

The capital cost of this option is estimated to be 4.2 times more expensive than Option 1b (excavated trench). The lifetime cost for this option is estimated to be £122 million over a 40 year life. This is based upon 190 km of pipeline requiring four PIG trap facilities and the installation of one compressor station.

Environment

Landscape & Visual

It is likely that there will be some temporary, localised adverse landscape and visual effects during the construction period including impacts on a National Trail and national cycle routes. Adverse effects upon the landscape can be limited if key landscape features are avoided through appropriate routeing of the pipeline. There will also be the potential for landscape effects on landscape character and visual impacts during the operational phase as a result of the compression station; however careful siting and design of the compressor station will reduce the significance of these impacts. The implementation of mitigation measures should also be able to minimise visual effects experienced by users of the national trail, national cycle routes and residents along the affected route.

Landscape and visual is not considered to be material in the consideration of this option as the Preferred Strategic Option at this stage; however, due to the compressor station landscape and visual effects should still be a consideration in decision-making. This option has therefore been recorded as **'complies with the guiding principles, but only after substantive mitigation'**.

Ecology

Option 2 has the potential to impact upon the Humber Estuary which is designated as an SPA, SAC, Ramsar, IBA and SSSI. It also has the potential to impact 8 SSSIs and an RSPB reserve. These impacts will be during the construction phase due to noise and vibration, risk of pollution and disturbance. Given the international importance of the Humber Estuary habitat, it will be necessary to demonstrate that any scheme does not have an adverse effect on the integrity of the constituent qualifying habitats and populations (most notably birds and fish).

At this stage it is assumed that these statutory designated sites can be avoided, through careful route alignment and using non open cut construction techniques (such as boring, tunnelling or directional drilling techniques) to cross the Humber. Therefore Ecological constraints would not be considered material in the selection of the Preferred Strategic Option. This option should therefore be recorded as **'complies with the guiding principles with no substantive concern'**.

Historic Environment

This option has the potential to impact upon 16 Scheduled Monuments, 29 listed buildings and 2 Registered Parks and Garden. It is assumed at this stage that any high value designated heritage assets can be avoided through careful route alignment. Therefore the Historic Environment would not be material in the consideration of this option as the Preferred Strategic Option at this stage. This option **'complies with guiding principles and is of no substantive concern'**.

Other Environmental Issues

This option has the potential to impact one geological SSSI, flood defences, watercourses and Source Protection Zones. As this option involves the construction and operation of a compressor station it is likely that there will be effects on air quality receptors as a result of compressor station emissions and impacts due to noise.

Potential impacts to geological SSSIs may be avoided by careful routeing of the pipeline. Watercourses and flood defences will be avoided where possible; however, there are well developed techniques that can be applied to avoid, minimise and reduce adverse impacts. At this stage it should be possible to avoid Source Protection Zones. It should be possible to avoid significant air quality and noise impacts through careful siting and design of the compressor station and regular monitoring and maintenance. Due to the compressor station, air quality and noise should be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as **'complies with the guiding principles, but only after substantive mitigation'**.

Socio-economics

Option 2 has the potential to impact upon existing pipelines and overhead powerlines, national cycle routes and a National Trail. At this stage it is assumed that impacts could be avoided with careful routeing and design therefore it is no not considered that socio-economic factors would be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as **'complies with the guiding principles with no substantive concern'**.

Summary

Option 2 compares relatively favourably with the other options in terms of technical issues; however, the installation of a compressor station would mean that this would be a consideration in the decision-making.

Considerations in the decision-making are considered to be cost as this option compares unfavourably with the other options being 4.2 times higher that the cheapest option 1b (excavated trench), and Landscape and Visual, Noise and Air Quality issues due to the construction of the compressor station and the length of the pipeline (190 km) as it is recognised that a longer pipeline will result in a greater risk in terms of construction period and land take, and the likelihood of affecting more environmental features will increase. It is considered at this stage that other environmental and socio economic issues can be adequately managed.

Option 3 - Onshore (no compression), pipelines routed around Hull to Asselby and Keadby and tie to Feeders 9 and 22 (250 km)

Technical

The construction method to be utilised for Option 3 are well founded and are considered as having a low risk in terms of technical complexity. As the method is well established, straightforward to install and maintain it is not expected that there would be any significant programme issues. This option would increase the existing capacity of the No. 9 Feeder.

Cost

The capital cost of this option is estimated to be 4.1 times more expensive than Option 1b (excavated trench). The lifetime cost for this option is estimated to be £92 million over a 40 year life. This is based upon 250 km of pipeline requiring eight PIG trap facilities.

Environment

Landscape & Visual

It is likely that there will be some temporary, localised adverse landscape and visual effects during the construction period including impacts on a National Trail and national cycle routes. Adverse effects upon the landscape can be limited if key landscape features are avoided through appropriate routeing of the pipeline. The implementation of mitigation measures should also be able to minimise visual effects experienced by users of the national trail, national cycle routes and residents along the affected route. Landscape would not be material in the consideration of this Option as the Preferred Strategic Option at this stage. This option **'complies with guiding principles and is of no substantive concern'**.

Ecology

Option 3 has the potential to impact upon the Humber Estuary which is designated as an SPA, SAC, Ramsar, IBA and SSSI, 13 other SSSIs and an RSPB reserve during the construction phase due to noise and vibration, pollution and disturbance. These impacts will be during the construction phase due to noise and vibration, risk of pollution and disturbance. Given the international importance of the habitat, it will be necessary to demonstrate that any scheme does not have an adverse effect on the integrity of the constituent qualifying habitats and populations (most notably birds and fish).

At this stage it is assumed that these statutory designated sites can be avoided, through careful route alignment and using non open cut construction techniques (such as boring, tunnelling or directional drilling techniques) to cross the Humber. Therefore Ecological constraints would not be considered material in the selection of the Preferred Strategic Option. This option should therefore be recorded as **'complies with the guiding principles with no substantive concern'**.

Historic Environment

This option has the potential to impact upon 51 Scheduled Monuments and 72 listed buildings. It is assumed at this stage that any high value designated heritage assets can be avoided through careful route alignment. Therefore the Historic Environment would not be material in the consideration of this option as the Preferred Strategic Option at this stage. This option **'complies with guiding principles and is of no substantive concern'**.

Other Environmental Issues

This option has the potential to impact four geological SSSI, flood defences, watercourses and Source Protection Zones. At this stage it should be possible to avoid geological SSSIs and Source Protection Zones. Watercourses and flood defences will be avoided where possible; however, there are well developed techniques that can be applied to avoid, minimise

and reduce adverse impacts. Therefore other environmental issues should not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as **'complies with the guiding principles with no substantive concern'**.

Socio-economics

Option 3 has the potential to impact upon existing pipelines and overhead powerlines, national cycle routes and a National Trail. At this stage it is assumed that impacts could be avoided with careful routeing and design therefore it is no not considered that socio-economic factors would be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as **'complies with the guiding principles with no substantive concern'**.

Summary

Option 3 compares relatively favourably with the other options in terms of technical issues, although not sufficiently so to be a major consideration in decision-making. Considerations in the decision-making are considered to be cost as this option compares unfavourably with the other options being 4.1 times higher that the cheapest option 1b (excavated trench), and the length of the pipeline (250 km) as it is recognised that a longer pipeline will result in a greater risk in terms of construction period and land take, and the likelihood of affecting more environmental features will increase. It is considered at this stage that other environmental and socio economic issues can be adequately managed.

Option 4 – Offshore pipeline between Easington and Theddlethorpe, onshore pipeline between Theddlethorpe to Hatton and Compression (85 km)

Technical

The construction method to be utilised for Option 4 are well founded and are considered as having a low risk in terms of technical complexity, however the offshore aspect would be new to National Grid and therefore external expertise would need to be sought. As the method is well established, straightforward to install and maintain it is not expected that there would be any significant programme issues however, offshore aspects may be seasonal/weather dependent. The compressor station will also require on-going maintenance throughout its lifetime. This option would increase the existing capacity of the No. 9 Feeder.

Cost

The capital cost of this option is estimated to be 3.1 times more expensive than Option 1b (excavated trench). The lifetime cost for this option is estimated to be £102 million over a 40 year life. This is based upon 85 km of pipeline requiring two PIG trap facilities and the life time cost of maintenance installation of one compressor station.

Environment

Landscape & Visual

This option has the potential to impact upon two nationally designated landscapes: the Lincolnshire Wolds AONB and the Spurn Heritage Coast. It is likely that there will be some temporary, localised adverse landscape and visual effects during the construction period. Adverse effects upon the landscape can be limited if key landscape features are avoided through appropriate routeing of the pipeline. The Lincolnshire Wolds AONB can be avoided, however it should be noted that this would require a considerable re-route which would also cause landscape impacts. As impacts are likely to be limited to the construction phase, and with the implementation of appropriate mitigation to avoid permanent scarring of the landscape, it is likely that the pipeline could be routed through the AONB.

There will also be the potential for landscape effects on landscape character and visual impacts during the operational phase as a result of the compression station; however careful siting and design of the compressor station will reduce the significance of these impacts. Landscape and visual is not considered to be material in the consideration of this option as the Preferred Strategic Option at this stage; however, due to the presents of the AONB, and the construction of the compressor station landscape and visual effects should still be a consideration in decision-making. This option has therefore been recorded as **'complies with the guiding principles, but only after substantive mitigation'**.

Ecology

The offshore option 4 has the potential to impact the Humber Estuary which is designated as an SPA, SAC, Ramsar, IBA and SSSI, the Saltfleetby-Theddlethorpe Dunes & Gibraltar Point SAC, 8 SSSIs and 2 National Nature Reserves (NNRs) during the construction phase due to noise and vibration, pollution and disturbance to birds and marine life (e.g. River Lamprey) associated with the designated sites using habitat outside of the designated area. Given the international importance of the Humber Estuary and the Saltfleetby-Theddlethorpe Dunes & Gibraltar Point SAC habitats, it will be necessary to demonstrate that any scheme does not have an adverse effect on the integrity of the constituent qualifying habitats and populations (most notably birds and fish).

At this stage it is assumed that these statutory designated sites can be avoided through careful route alignment, and that ecological constraints would not be material in the selection of this as the Preferred Strategic Option. This option **'complies with guiding principles and is of no substantive concern'**.

Historic Environment

This option has the potential to impact upon 20 Scheduled Monuments and 15 listed buildings. It is assumed at this stage that any high value designated heritage assets can be avoided through careful route alignment. Therefore the Historic Environment would not be material in the consideration of this option as the Preferred Strategic Option at this stage. This option **'complies with guiding principles and is of no substantive concern'**.

Other Environmental Issues

This option has the potential to impact one geological SSSI, flood defences, watercourses and Source Protection Zones. As this option involves the construction and operation of a compressor station it is likely that there will be effects on air quality receptors as a result of compressor station emissions and impacts due to noise.

At this stage it should be possible to avoid Source Protection Zones and the geological SSSIs by careful routeing of the pipeline. Watercourses and flood defences will be avoided where possible; however, there are well developed techniques that can be applied to avoid, minimise and reduce adverse impacts. It should be possible to avoid significant air quality and noise impacts through careful siting and design of the compressor station and regular monitoring and maintenance. Due to the compressor station, air quality and noise should be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as **'complies with the guiding principles, but only after substantive mitigation'**.

Socio-economics

Option 4 has the potential to impact upon onshore and offshore pipelines, windfarm infrastructure, offshore platforms, submarine cables and licensed dredging activity. It also has the potential to be affected during construction by unexploded ordnance. At this stage and following a full ordnance survey prior to construction it is assumed that impacts could be avoided with careful routeing and design therefore it is no not considered that socio-economic factors would be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as **'complies with the guiding principles with no substantive concern'**.

Summary

Option 4 compares relatively favourably with the other options in terms of technical issues; however, the installation of a compressor station would mean that this would be a consideration in the decision-making.

Considerations in the decision-making are considered to be cost as this option compares unfavourably with the other options being 3.1 times higher that the cheapest option 1b (excavated trench), and Landscape and Visual, Noise and Air Quality issues due to the construction of the compressor station and the length of the pipeline (85 km) as it is recognised that a longer pipeline will result in a greater risk in terms of construction period and land take, and the likelihood of affecting more environmental features will increase. It is considered at this stage that other environmental and socio economic issues can be adequately managed.

Option 5 – Offshore pipeline Easington to Bacton with compression, Kings Lynn to Peterborough onshore pipeline, high flow modifications and re-wheels (200 km)

Technical

The construction method to be utilised for Option 5 are well founded and are considered as having a low risk in terms of technical complexity, however the offshore aspect would be new to National Grid and therefore external expertise would need to be sought. As the method is well established, straightforward to install and maintain it is not expected that there would be any significant programme issues however, offshore aspects may be seasonal/weather dependent. The compressor station will also require on-going maintenance throughout its lifetime. This option would increase the existing capacity of the No. 9 Feeder.

Cost

The capital cost of this option is estimated to be 6.8 times more expensive than Option 1b (excavated trench). The lifetime cost for this option is estimated to be £124 million over a 40 year life. This is based upon 200 km of pipeline requiring four PIG trap facilities and the life time cost of maintenance installation of one compressor station.

Environment

Landscape & Visual

This option has the potential to impact upon two nationally designated landscapes: the Norfolk Coast AONB and the Spurn Heritage Coast and national cycle routes. It is likely that there will be some temporary, localised adverse landscape and visual effects during the construction period. Adverse effects upon the landscape can be limited if key landscape features are avoided through appropriate routeing of the pipeline. The implementation of mitigation measures should also be able to minimise visual effects experienced by users of the national cycle routes and residents along the affected route.

There will also be the potential for landscape effects on landscape character and visual impacts during the operational phase as a result of the compression station; however careful siting and design of the compressor station will reduce the significance of these impacts. Landscape and visual is not considered to be material in the consideration of this option as the Preferred Strategic Option at this stage; however, the compressor station landscape and visual effects should still be a consideration in decision-making. This option has therefore been recorded as **'complies with the guiding principles, but only after substantive mitigation'**.

Ecology

The offshore option 5 has the potential to impact the Inner Dowsing, Race Bank and North Ridge Candidate Marine SAC, the Humber Estuary which is designated as an SPA, SAC, Ramsar, IBA and SSSI, Norfolk Valley Fens SAC and 4 SSSIs and a NNR during the construction phase due to noise and vibration, pollution and disturbance. Given the international importance of these habitats, it will be necessary to demonstrate that any scheme does not have an adverse effect on the integrity of the constituent qualifying habitats and populations (most notably birds and fish).

At this stage it is assumed that these statutory designated sites can be avoided through careful route alignment, and that ecological constraints would not be material in the selection of this as the Preferred Strategic Option. This option **'complies with guiding principles and is of no substantive concern'**.

Historic Environment

This option has the potential to impact upon 24 Scheduled Monuments, 52 listed buildings and 1 Registered Parks and Garden. It is assumed at this stage that any high value designated heritage assets can be avoided through careful route alignment. Therefore the Historic Environment would not be material in the consideration of this option as the Preferred Strategic Option at this stage. This option **'complies with guiding principles and is of no substantive concern'**.

Other Environmental Issues

This option has the potential to impact four geological SSSI, flood defences, flood storage areas and watercourses. As this option involves the construction and operation of a compressor station it is likely that there will be effects on air quality receptors as a result of compressor station emissions and impacts due to noise.

At this stage it should be possible to avoid the geological SSSIs by careful routeing of the pipeline. Watercourses and flood defences will be avoided where possible; however, there are well developed techniques that can be applied to avoid, minimise and reduce adverse impacts. It should be possible to avoid significant air quality and noise impacts through careful siting and design of the compressor station and regular monitoring and maintenance. Due to the compressor station, air quality and noise should be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as **'complies with the guiding principles, but only after substantive mitigation'**.

Socio-economics

Option 5 has the potential to impact on and offshore pipelines, windfarm infrastructure, offshore platforms, submarine cables, licensed dredging activity, overhead powerlines, and national cycle routes during construction. It also has the potential to be affected during construction by unexploded ordnance. At this stage and following a full ordnance survey prior to construction it is assumed that impacts could be avoided with careful routeing and design therefore it is no not considered that socio-economic factors would be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as **'complies with the guiding principles with no substantive concern'**.

Summary

Option 5 compares relatively favourably with the other options in terms of technical issues. However, the installation of a compressor station would mean that this would be a consideration in the decision-making.

Considerations in the decision-making are considered to be cost as this option compares unfavourably with the other options being 6.8 times higher that the cheapest option 1b (excavated trench), and Landscape and Visual, Noise and Air Quality issues due to the construction of the compressor station and the length of the pipeline (200 km) as it is recognised that a longer pipeline will result in a greater risk in terms of construction period and land take, and the likelihood of affecting more environmental features will increase. It is considered at this stage that other environmental and socio economic issues can be adequately managed.

9 Statutory Consultee and Key Stakeholder Consultation

A Draft Strategic Options Report was issued to the following statutory consultees and key stakeholders for comment, in May 2012.

- AB Ports;
- Natural England;
- Environment Agency;
- English Heritage;
- Marine Management Organisation;
- North Lincolnshire Council;
- Crown Estates; and
- East Riding of Yorkshire Council.

A summary of the responses is contained in Appendix 5.

The consultation process has not changed the initial outcome of the Draft Strategic Options Report that Options 1a, 1b and 1c are the most favourable to take forward to the next stage of assessment. And this was supported by many of the consultee comments..

Option 1c has subsequently been discounted for technical reasons outlined below.

10 Conclusions

This report describes the review that National Grid has conducted of potential Strategic Options to replace a section of the No. 9 Feeder pipeline. The review assessed which of the Strategic Options available to meet the Need Case is the most appropriate, taking into account the considerations set out in this report and comments received from consultees.

This report:

- Reviews the technology options available to meet the identified requirement;
- Assesses the lifetime costs of each option as well as the initial capital cost;
- Assesses the environmental and socio-economic effects of each option; and
- Considers the comments received from consultees.

There are seven Strategic Options which would meet the Need Case. These are as follows:

Direct Humber Estuary Crossing

- Option 1a – Direct Humber Estuary Crossing – Tunnel (6 km)
- Option 1b – Direct Humber Estuary Crossing - Excavated Trench (6 km); and
- Option 1c – Direct Humber Estuary Crossing - Horizontal Directional Drill (HDD) with cofferdam (6 km).

Onshore Pipeline

- Option 2 - Onshore - Paull to Kirmington including twin pipelines, single pipeline, tie to Feeders 9 and 22 and compression (190 km); and
- Option 3 - Onshore (no compression), pipelines routed around Hull to Asselby and Keadby and tie to Feeders 9 and 22 (250 km).

Offshore pipeline

- Option 4 – Offshore pipeline between Easington and Theddlethorpe, onshore pipeline between Theddlethorpe to Hatton and Compression (85 km); and
- Option 5 – Offshore pipeline Easington to Bacton with compression, Kings Lynn to Peterborough onshore pipeline, high flow modifications and re-wheels (200 km).

As can be seen for the options appraisal summary in Section 8, all the options with the exception of Option 1c compare favourable in terms of technical issues. Option 1c construction method has a high risk of failure which also has the knock-on effect of increasing capital costs. In general the longer pipelines, and those with compressor stations, cost more. Option 1b (excavated trench) is the least expensive option and Option 5 is the most expensive option at 6.8 times higher than 1b (excavated trench).

The longer pipelines (Options 2, 3, 4 and 5) are expected to have a greater risk of affecting more environmental features, due to the longer construction period and increased land take. Options which include compressor stations (Options 2, 4 and 5) will potentially cause Landscape and Visual, Noise and Air Quality impacts.

Other considerations in the appraisal of the options include the spoil generated by the tunnel construction of Option 1a and impacts on the Humber Estuary, flood defences and shipping from Option 1b and 1c.

Following the appraisal, the challenge and review workshops and consultation, the project team is recommending that the direct Humber Estuary crossings (options 1a, and 1b) are taken forward to the next stage of assessment (the Level 2 Options Appraisal – Outline routeing/siting study) and that Options 1c, 2, 3, 4 and 5 are discounted at this stage.

Options 1a and 1b comply with the over-arching guiding principles of the Options Appraisal. They are substantially shorter than the other options and therefore these options would result in fewer impacts overall than the longer pipelines. Although Options 1a and 1b could impact upon Humber Estuary site of nature conservation importance, the estuary crossing is relatively short (3 km) and it is thought that appropriate mitigation can be implemented at the more detailed stages to ensure potential effects are minimised or avoided. The options utilise existing infrastructure, avoiding the need to construct new AGIs, and they are financially cheaper options.

In addition Options 1a and 1b do not require the installation of a compressor station, resulting in fewer impacts on noise, air quality, landscape and visual amenity.

Option 1c has been discounted due to the technical limitations of the Horizontal Directional Drill technique over the required length, along with the limited availability of backup procedures should the technology fail.

11 Next Steps

National Grid has now obtained feedback from statutory consultees and key stakeholders on the appraisal process undertaken to date and documented in this report, and the recommendations that have been made.

Any comments received from consultees have been documented and used to inform the final recommendations of this strategic options appraisal.

Options 1a and 1b will now be taken forward to the next stage of assessment – the Stage 2 Options Appraisal.

A Route Corridor Investigation Study will now be undertaken to identify the potential route corridors to be considered within the area of the preferred strategic option. The potential route corridors will then be subject to further public consultation before any decision is taken on which of the potential route corridors to progress to detailed assessment.

Glossary and Abbreviations

Term	Description
AGI	Above Ground Installation.
Anchorage Area	An area in which vessels anchor or may anchor.
Area of Outstanding Natural Beauty (AONB)	Areas of Outstanding Natural Beauty are areas of high scenic quality that have statutory protection in order to conserve and enhance the natural beauty of their landscapes.
Barg	Unit of gauge pressure.
Biodiversity Action Plan (BAP) Priority Habitat	BAP Priority Habitats listed in the UK Biodiversity Action Plan.
Cable Area, Power Line	An area which contains one or more submarine cables.
Cable, submarine	An assembly of wires or fibres, or a wire rope or chain which has been laid underwater or buried beneath the seabed.
Cm	Centimetres
Compression	As gas is transported through a pipeline, it loses pressure due to friction. Compression is the process of increasing the pressure of the gas to enable it to be transported effectively. The pressure of gas within a pipeline is increased at compressor stations which usually occur between 40 and 100 mile intervals along a pipeline.
cSAC	A site becomes known as a candidate SAC (cSAC) when it is submitted to the European Commission. Candidate SACs are subject to full protection under the Habitats Directive (transposed through The Conservation of Habitats and Species Regulations 2010).
EPBM	Earth Pressure Balance Machine.
EPDM	Ellylane Propylene Driven Manover
Flood Zone	Flood Zone 1: This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%). Flood Zone 2: This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% – 0.1%) in any year. Flood Zone 3: This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year. (PPS25: Development and Flood Risk, revised March 2010).
GNI	Gas Network Investment Team.
Groundwater Protection Zone (Source Protection Zones)	The Environment Agency have designated Source Protection Zones (SPZs) for 2000 groundwater sources such as wells, boreholes and springs used for public drinking water supply. These zones show the risk of contamination from any activities that might cause pollution in the area.
Gwh/d	Gigawatt hours per day.
HDD	Horizontal Directional Drilling.
Heritage Coast	Heritage Coasts represent stretches of the UK's most beautiful, undeveloped coastline, which are managed to conserve their natural beauty and, where appropriate, to improve accessibility for visitors.
IBA	Important Bird Areas hold significant numbers of one or more globally threatened species and are one of a set of sites that together hold a suite of restricted-range species or biome-restricted species. IBAs have exceptionally large numbers of migratory or congregatory species.
ILI	In Line Inspection.
Internal Drainage Board	An Internal Drainage Board - (IDB) is a type of operating authority which is established in areas of special drainage need in England and Wales with permissive powers to undertake work to secure clean water drainage and water level management within drainage districts.
Km	Kilometre.
Listed Building	Grade I buildings are of exceptional interest, sometimes considered to be internationally important. . Grade II* buildings are particularly important buildings of more than special interest. Grade II buildings are nationally important and of special interest.
LNG	Liquefied Natural Gas.
Main Rivers	Main Rivers are usually larger streams and rivers. The Environment Agency has powers to carry out flood defence works apply to main rivers only. . In England, Defra decides which are the main rivers.
Marine Management Organisation	Marine Management Organisation (MMO) has been established to make a significant contribution to sustainable development in the marine area and to promote the UK government's vision for clean, healthy, safe, productive and biologically diverse oceans and seas.
Mcm/d	Million Cubic Metres Per Day.
Military Practice Area	An area within which naval, military or aerial exercises are carried out. Also called an exercise area.
Mm	Millimetres.
MW	Megawatt.
National Nature Reserves (NNR)	Many of the finest sites in England for wildlife and geology are National Nature Reserves. Many NNRs contain nationally important populations of rare flowers, ferns and mosses, butterflies and other insects, and of course nesting and wintering birds. These sites are designated under Section 19(1) of the National Parks and Access to the Countryside Act 1949 and Section 35(1) of the Wildlife and Countryside Act 1981.
NCA	England has been divided into areas with similar landscape character, which are called National Character Areas (NCAs).
NTS	National Transmission System.
Offshore Platform	A permanent offshore structure, either fixed or floating, used in the production of oil or natural gas.
Ofgem	The Office of Gas and Electricity Markets.
Open cut	Standard pipeline construction using open cut methods.
PIG	Pipeline Internal Gauge.

Term	Description
Pipeline, submarine/ on land	Pipeline is a string of interconnected pipes used for the transport of matter, nowadays mainly oil or gas.
Potential Strategic Options	Initial list of options that have been found to work technically and have benefit over other options. These 'potential options' are put forward for appraisal and scrutiny.
Preferred Strategic Option	An option that has been subject to the level 1 Options Appraisal, consultation and analysis and has been found to be the best option to carry forward.
Ramsar Sites	Ramsar sites are wetlands of international importance, designated under the Ramsar Convention.
Registered Parks and Garden	The Register of Parks and Gardens of special historic interest in England contains nearly 1450 sites and is maintained by, English Heritage.
RSPB reserve	Royal Society for the Protection of Birds reserve.
Scheduled Monument	A Scheduled Monument is an 'important' archaeological site or historic building, given protection under the Ancient Monuments and Archaeological Areas Act 1979. 'Scheduling' is shorthand for the process through which nationally important sites and monuments are given legal protection by being placed on a list, or 'schedule'.
SF6	Sulfur hexafluoride.
Special Areas of Conservation (SAC)	SACs are areas which have been given special protection under the European Union's Habitats Directive. They provide increased protection to a variety of wild animals, plants and habitats and are a vital part of global efforts to conserve the world's biodiversity.
Special Protection Areas (SPA)	SPAs are areas which have been identified as being of international importance for the breeding, feeding, wintering or the migration of rare and vulnerable species of birds found within European Union countries.
Special Scientific Interest (SSSI)	SSSIs are the country's very best wildlife and geographical sites. They include some of the most spectacular and beautiful habitats. Natural England has responsibility for identifying and protecting the SSSIs in England under the Wildlife and Countryside Act 1981 (as amended).
Strategic Options	Strategic, as at this stage the work is high-level and broad-based. Options, accepted term in the planning, development and EIA areas. Optioneering was the term previously used.
TBM	Tunnel Bore Machines.
tCO2e	Tonnes of carbon dioxide equivalent.
Traffic Separation Scheme Lane (part)	A traffic separation scheme is a scheme which aims to reduce the risk of collision in congested and/ or converging areas by separating traffic moving in opposite, or nearly opposite, directions.
UKCS	United Kingdom Continental Shelf.
VIV	Vortex Induced Vibration.

References

Associated British Ports, (August 2010) Marine Environmental Research (ABP Mer) Seabed Condition and Stabilisation Options Study

National Grid, (January 2011) National Transmission System No. 9 Feeder – Replacement Strategy "Need Case" Report

National Grid, (May 2011) Strategic Options Challenge and Review Workshop Report

National Grid, (November 2011) Methodological Guidance for Options Appraisal – Level 1 Options Appraisal

Transco Humber River Pipeline Span VIV Monitoring 2H Offshore Engineering Ltd Doc. No: 1663-RPT-001 (December 2003)

Transco Pipeline Span VIV Assessment 2H Offshore Engineering Ltd Doc. No: 1525-TNE-001 (April 2002)

List of Appendices

Appendix 1 Overview of Construction Options

There are a number of different construction options that can be considered as part of the strategic options assessment. These include:

- Trench Excavations Onshore;
- Trenchless Technique Methods;
- Tunnelling and Pipe Pulled through tunnel;
- Horizontal Directional Drilling (HDD); and
- Open Cut Trench Excavation and Pipe Installation by Bottom Pull.

This Appendix provides a description of each of these construction methodologies. The construction methodologies described are intended to illustrate general techniques used in the construction of high pressure gas pipelines.

Trench Excavations Onshore

The sequence of activities will generally be, surveying the route, clearing and fencing the working width, installing pre-construction drainage, topsoil stripping, stringing out the pipes, field bending, welding, non-destructive testing and coating the pipeline, excavating and placing the pipeline into the trench, tie in welding, backfilling the trench, installing post construction drainage, hydrostatic testing, replacing the topsoil over the pipeline and reinstating the working area. Figure 2 displays the Standard Cross Country Pipeline Construction.

The construction working width is normally 38 metres (m), wider widths at crossing locations may be required to accommodate additional storage for spoil, temporary work areas etc (for example, an additional 45 m). Figure 3 shows the typical area required for a road crossing. The rate of construction is usually at a rate of 200 m to 1 kilometre (km) per day. Trenches dug to hold the pipe must be a minimum 30 to 40 centimetres (cm) wider than the diameter of the pipe. Excavation is carried out to a depth sufficient to allow the pipe to have a minimum cover of 1.2 m. The minimum depth will be deeper at major crossings such as roads, rail crossings and major water courses where a minimum of 2 m cover is required and at ditched and minor watercourses a minimum cover of 1.7 m is required.

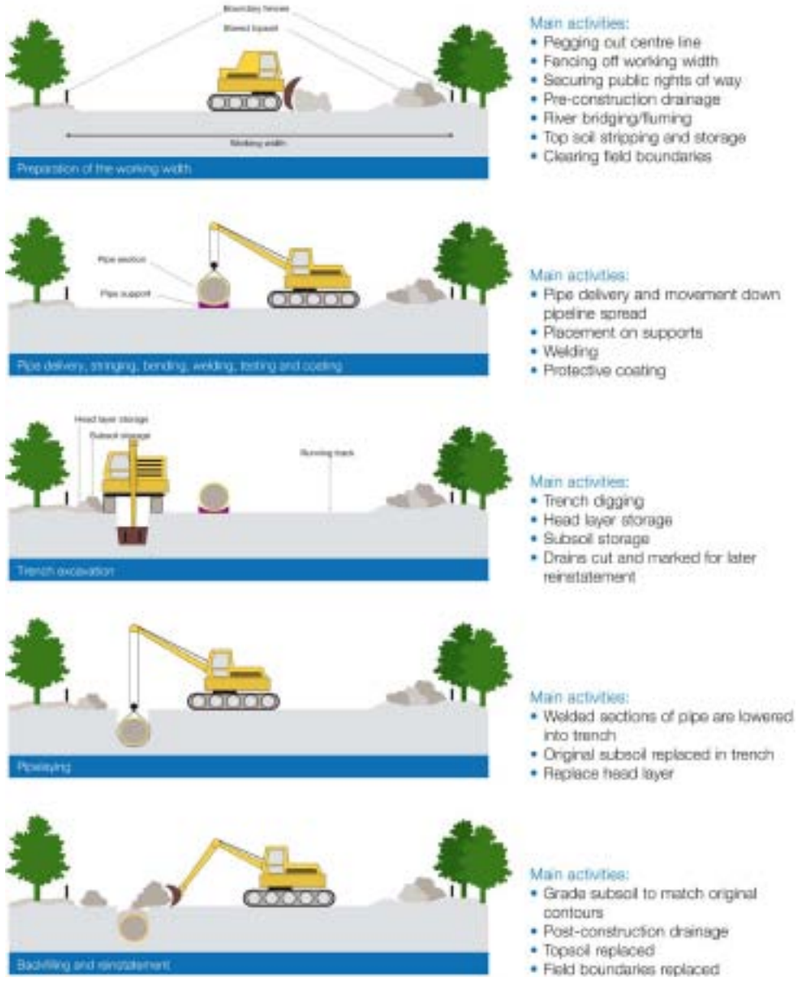


Figure 2 Standard Cross Country Pipeline Construction

Trenchless or "special crossings" (such as boring, tunnelling or directional drilling techniques) will be used where crossing of features such as roads, railways, watercourses or other services are required. The method of construction practiced will be adapted to suit each site's specific needs and to satisfy the requirements of the relevant authorities and landowners. Generally these techniques take place from pits excavated on either side of the crossing. The equipment and pipe is placed in a larger pit excavated on one side of the crossing and pushed to a smaller pit excavated on the other side of the crossing.

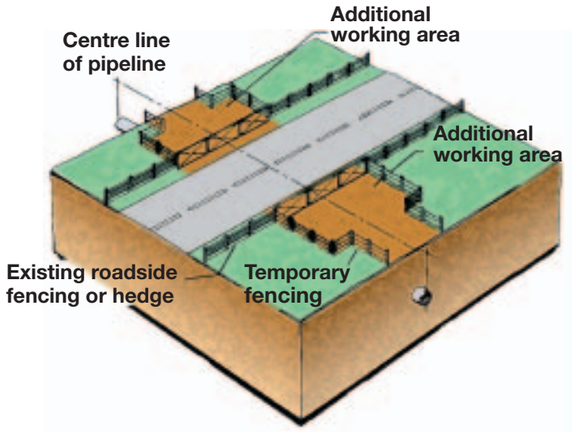


Figure 3 Typical Road Crossing

Trenchless Technique Methods

Auger Bore

Auger boring starts from an excavated entry pit that is part of the pipeline trench. On the opposite side of the crossing a smaller reception pit is excavated. The pit depth depends on the nature of the crossing and ground conditions but will typically be between 3 m to 5 m. Auger boring equipment is installed in the entry pit and a section of pipe is pushed under the obstacle by using hydraulic thrust. An auger is used to remove spoil and pass it back through the pipe. A auger bore crossing is shown in Figure 4.

Figure 4 Auger Bore Crossing

Pipe-Jack

The Pipe-jack method uses a hydraulic ram to thrust the open ended pipe under the obstacle. Miners or mechanical methods are used to remove the soil as the pipe is thrust forward. The excavated material is removed via the exposed end of the pipe. As each pipe section progresses forward, another is welded on and in this manner, the pipe is installed. This method is usually used for larger diameter pipe or the installation of concrete carrier pipe. The welded pipe is then installed within the concrete sleeve and grouted in.

Micro-Tunnelling

Involves the use of steerable remote control pipe-jacking. Pre-cast concrete jacking pipes are placed behind a micro-tunnelling machine with a cutting head lubricated with water or a mud mix. Small quantities of bentonite may also be used to reduce friction. The excavated material is removed with the drill fluid and is returned to the surface via the tunnel entrance where the fluid is filtered to remove the cuttings and returned to temporary mud storage tanks for re-use.

Tunnelling and Pipe Pulled Through Tunnel

This method would involve sinking vertical shafts to a depth in excess of 30 m on either side of the crossing, and constructing a tunnel beneath the entire crossing. Tunnel excavation and lining with concrete segments is followed by post installation grouting to fill any annulus between the segments and the tunnel bore. The tunnel entry and exit positions would extend back to ground level so that continuous pulling operations through the tunnel can be carried out.

There are two types of Tunnel Bore Machines (TBM) which could be used, a conventional Earth Pressure Balance Machine (EPBM) and a Slurry Shield machine. The selection of the method to be used would depend on the appointed contractor, ground conditions, ground water and external water pressure.

Tunnel Construction – EPBM

The EPBM would be assembled in a shaft of around 14 m diameter and would drive itself to another shaft (the other side of the crossing) from where it would be recovered. In the driving process the tunnel is formed using pre-cast concrete segments. The concrete lining installed behind the TBM is filled around the outside with a sealer (Ellylane Propylene Driven Manover - EPDM) to provide a water tight lining. Spoil is removed from the tunnel face by a screw conveyor, and transferred to muck skips which are pulled on a rail track system, installed from the launch pit in the tunnel as it advances, which are pulled on rail track by locomotives to the drive shaft, from where the waste is recovered to the surface. As spoil arising will be in a semi saturated condition these will be left to drain within the spoil bays prior to removal from site. The pipeline would then be installed by pulling pre-assembled pipe strings from an adjacent fabrication facility.

A typical example illustrating the size and sophistication of a conventional TBM is shown in Figure 5.

Figure 5 Typical TBM

Figure 6 shows a typical view of a completed tunnel.

Figure 6 Completed Tunnel with Floor and Services

Tunnel Construction – Slurry Shield Machine

The Slurry Shield is a TBM with a closed face, supporting the ground by means of a slurry filling in the front cell, created from the excavated ground mixed with bentonite, polymer, or a foaming compound. The slurry admixtures are pumped to the face from the surface and the excavated material is returned to the surface as a slurry by pumping. One feature of this method is that cofferdams (essentially excavations with a sloping base and sides supported by steel sheet piles or other forms of deep retaining walls), could be used in place of the shafts at each end of the tunnel. The cofferdams would enable a shallow excavation to be made and the TBM would then commence its drive through the surface materials before driving into the bed rock, the TBM would then resurface in a reception cofferdam on the other side of the crossing.

As the Slurry Shield Machine excavates its way forward, the tunnel is simultaneously lined using concrete tunnel segments delivered to the face by skips, which are pulled on rail track by locomotives to and from the drive cofferdam.

On completion of the tunnel drive the TBM would arrive at the reception shaft which, in Figure 7 comprises a sheet piled arrangement.

Figure 7 TBM Reception Shaft

The Slurry Shield equipment at the tunnel headworks is expected to include re-processing plant, which would clean and process the slurry returned from the tunnelling face. The recovered slurry would then be supplemented with fresh supplies as required and is then pumped back to the tunnel face while the recovered waste transported off site to a licensed disposal facility.

Spoil removed as a slurry also requires its own space within the tunnel and in combination with the air delivery system, a minimum tunnel internal diameter of 2.44 m would be necessary for the work.

Pipeline Fabrication

A crossing will require the pipe to be fabricated in strings potentially between 800 m and 1,000 m. A typical arrangement is shown in Figure 8.

Figure 8 Pipe String Fabrication

On one side of the crossing a winch spread will be set up. Pulling wires would be extended from the winch spread to the pulling head on the pipe on the other side of the crossing. The pulling of the pipe into a tunnel from a stringing site is presented in Figure 9.

Figure 9 Pipe Pulling into a Tunnel

Disposal of Excavated Material from the Tunnel

Excavated material from the tunnel would need to be transferred directly to waiting lorries for disposal off site or transferred to temporary storage areas prior to subsequent loading into lorries. Arisings from the drive pit, reception pit and transition trench would be stored in temporary stockpiles before being returned for reinstatement of the excavations on completion of the works. Bulk excavated material would need to be disposed of, on a 24 hrs/day operation, to a permanent disposal location.

Horizontal Directional Drilling (HDD)

The principle of pipeline construction using the HDD method can be broken down into four fundamental functions Pilot Hole Drilling, Hole-Opening Operations, Pipeline Fabrication and Pipeline Installation.

The HDD site is prepared, the drilling rig and associated equipment is mobilised and set up over the required HDD entry point (see Figure 10).

Figure 10 HDD Drilling Rig set up for Drilling

A pilot hole is drilled using a drill bit, the drill head and the pressure injection of drilling fluid. Drill rods are added to the drill string as the drill progresses. The location of the drill bit is monitored using the HDD locating system. An electronic transmitter in the drill head informs the operator of the location, pitch and roll of the drill head and allows the operator to maintain the pre-planned path of the bore. Bentonite clay is used to facilitate drilling operations, to lubricate and stabilise the ground.

Cuttings are returned with the drilling mud and removed by filters so the drilling mud can be re-used. Once the drill bit exits the other end of the drill hole, the drill head is removed and a reamer is attached to the drill string. During the reaming process drilling fluid is pumped under pressure through the drill string to the reamer. As the drill rig pulls the reamer back, drill pipe is attached continuously behind the reamer for the subsequent reaming and pipe pulling operations.

Once the pilot hole drilling operations have been completed, the drilled hole will be enlarged to the required diameter for the installation of the pipeline. The pipe is then pulled back towards the exit area by the drill rig.

Open Cut Trench Excavation and Pipe Installation by Bottom Pull

This method requires the use of dredging and land based excavation equipment to construct a trench. A gated sheet piled cofferdams and a concrete coated pipe would be pulled from a pipe fabrication facility into the trench from one side of the crossing to the other. A typical arrangement used in the construction is shown in Figure 11.

Figure 11 Gated Cofferdam

Upon installation of the cofferdams, excavation of the trench can be completed. A trench excavation to a depth of 6 m would be required to give 4 m of cover to the pipe; this could result in an excavation typically 100 m wide at the level of the crossing.

A trailer / hopper dredger could be used for the bulk of the excavation work. Dredged material would be transported to designated disposal areas. Once the trench is completed, maintenance dredging would continue to keep the excavation open up to the time that the wire laying commences. Excavated material from the foreshores could be side-cast for re-use as backfill. Figure 12 shows trench formation by a Grab Dredger.

Figure 12 Dredging of Trench

To avoid the need to build causeways and the need for any onshore plant to access the mud flats a shallow draught back-hoe type dredger could work inshore, digging a trench for itself, on High Tides. This operation would continue until the trench was dredged across the mud flats all the way into the flood defence cofferdams. Dredged material from the mud flats would, subject to approval by the authorities, be stored for later reinstatement.

Figure 13 shows a backhoe dredger with material being side cast and stored local to the trench.

Figure 13 Backhoe Dredger

While the trench is being excavated, the proposed pipeline is fabricated onshore. The pipe will be fabricated in strings of typically 500 m in length. A typical pipe fabrication arrangement is shown in Figure 8.

A winch spread will be set up with pulling wires extending from the winch spread to the pulling head welded to the pipe. The pipe strings are then pulled from the fabrication site, through the cofferdam, into the pre-excavated trench across the crossing a typical arrangement is shown in Figure 14.

Figure 14 Pipe Pull through Cofferdam

On completion of the pulling operation the pipeline trench will be backfilled using the stored excavated material supplemented by appropriate imported material, as required.

Pipeline Testing

Following the mechanical completion of the pipeline, all sections of pipeline will be cleaned and internally checked using air or water-driven cleaning and gauging pieces of equipment known as 'Pipeline Internal Gauges' (PIGs). A hydrostatic test will then be carried out to demonstrate fitness for purpose in compliance with National Grid's specification for Pipeline Testing PT/3. After drying, the pipeline will be commissioned with gas.

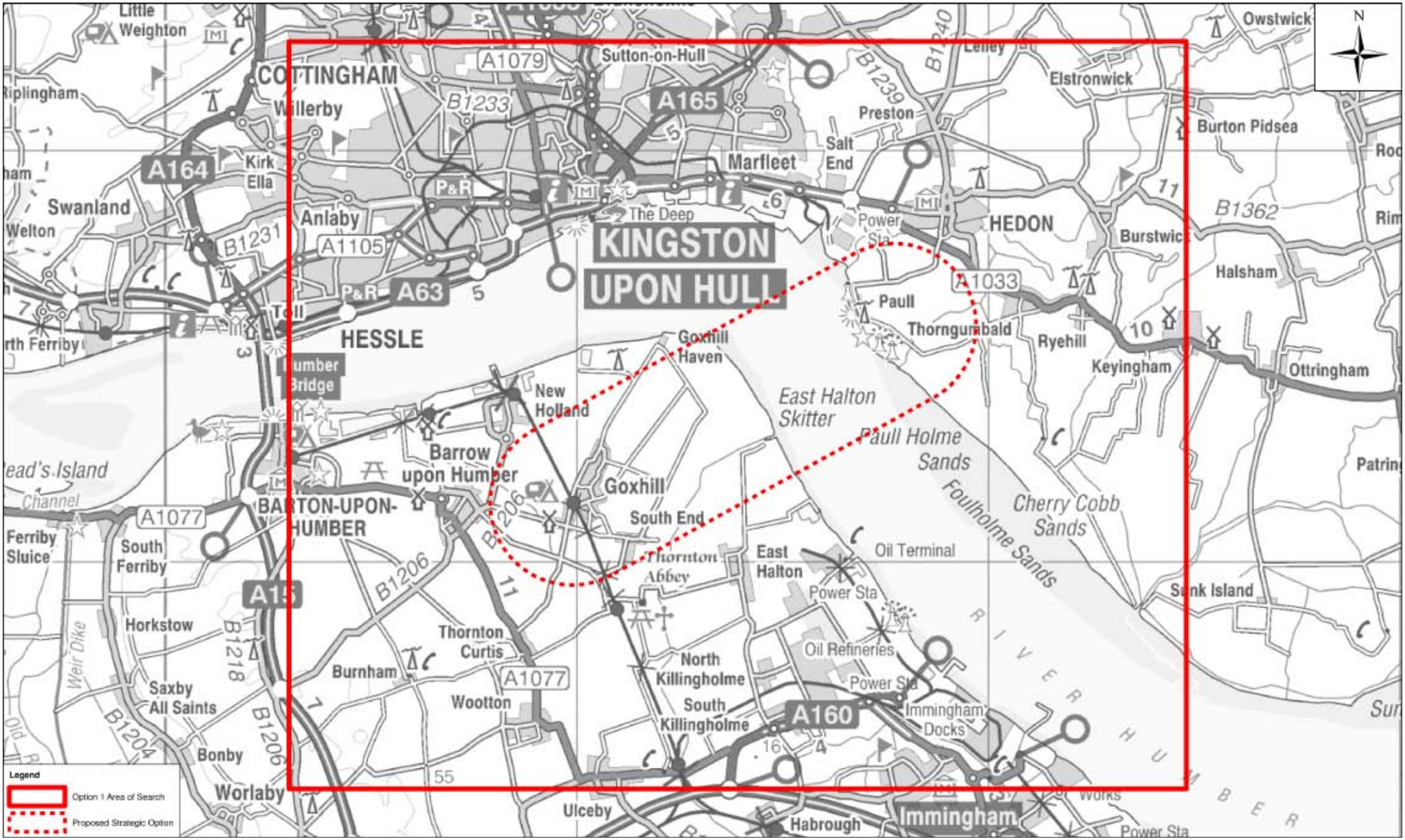
Compression

As gas is transported through a pipeline, it loses pressure due to friction. Compression is the process of increasing the pressure of the gas to enable it to be transported effectively. The pressure of gas within a pipeline is increased at compressor stations which usually occur between 40 and 100 mile intervals along a pipeline.

A compressor would be required to compress the gas prior to transportation along the pipeline. Compressor stations increase the pressure of gas within the pipeline using gas compression machinery i.e. a turbine, motor, or engine. Compressor stations usually contain some type of liquid separator. Usually, these separators consist of scrubbers and filters that capture any liquids or other unwanted particles from the natural gas in the pipeline.

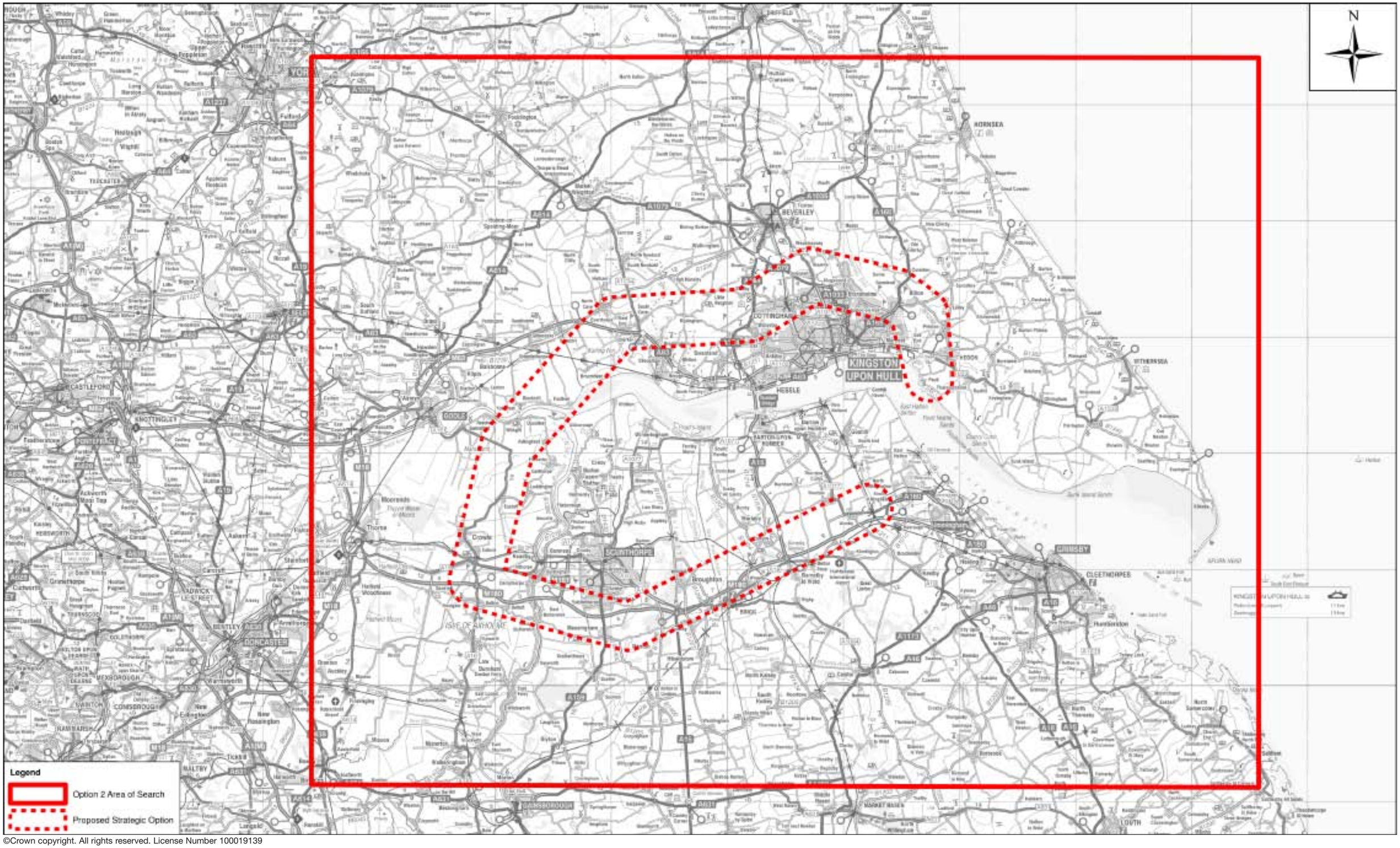
Option 1 (incorporating Options 1a, b & c) Potential Strategic Option

Appendix 2, Option 1, Scale 1:85,000



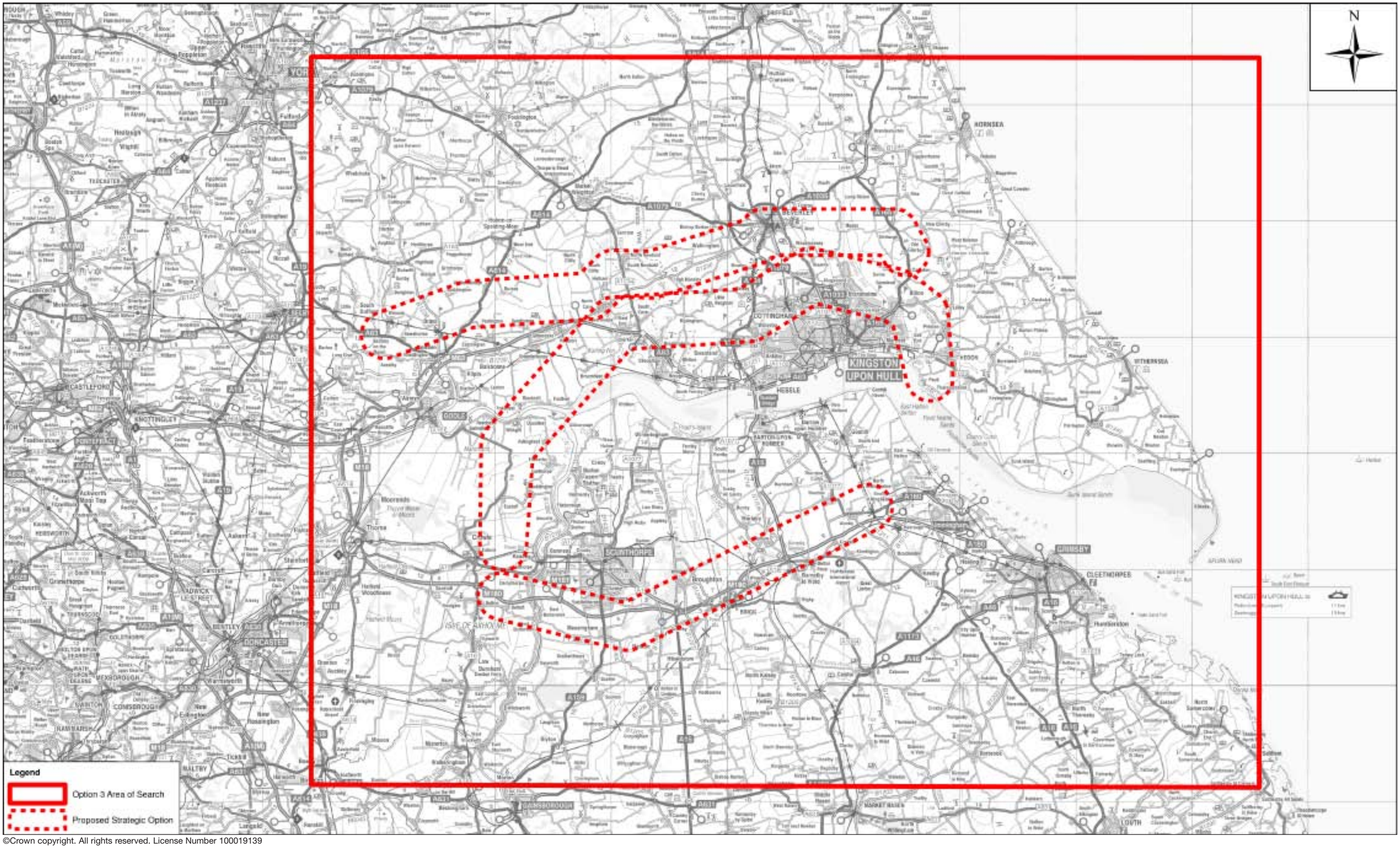
Option 2 Potential Strategic Option

Appendix 2, Option 2, Scale 1:300,000



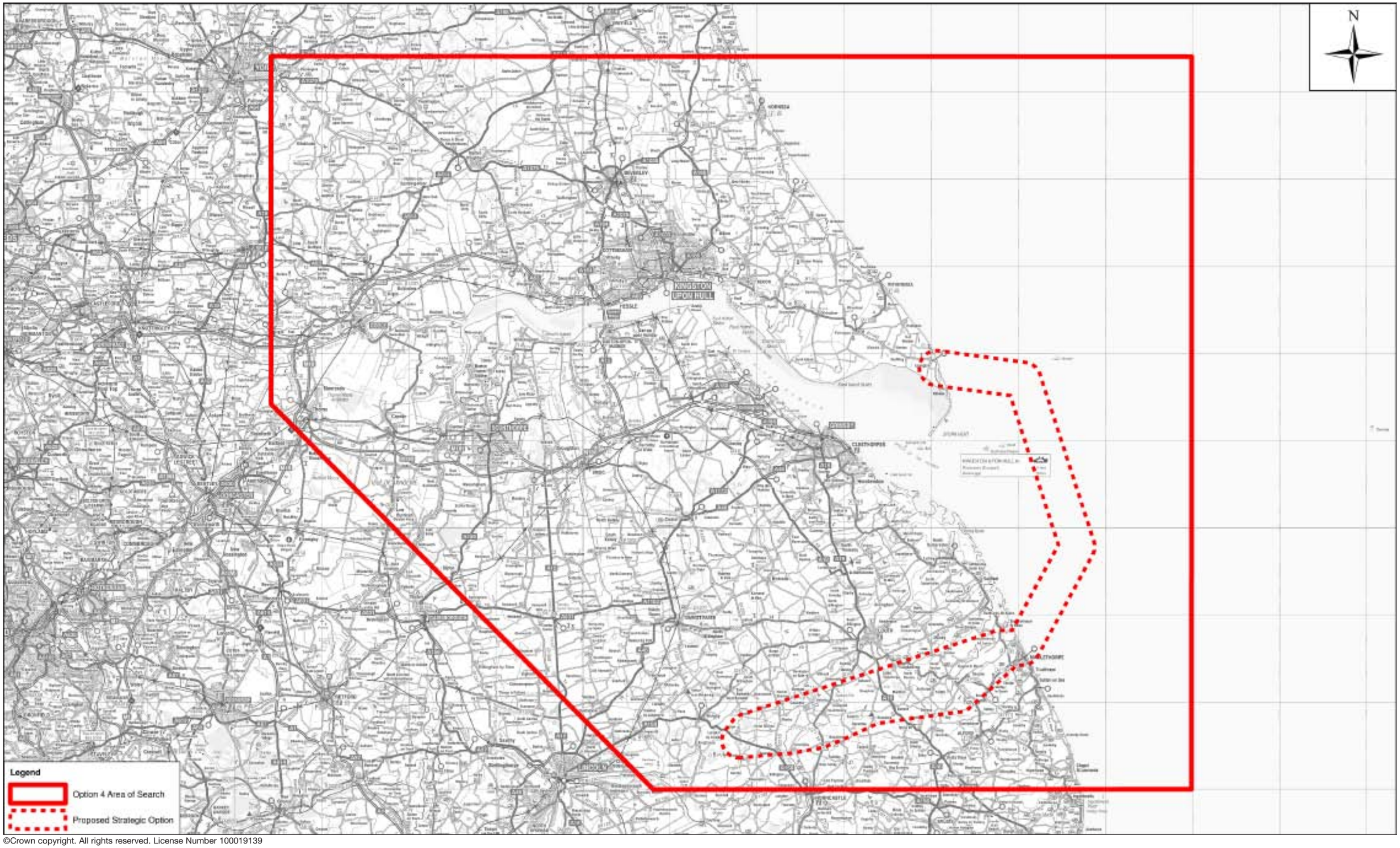
Option 3 Potential Strategic Option

Appendix 2, Option 3, Scale 1:300,000



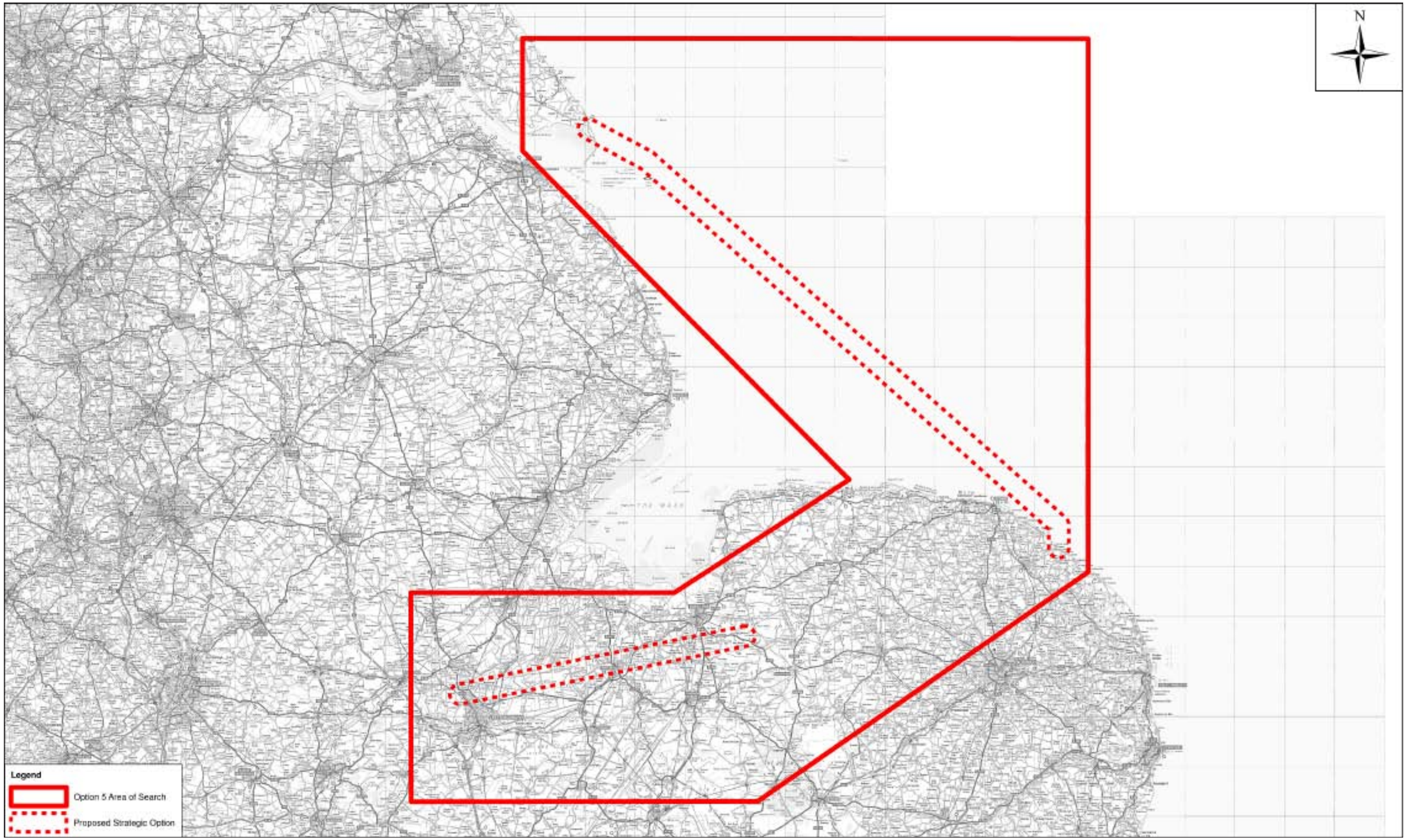
Option 4 Potential Strategic Option

Appendix 2, Option 4, Scale 1:400,000



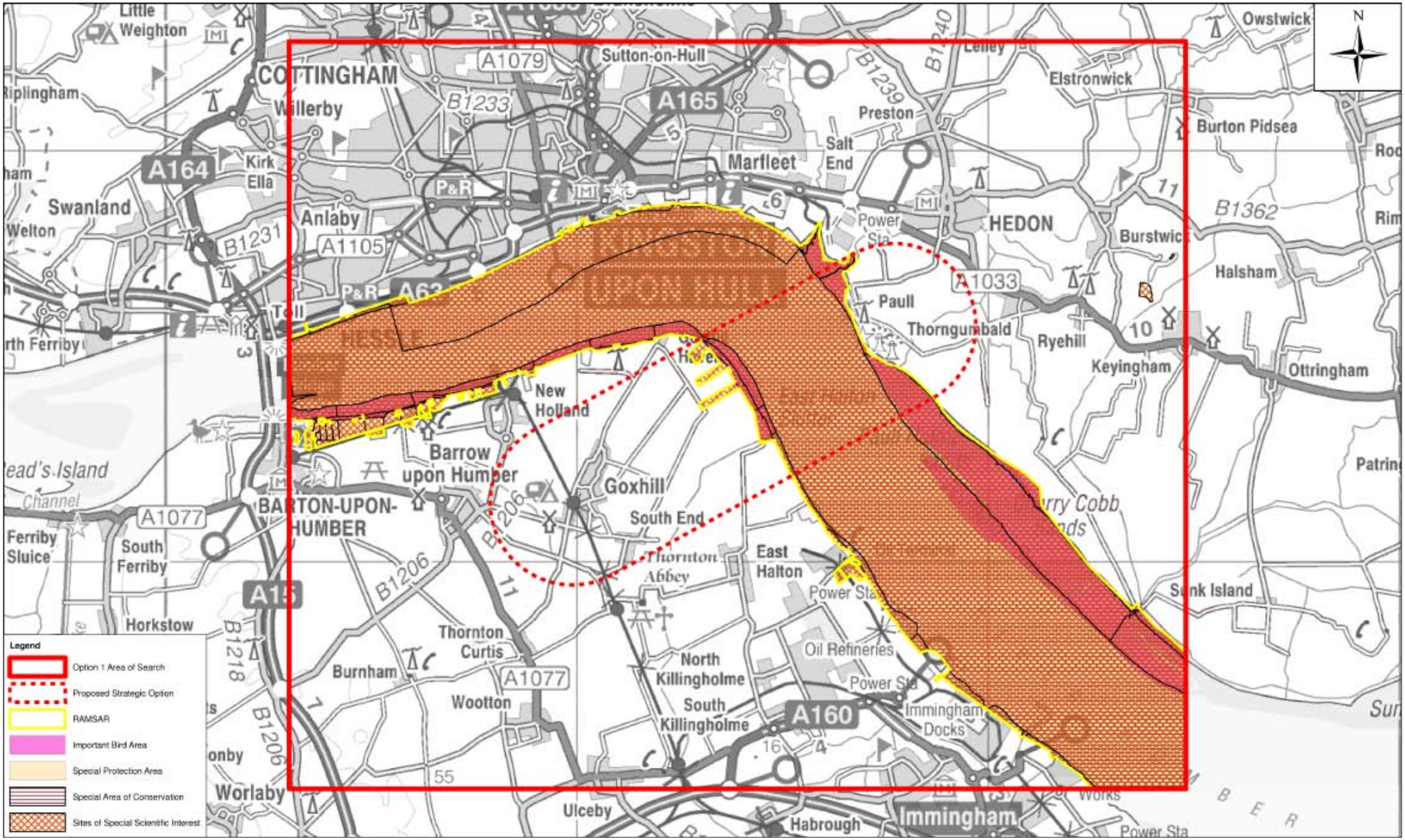
Option 5 Potential Strategic Option

Appendix 2, Option 5, Scale 1:700,000



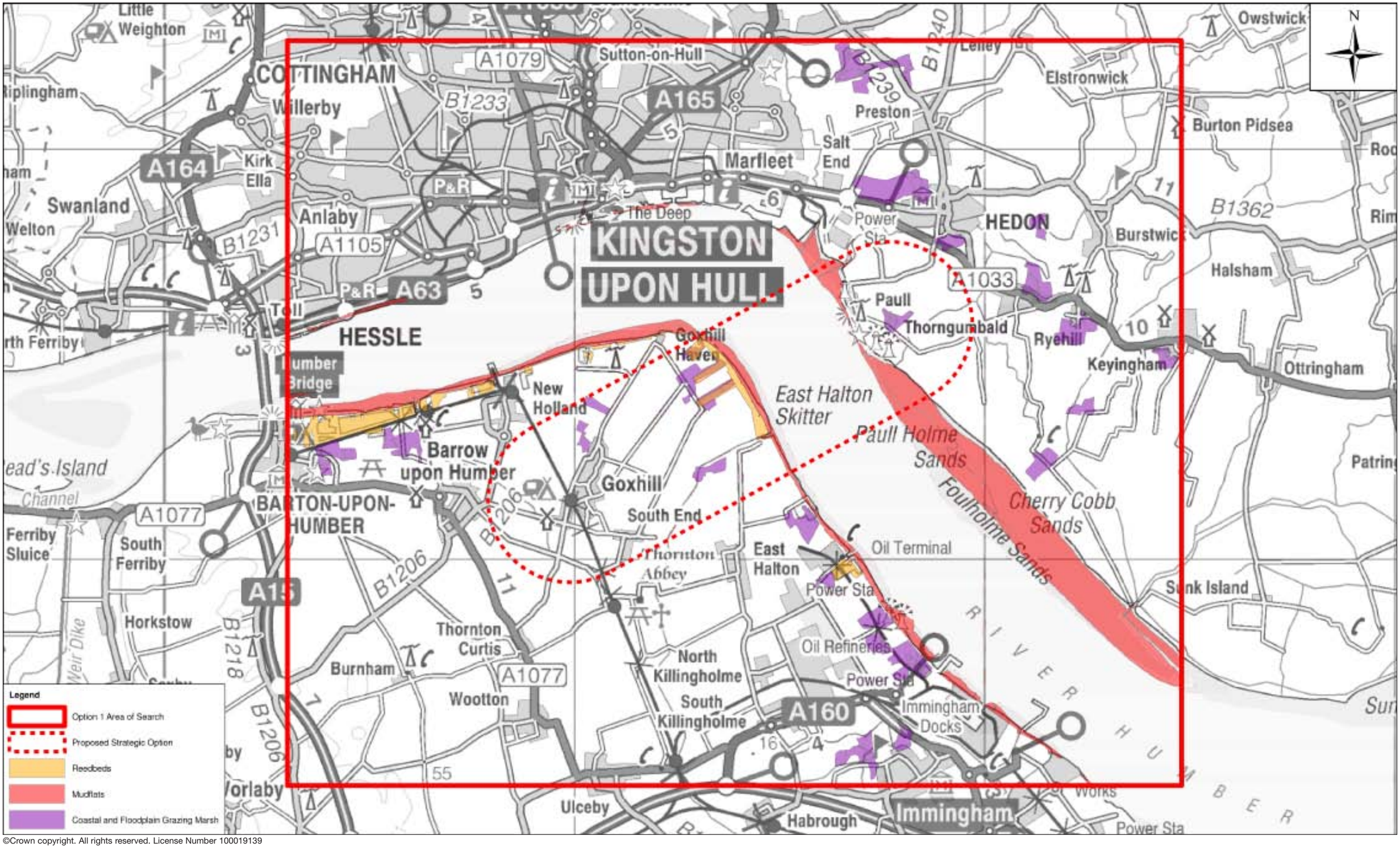
Option 1 (incorporating Options 1a, b & c) Nature Conservation Designations and Features

Appendix 3, Option 1 / Figure 1a, Scale 1:85,000



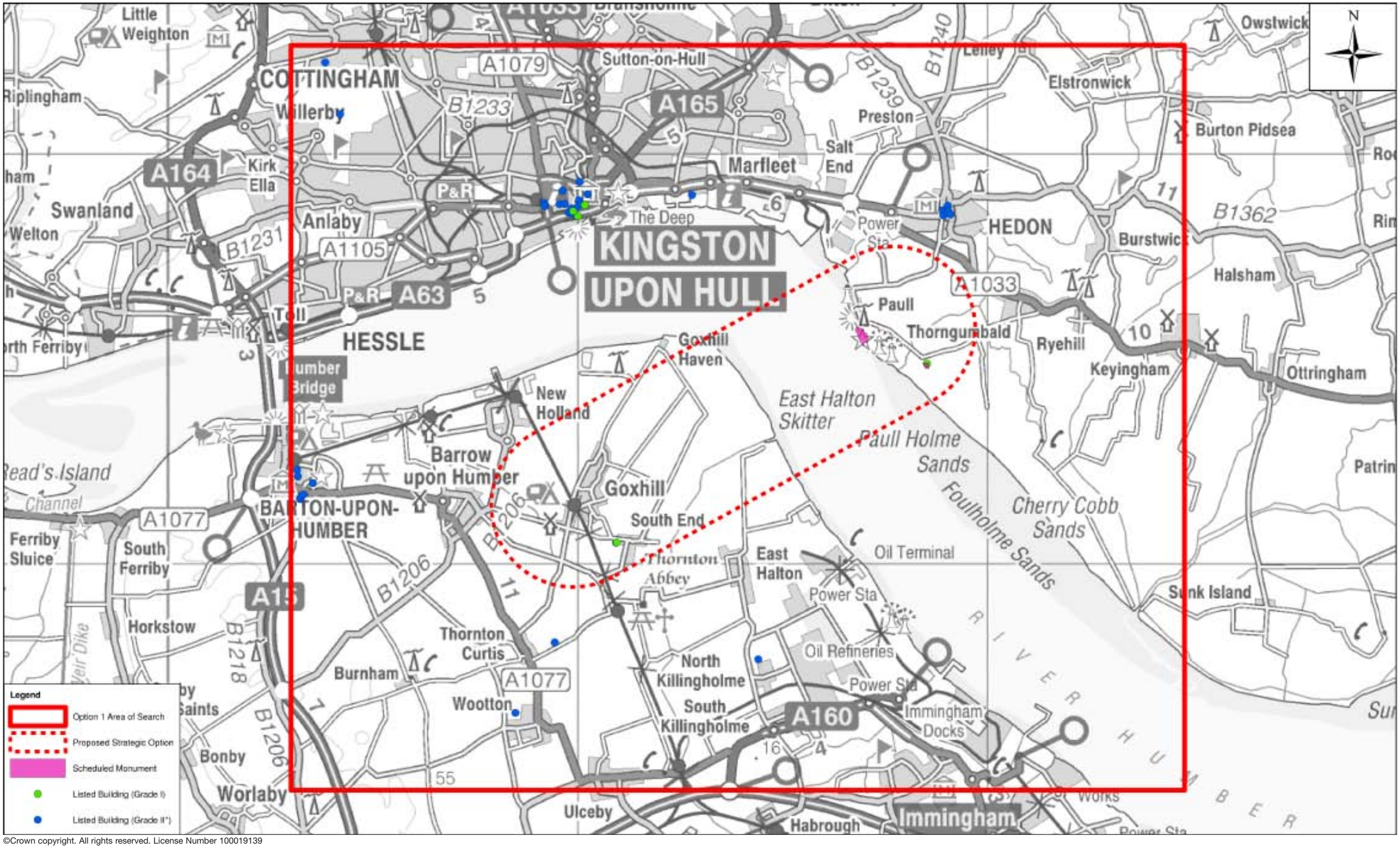
Option 1 (incorporating Options 1a, b & c) UK Bap Priority Habitat

Appendix 3, Option 1 / Figure 1b, Scale 1:85,000



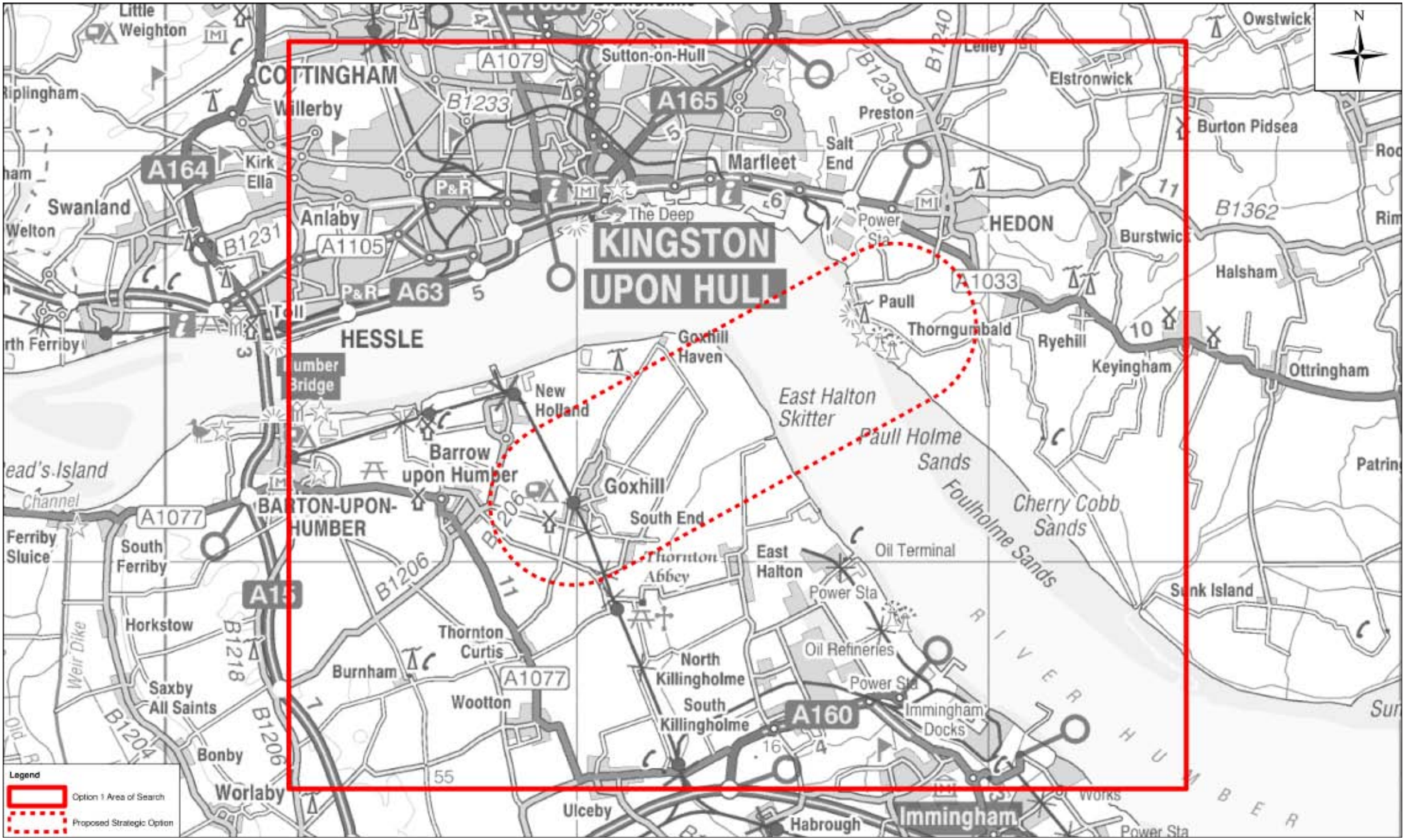
Option 1 (incorporating Options 1a, b & c) Cultural Heritage Designations

Appendix 3, Option 1 / Figure 2, Scale 1:85,000



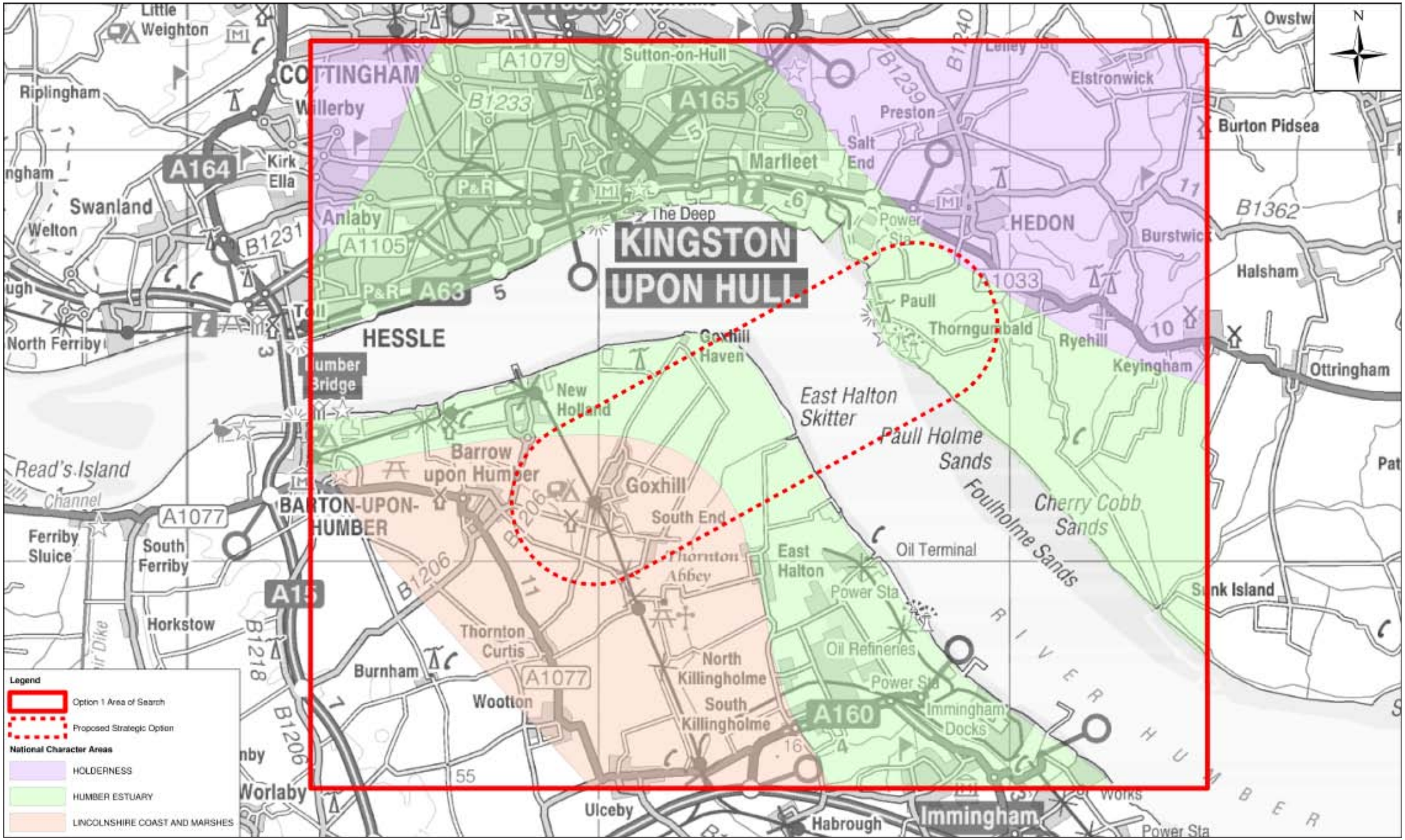
Option 1 (incorporating Options 1a, b & c) Landscape Designations and Features (no landscape designations within this area)

Appendix 3, Option 1 / Figure 3a, Scale 1:85,000



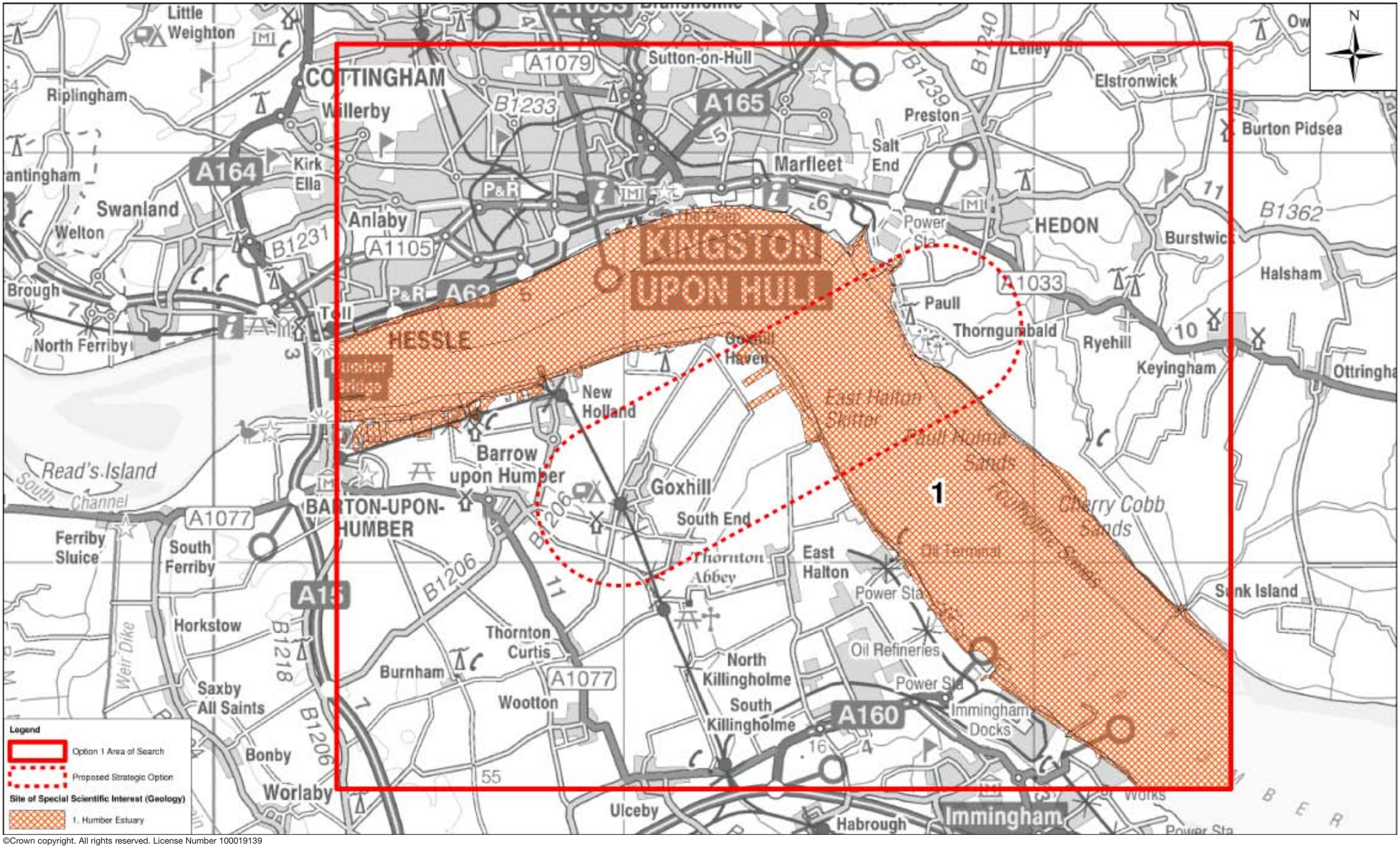
Option 1 (incorporating Options 1a, b & c) National Character Areas

Appendix 3, Option 1 / Figure 3b, Scale 1:85,000



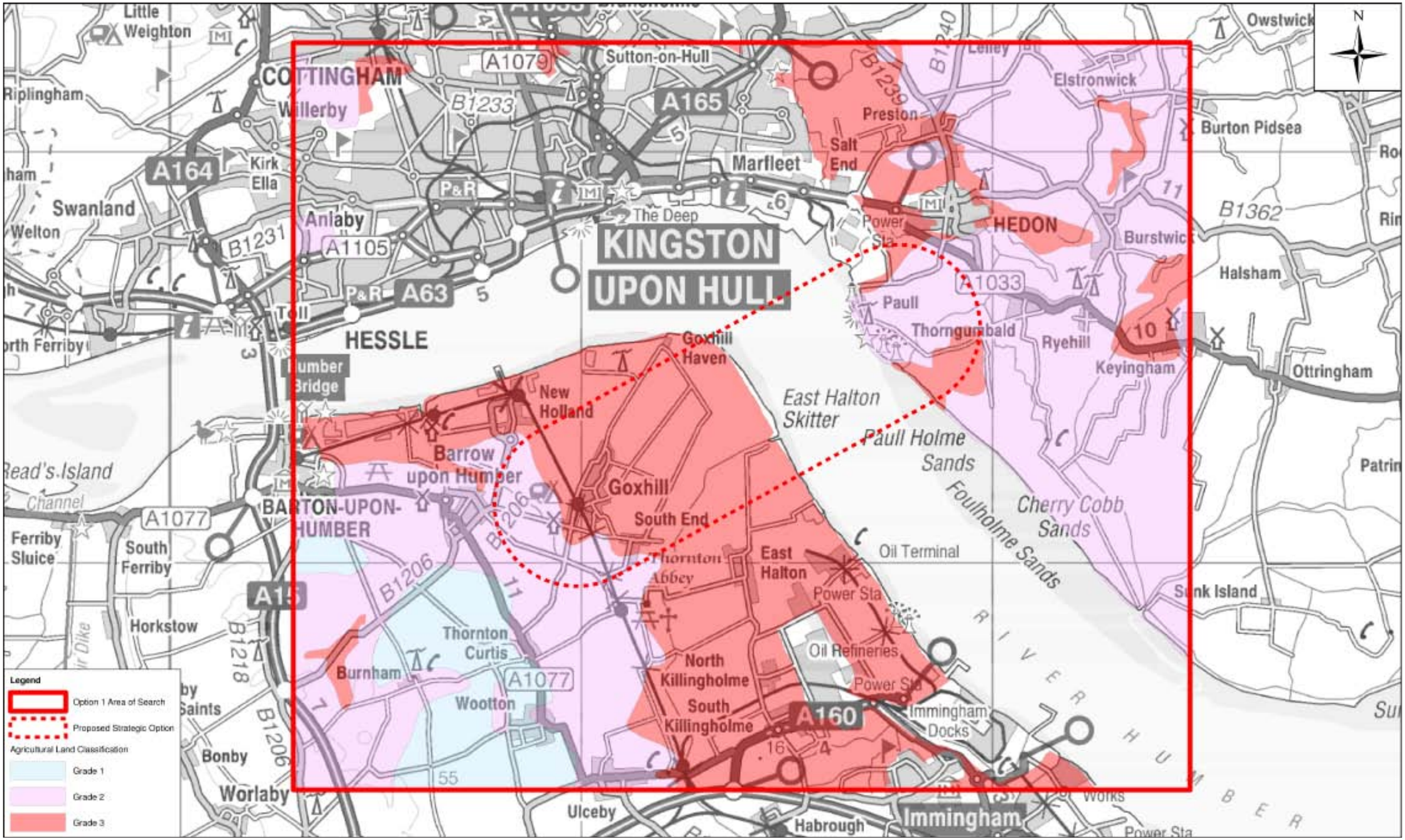
Option 1 (incorporating Options 1a, b & c) Geological Designations

Appendix 3, Option 1 / Figure 4a, Scale 1:85,000



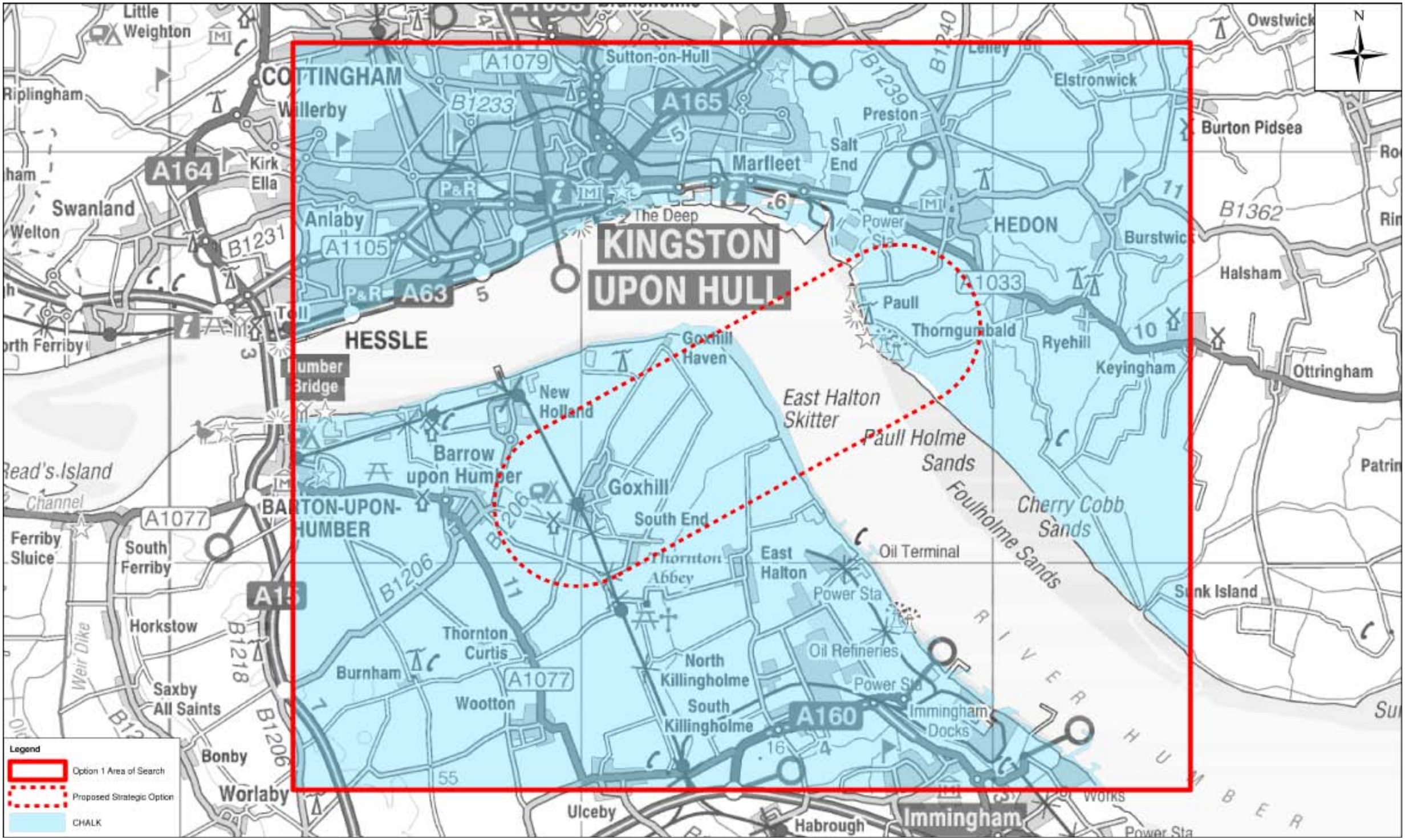
Option 1 (incorporating Options 1a, b & c) Agricultural Land Classification

Appendix 3, Option 1 / Figure 4b, Scale 1:85,000



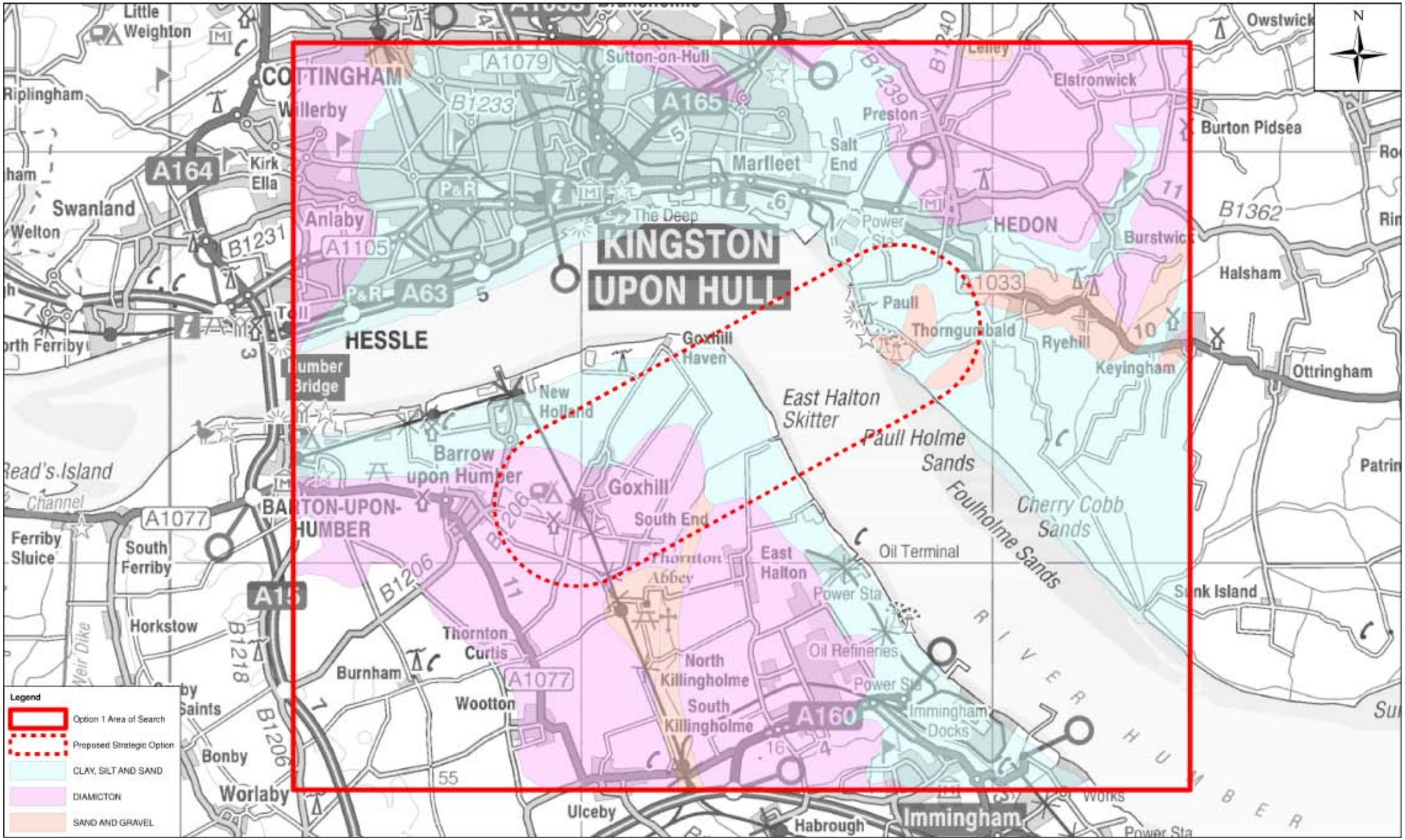
Option 1 (incorporating Options 1a, b & c) Bedrock Geology

Appendix 3, Option 1 / Figure 4c, Scale 1:85,000



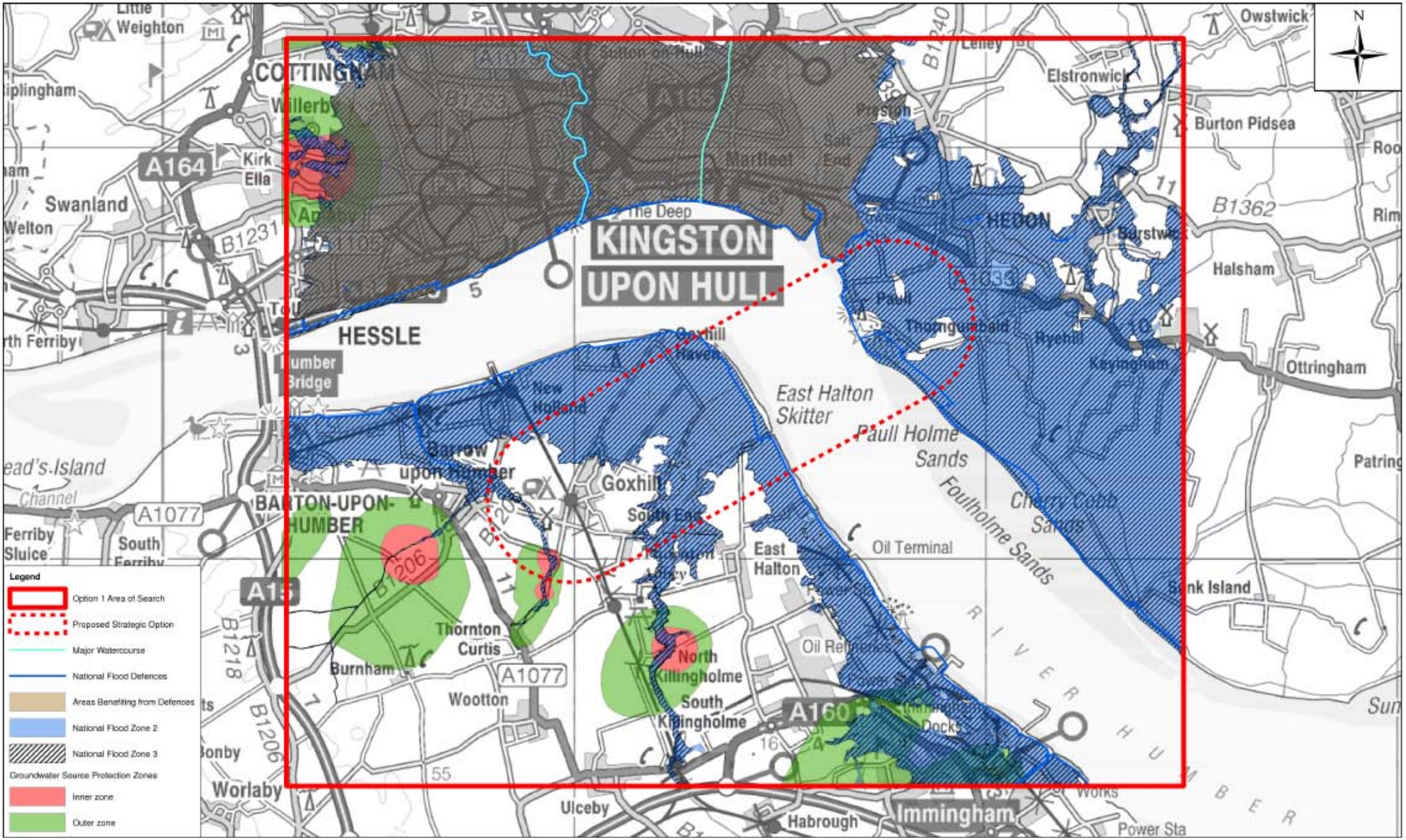
Option 1 (incorporating Options 1a, b & c) Superficial Geology

Appendix 3, Option 1 / Figure 4d, Scale 1:85,000



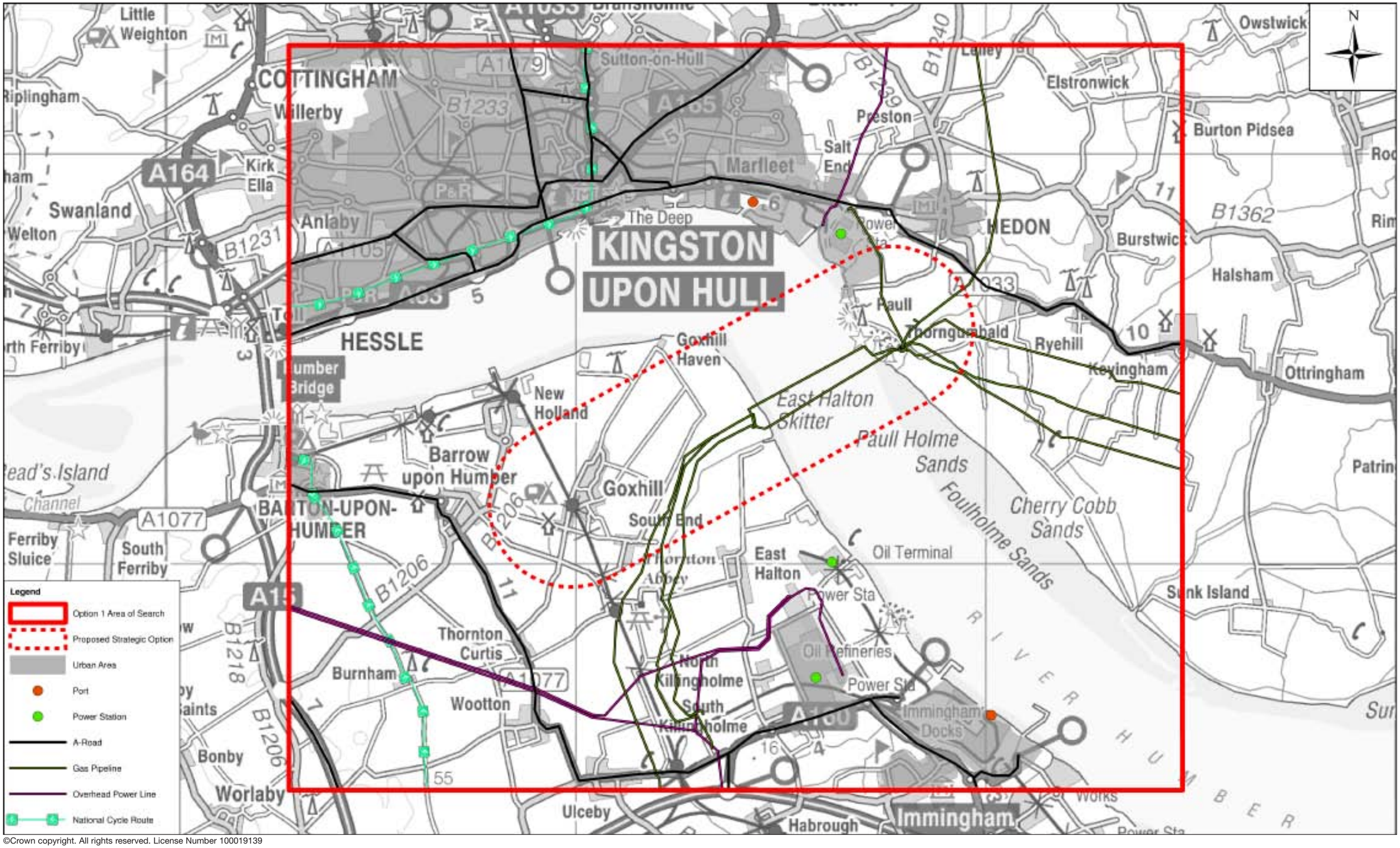
Option 1 (incorporating Options 1a, b & c) Water Resources and Flooding

Appendix 3, Option 1 / Figure 5, Scale 1:85,000



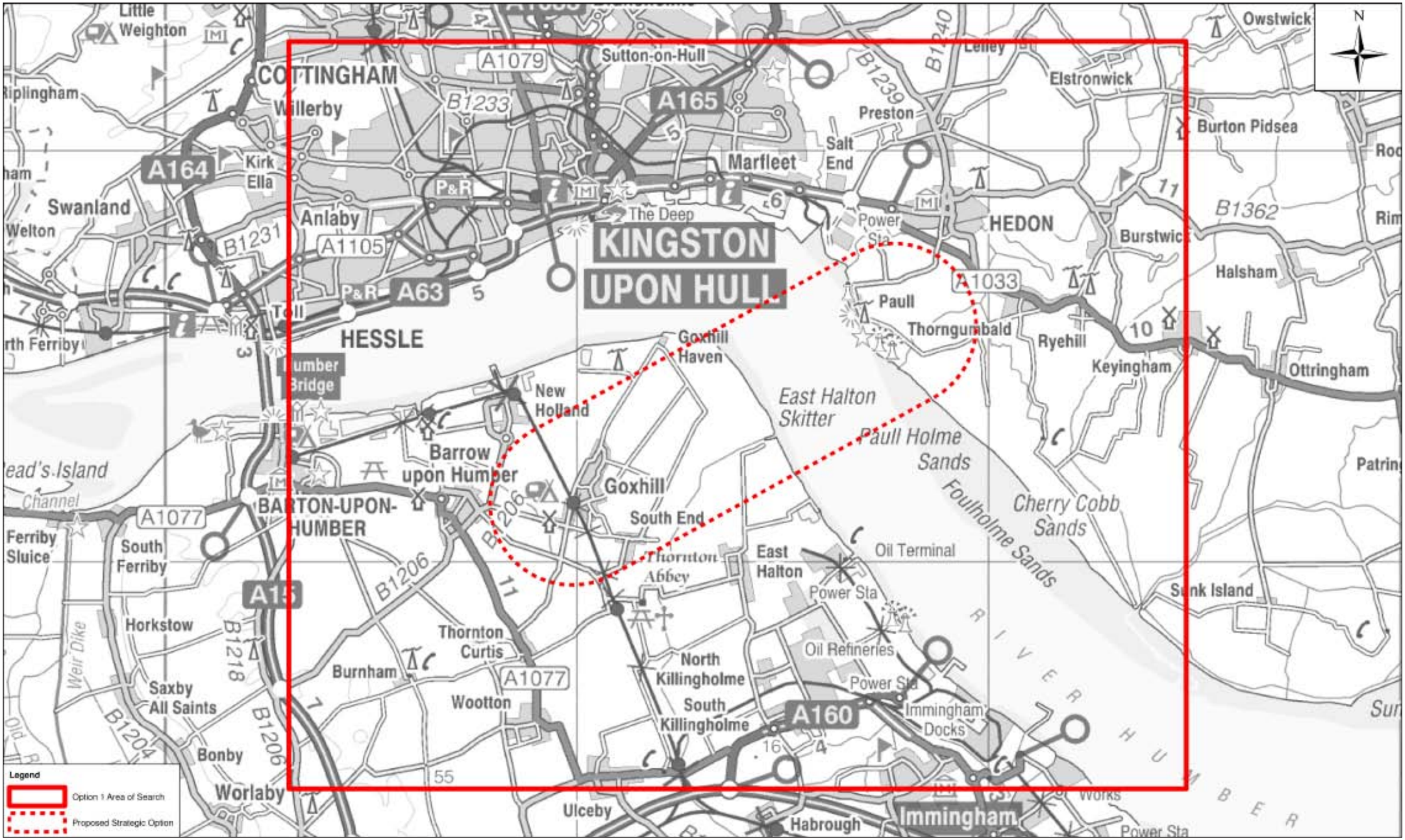
Option 1 (incorporating Options 1a, b & c) Socio-Economic Features

Appendix 3, Option 1 / Figure 6, Scale 1:85,000



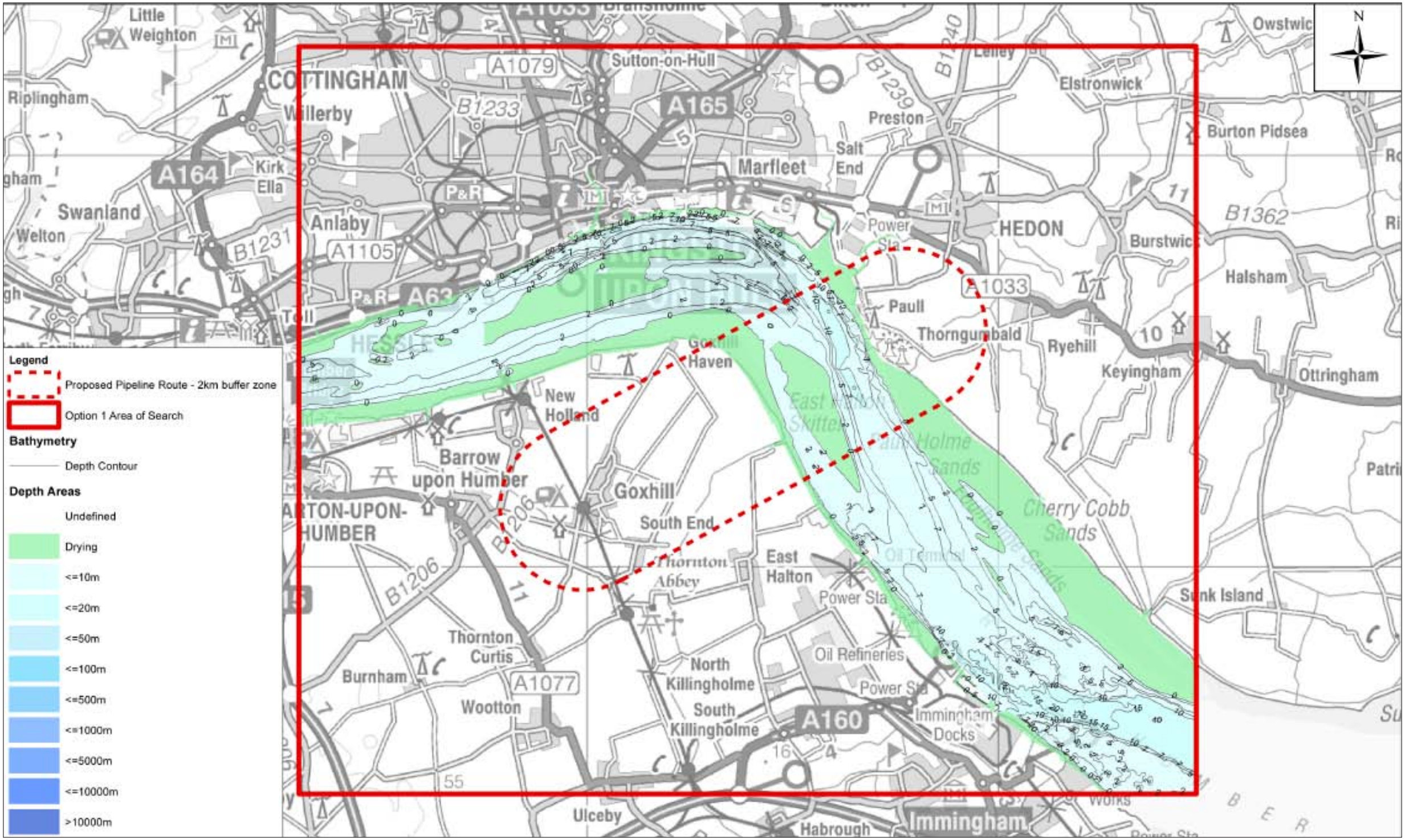
Option 1 (incorporating Options 1a, b & c) Marine Nature Conservation Designations (no marine designations within this area)

Appendix 3, Option 1 / Figure 7, Scale 1:85,000



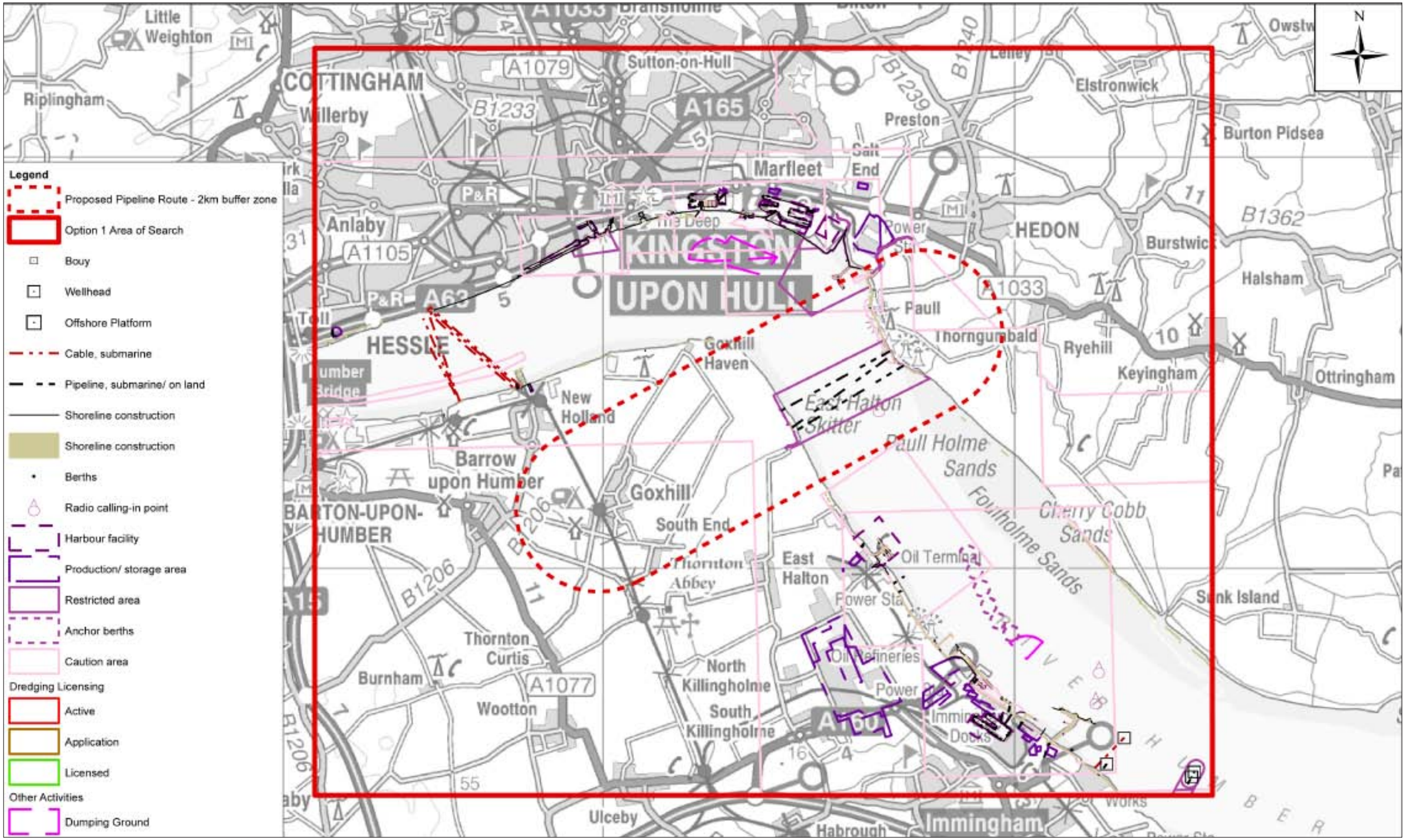
Option 1 Bathymetry and Depth Areas

Appendix 3, Option 1 / Figure 8, Scale 1:85,000



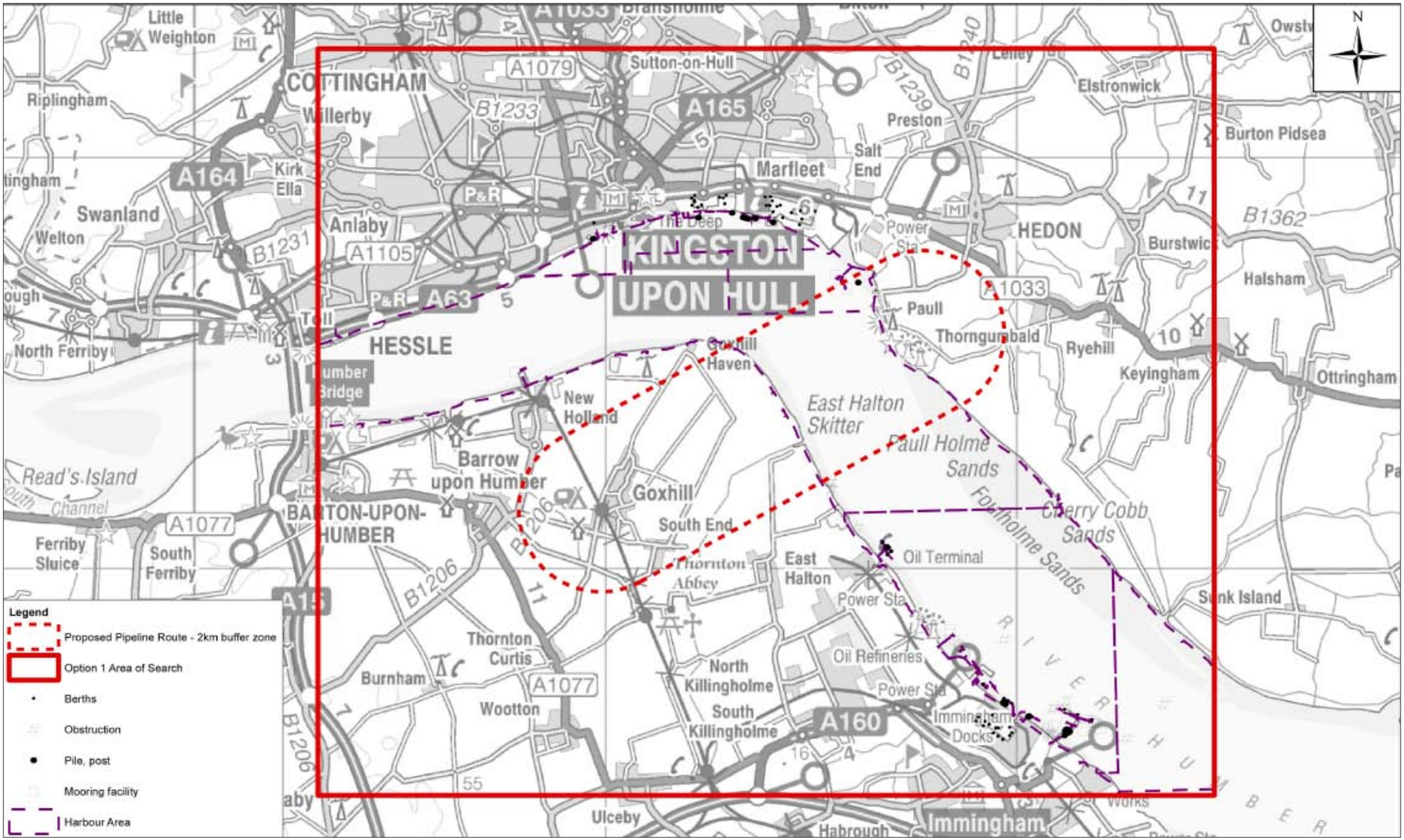
Option 1 Marine Infrastructure and Other Marine Constraints

Appendix 3, Option 1 / Figure 9, Scale 1:85,000



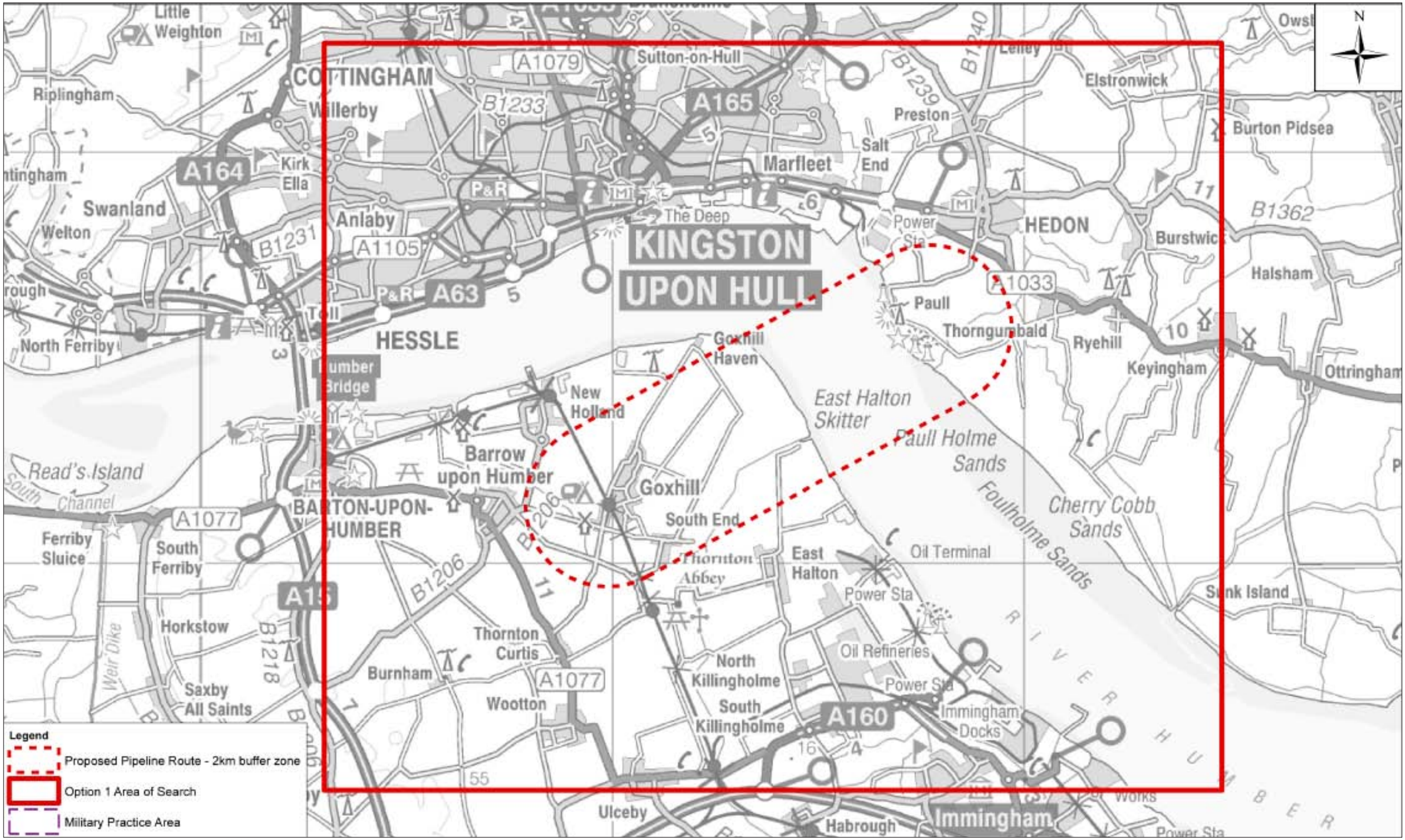
Option 1 Navigation and Shipping Constraints

Appendix 3, Option 1 / Figure 10, Scale 1:85,000



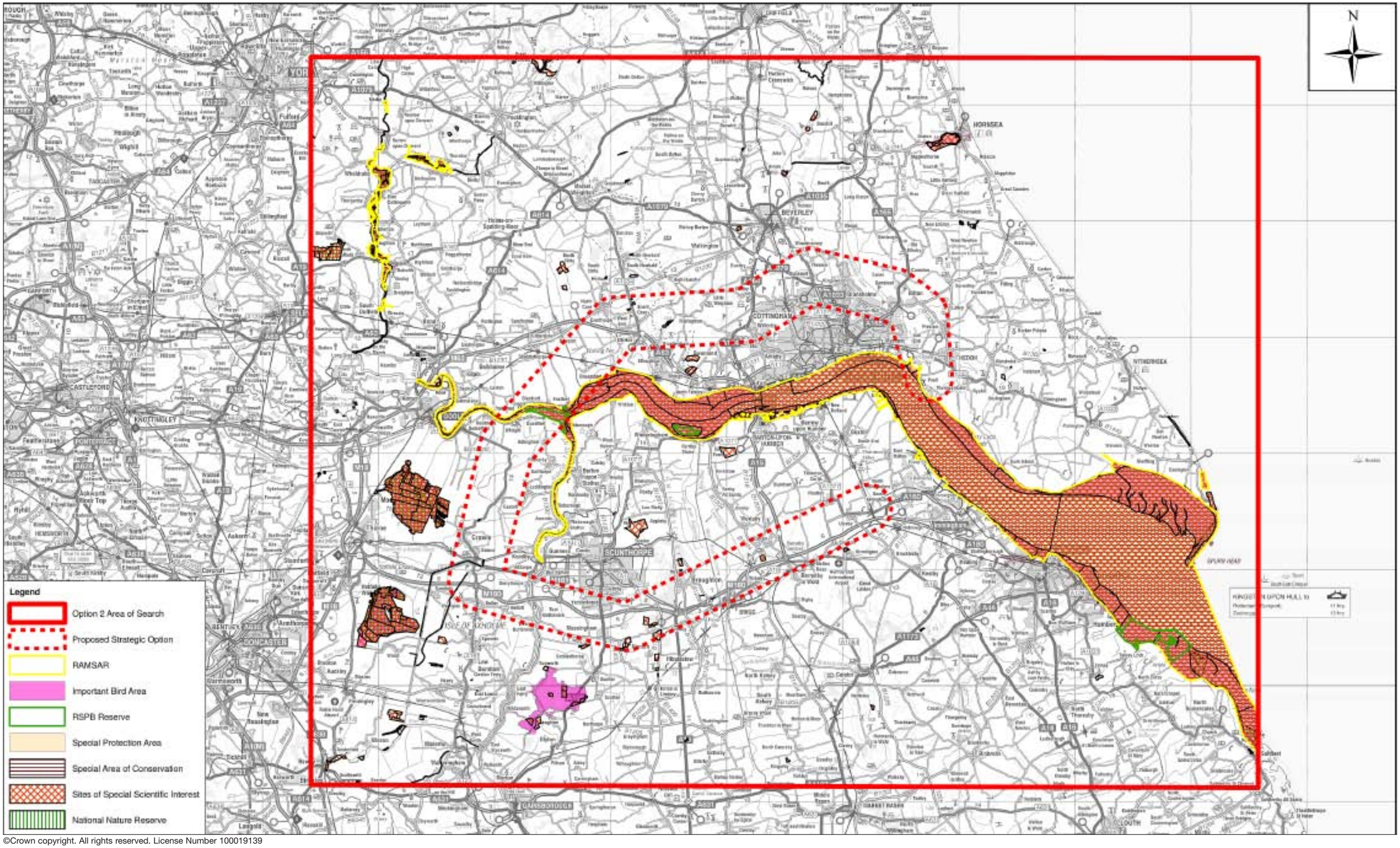
Option 1 MoD Marine Constraints (no MoD marine constraints within this area)

Appendix 3, Option 1 / Figure 11, Scale 1:85,000



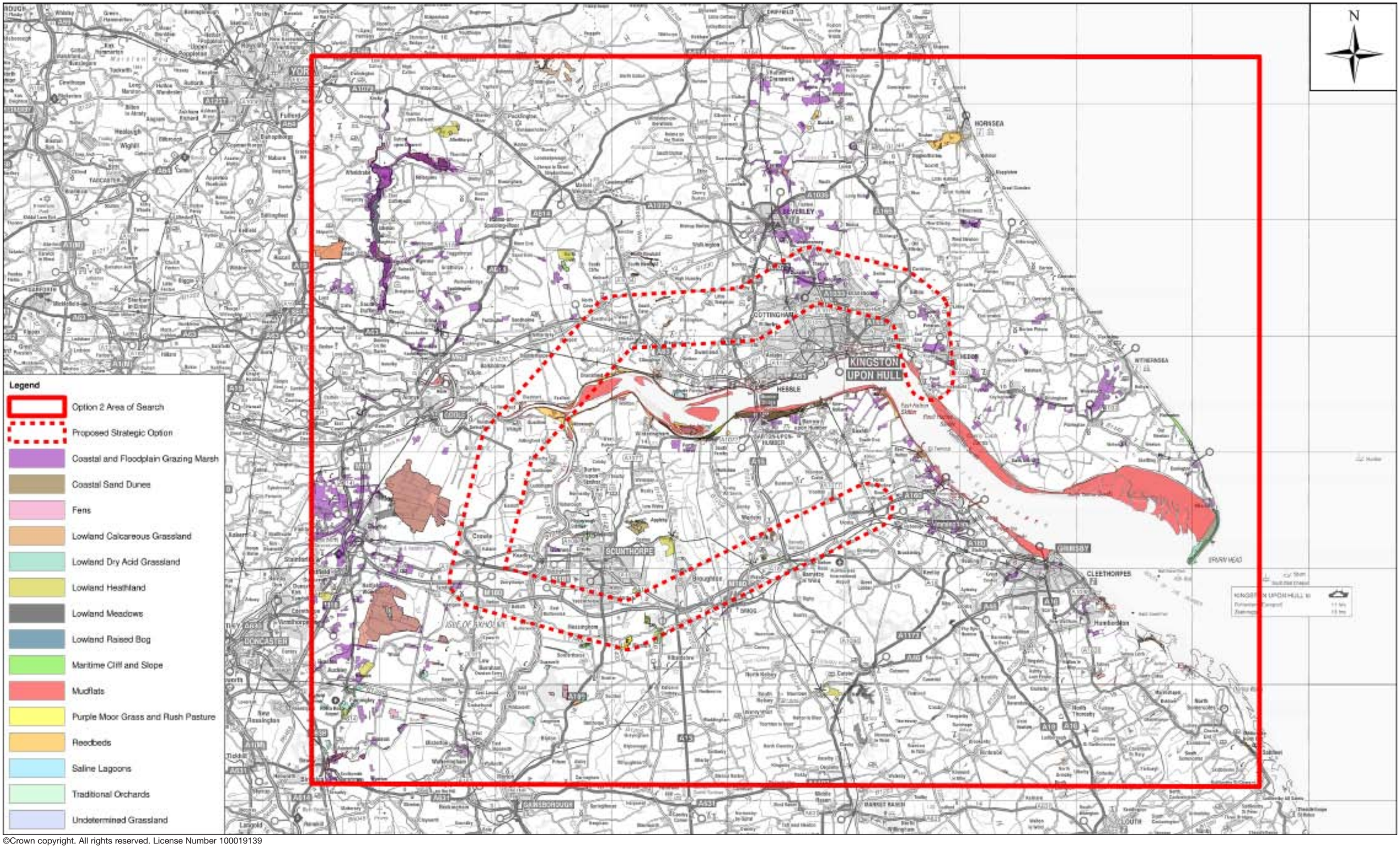
Option 2 Nature Conservation Designations and Features

Appendix 3, Option 2 / Figure 1A, Scale 1:300,000



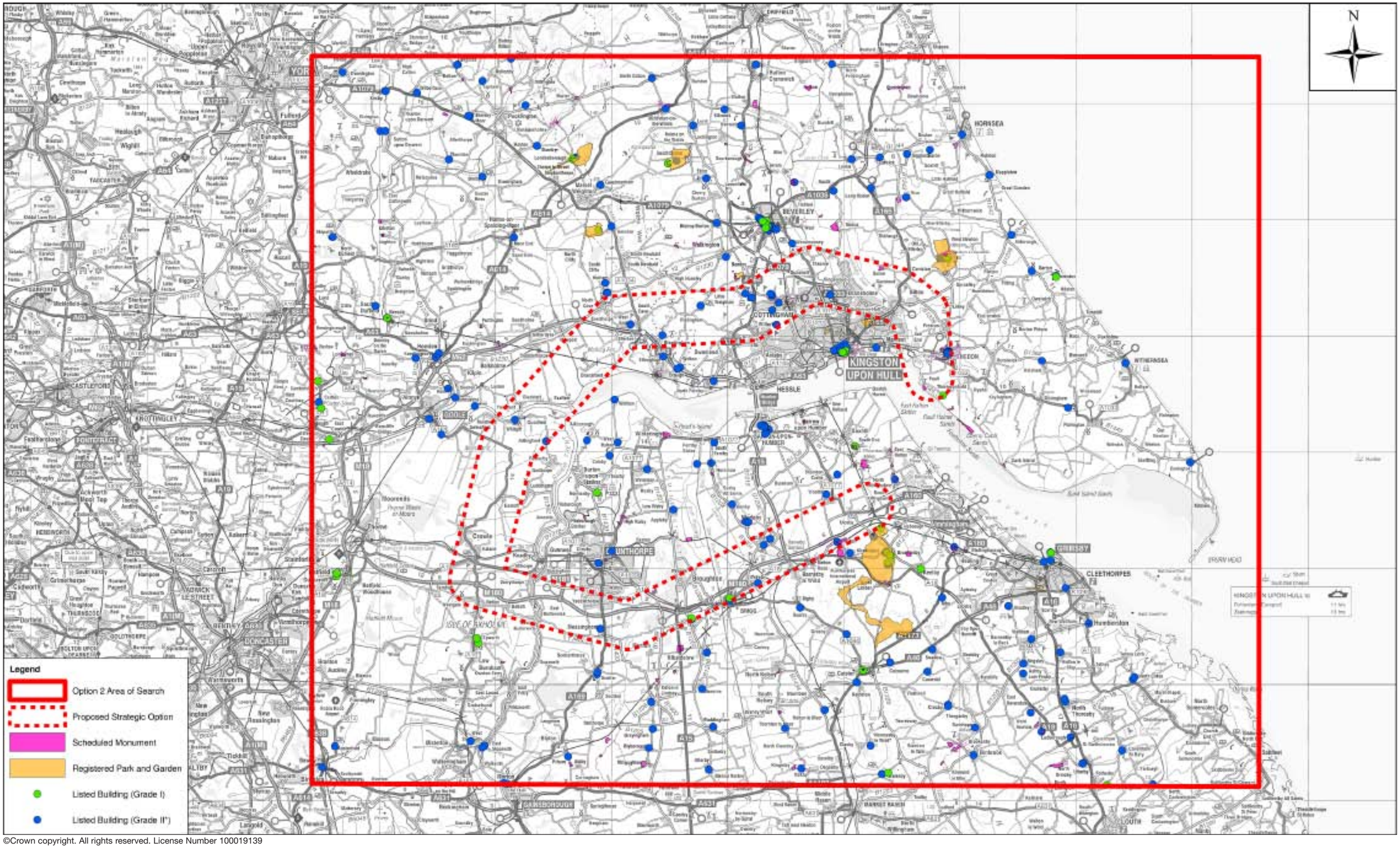
Option 2 UK Bap Priority Habitat

Appendix 3, Option 2 / Figure 1B, Scale 1:300,000



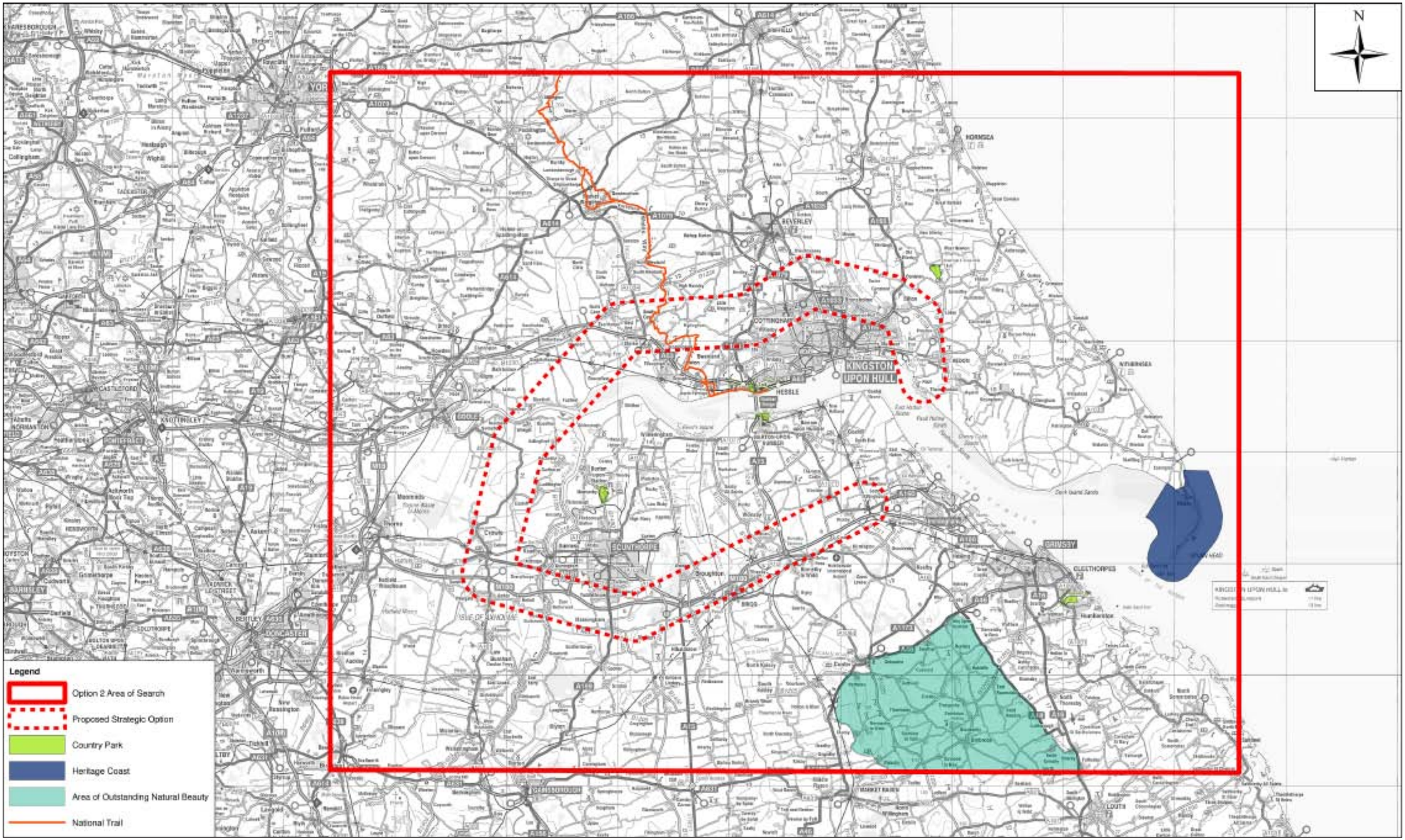
Option 2 Cultural Heritage Designations

Appendix 3, Option 2 / Figure 2, Scale 1:300,000



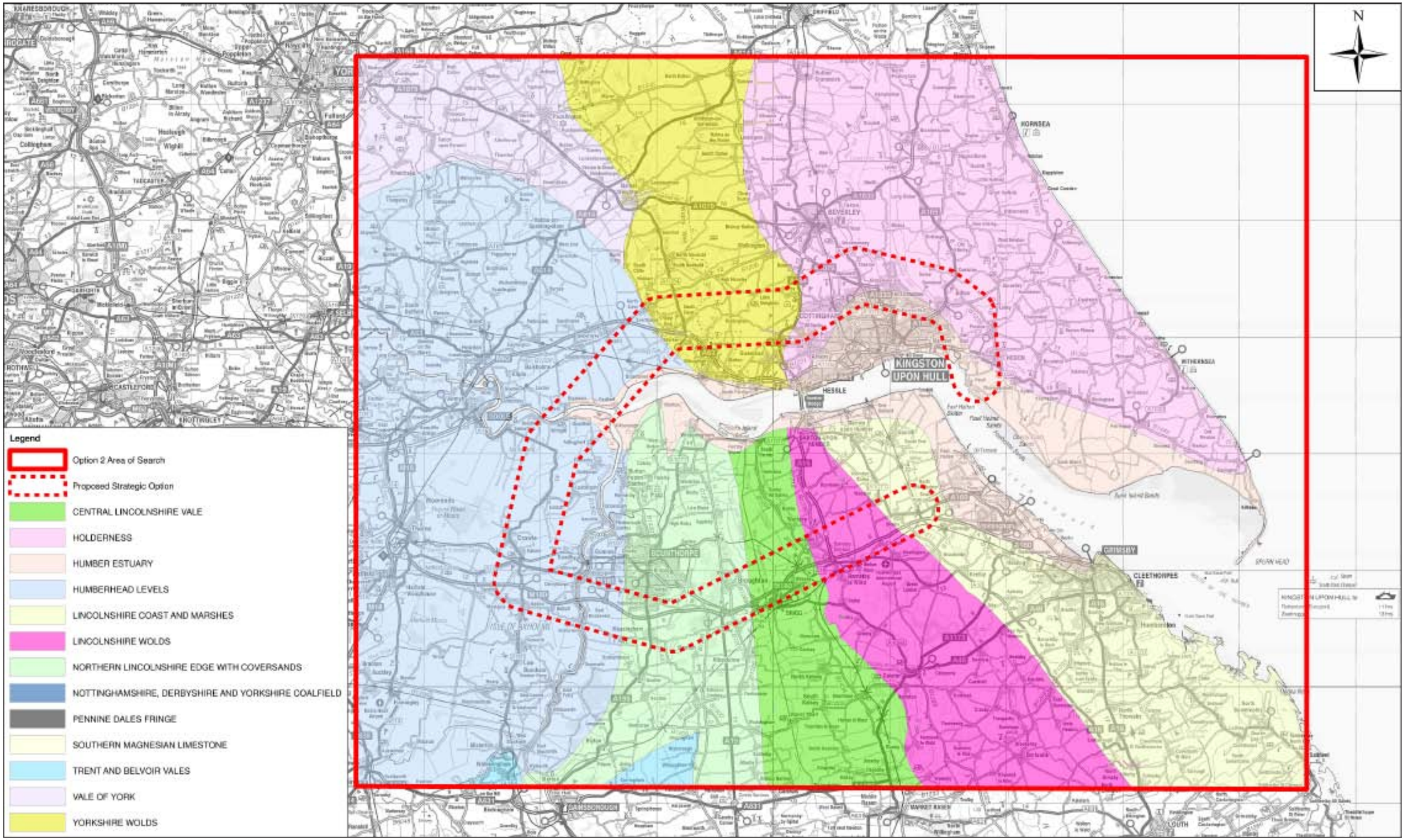
Option 2 Landscape Designations and Features

Appendix 3, Option 2 / Figure 3A, Scale 1:300,000



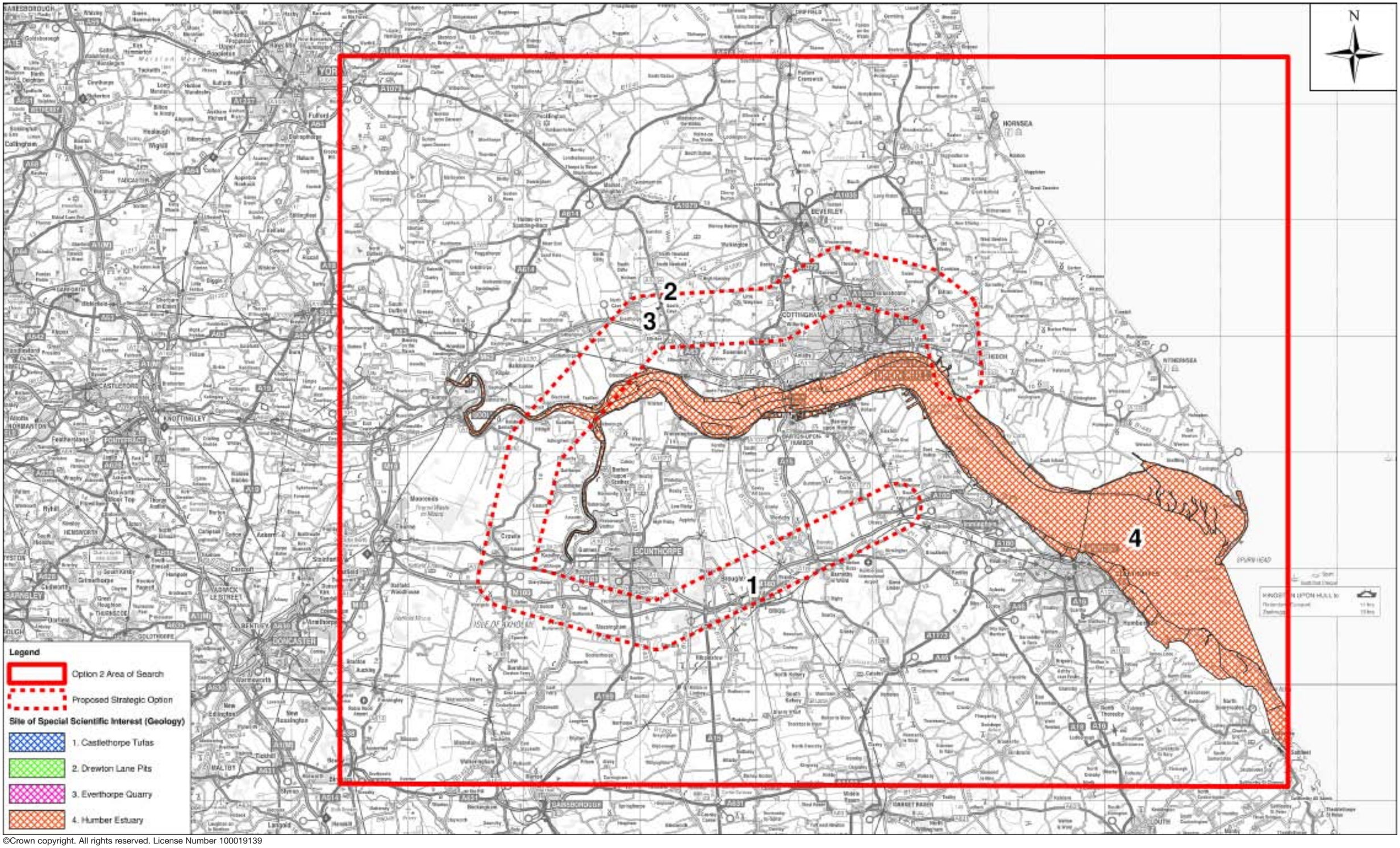
Option 2 National Character Areas

Appendix 3, Option 2 / Figure 3B, Scale 1:300,000



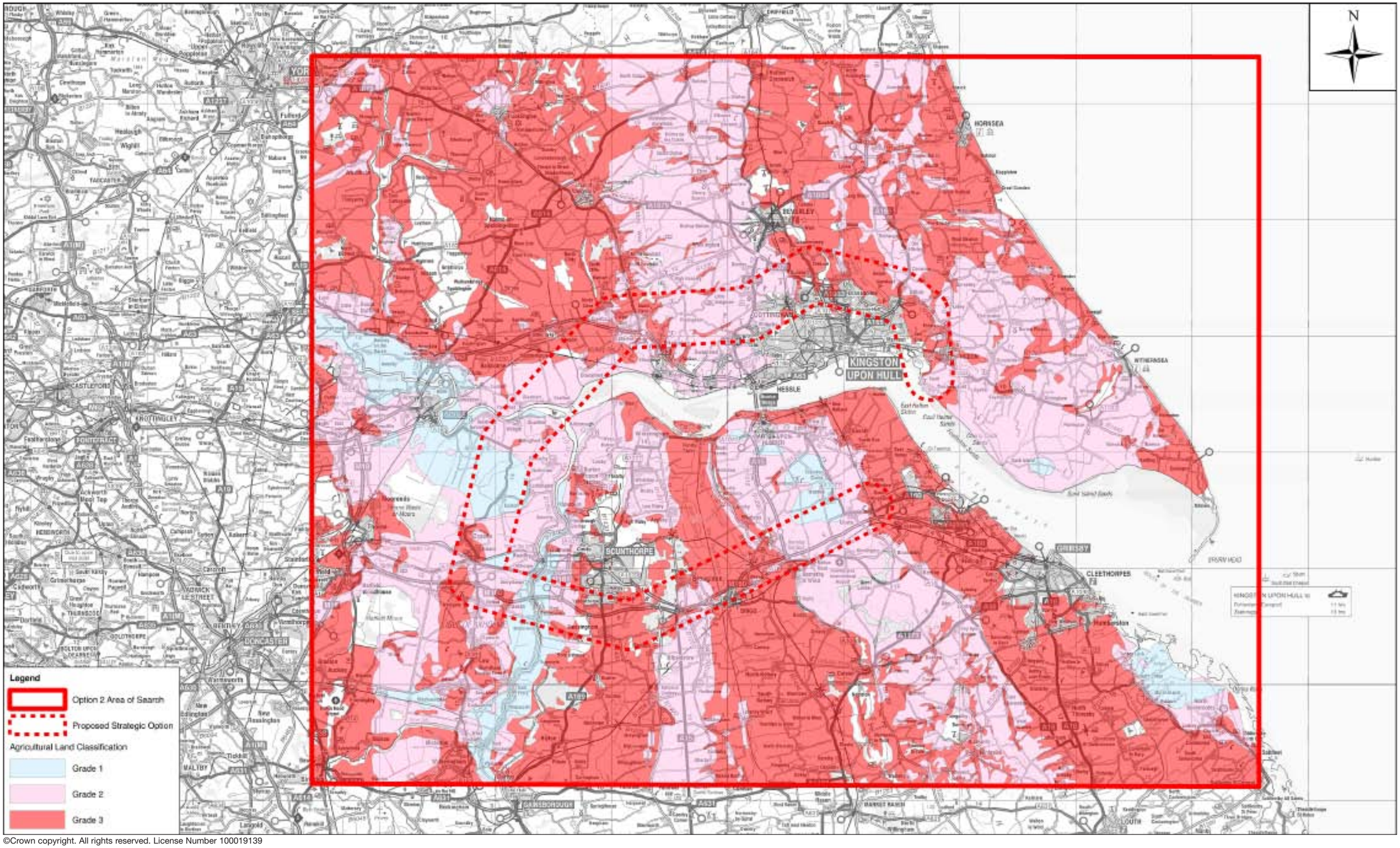
Option 2 Geological Designations

Appendix 3, Option 2 / Figure 4a, Scale 1:300,000



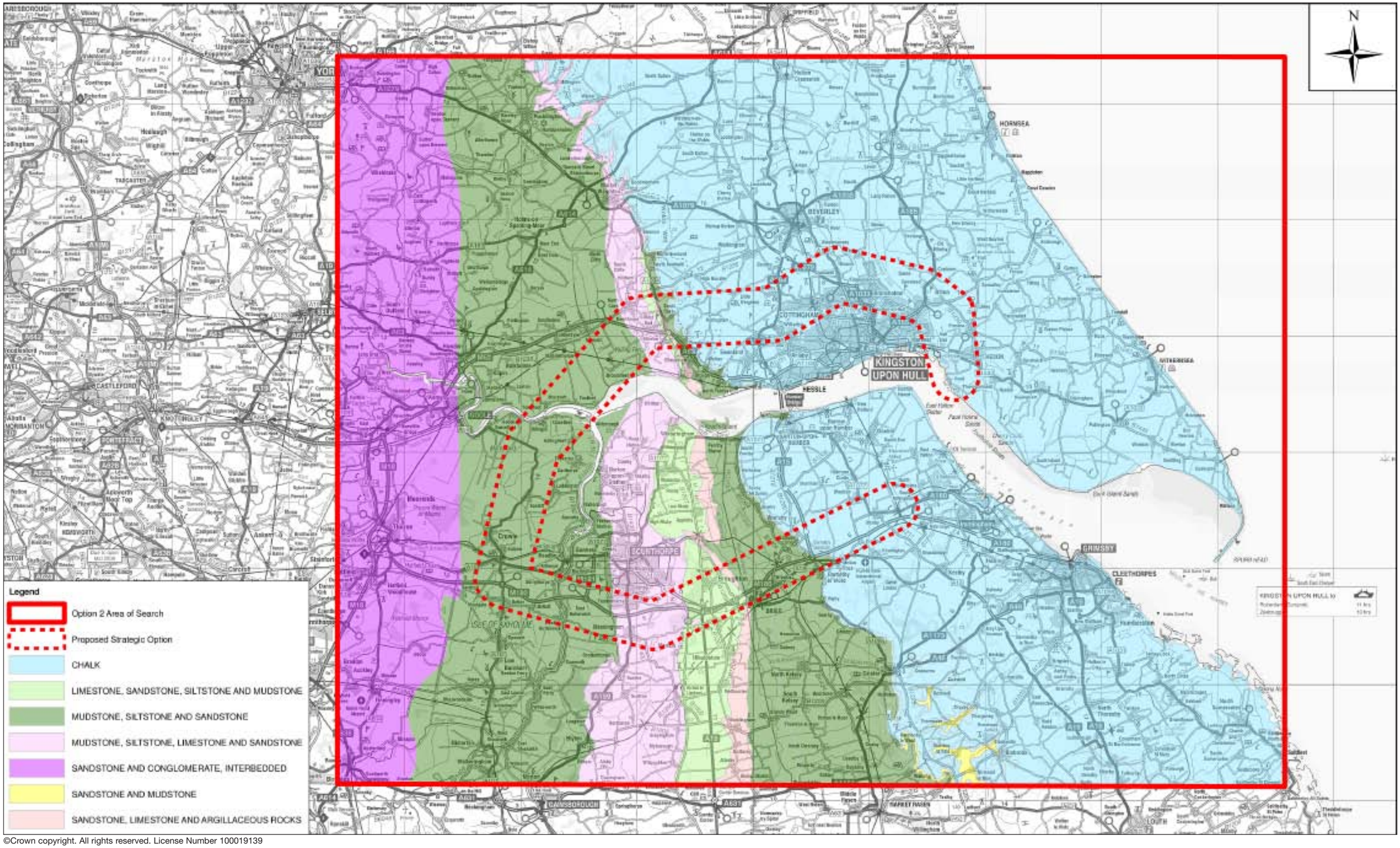
Option 2 Agricultural Land Classification

Appendix 3, Option 2 / Figure 4b, Scale 1:300,000



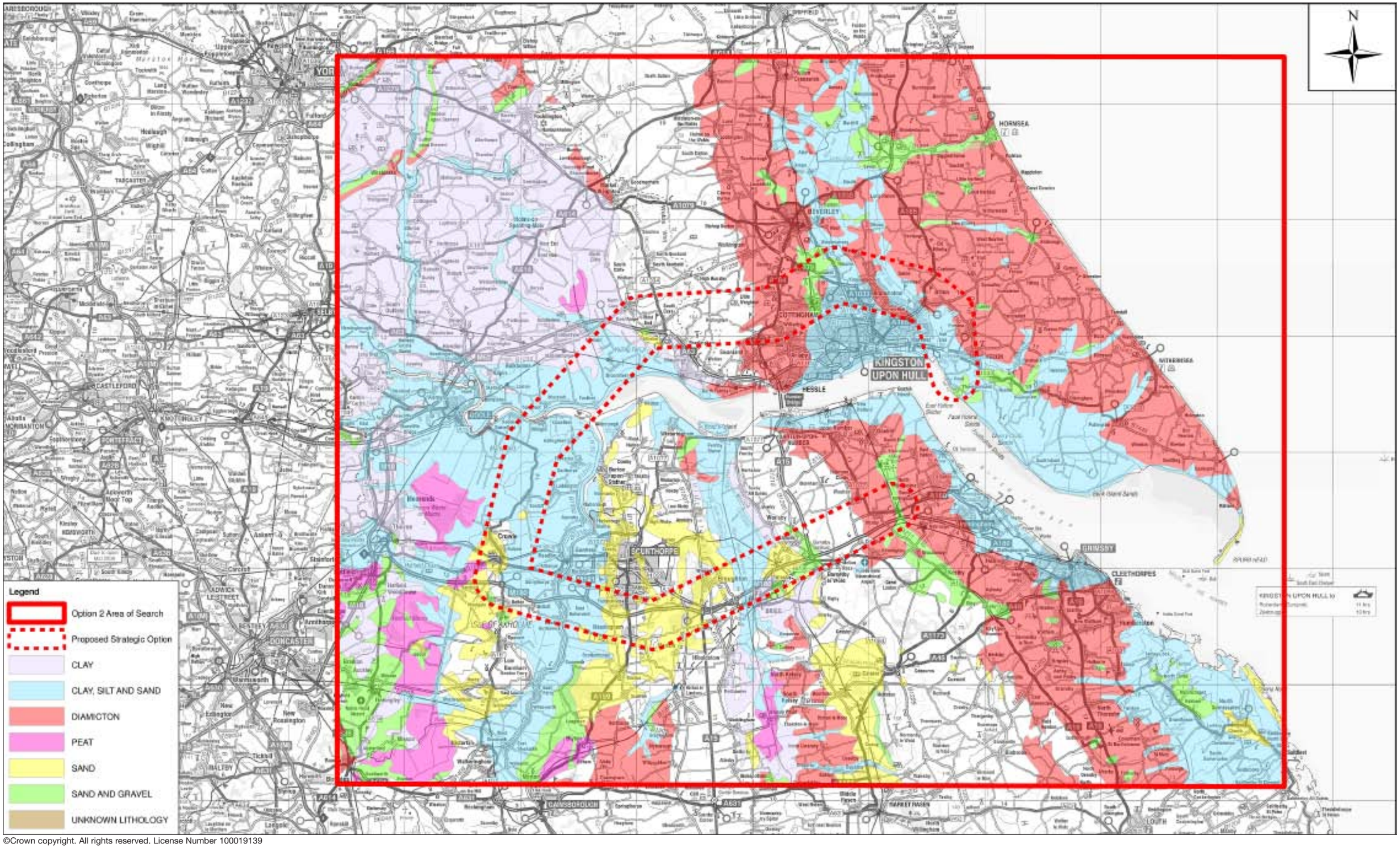
Option 2 Bedrock Geology

Appendix 3, Option 2 / Figure 4c, Scale 1:300,000



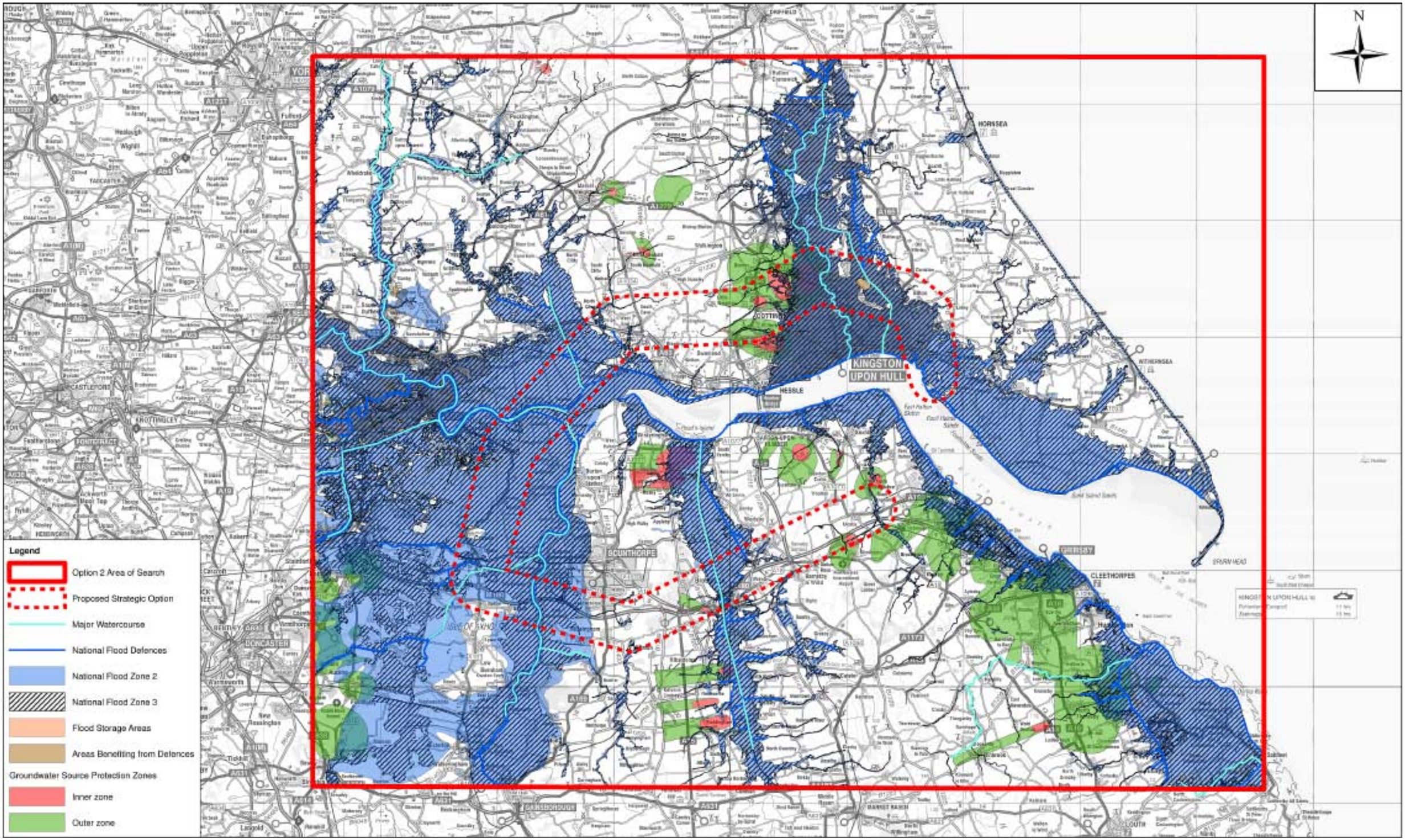
Option 2 Superficial Geology

Appendix 3, Option 2 / Figure 4d, Scale 1:300,000



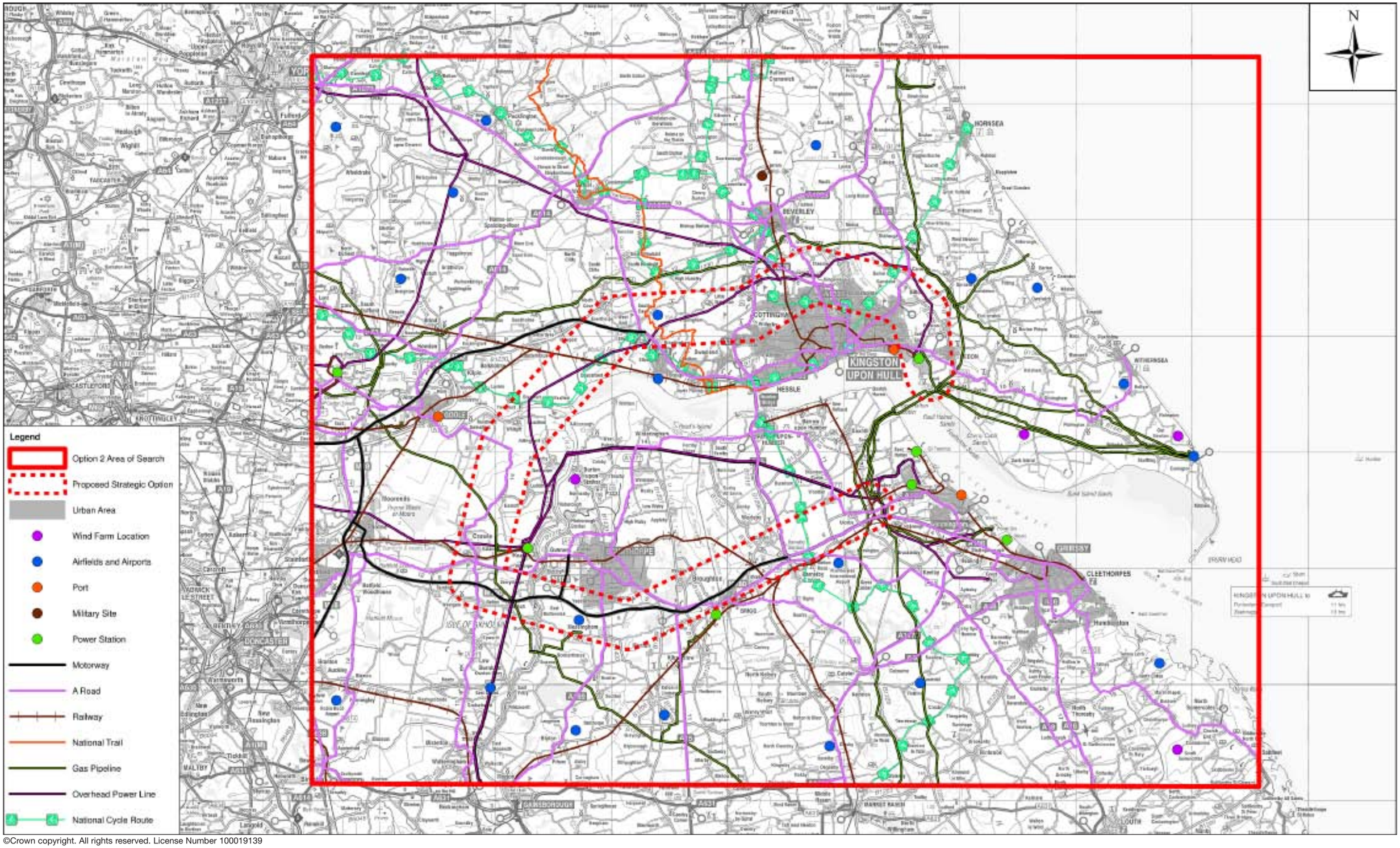
Option 2 Water Resources and Flooding

Appendix 3, Option 2 / Figure 5, Scale 1:300,000



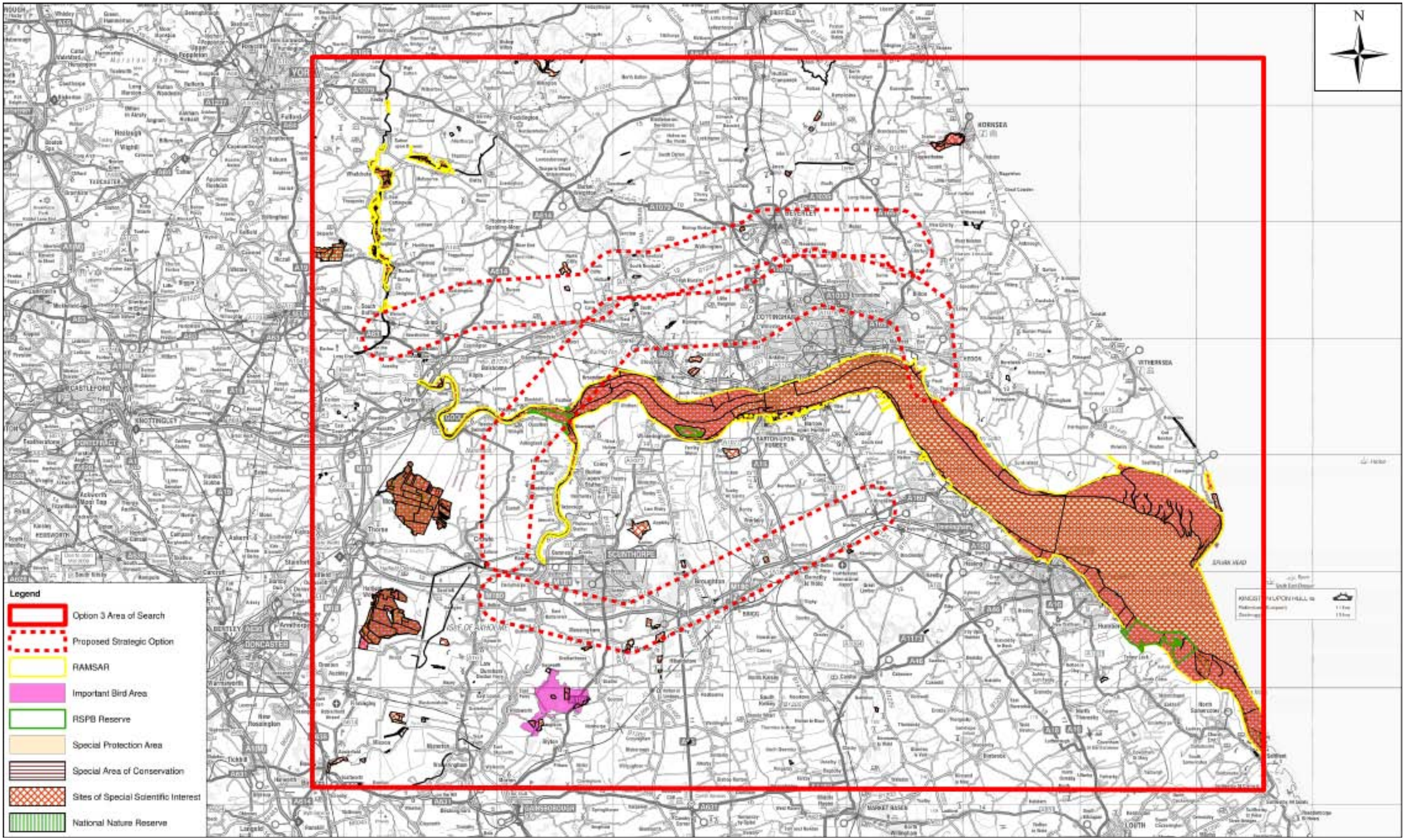
Option 2 Socio-Economic Features

Appendix 3, Option 2 / Figure 6, Scale 1:300,000



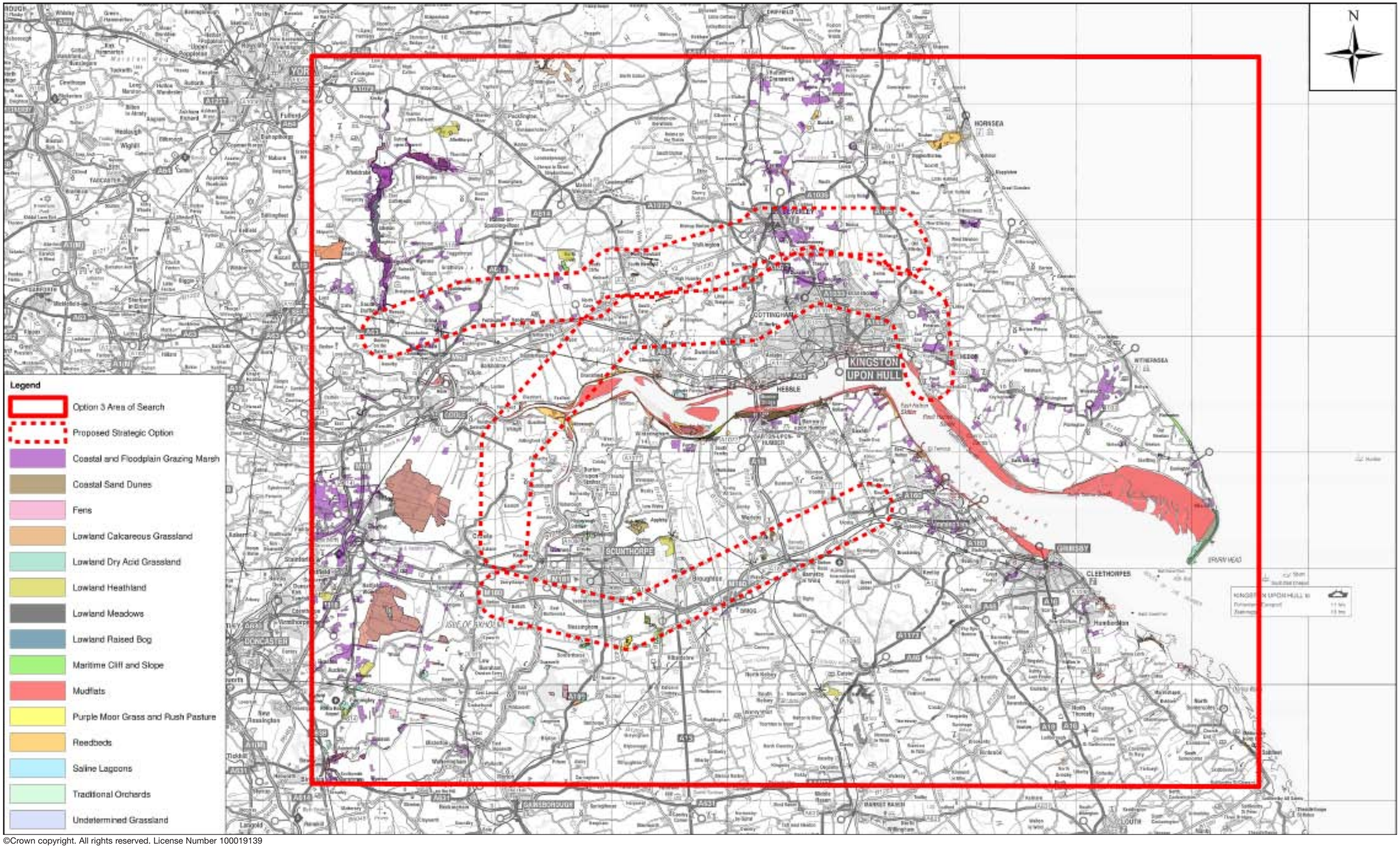
Option 3 Nature Conservation Designations and Features

Appendix 3, Option 3 / Figure 1A, Scale 1:300,000



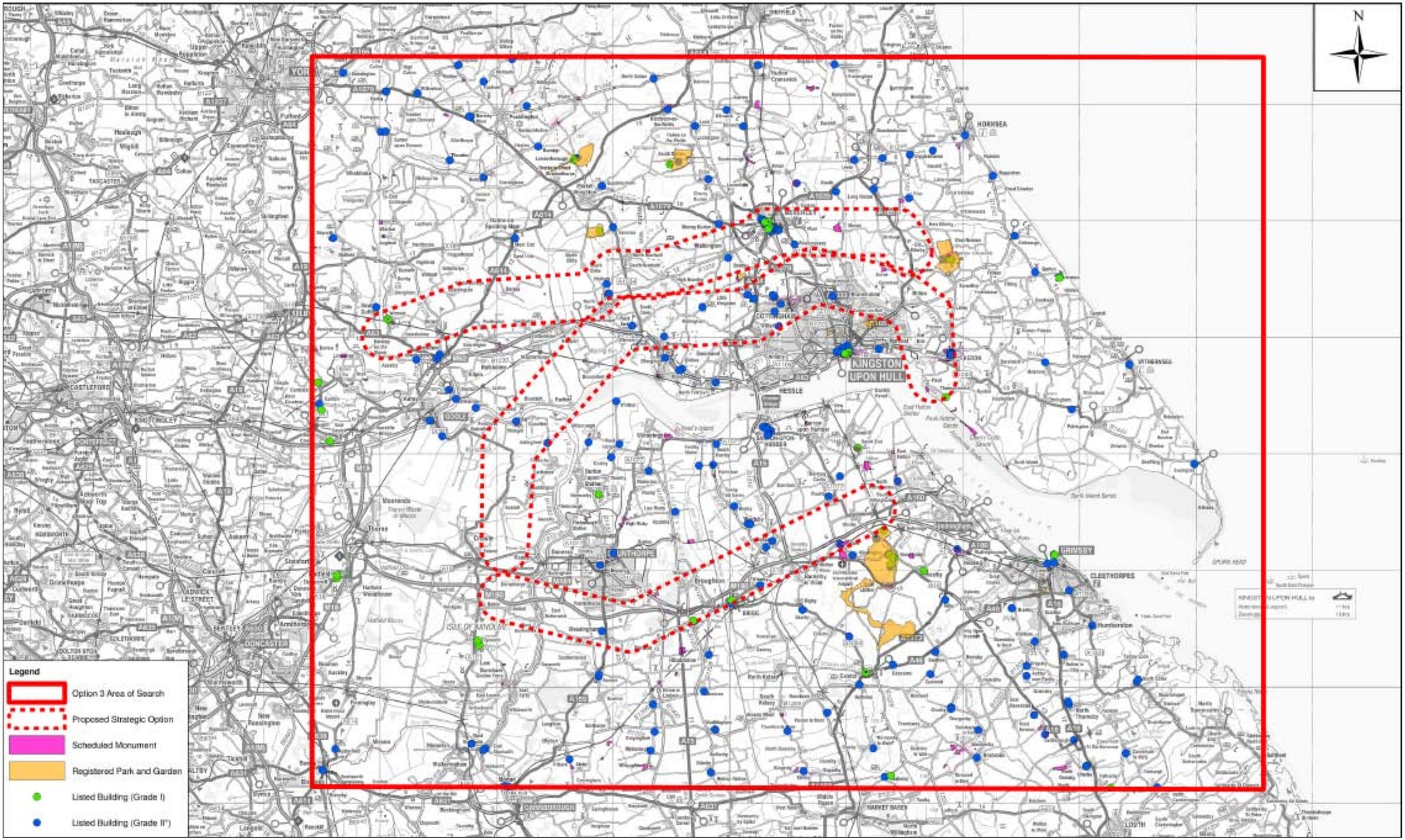
Option 3 UK Bap Priority Habitat

Appendix 3, Option 3 / Figure 1B, Scale 1:300,000



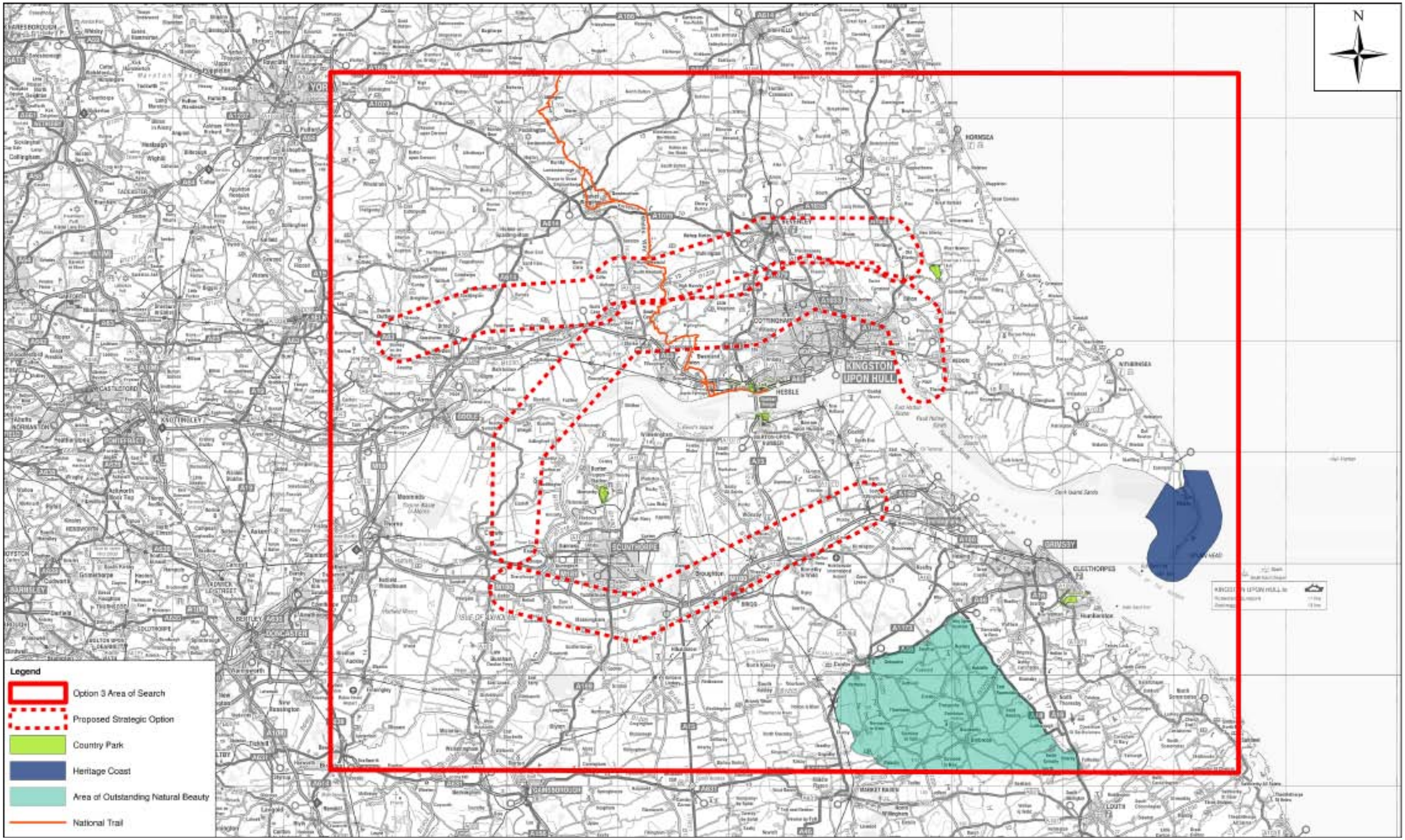
Option 3 Cultural Heritage Designations

Appendix 3, Option 3 / Figure 2, Scale 1:300,000



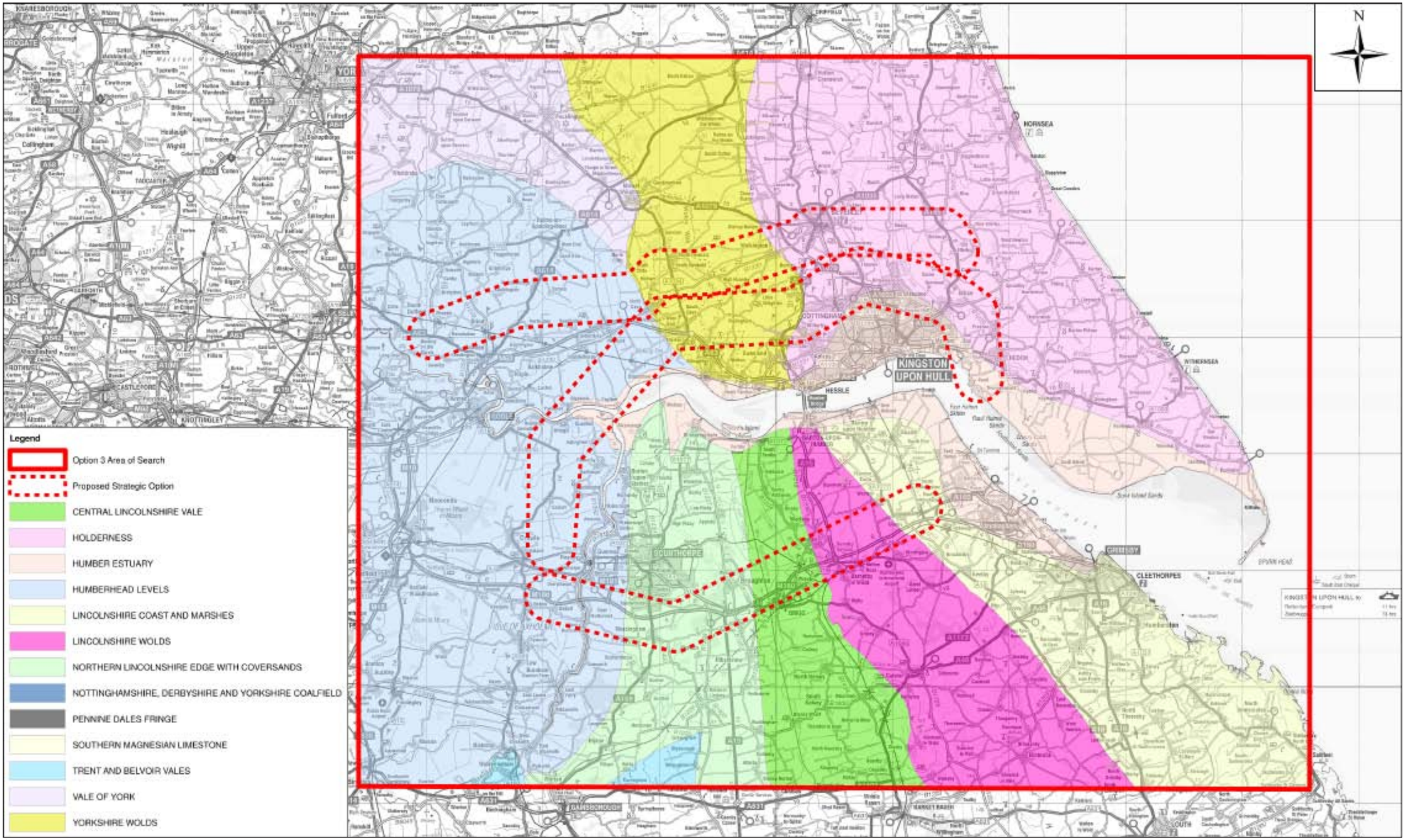
Option 3 Landscape Designations and Features

Appendix 3, Option 3 / Figure 3A, Scale 1:300,000



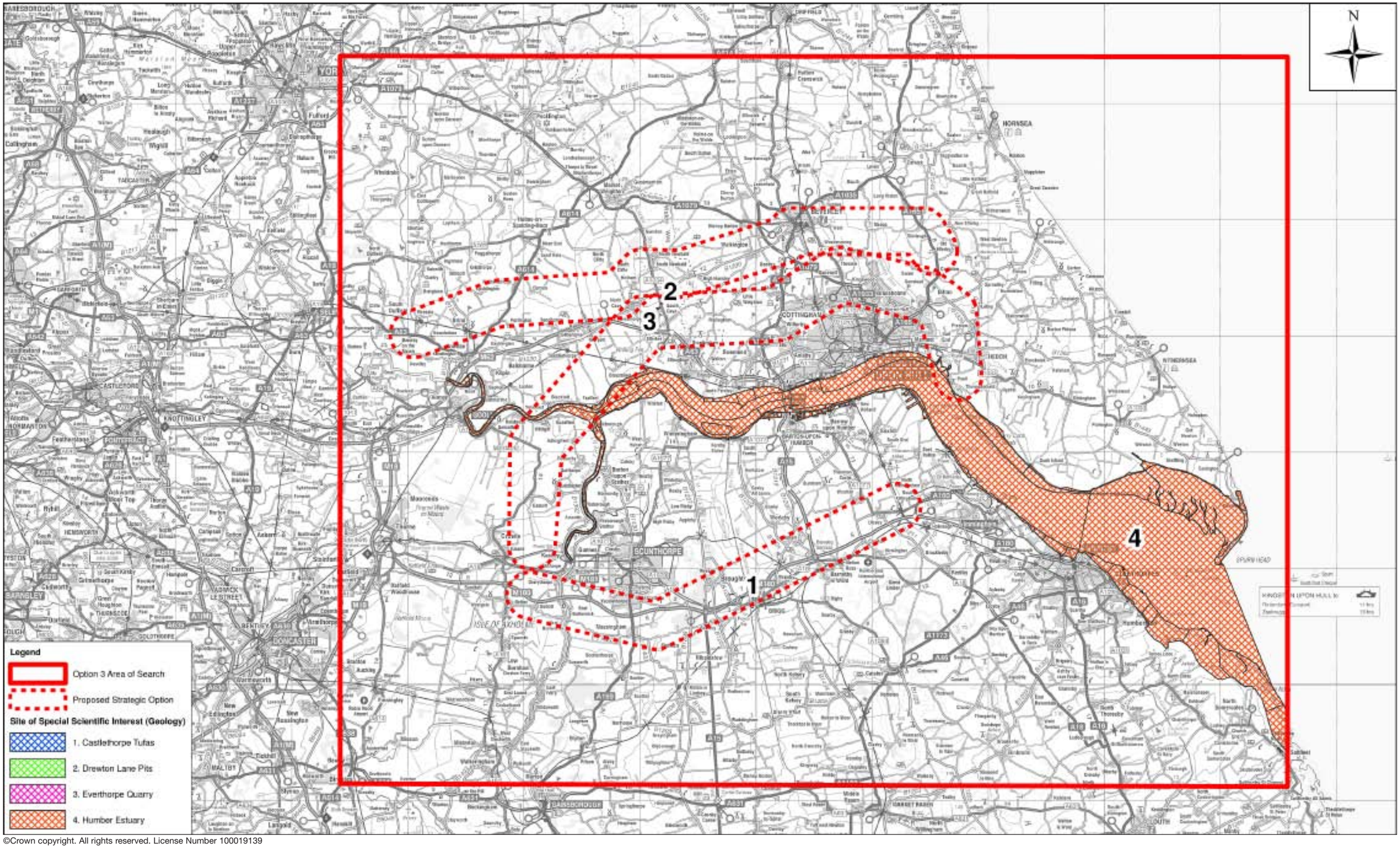
Option 3 National Character Areas

Appendix 3, Option 3 / Figure 3B, Scale 1:300,000



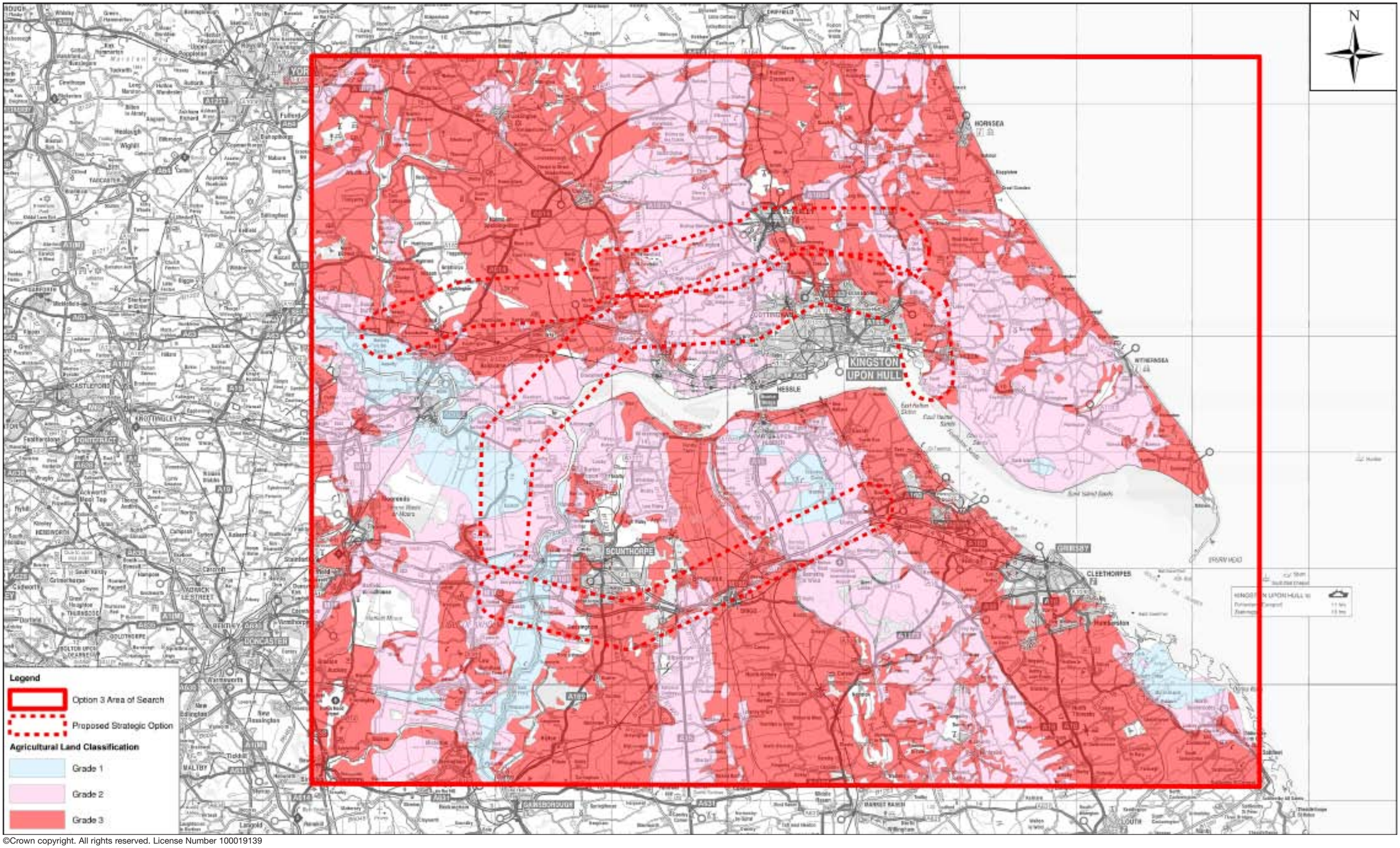
Option 3 Geological Designations

Appendix 3, Option 3 / Figure 4a, Scale 1:300,000



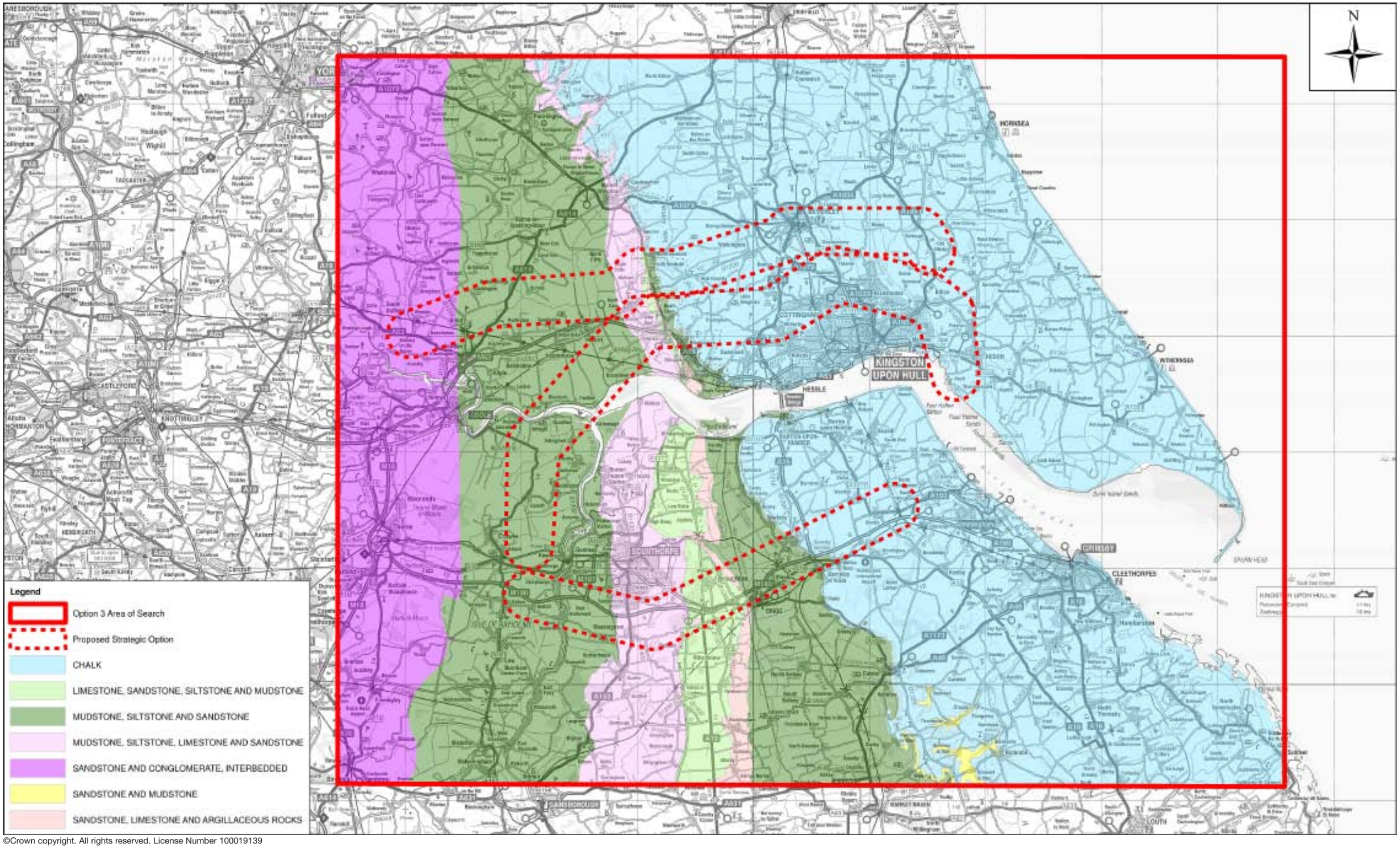
Option 3 Agricultural Land Classification

Appendix 3, Option 3 / Figure 4b, Scale 1:300,000



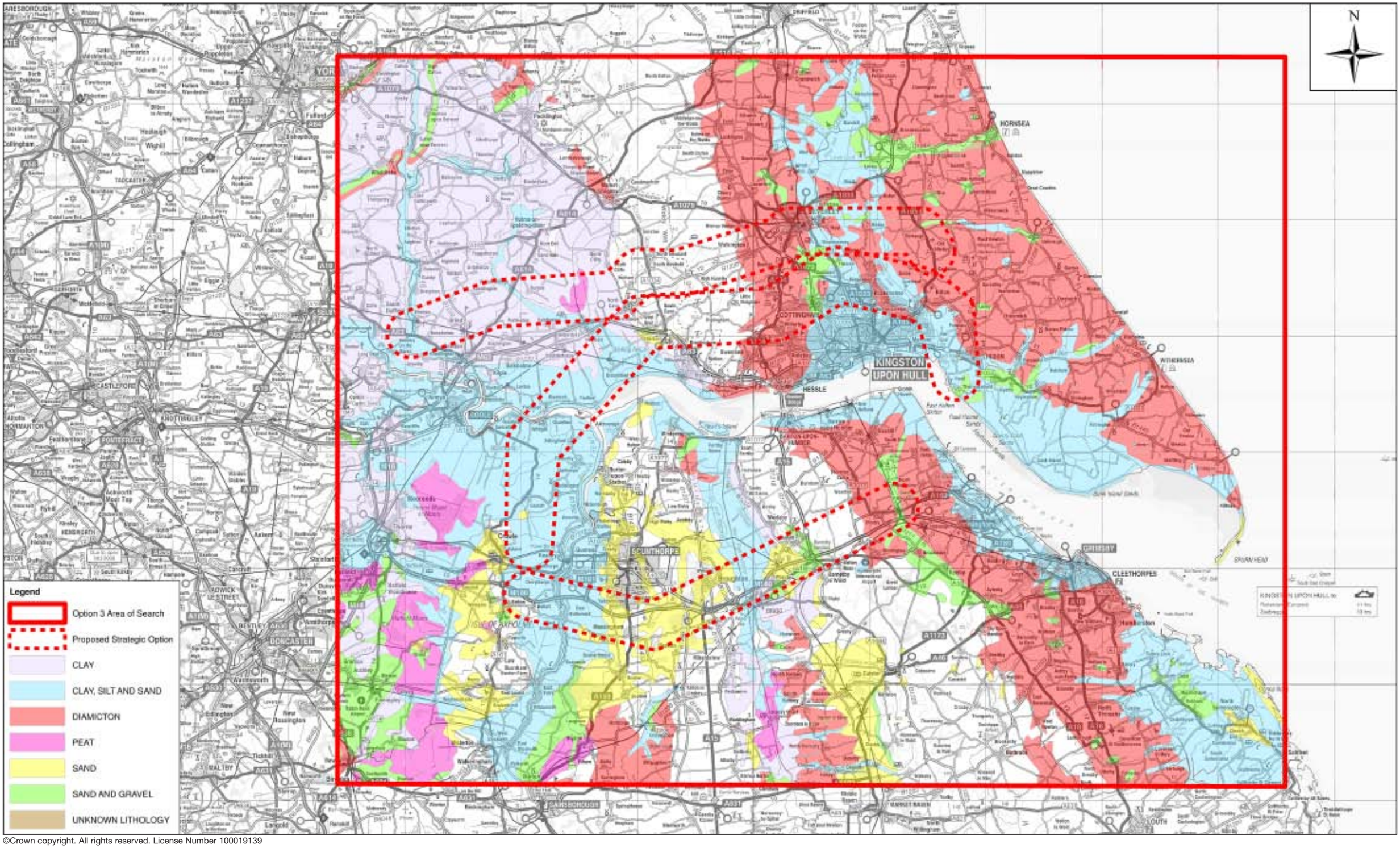
Option 3 Bedrock Geology

Appendix 3, Option 3 / Figure 4c, Scale 1:300,000



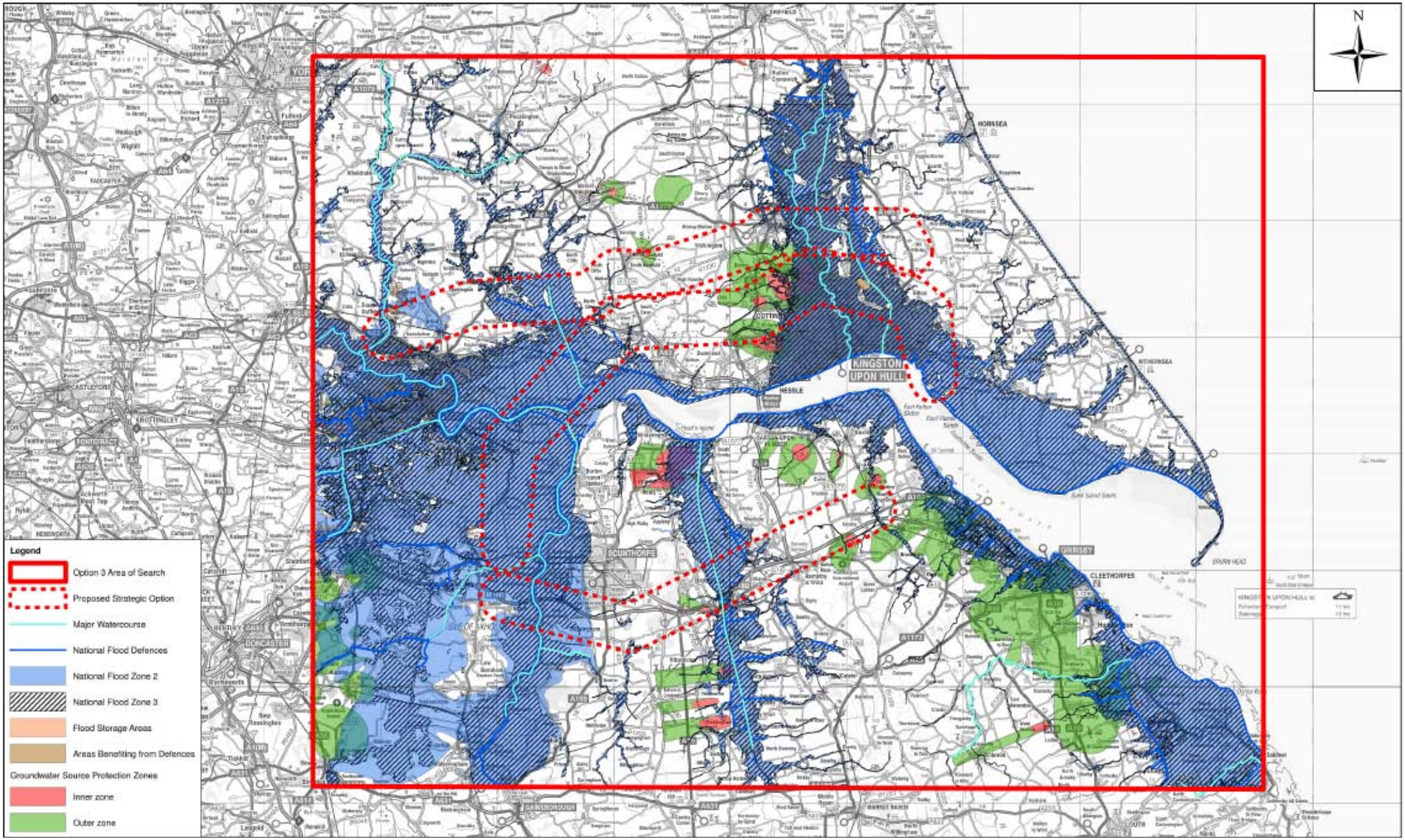
Option 3 Superficial Geology

Appendix 3, Option 3 / Figure 4d, Scale 1:300,000



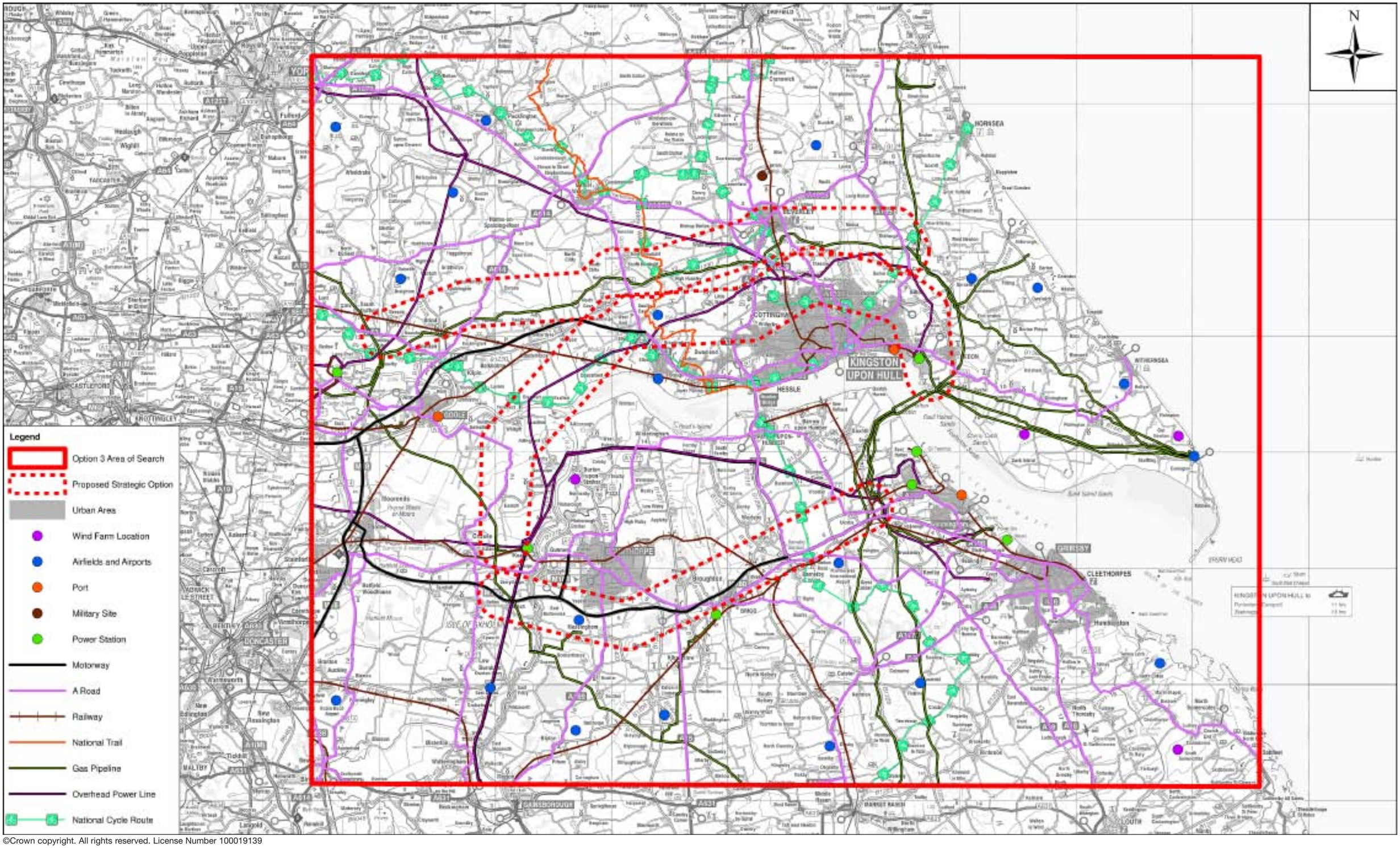
Option 3 Water Resources and Flooding

Appendix 3, Option 3 / Figure 5, Scale 1:300,000



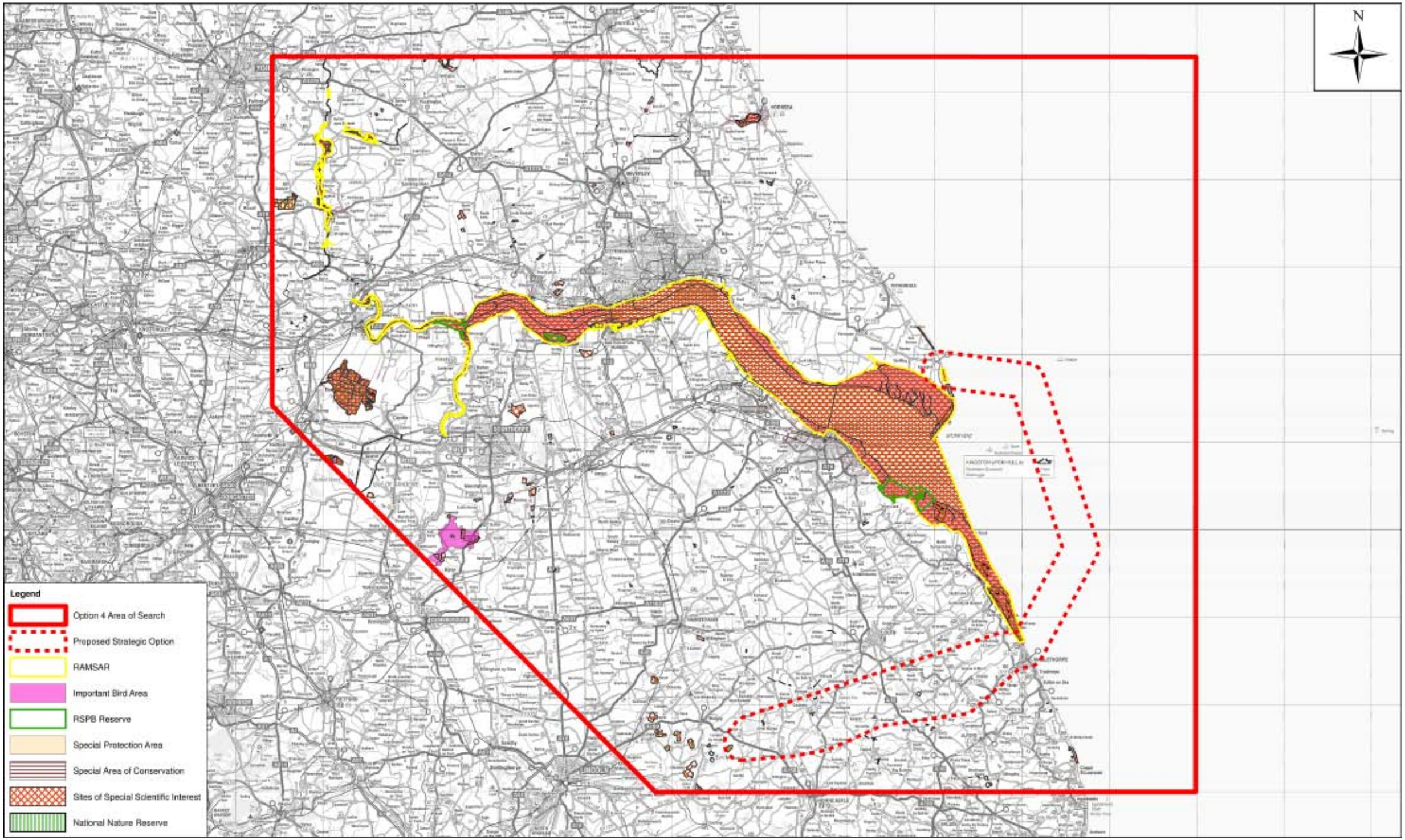
Option 3 Socio-Economic Features

Appendix 3, Option 3 / Figure 6, Scale 1:300,000



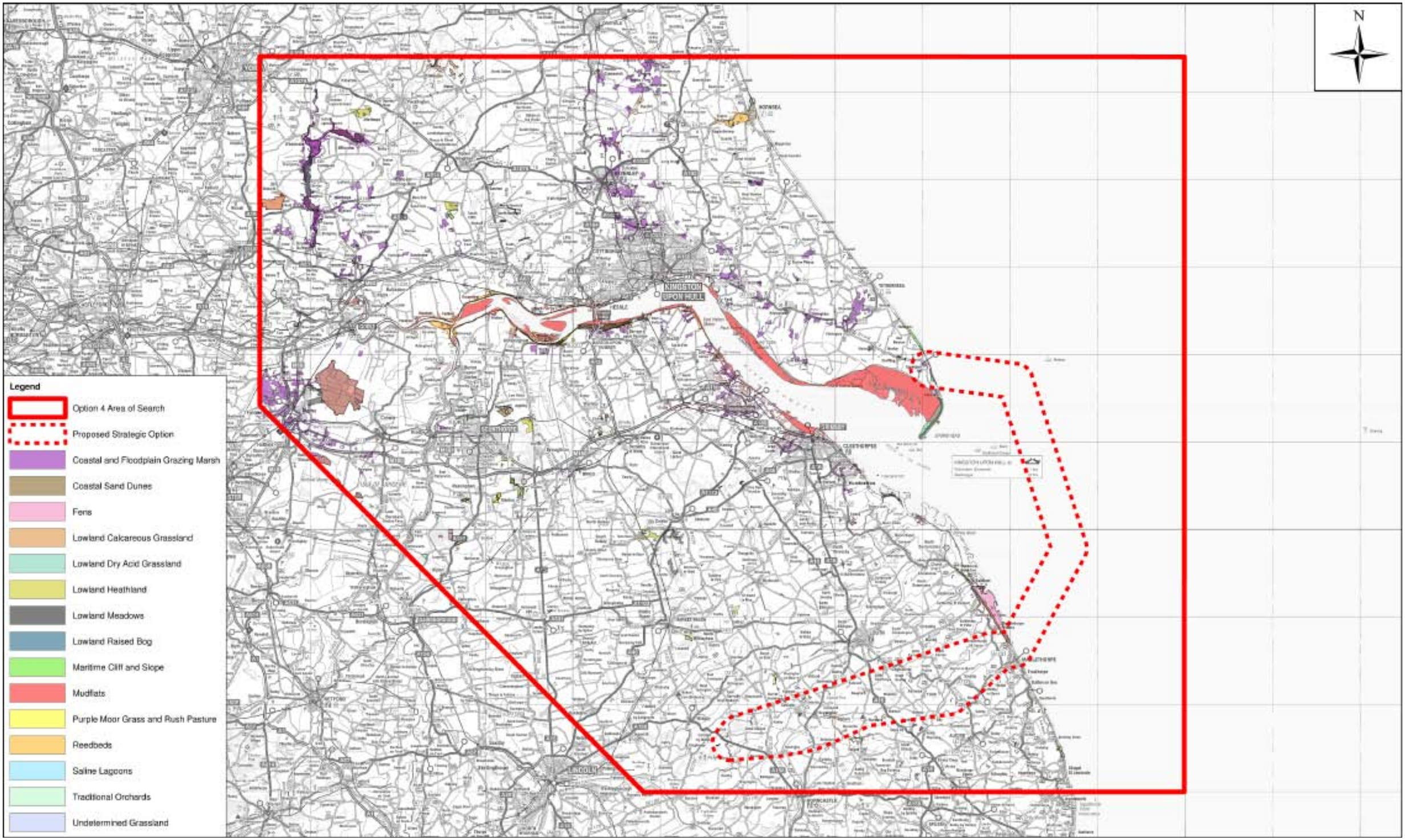
Option 4 Nature Conservation Designations and Features

Appendix 3, Option 4 / Figure 1a, Scale 1:400,000



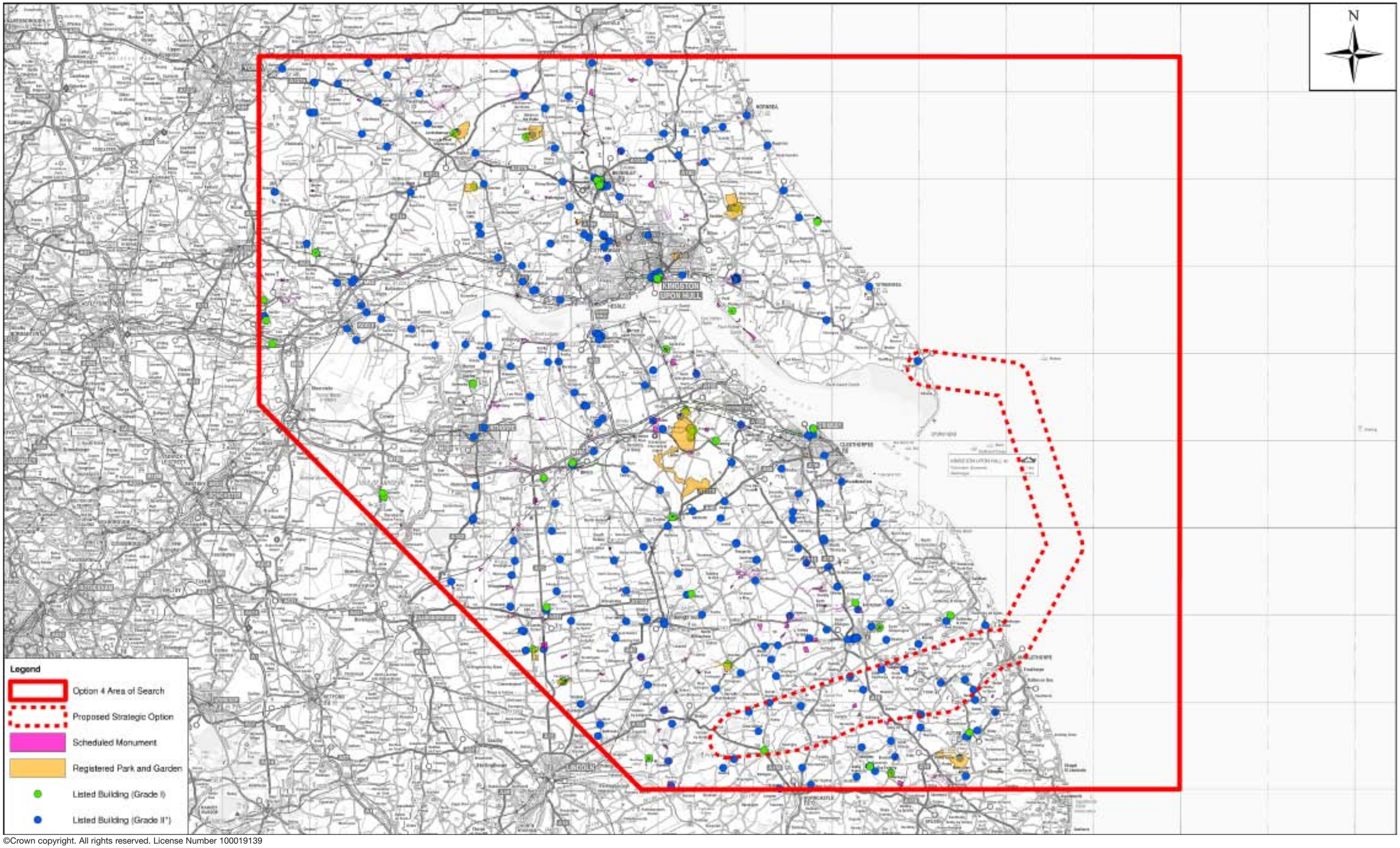
Option 4 UK Bap Priority Habitat

Appendix 3, Option 4 / Figure 1b, Scale 1:400,000



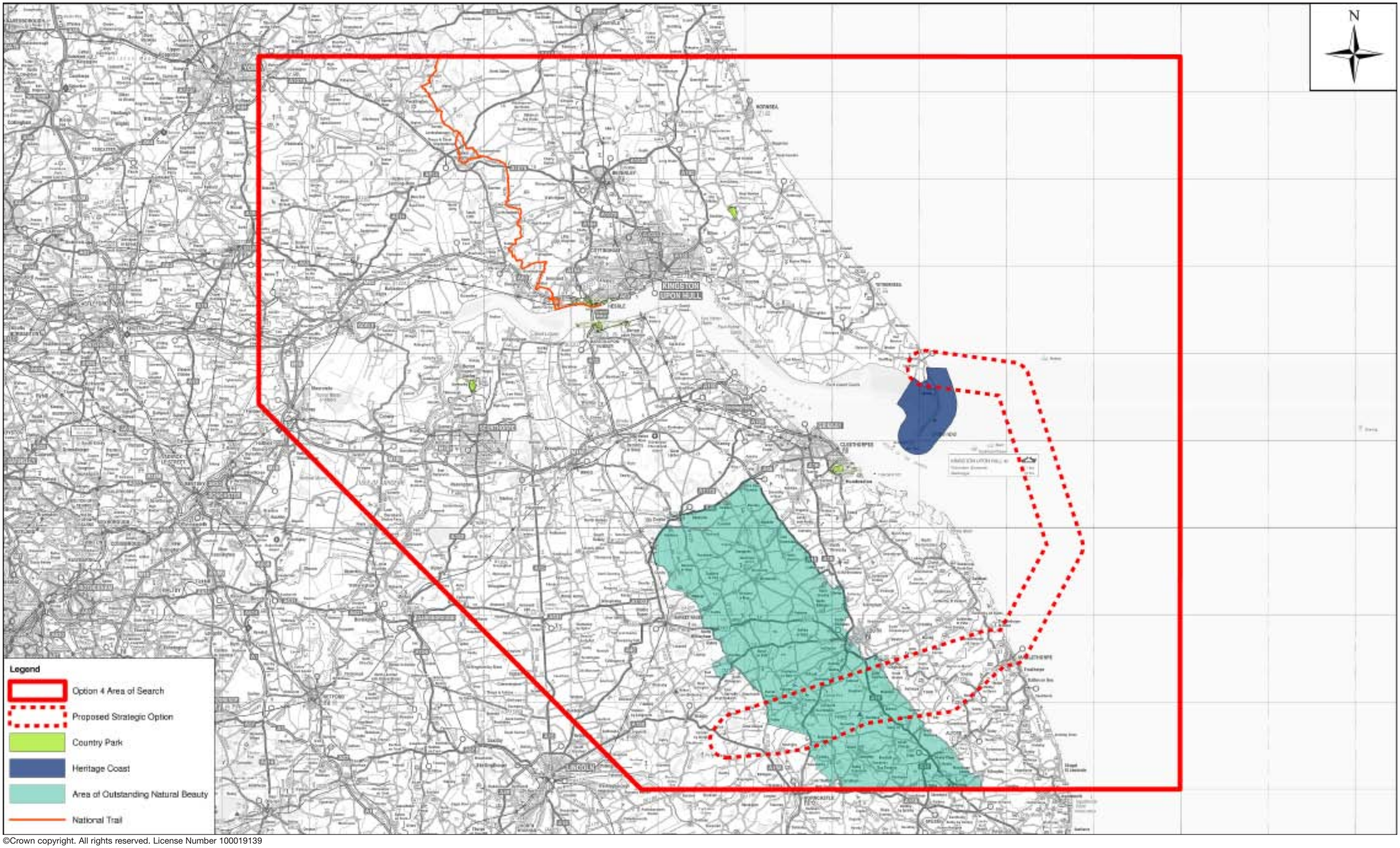
Option 4 Cultural Heritage Designations

Appendix 3, Option 4 / Figure 2, Scale 1:400,000



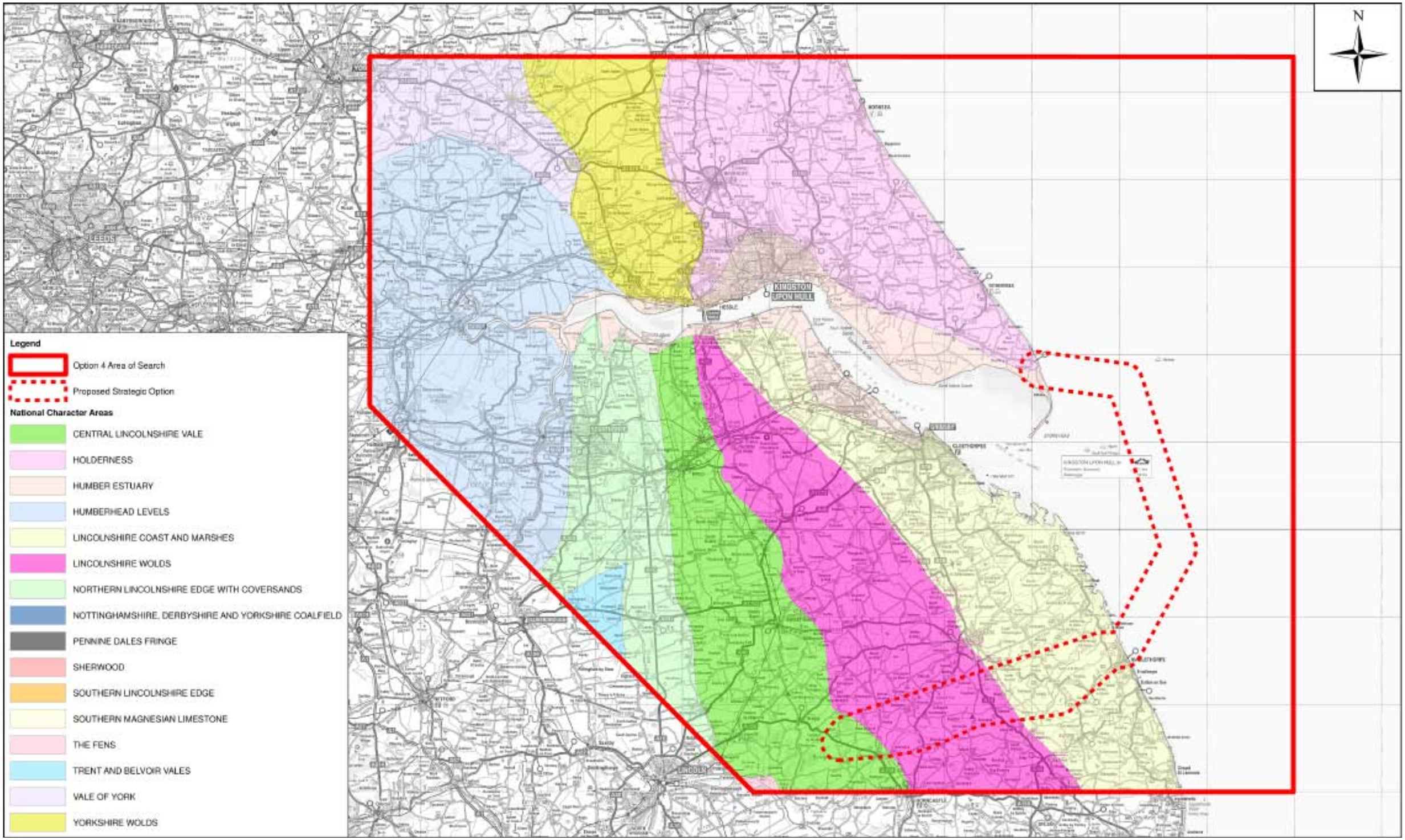
Option 4 Landscape Designations and Features

Appendix 3, Option 4 / Figure 3a, Scale 1:400,000



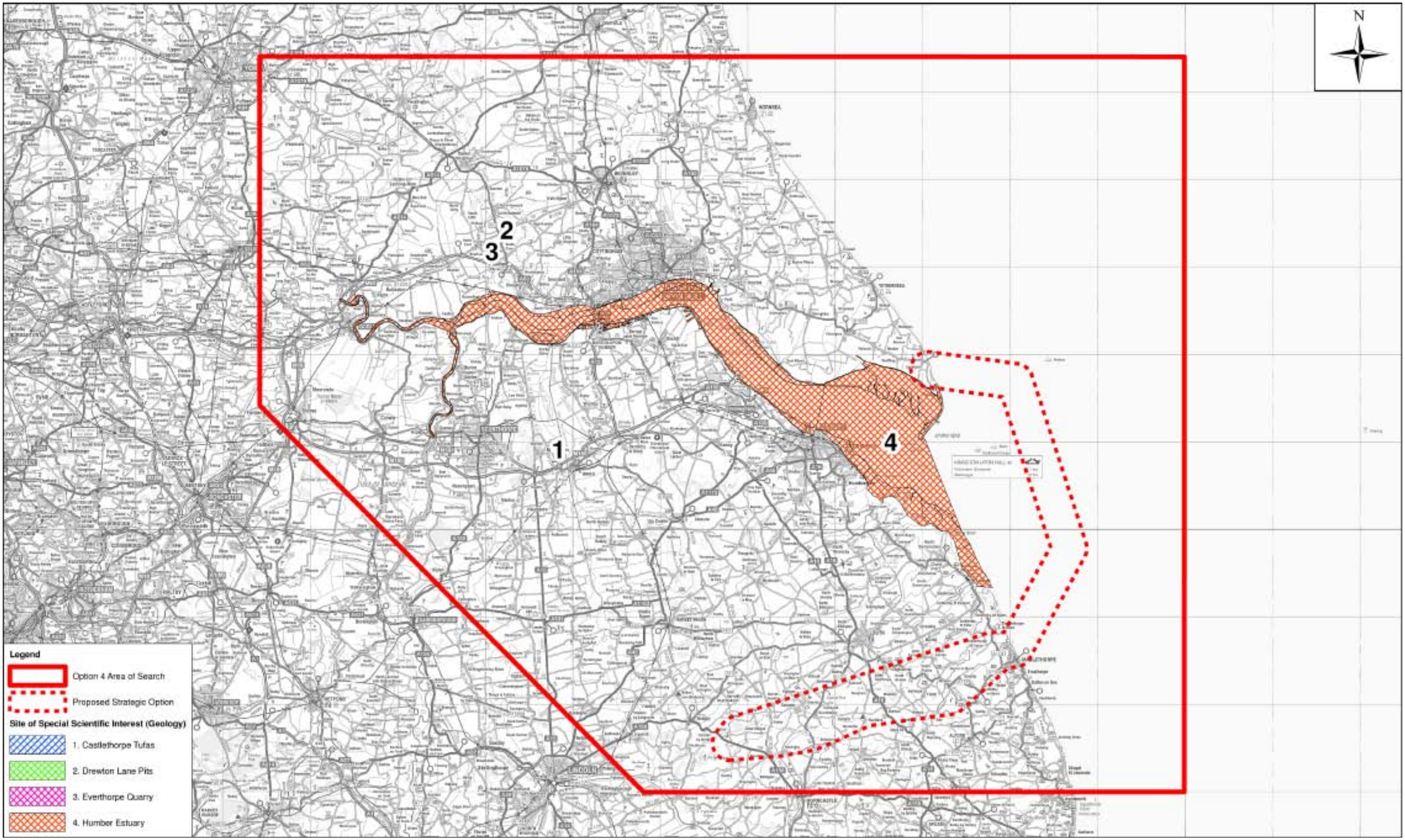
Option 4 National Character Areas

Appendix 3, Option 4 / Figure 3b, Scale 1:400,000



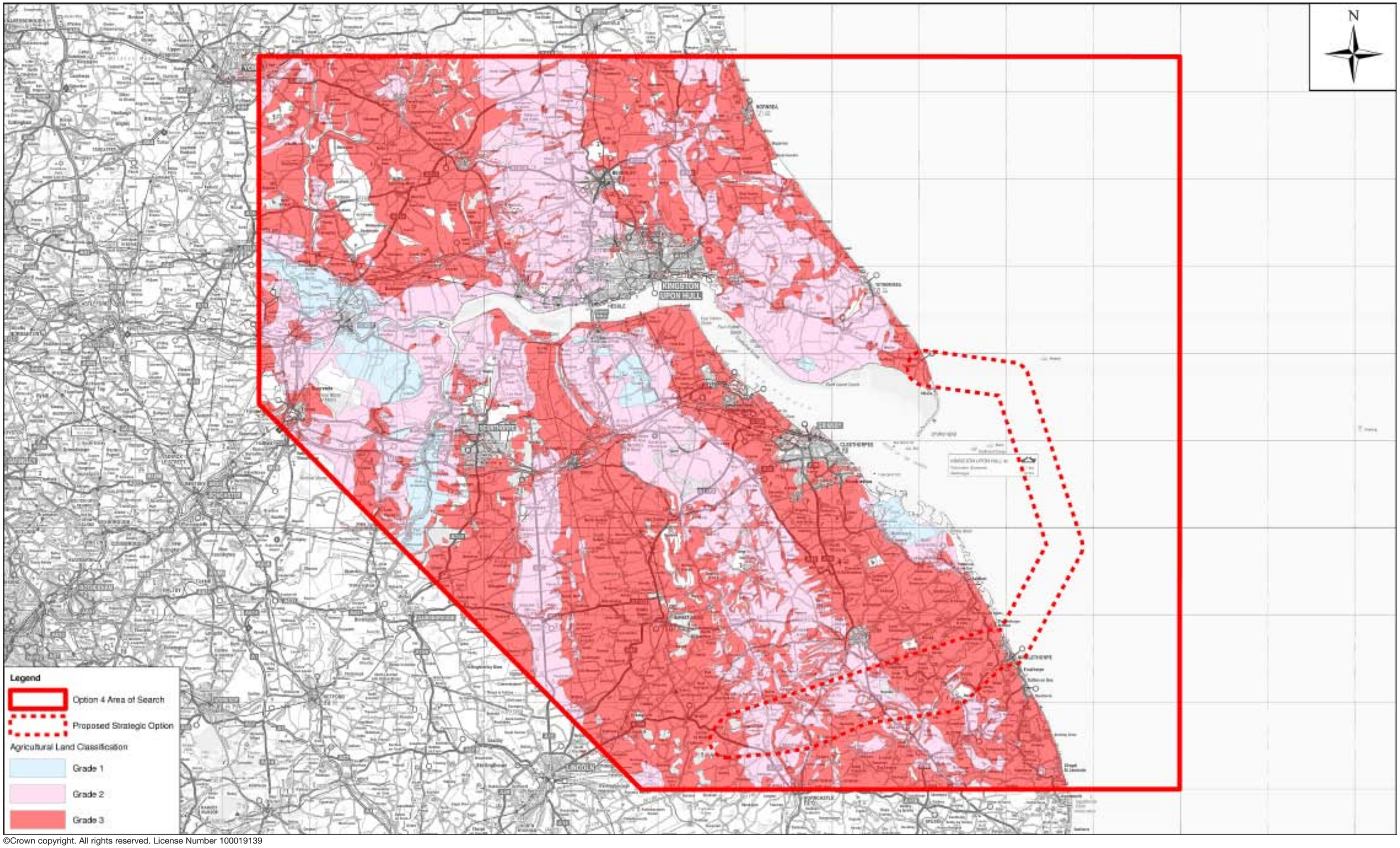
Option 4 Geological Designations

Appendix 3, Option 4 / Figure 4a, Scale 1:400,000



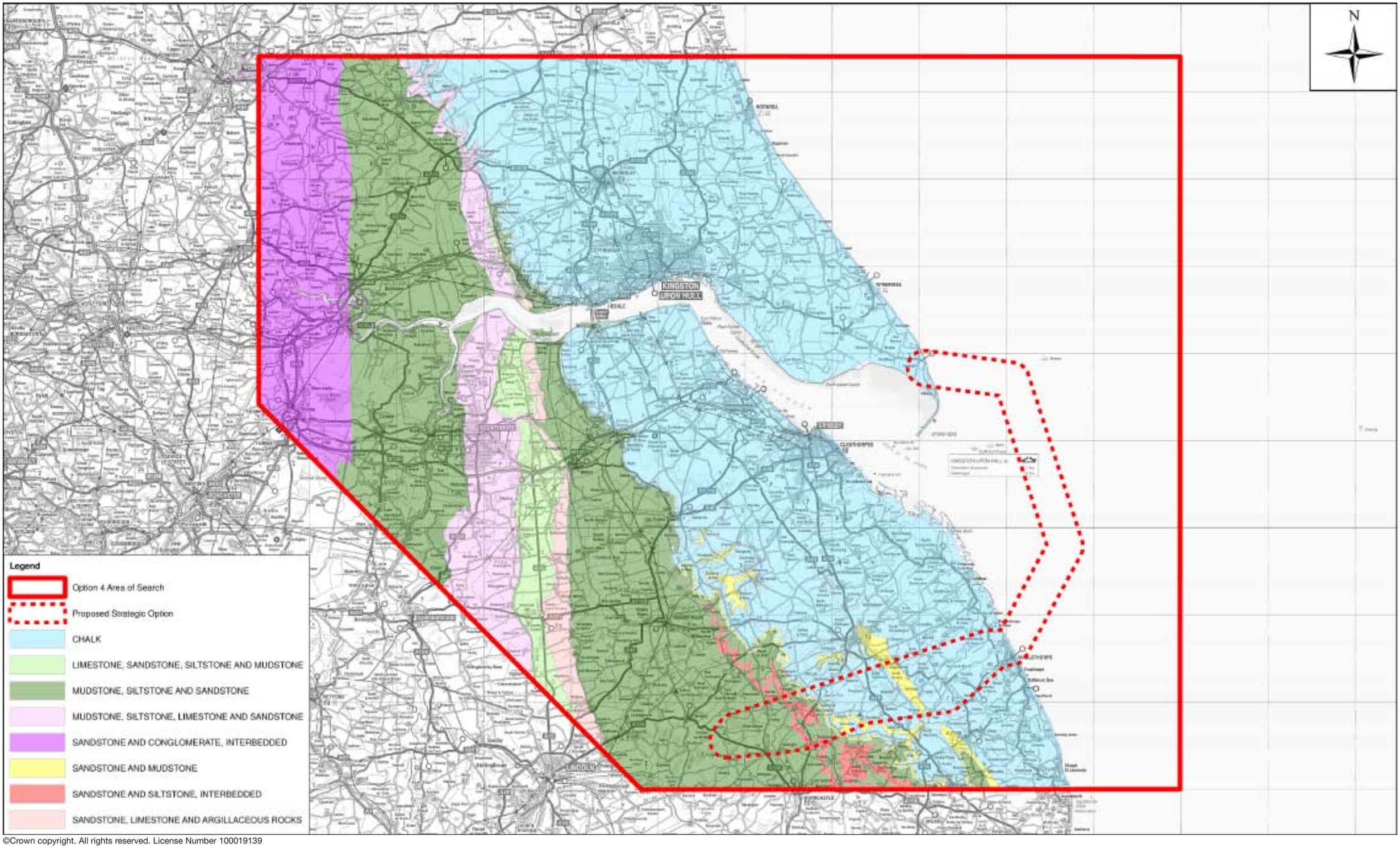
Option 4 Agricultural Land Classification

Appendix 3, Option 4 / Figure 4b, Scale 1:400,000



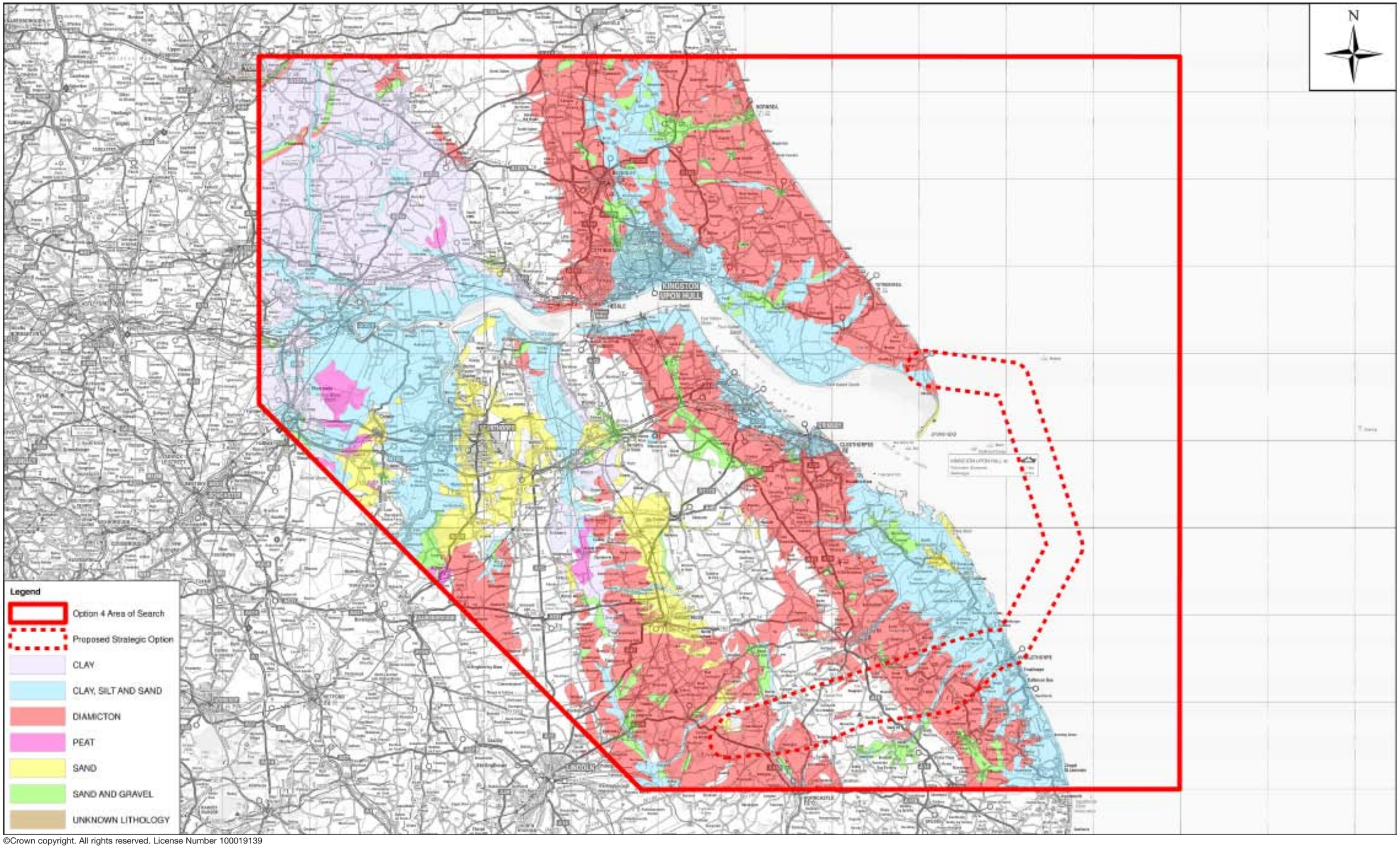
Option 4 Bedrock Geology

Appendix 3, Option 4 / Figure 4c, Scale 1:400,000



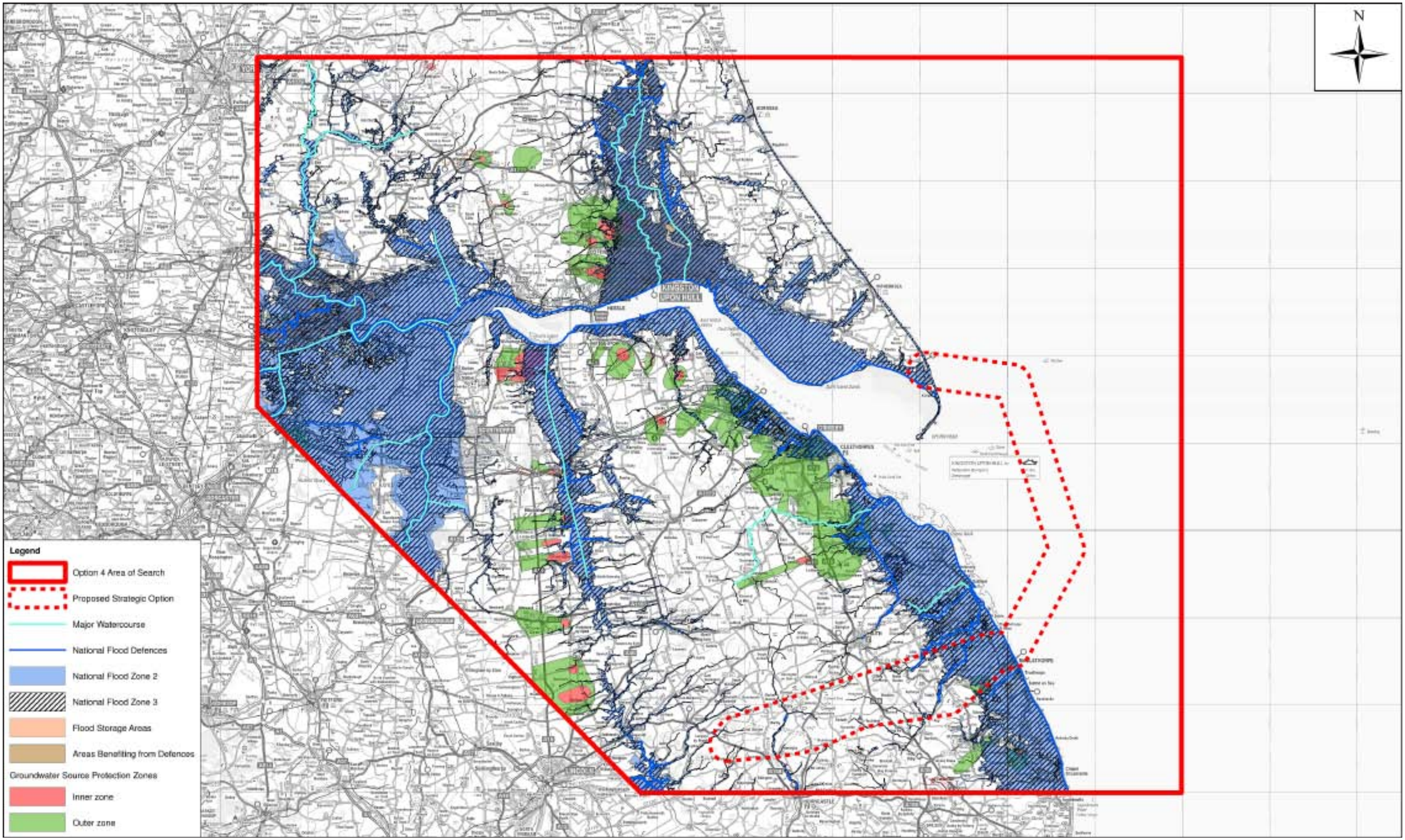
Option 4 Superficial Geology

Appendix 3, Option 4 / Figure 4d, Scale 1:400,000



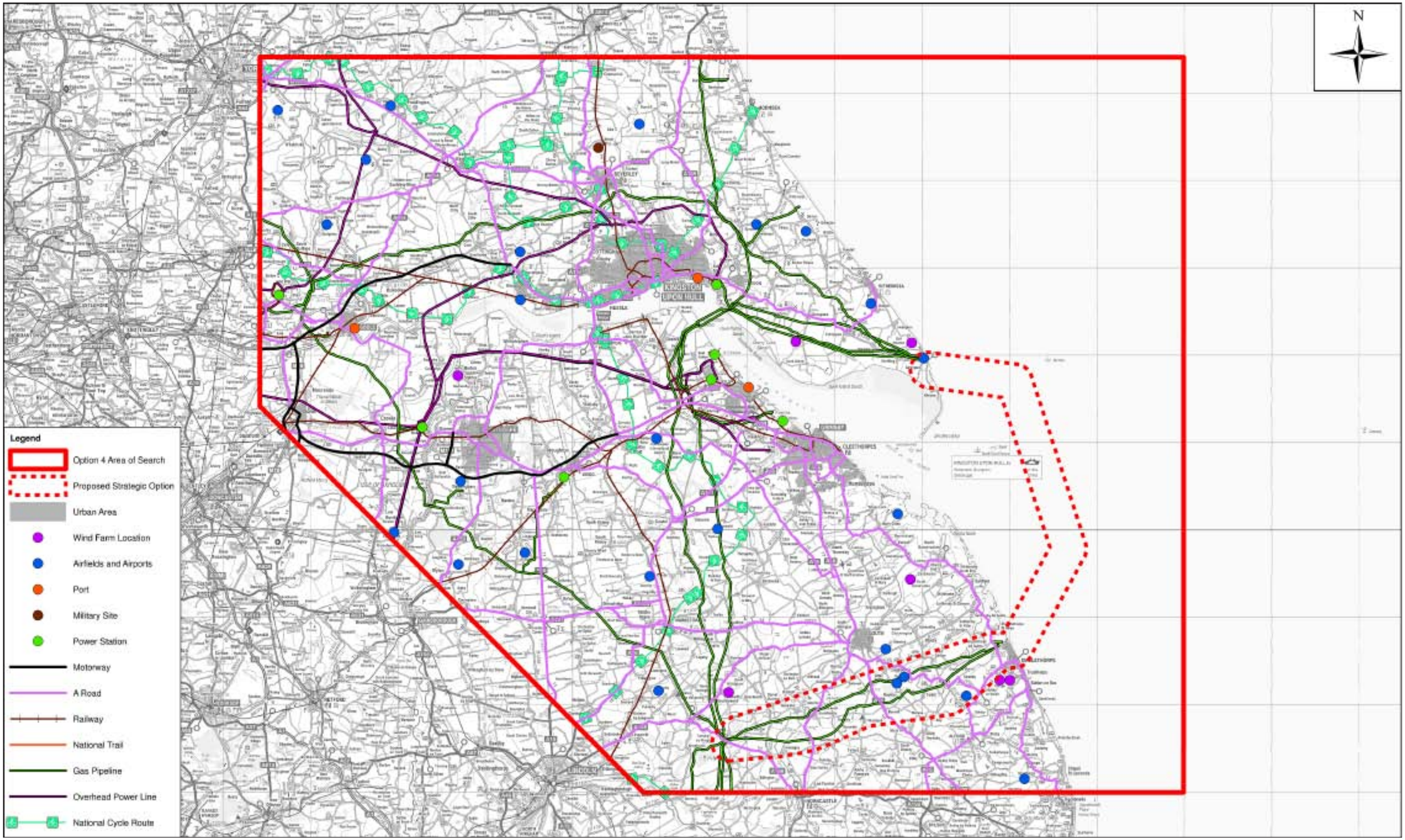
Option 4 Water Resources and Flooding

Appendix 3, Option 4 / Figure 5, Scale 1:400,000



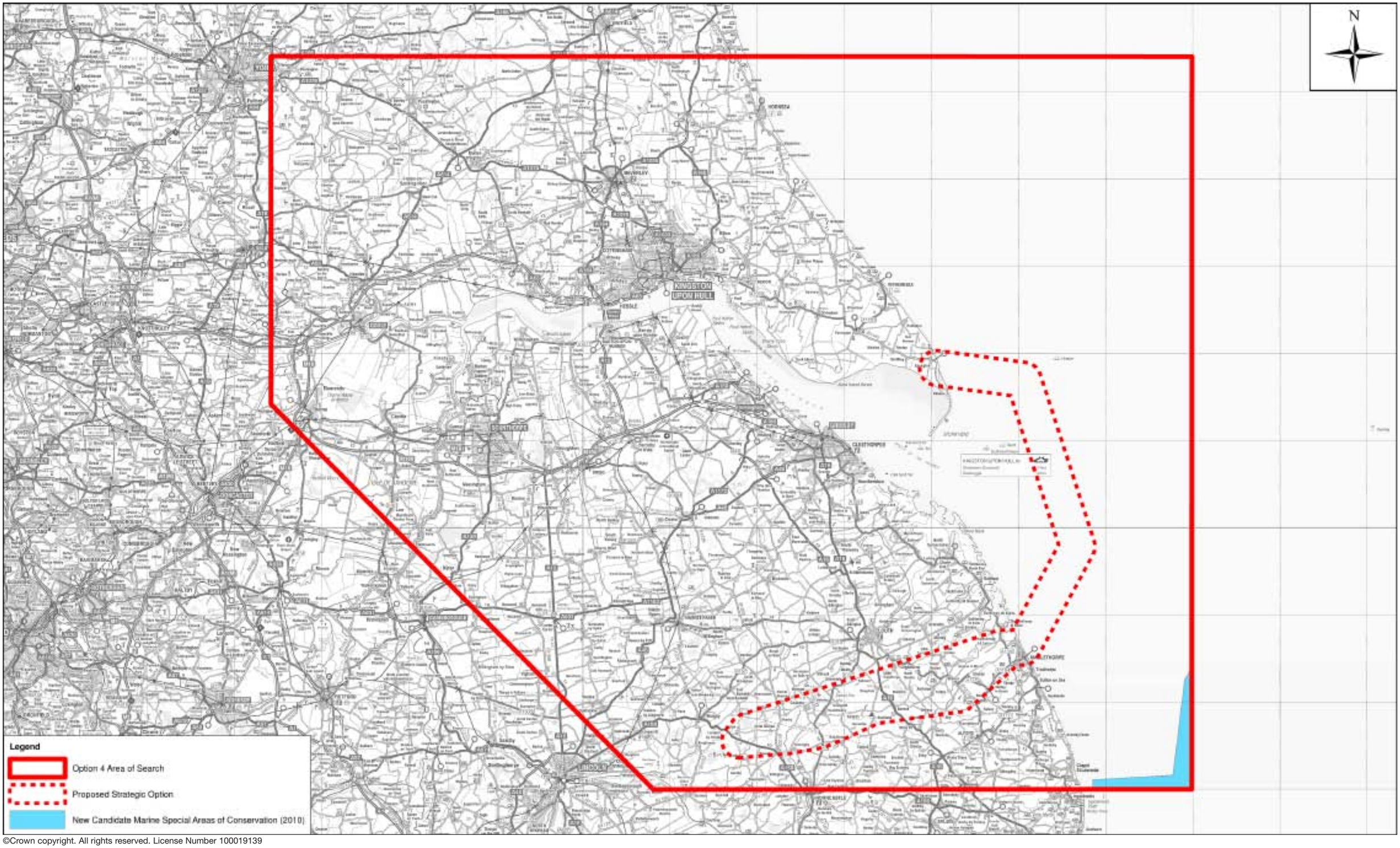
Option 4 Socio-Economic Features

Appendix 3, Option 4 / Figure 6, Scale 1:400,000



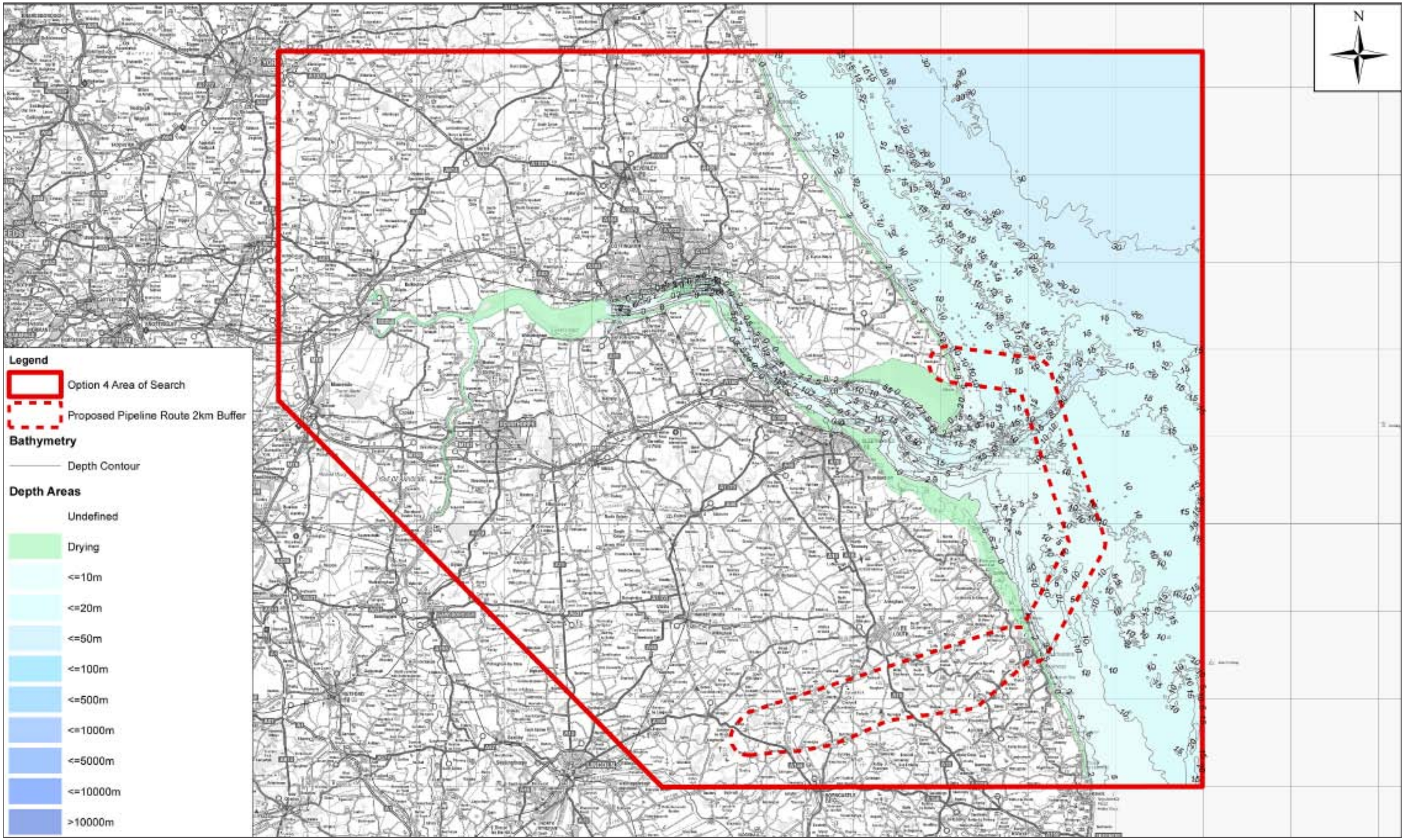
Option 4 Marine Nature Conservation Designations

Appendix 3, Option 4 / Figure 7, Scale 1:400,000



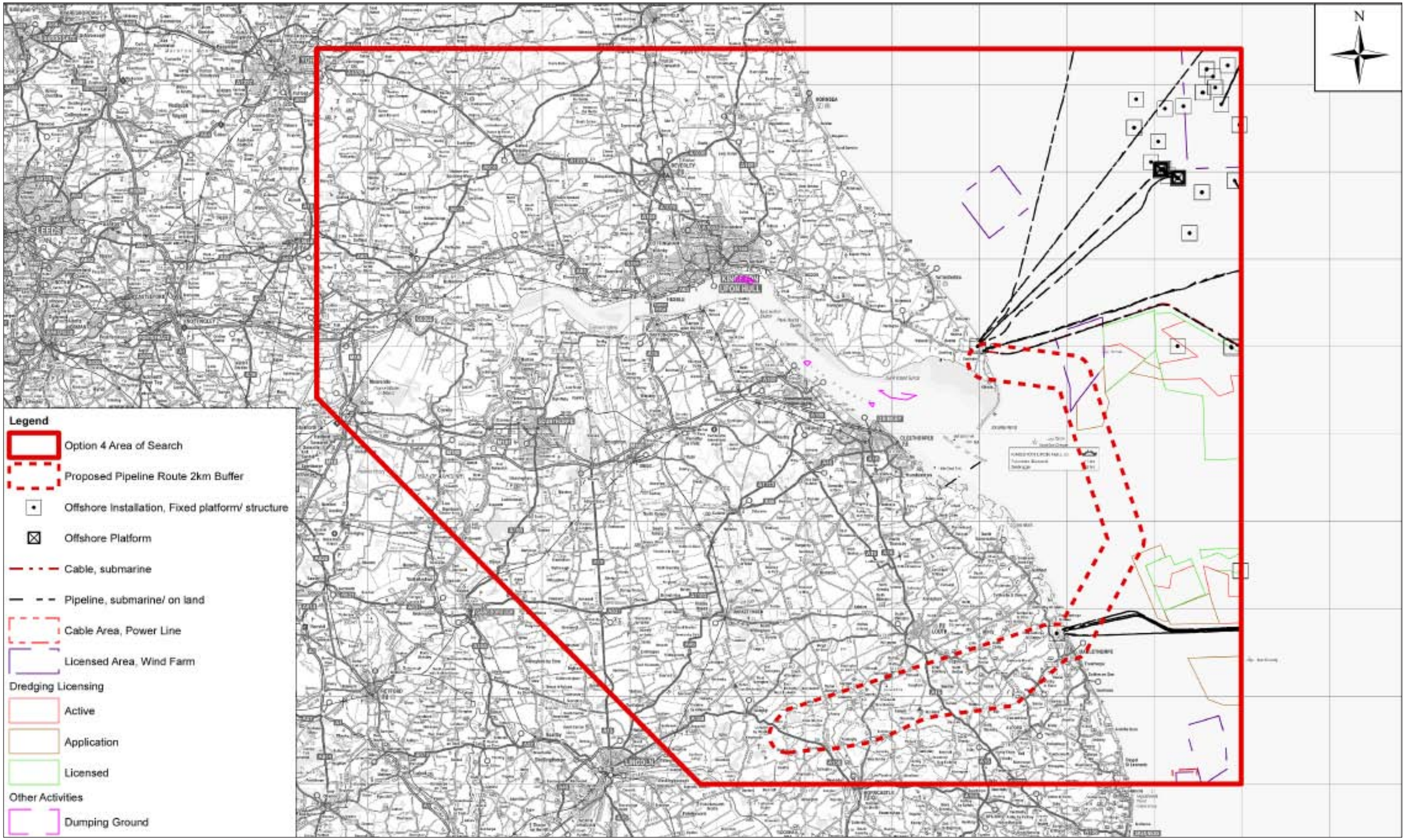
Option 4 Bathymetry and Depth Areas

Appendix 3, Option 4 / Figure 8, Scale 1:400,000



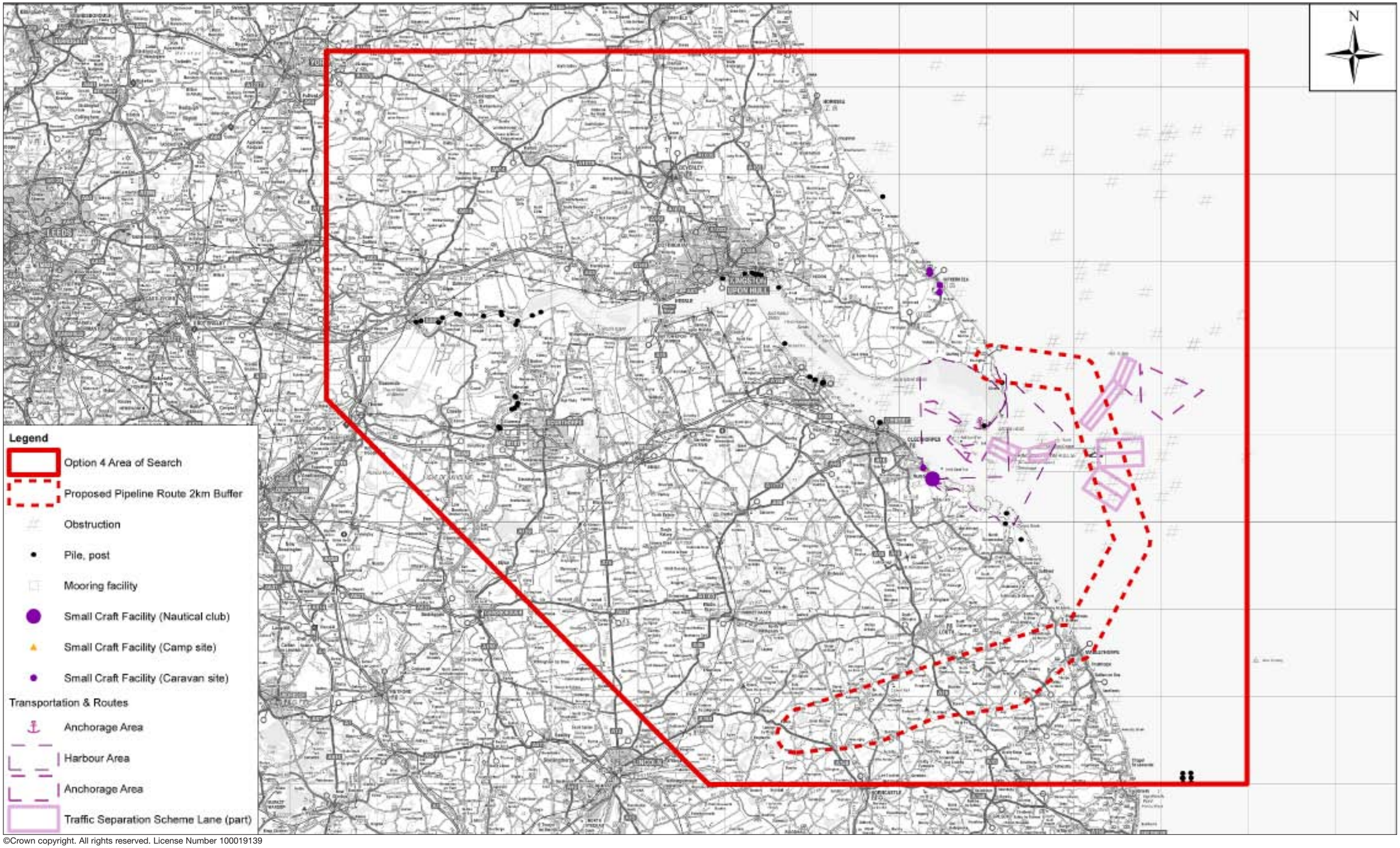
Option 4 Marine Infrastructure and Other Marine Constraints

Appendix 3, Option 4 / Figure 9, Scale 1:400,000



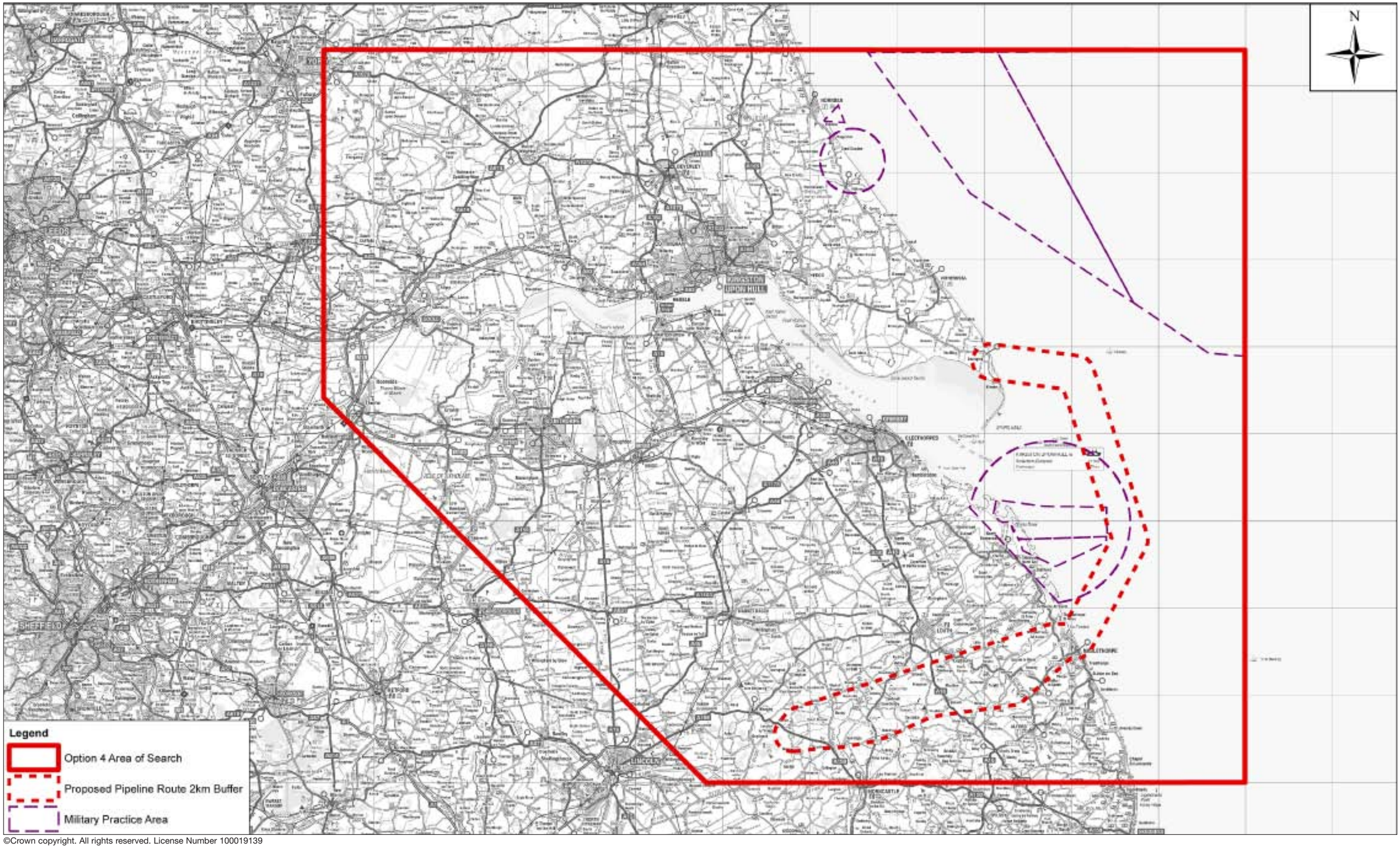
Option 4 Navigation and Shipping Constraints

Appendix 3, Option 4 / Figure 10, Scale 1:400,000



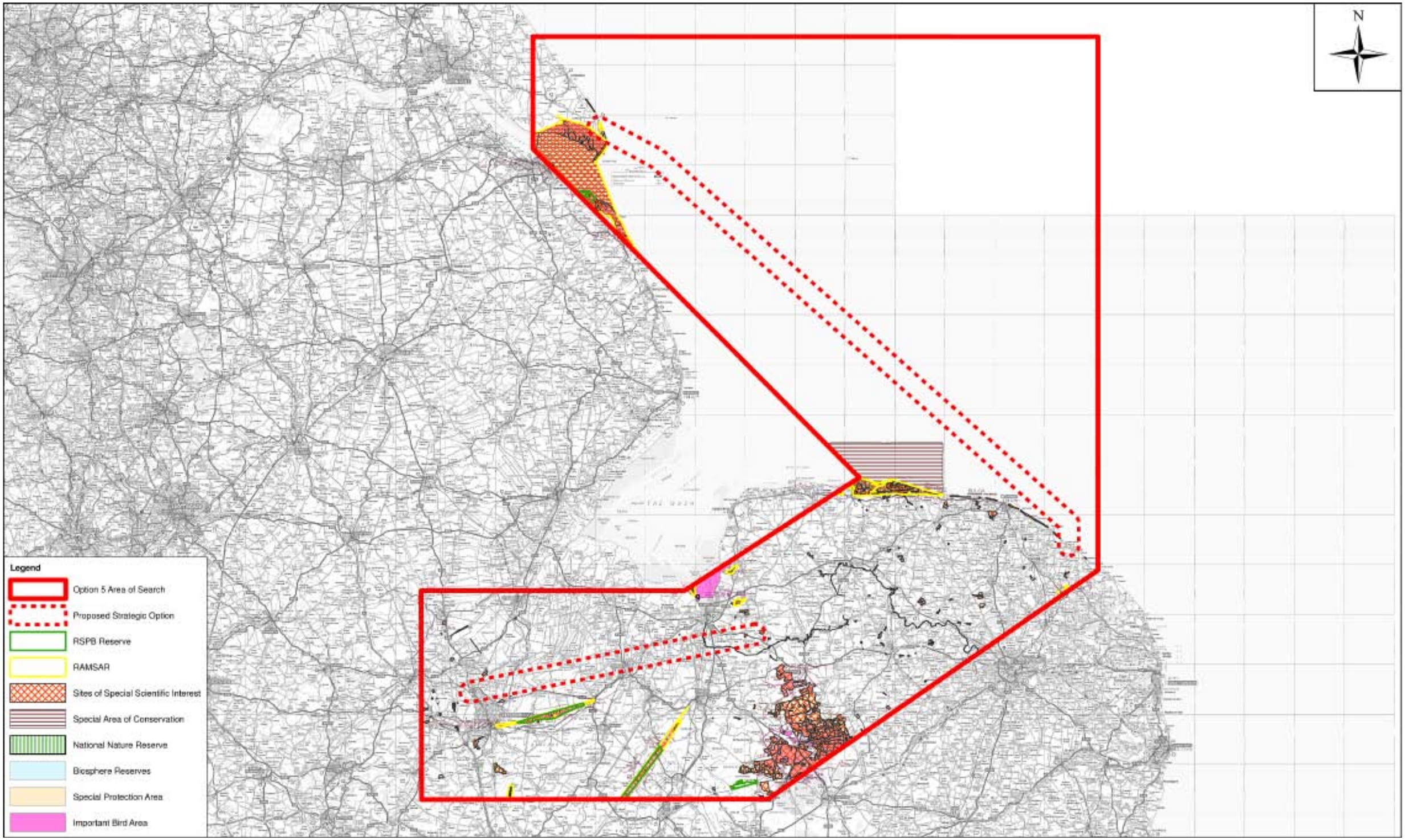
Option 4 MoD Marine Constraints

Appendix 3, Option 4 / Figure 11, Scale 1:400,000



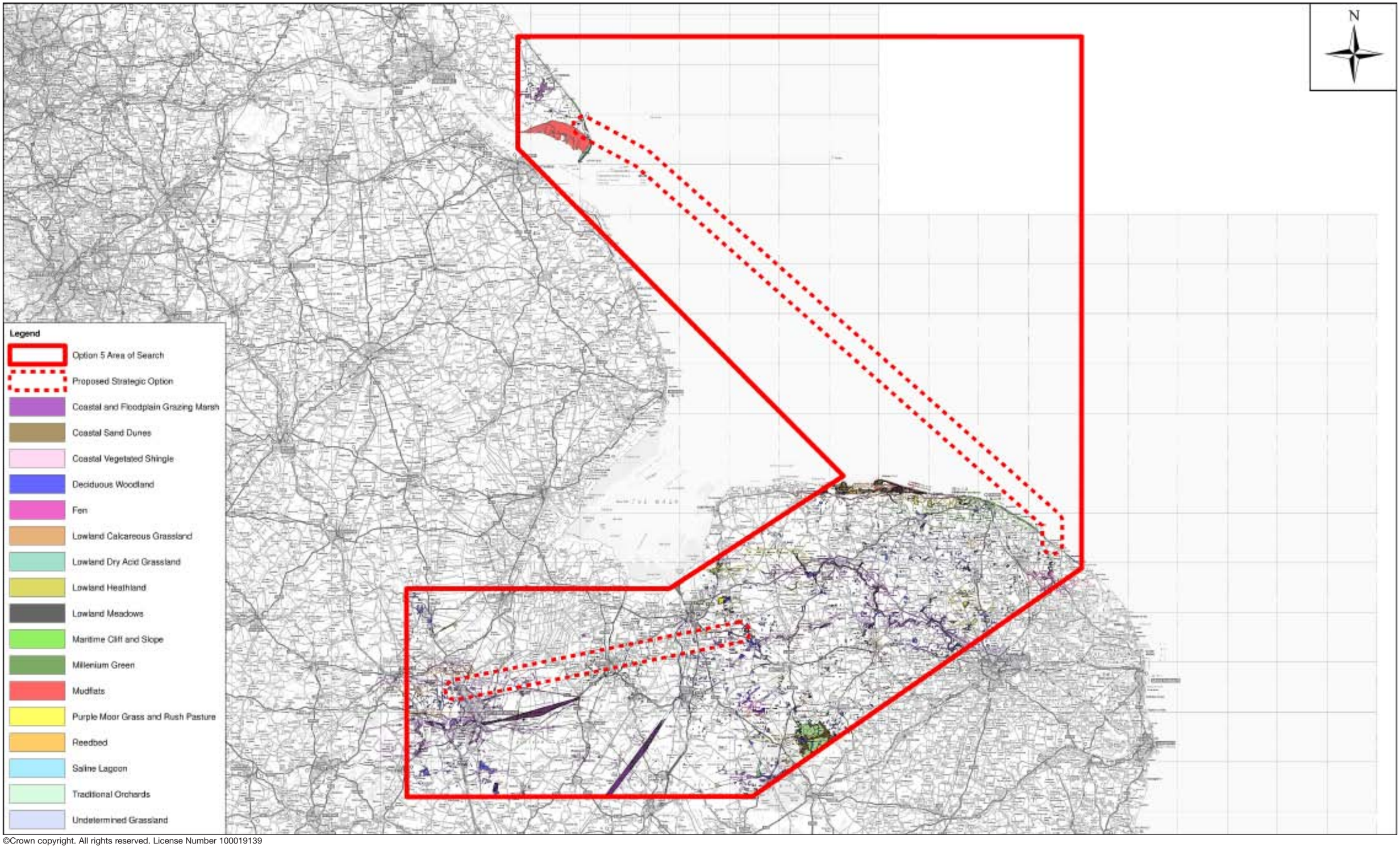
Option 5 Nature Conservation Designations and Features

Appendix 3, Option 5 / Figure 1a, Scale 1:700,000



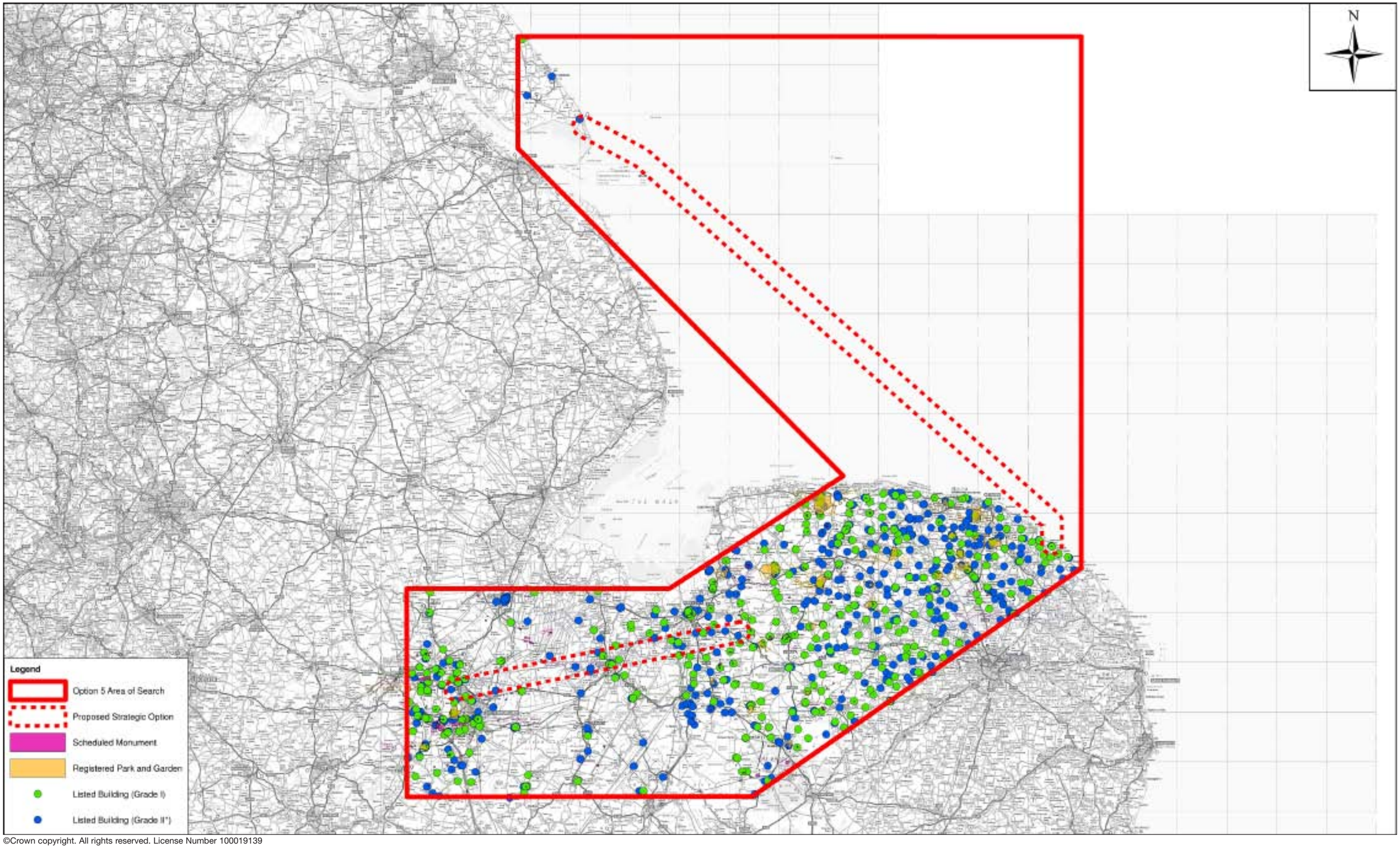
Option 5 UK Bap Priority Habitat

Appendix 3, Option 5 / Figure 1b, Scale 1:700,000



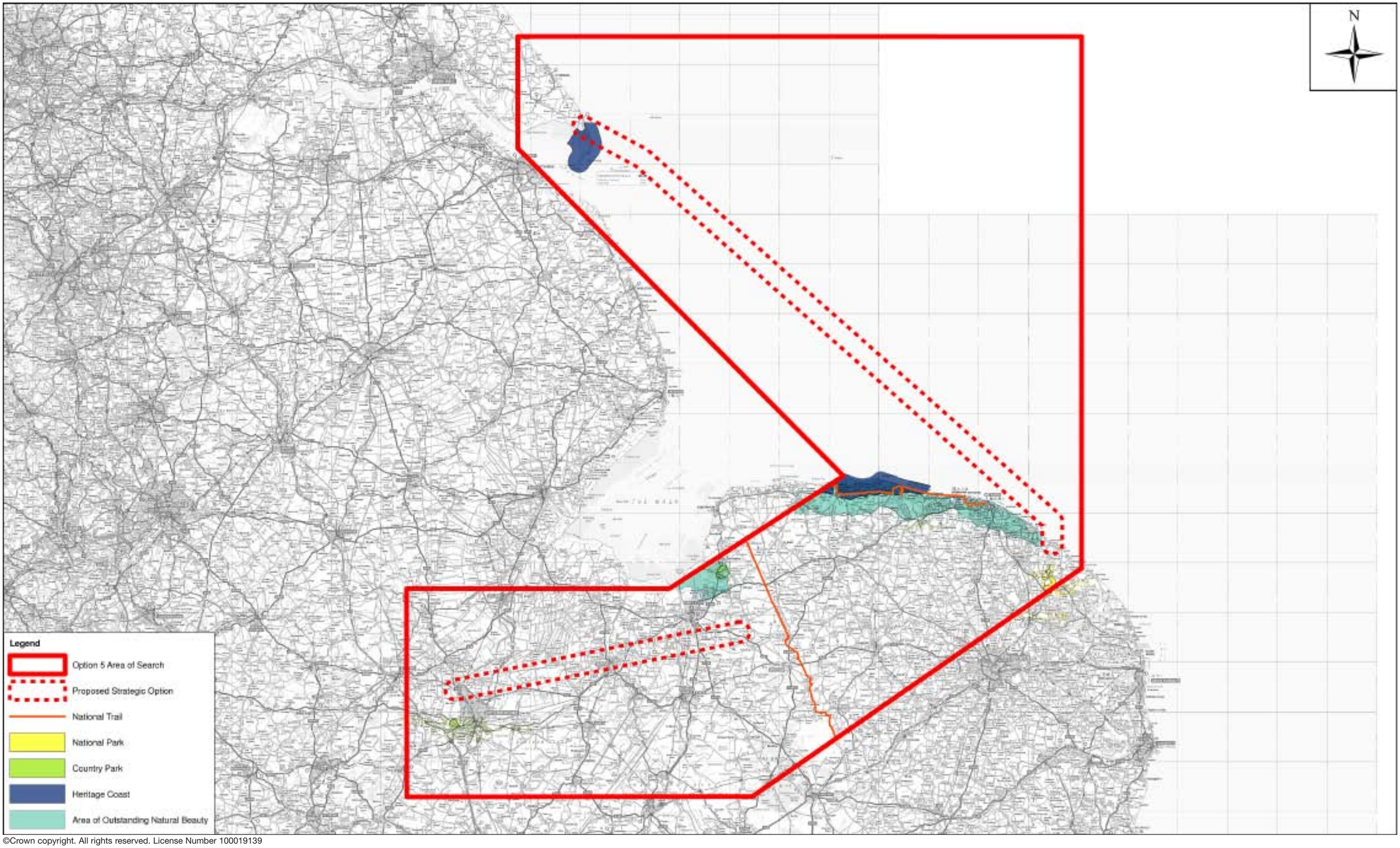
Option 5 Cultural Heritage Designations

Appendix 3, Option 5 / Figure 2, Scale 1:700,000



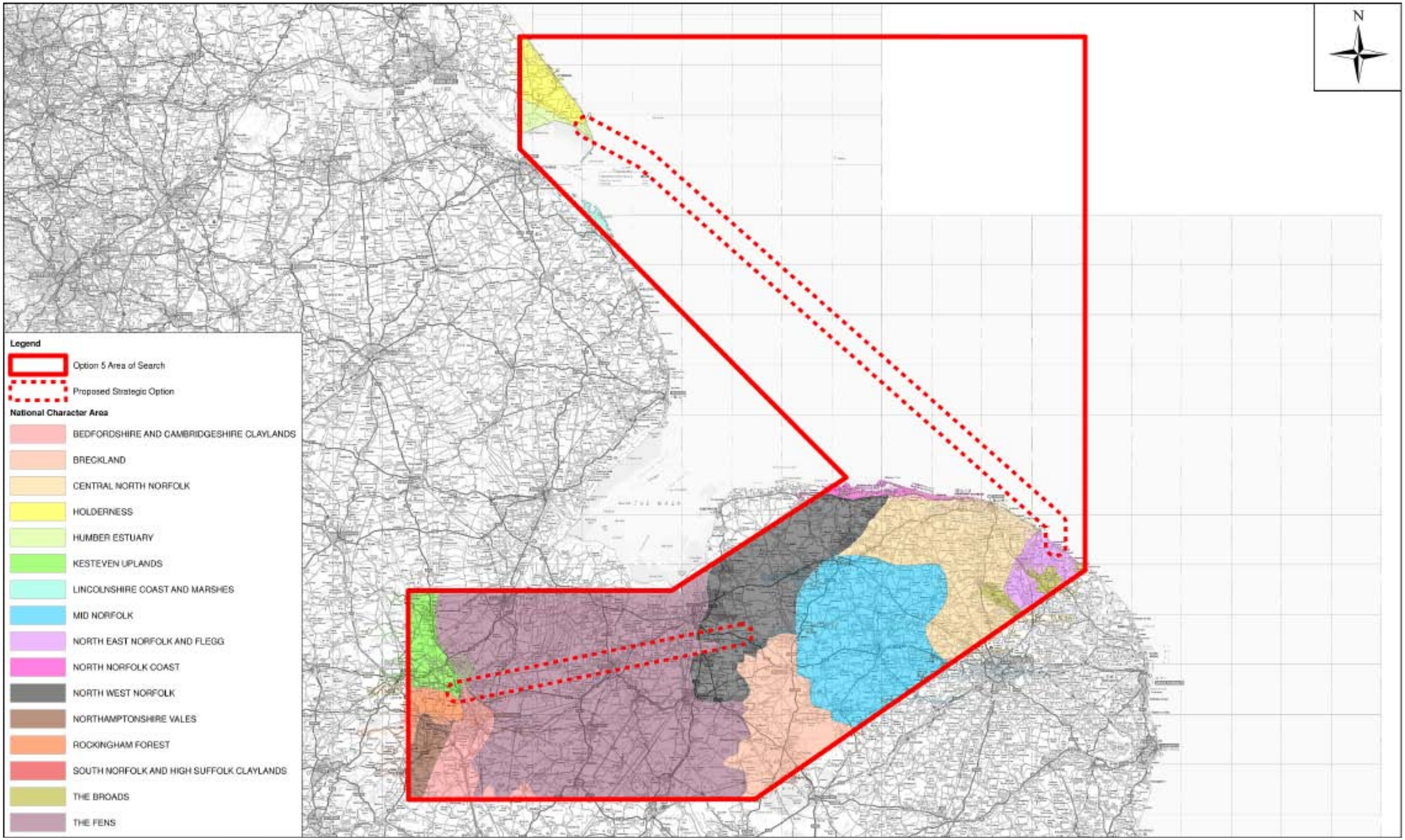
Option 5 Landscape Designations and Features

Appendix 3, Option 5 / Figure 3a, Scale 1:700,000



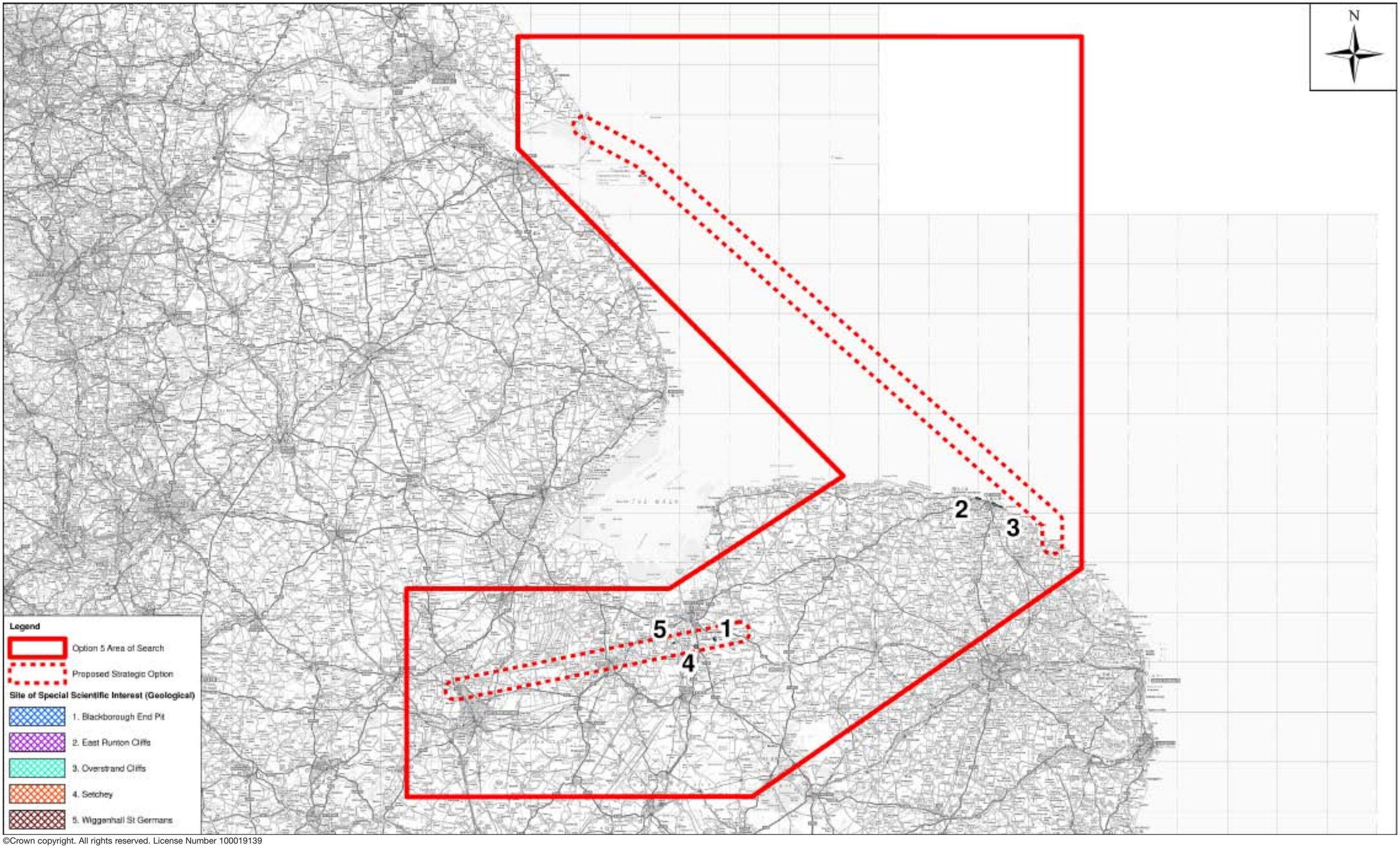
Option 5 National Character Areas

Appendix 3, Option 5 / Figure 3b, Scale 1:700,000



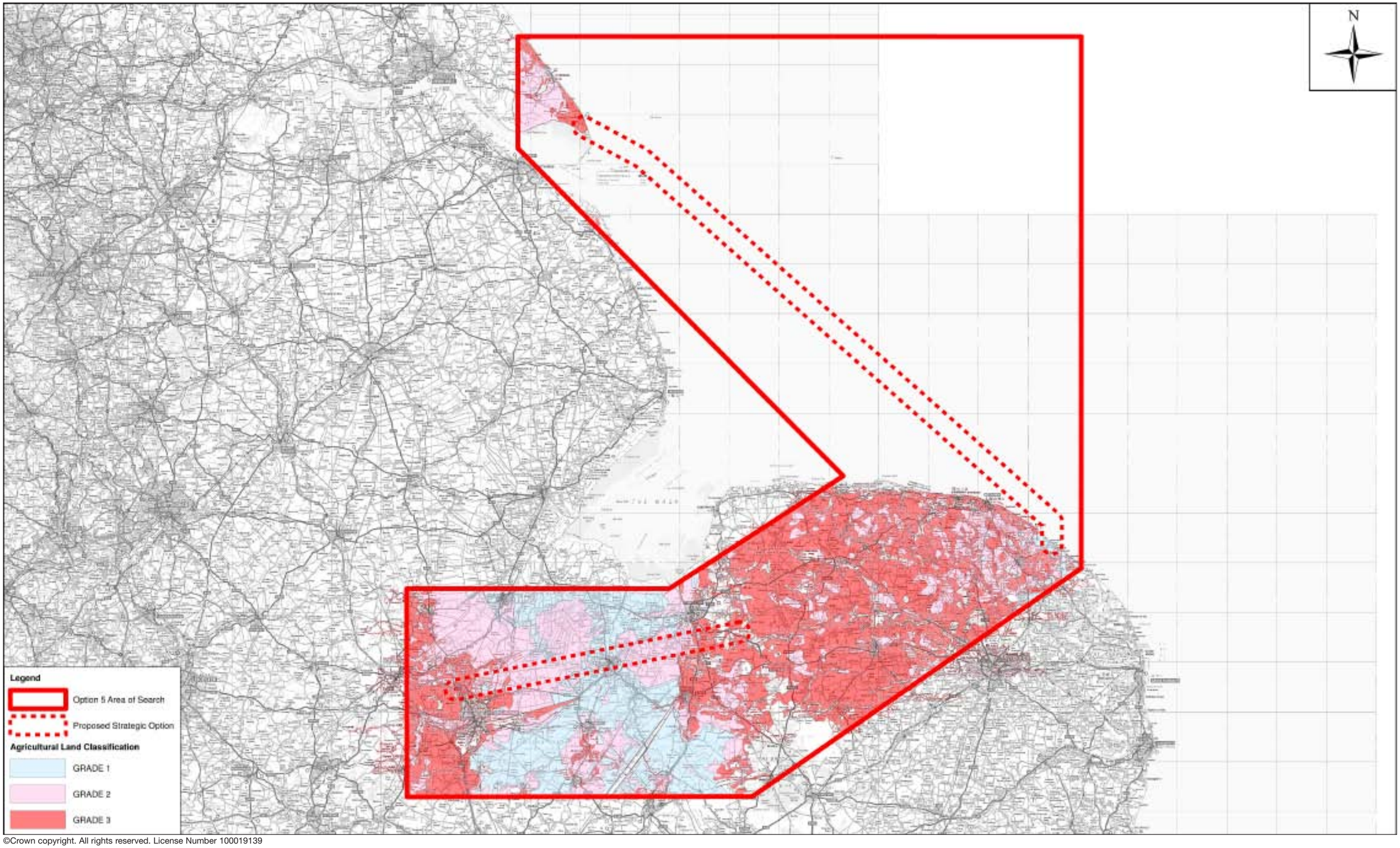
Option 5 Geological Designations

Appendix 3, Option 5 / Figure 4a, Scale 1:700,000



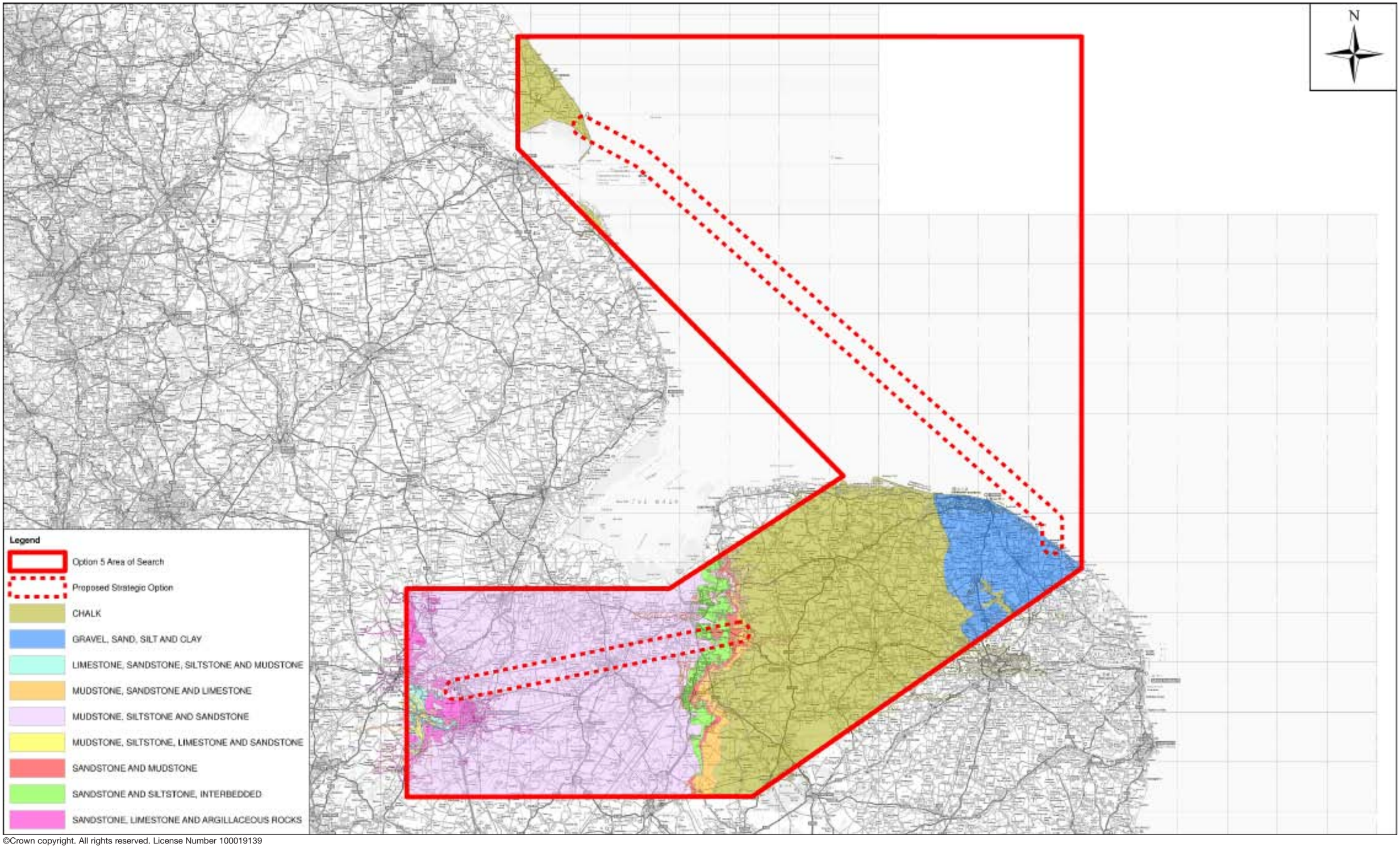
Option 5 Agricultural Land Classification

Appendix 3, Option 5 / Figure 4b, Scale 1:700,000



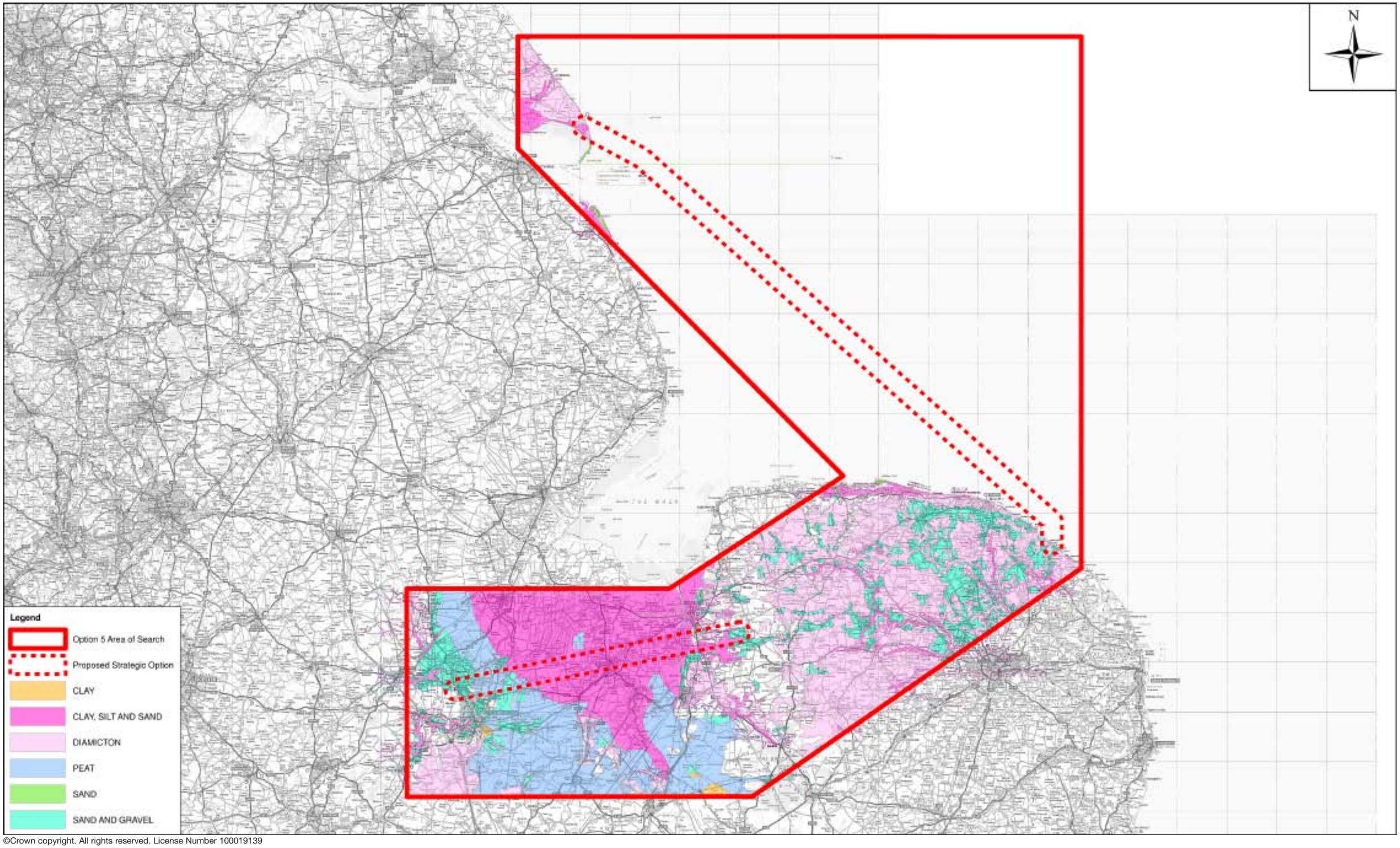
Option 5 Bedrock Geology

Appendix 3, Option 5 / Figure 4c, Scale 1:700,000



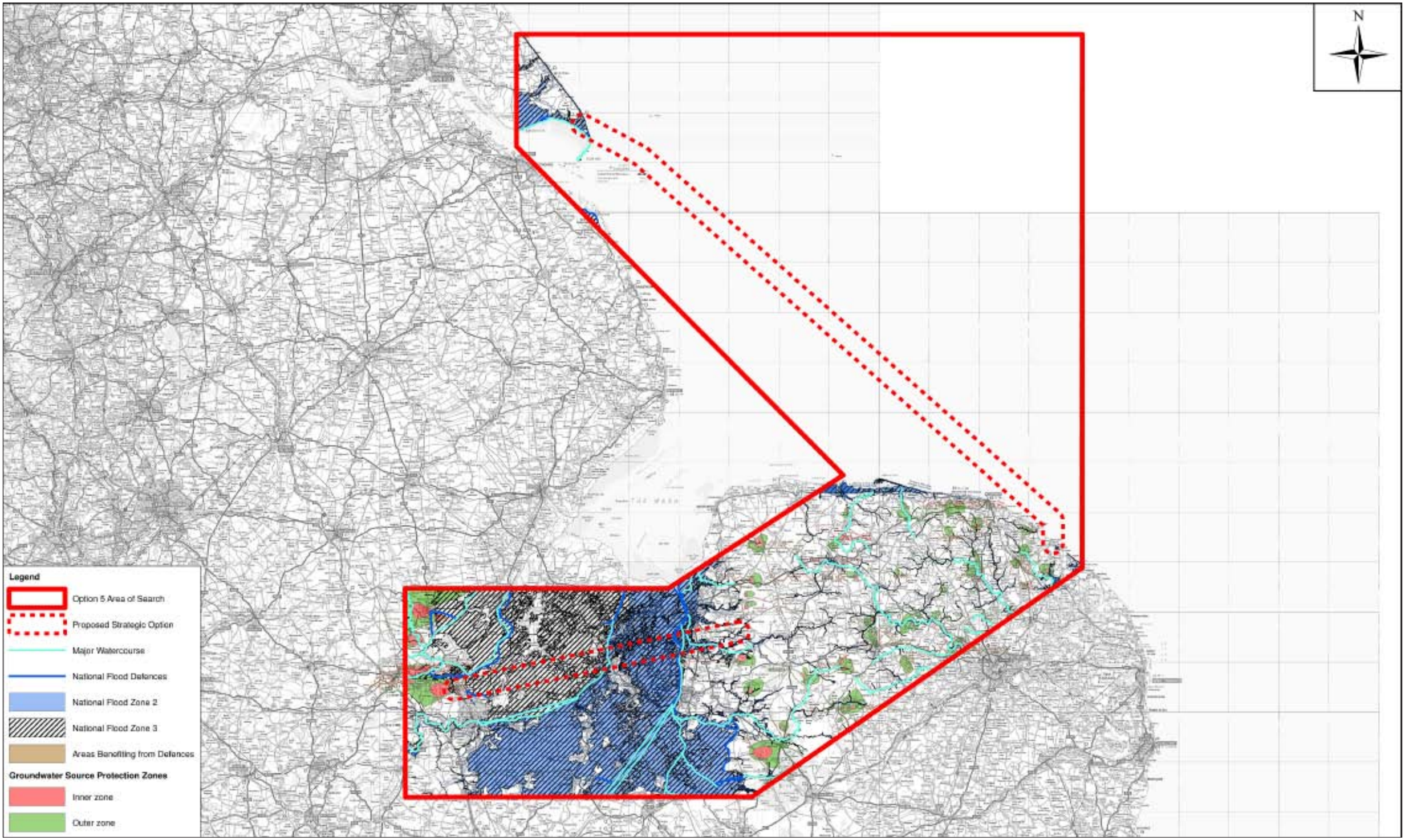
Option 5 Superficial Geology

Appendix 3, Option 5 / Figure 4d, Scale 1:700,000



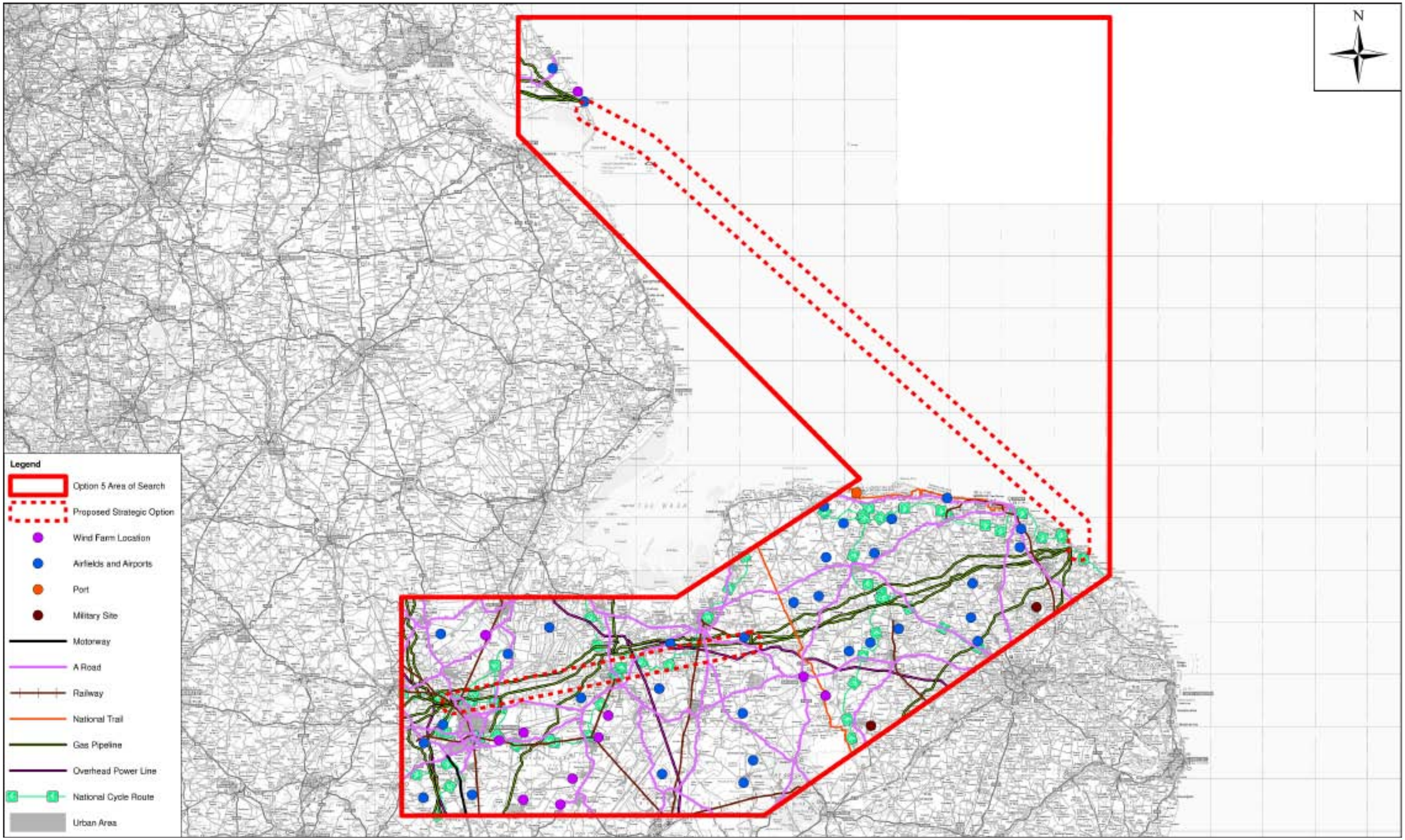
Option 5 Water Resources and Flooding

Appendix 3, Option 5 / Figure 5, Scale 1:700,000



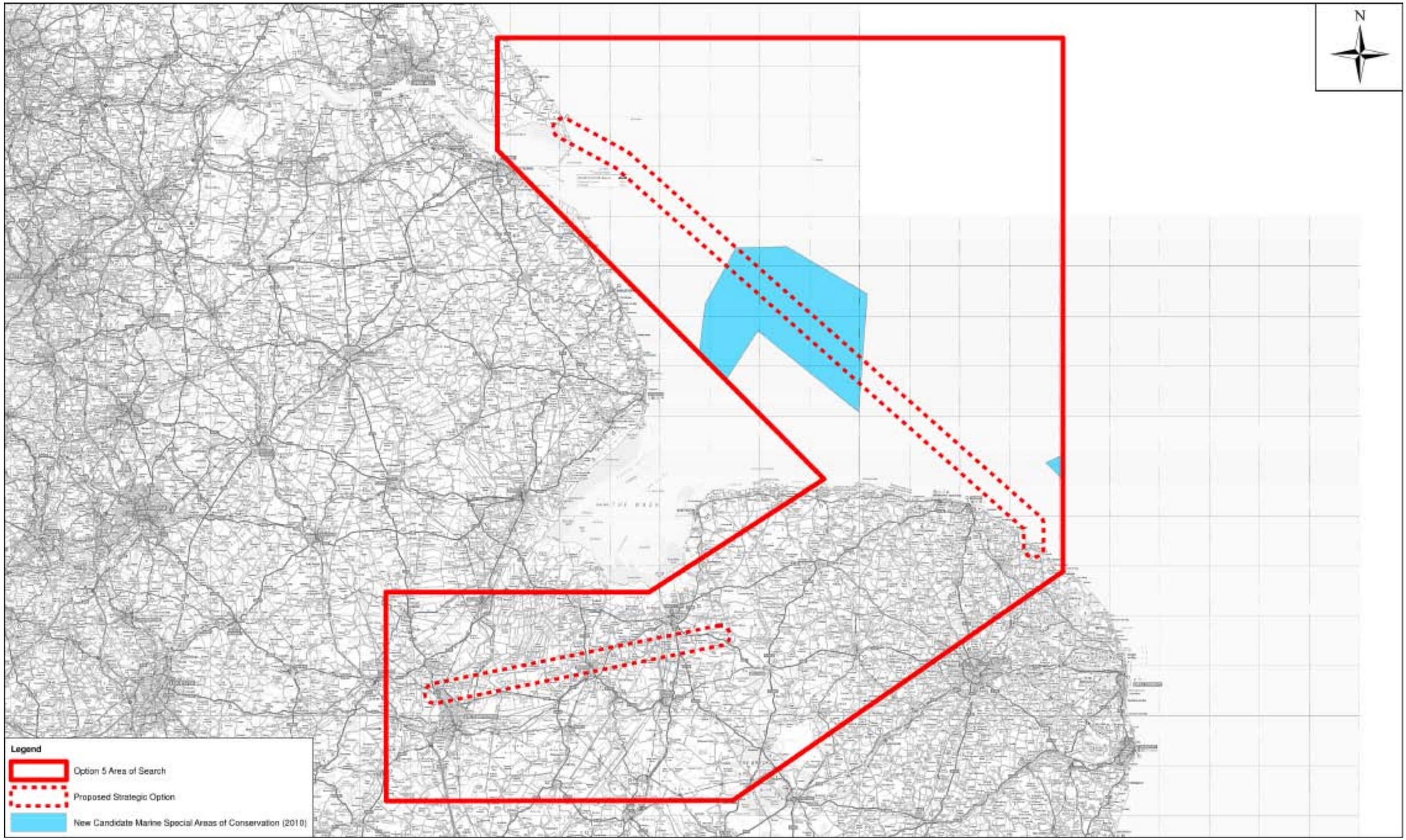
Option 5 Socio-Economic Features

Appendix 3, Option 5 / Figure 6, Scale 1:700,000



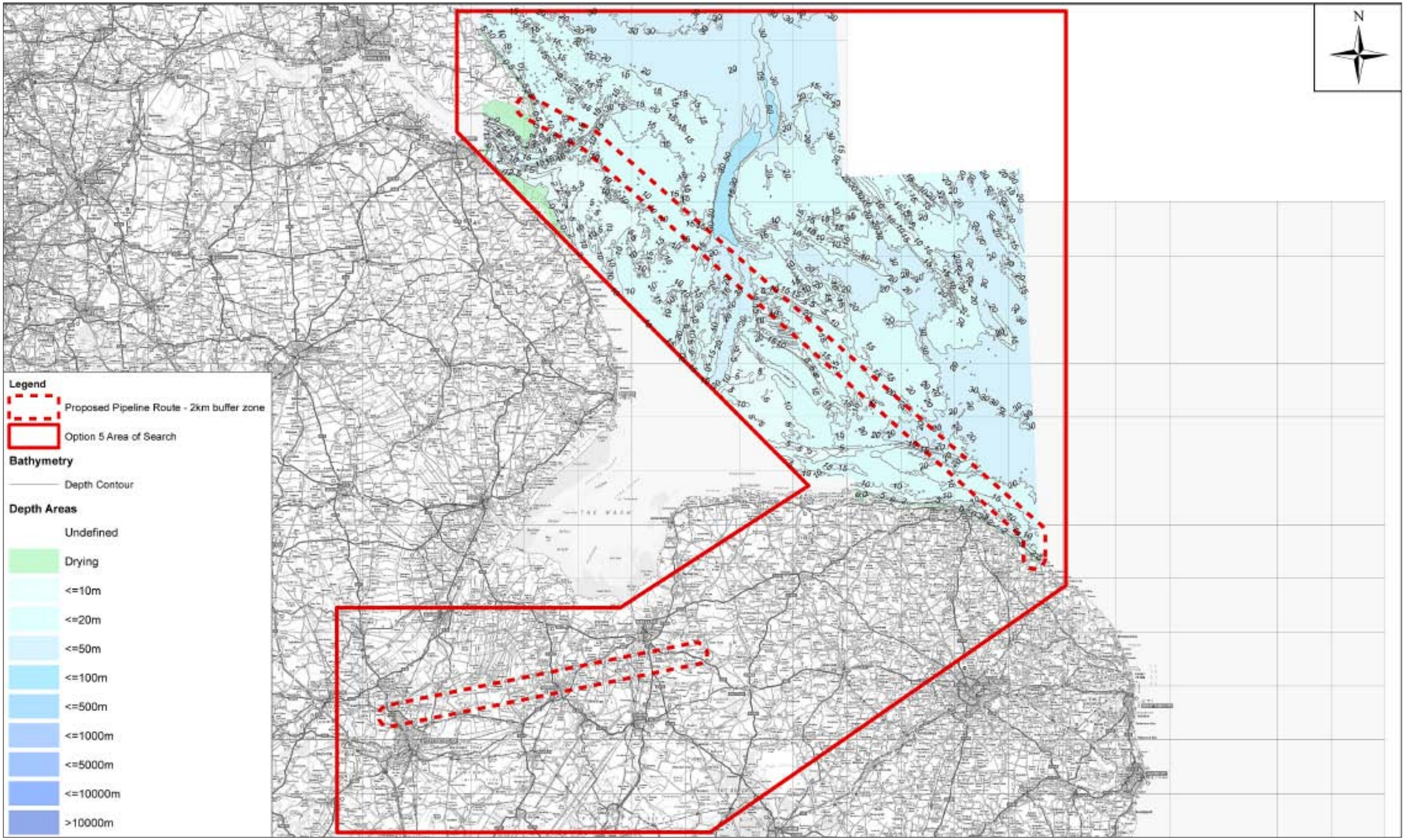
Option 5 Marine Nature Conservation Designations

Appendix 3, Option 5 / Figure 7, Scale 1:700,000



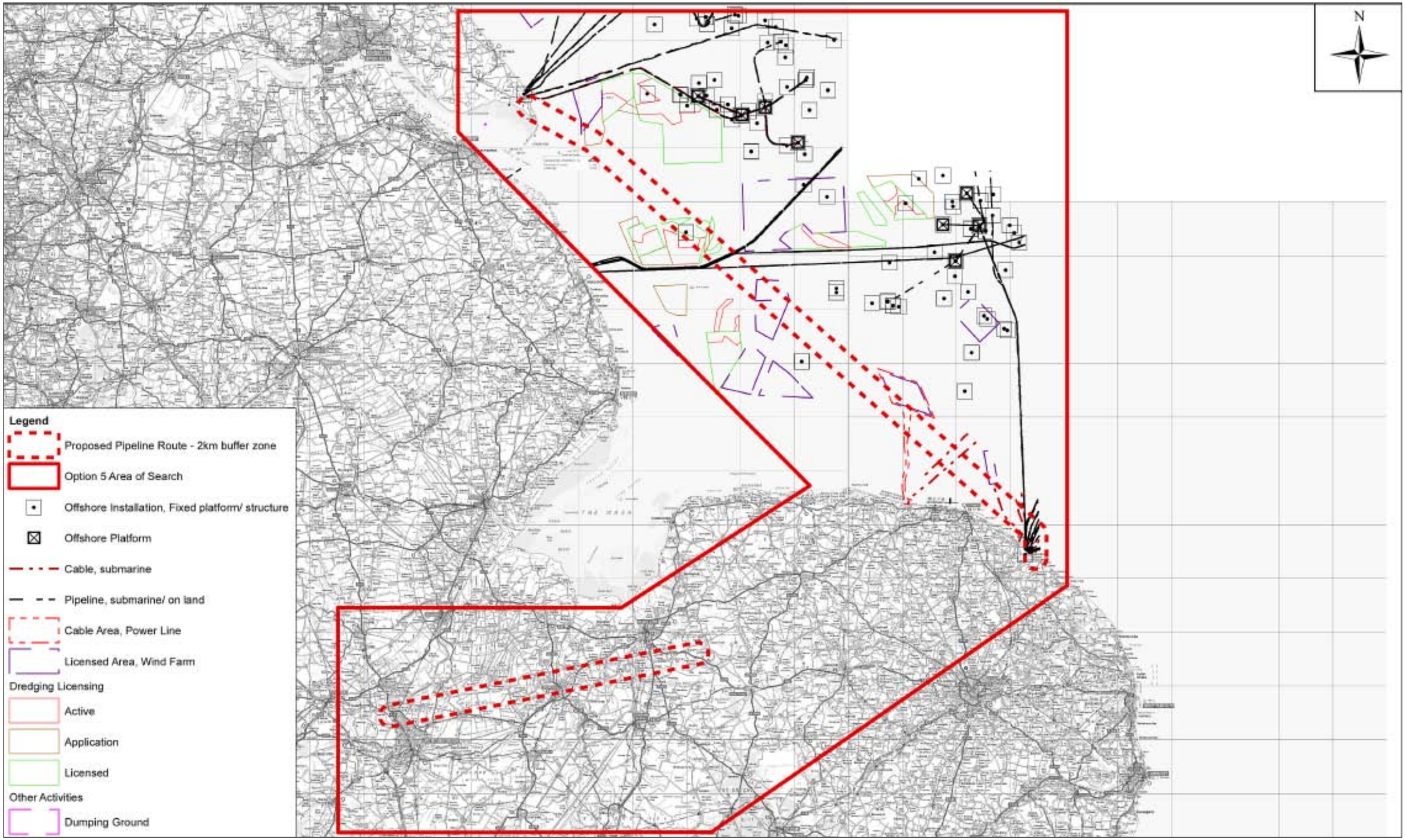
Option 5 Bathymetry and Depth Areas

Appendix 3, Option 5 / Figure 8, Scale 1:700,000



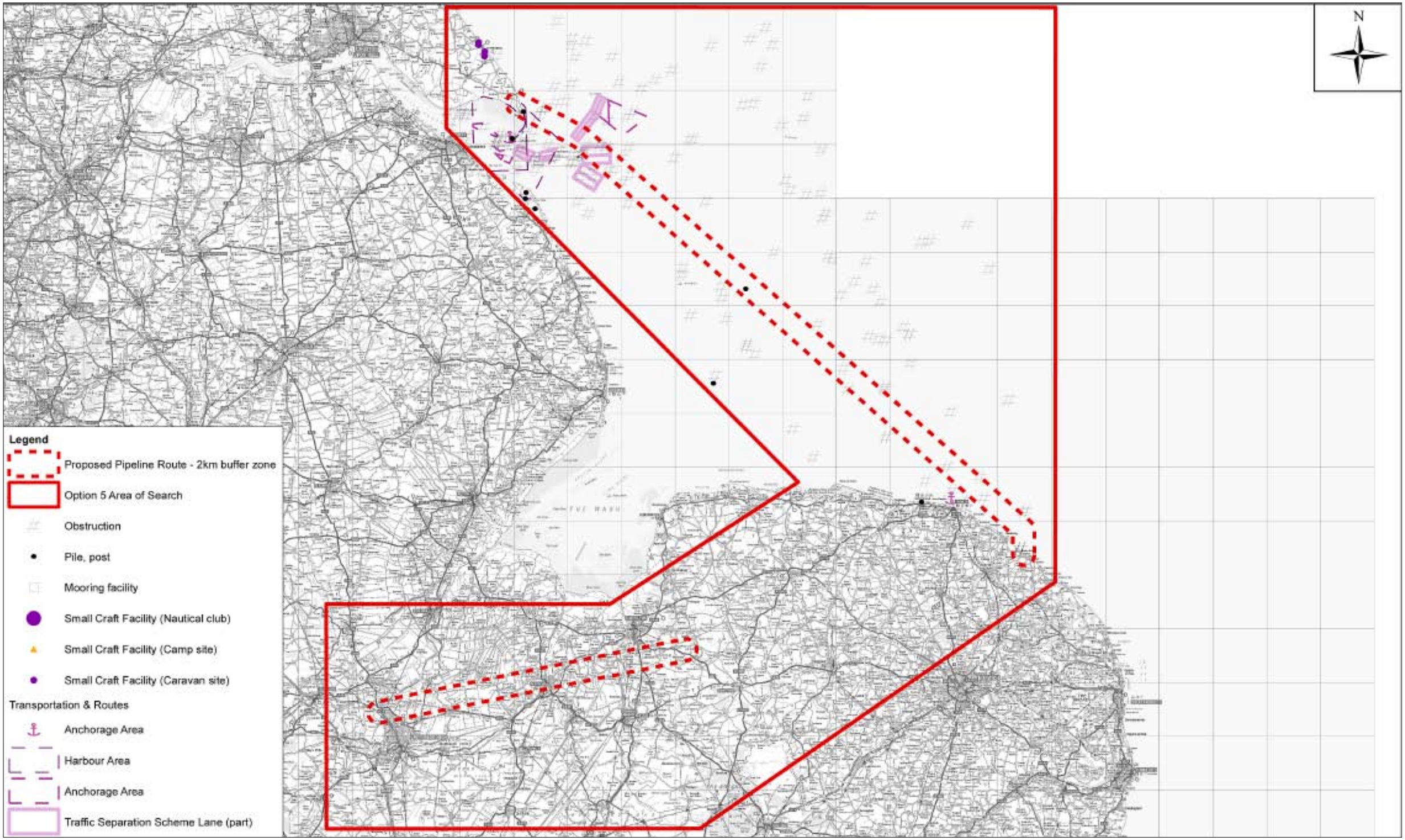
Option 5 Marine Infrastructure and Other Marine Constraints

Appendix 3, Option 5 / Figure 9, Scale 1:700,000



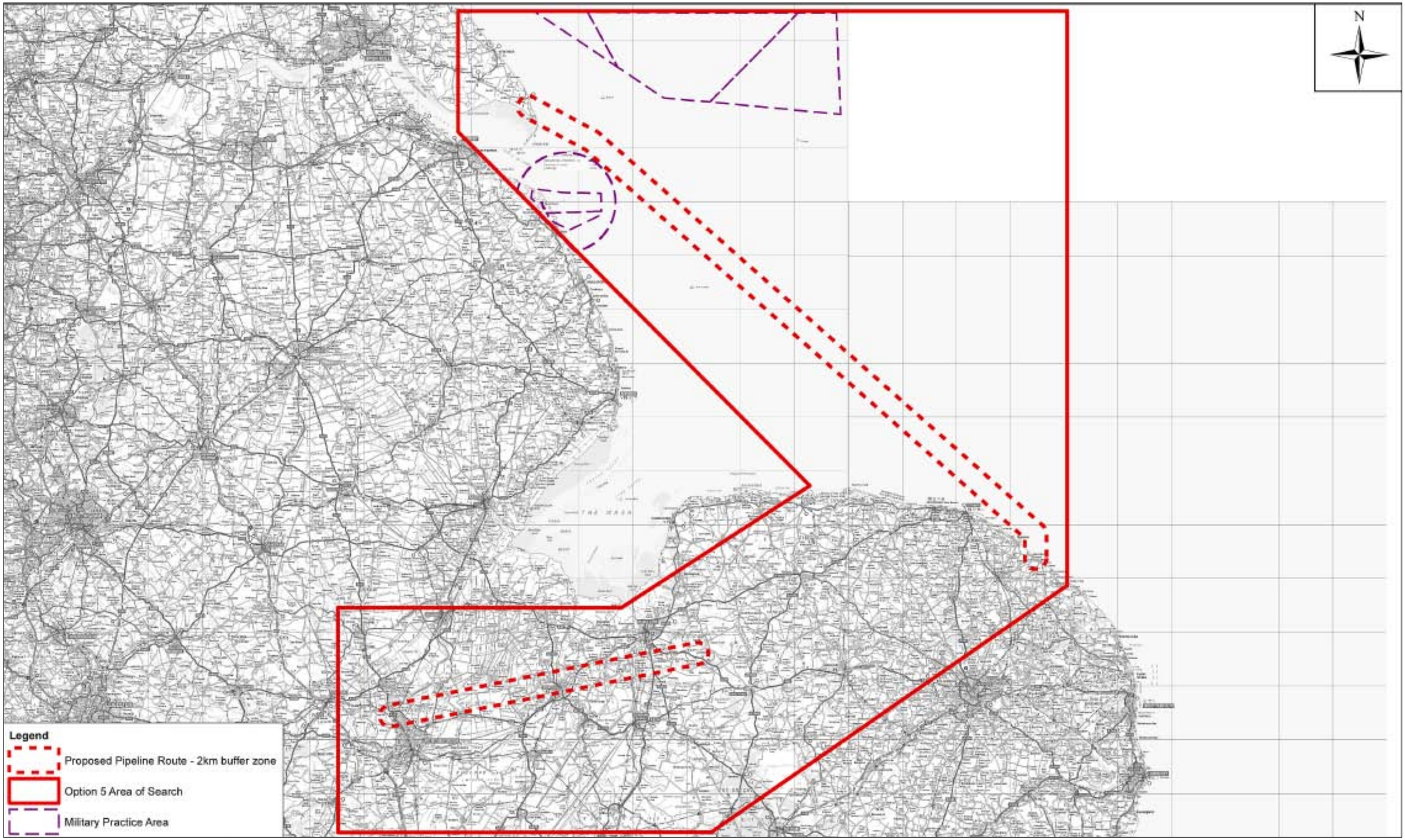
Option 5 Navigation and Shipping Constraints

Appendix 3, Option 5 / Figure 10, Scale 1:700,000



Option 5 MoD Marine Constraints

Appendix 3, Option 5 / Figure 11, Scale 1:700,000



Appendix 4 Option Appraisal Summary Tables (OASTs)

Strategic Option 1a: Direct Humber Estuary Crossing - Tunnel (6 km)

Technical	
Technical complexity	Tunnel construction is a proven technology, t and would be considered as medium- high risk in terms of technical complexity.
Construction/delivery issues	The construction technology is well established and at this stage it is not expected that there would be significant implications with regard to programme delivery.
Technology issues	Technology is a well established method used in the construction industry therefore, no issues are foreseen to cross the estuary with this method.
Capacity issues	This option delivers the existing capacity.
Network efficiencies/ benefits	N/A
Overall Technical Consideration [Optional]: This option compares relatively favourably with the other options in terms of technical issues, although not sufficiently so to be a major consideration in decision-making.	

Cost	
Capital Cost	The capital cost of this option is estimated to be 1.2 times more expensive than Option 1b (excavated trench).
Lifetime Cost	The lifetime cost for this option is estimated to be £45 million over a 40 year life. This is based upon 6 km of pipeline requiring 'PIG' trap facilities on the north and south banks of the estuary . 'PIG' traps enable in-line inspection of the pipeline to be carried out across the estuary..
Overall Cost [Optional]: The option compares favourably with the other options in terms of both Capital and Lifetime Cost, sufficiently so that this could potentially be a major consideration in the decision-making.	

Environment			
Sub Topics	**Summary potential effects (adverse and beneficial)**	**Summary mitigation and residual effects**	**Summary implications and outcome**
Landscape & Visual	The route of this option will have to pass through three NCAs, and whilst the scale and robustness of the NCA would ensure that impacts would not be significant, there will inevitably be some short-term localised adverse landscape effects due to the flat nature of the landform in each area. Settlement pattern is such that the tunnel launch and reception shafts may have the potential for short-term localised adverse visual impacts during construction.	Adverse effects upon the landscape character can be limited if key landscape features are avoided through appropriate routeing of the pipeline and siting of the tunnel launch and reception shafts.	It should be possible to avoid landscape effects during the construction period through careful siting of the tunnel launch and reception shafts and routing of the pipeline. Landscape and Visual should thus not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'Complies with the guiding principles with no substantive concern'.
Ecology	Tunnelling under the Humber Estuary has the potential to impact upon the River Humber Estuary which is of very high biodiversity value and is designated as an SPA, SAC, Ramsar, IBA and SSSI. There is the potential for impacts during the construction phase in terms of noise and vibration effects, risk of pollution and general disturbance to flora and fauna. Given the international importance of the habitat, it will be necessary to demonstrate that any scheme does not have an adverse effect on the integrity of the constituent qualifying habitats and populations (most notably birds and fish).	As this construction method has a relatively restricted development footprint associated with the tunnel launch/ reception shaft locations it should be possible to avoid direct impacts upon the statutory designated sites through careful route alignment and shaft positioning. The implementation of a buffer area (as wide as possible) between the tunnel launch/ reception shaft and the estuary designated site should mitigate disturbance effects.	At this stage it is assumed that direct impacts on statutory designated sites can be avoided. It is also assumed that indirect impacts can be mitigated. Therefore Ecology should not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'Complies with the guiding principles with no substantive concern'.

Environment			
Sub Topics	**Summary potential effects (adverse and beneficial)**	**Summary mitigation and residual effects**	**Summary implications and outcome**
Historic Environment	Tunnelling under the Humber Estuary has the potential to impact upon designated heritage assets (schedule monument and listed buildings) due to the tunnels launch and reception shafts. There is also the potential for physical and setting impacts on non-designated heritage assets or previously un-recorded sites.	It is assumed that high value designated heritage assets can be avoided through careful route alignment avoiding significant physical or setting impacts.	At this stage it is assumed that any high value designated heritage assets can be avoided. Historic Environment should not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'Complies with the guiding principles with no substantive concern'.
Other environmental issues	Tunnelling under the Humber Estuary has the potential to cause short term temporary impacts on the water environment during construction. The option also has the potential to impact flood defences. This Option is likely to generate a significant amount of spoil and other waste including non-recyclable waste during construction.	The use of the tunnelling method should reduce any impacts on the marine environment and careful siting of the launch/ reception shaftsand routing of the pipeline should minimise impacts on the flood defences. Environment Agency consent will be required for any works that impact flood defences or Main Rivers. Waste management practices will be implemented to minimise the impact where possible.	It should be possible to avoid water environment effects during the construction period through careful siting of the tunnel launch and reception shafts and routing of the pipeline. Water constraints are not likely to be a material consideration in the selection of the Preferred Strategic Option. This option should therefore be recorded as 'Complies with the guiding principles with no substantive concern'. This option is relatively waste-intensive compared with the other options. Therefore waste is considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'Complies with guiding principles, but is relatively resource- and/or waste-intensive compared with other options'.
Overall Environmental implications [Optional]: The summary environmental implications for this option are that environment issues are likely to be manageable. However, the spoil generated by the tunnel construction will be a factor to be considered in the decision-making.			

Socio-economics			
Socio-economics	Option 1a has the potential to impact upon shipping and other activities associated with the Port of Hull as well as existing onshore and offshore pipelines.=	Tunnelling construction techniques will mean that the impacts to shipping could be avoided. Potential impacts on the existing pipelines would be avoided with careful routeing.	At this stage it is assumed that impacts could be avoided therefore it is no not considered that socio-economic factors would be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'Complies with the guiding principles with no substantive concern'.
Overall Socio-economic impact [Optional]: At this stage of the process, socio economic issues can be adequately managed therefore will not be a major consideration in the decision-making.			

Strategic Option 1b: Direct Humber Estuary Crossing - Excavated Trench (6 km)

Technical	
Technical complexity	Excavated Trench construction methodology is well established and is considered to be medium risk in terms of technical complexity due to the challenging estuary conditions.
Construction/delivery issues	The technology is well established; however the challenging estuary conditions and the uncertainty over gaining approval for this method (due to the length of construction period) may have significant implications with regard to programme delivery.
Technology issues	As above.
Capacity issues	This option delivers the existing capacity.
Network efficiencies/ benefits	N/A
Overall Technical Consideration [Optional]: This option compares relatively favourably with the other options in terms of technical issues, although not sufficiently so to be a major consideration in decision-making.	

Cost	
Capital Cost	The capital cost of this option is estimated to be the lowest of all the options.
Lifetime Cost	The lifetime cost for this option is estimated to be £45 million over a 40 year life. This is based upon 6 km of pipeline requiring 'PIG' trap facilities on the north and south banks of the estuary . 'PIG' traps enable in-line inspection of the pipeline across the estuary..
Overall Cost [Optional]: The option compares favourably with the other options in terms of both Capital and Lifetime Cost. The option is recorded as having the lowest capital cost therefore cost could potentially be a major consideration in the decision-making.	

Environment			
Sub Topics	**Summary potential effects (adverse and beneficial)**	**Summary mitigation and residual effects**	**Summary implications and outcome**
Landscape & Visual	The route of this option will have to pass through three NCAs, and whilst the scale and robustness of the NCA would ensure that impacts would not be significant, there will inevitably be some short-term localised adverse landscape effects due to the flat nature of the landform in each area. Settlement pattern is such that during construction there is a potential for short-term localised adverse visual impacts.	Adverse effects upon the landscape character can be limited if key landscape features are avoided through appropriate routing of the pipeline.	It should be possible to avoid landscape effects during the construction period through careful routing of the pipeline. Landscape and Visual should thus not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'Complies with the guiding principles with no substantive concern'.
Ecology	The Humber Estuary is of very high biodiversity value and is designated as an SPA, SAC, Ramsar, IBA and SSSI. Given the international importance of the habitat, it will be necessary to demonstrate that any scheme does not have an adverse effect on the integrity of the constituent qualifying habitats and populations (most notably birds and fish). Excavating a trench across the Humber has the potential to cause construction phase impacts due to noise and vibration effects, risk of pollution and disturbance to flora and fauna.	It would not be possible to avoid direct impacts on statutory designated sites using the excavated trench method and construction phase impacts are unlikely to be readily mitigated through standard protection measures.	At this stage it is assumed that direct impacts on statutory designated sites cannot be avoided. Ecology is therefore considered to be material in the selection of the Preferred Strategic Option. This option has therefore been recorded as 'Option complies with guiding principles, but only after substantive mitigation'.

Environment			
Sub Topics	**Summary potential effects (adverse and beneficial)**	**Summary mitigation and residual effects**	**Summary implications and outcome**
Historic Environment	Option 1b an excavated trench across the Humber Estuary has the potential to impact upon designated heritage assets (a schedule monument and listed buildings). There is also the potential for physical and setting impacts on non-designated heritage assets or previously un-recorded sites.	It is assumed that high value designated heritage assets can be avoided through careful route alignment avoiding significant physical or setting impacts.	At this stage it is assumed that any high value designated heritage assets can be avoided. Historic Environment should not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'Complies with the guiding principles with no substantive concern'.
Other environmental issues	Excavating a trench through the Humber Estuary has the potential to cause short term temporary impacts on the water environment during construction. The option also has the potential to impact flood defences.	Excavating a trench across the Humber would mean it would not be possible to avoid direct impacts on the water environment. However, careful routing of the pipeline should minimise impacts on the flood defences. Environment Agency consent will be required for any works that impact flood defences or Main Rivers.	Direct impacts on the Humber Estuary cannot be avoided therefore Water constraints are considered to be material in the selection of the Preferred Strategic Option. This Option has therefore been recorded as 'Option complies with guiding principles, but only after substantive mitigation'.
Overall Environmental implications [Optional]: The summary environmental implications for this option are that whilst Landscape and Visual and Historic Environment issues will probably be manageable, there is a risk that potential impacts on the Humber Estuary and flood defences could either make the option difficult to obtain consent and/or that mitigation could increase the cost of the option. It is recognised that an alternative longer pipeline will result in a greater risk in terms of construction period and land take, and the likelihood of affecting more environmental features will increase, however, impacts on the Humber Estuary will be a factor to be considered in the decision-making.			

Socio-economics			
Socio-economics	Option 1b has the potential to impact upon shipping and other activities associated with the Port of Hull as well as existing onshore and offshore pipelines.	The excavated trench option would mean that it would not be possible to avoid impacts to shipping. However, potential impacts on the existing pipelines would be avoided with careful routeing.	As impacts on shipping would not be avoided at this stage and are likely to be significant given the length of the construction period, shipping constraints would be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'Option complies with guiding principles, but only after substantive mitigation'.
Overall Socio-economic impact [Optional]: At this stage of the process, impacts on shipping would not be avoided therefore will be a major consideration in the decision-making.			

Strategic Option 1c: Direct Humber Estuary Crossing - Horizontal Directional Drill (6 km)

Technical	
Technical complexity	HDD as a construction method for the direct Humber Estuary crossing is considered to be high risk in terms of technical complexity as the method has not been proven over this length. The method would require a cofferdam to be constructed in the estuary. This would enable the HDD to be carried out in two drills from the cofferdam. However, the risk of failure would still be high..
Construction/delivery issues	The technology has a high risk of failure due to it being unproven over this length and dependent upon strata encountered. The construction of a cofferdam in the estuary for the construction period of approximately one year would reduce the risk of failure, however there is uncertainty over gaining approval for the method due to this structure in the navigable channel. Therefore this construction method could have significant implications with regard to programme delivery.
Technology issues	The technology is available however, as mentioned above the technique is not proven over the length of the estuary.
Capacity issues	This option delivers the existing capacity.
Network efficiencies/ benefits	N/A
Overall Technical consideration [Optional]: This option compares unfavourably with the other options in terms of technical issues due to the high risk of method failure. This should be a major consideration in the decision-making.	

Cost	
Capital Cost	The capital cost of this option is estimated to be the lowest. However, because of the significant possibility of failure with HDD methods the costs of the excavated trench option have also been included. Consequently, it would be 1.5 times more expensive than Option 1b.
Lifetime Cost	The lifetime cost for this option is estimated to be £45 million over a 40 year life. This is based upon 6 km of pipeline requiring a 'PIG' trap facilities on the north and south banks of the estuary . 'PIG' traps enable in-line inspection of the pipeline to be carried out across the estuary.
Overall cost [Optional]: The option compares favourably with the other options in terms of only Capital and Lifetime Cost. However, the high risk of failure must be considered in the overall decision making process.	

Environment			
Sub Topics	**Summary potential effects (adverse and beneficial)**	**Summary mitigation and residual effects**	**Summary implications and outcome**
Landscape & Visual	The route of this option will have to pass through three NCAs, and whilst the scale and robustness of the NCA would ensure that these would not be significant, there will inevitably be some short-term localised adverse landscape effects due to the flat nature of the landform in each area. Settlement pattern is such that the HDD launch and reception pits may have the potential for short-term localised adverse visual impacts during construction.	Adverse effects upon the landscape character can be limited if key landscape features are avoided through appropriate routing of the pipeline.	It should be possible to avoid landscape effects during the construction period through careful routing of the pipeline. Landscape and Visual should thus not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'Complies with the guiding principles with no substantive concern'.

Environment			
Sub Topics	**Summary potential effects (adverse and beneficial)**	**Summary mitigation and residual effects**	**Summary implications and outcome**
Ecology	The HDD option has the potential to cause impacts during construction due to noise and vibration, pollution (from bentonite breakout) and disturbance on the Humber Estuary (high biodiversity value) which is designated as an SPA, SAC, Ramsar, IBA and SSSI. Given the international importance of the habitat, it will be necessary to demonstrate that any scheme does not have an adverse effect on the integrity of the constituent qualifying habitats and populations (most notably birds and fish).	With horizontal directional drilling, it would not be possible to avoid direct impacts on statutory designated sites as a permanent structure (cofferdam) would be required in the estuary and there is a risk from bentonite. Construction phase impacts are unlikely to be readily mitigated through standard protection measures.	Although it should be possible to avoid some effects on the designated sites due to the HDD construction methodology, the construction of a cofferdam in the estuary will mean that direct impacts on statutory designated sites cannot be completely avoided. Ecology is therefore considered to be material in the selection of the Preferred Strategic Option. This option has therefore been recorded as 'Option complies with guiding principles, but only after substantive mitigation'.
Historic Environment	HDD under the Humber Estuary has the potential to impact upon designated heritage assets (a schedule monument and listed buildings) due to the HDD rig set up and entry/exit points. There is also the potential for physical and setting impacts on non-designated heritage assets or previously un-recorded sites.	It is assumed that high value designated heritage assets can be avoided through careful route alignment avoiding significant physical or setting impacts.	At this stage it is assumed that any high value designated heritage assets can be avoided. Historic Environment should not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'Complies with the guiding principles with no substantive concern'.
Other environmental issues	The HDD option with the construction of a cofferdam in the Estuary has the potential to cause short term temporary impacts on the water environment during construction. The option also has the potential to impact flood defences.	With horizontal directional drilling, it would not be possible to avoid direct impacts on the water environment due to the construction of the cofferdam in the Estuary. However, the use of HDD and careful siting of the launch and reception pits and routing of the pipeline should minimise impacts on the flood defences. Environment Agency consent will be required for any works that impact flood defences or Main Rivers.	Although it should be possible to avoid some water environment effects during the construction period through use of the HDD construction methodology, the construction of a cofferdam in the estuary will mean that direct impacts on the Humber Estuary cannot be avoided. Therefore Water constraints are considered to be material in the selection of the Preferred Strategic Option. This Option has therefore been recorded as 'Option complies with guiding principles, but only after substantive mitigation'.
Overall Environmental implications [Optional]: The summary environmental implications for this option are that whilst Landscape and Visual and Historic Environment issues will probably be manageable, there is a risk that potential impacts on the Humber Estuary and flood defences could either make the option difficult to obtain consent and/or that mitigation could increase the cost of the option. It is recognised that an alternative longer pipeline will result in a greater risk in terms of construction period and land take, and the likelihood of affecting more environmental features will increase however, impacts on the Humber Estuary will be a factor to be considered in the decision-making.			

Socio-economics			
Socio-economics	Option 1c has the potential to impact upon shipping and other activities associated with the Port of Hull as well as existing onshore and offshore pipelines.	HDD would avoid some of the impacts upon shipping. However, due to the construction of a cofferdam in the estuary it would not be possible to avoid all the shipping impacts. Potential impacts on the existing pipelines would be avoided with careful routeing.	The construction of the cofferdam in the estuary would mean that not all of the impacts on shipping would be avoided. Therefore shipping constraints would be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'Option complies with guiding principles, but only after substantive mitigation'.
Overall Socio-economic impact [Optional]: At this stage of the process, impacts on shipping would not be avoided and wil therefore will be a major consideration in the decision-making.			

Strategic Option 2: Onshore - Paull to Kirmington including twin pipelines, single pipeline, tie to Feeders 9 and 22 and compression (190 km)

Technical	
Technical Complexity	The construction methods used to install this option are well founded and are considered to be low risk in terms of technical complexity.
Construction/Delivery issues	The technology is well established, straightforward to install and maintain and would not therefore be expected to have significant implications with regard to programme delivery.
Technology Issues	The compressor station will require on-going maintenance throughout its lifetime (approximately 40 years).
Capacity Issues	This option would increase the existing capacity.
Network Efficiencies/ Benefits	N/A
Overall Technical Consideration [Optional]: This option compares relatively favourably with the other options in terms of technical issues. However, the installation of a compressor station would mean that this would be a consideration in the decision-making.	

Cost	
Capital Cost	The capital cost of this option is estimated to be 4.2 times more expensive than option 1b (excavated trench).
Lifetime Cost	The lifetime cost for this option is estimated to be £122 million over a 40 year life. This is based upon 190 km of pipeline requiring four PIGs trap facilities and the installation of one compressor station.
Overall Cost [Optional]: The option compares unfavourably with the other options in terms of both capital and lifetime cost, sufficiently so that this could potentially be a major consideration in the decision-making.	

Environment			
Sub Topics	**Summary Potential Effects (Adverse and Beneficial)**	**Summary Mitigation and Residual Effects**	**Summary Implications and Outcome**
Landscape & Visual	The route of this option will have to pass through eight NCAs, and whilst the scale and robustness of the NCAs would ensure that these impacts would not be significant, there will inevitably be some short-term localised adverse landscape effects due to the flat nature of the landform over the majority of the study area. The route is also likely to affect a National Trail and national cycle routes during construction. Settlement pattern is such that there is a potential for short-term localised adverse visual impacts during construction. The compressor station associated with this option will also potentially cause operational effects on landscape character and visual amenity.	Adverse landscape and visual effects can be limited if key landscape features are avoided through appropriate routeing of the pipeline and siting and design of the compressor station. The implementation of mitigation measures should also be able to minimise visual effects experienced by users of the national trail, national cycle routes and residents along the affected route.	It should be possible to avoid landscape effects during the construction period through careful routeing of the pipeline. However, due to the potential operational effects on landscape and visual from the construction of the compressor station, Landscape and Visual should be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles, but only after substantive mitigation'.
Ecology	The onshore Option 2 has the potential to impact the Humber Estuary which is designated as an SPA, SAC, Ramsar, IBA and SSSI. It also has the potential to impact 8 SSSIs and an RSPB reserve. These impacts will be during the construction phase due to noise and vibration, risk of pollution and disturbance. Given the international importance of the Humber Estuary habitat, it will be necessary to demonstrate that any scheme does not have an adverse effect on the integrity of the constituent qualifying habitats and populations (most notably birds and fish).	With careful route alignment and suitable construction techniques under the Humber Estuary (i.e. non open cut techniques), it should be possible to avoid impacts.	At this stage it is assumed that impacts on ecological sites can be avoided through careful routeing or use of appropriate construction methods, therefore Ecological constraints would not be considered material in the selection of the Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.
Historic Environment	This option has the potential to impact upon 16 scheduled Monuments, 29 listed buildings and 2 Registered Parks and Garden. There is also the potential for physical and setting impacts on non-designated heritage assets or previously un-recorded sites.	It is assumed that high value designated heritage assets can be avoided through careful route alignment avoiding significant physical or setting impacts.	At this stage it is assumed that any high value designated heritage assets can be avoided. Historic Environment should not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.
Other Environmental Issues	This option has the potential to impact one geological SSSI. There is also the potential to effect flood defences, watercourses and Source Protection Zones. As this option involves the construction and operation of a compressor station it is likely that there will be effects on air quality receptors as a result of compressor station emissions and impacts due to noise.	Potential impacts to geological SSSIs may be avoided by careful routeing of the pipeline. Watercourses and flood defences will be avoided where possible. However, there are well developed techniques that can be applied to avoid, minimise and reduce adverse impacts. At this stage it should be possible to avoid Source Protection Zones. It should be possible to avoid significant air quality and noise impacts through careful siting and design of the compressor station and regular monitoring and maintenance.	At this stage it is assumed that identified receptors can be avoided. However due to the compressor station, air quality and noise should be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles, but only after substantive mitigation'.
Overall Environmental Implications [Optional]: The summary environmental implications for this option are that whilst Ecological and Historic Environment issues will probably be manageable, there is a risk of potential impacts upon Landscape and Visual, Noise and Air Quality receptors due to the construction of the compressor station. This pipeline route is also substantially longer than options 1a, 1b and 1c and it is recognised that a longer pipeline will result in a greater risk in terms of construction period and land take, and the likelihood of affecting more environmental features will increase. Therefore, the construction of the compressor station and the length of the pipeline is likely to be a factor to be considered in the decision-making.			

Socio-economics			
Socio-economics	This option has the potential to impact upon existing pipelines and overhead powerlines, national cycle routes and a National Trail.	Potential impacts could be avoided with careful routeing and design.	It is not considered that socio-economic factors will be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.
Overall Socio-economic Impact [Optional]: At this stage of the process, socio economic issues can be adequately managed and therefore will not be a major consideration in the decision-making.			

Strategic Option 3: Onshore (no compression) - Pipelines routed around Hull to Asselby and Keadby and tie to Feeders 9 and 22 (250 km)

Technical	
Technical Complexity	The construction methods used to install this option are well founded and are considered to be low risk in terms of technical complexity.
Construction/Delivery issues	The technology is well established, straightforward to install and maintain and would not therefore be expected to have significant implications with regard to programme delivery.
Technology Issues	As above
Capacity Issues	This option would increase the existing capacity.
Network Efficiencies/ Benefits	N/A
Overall Technical Consideration [Optional]: This option compares relatively favourably with the other options in terms of technical issues, although not sufficiently so to be a major consideration in decision-making.	

Cost	
Capital Cost	The capital cost of this option is estimated to be 4.1 times more expensive than option 1b (excavated trench).
Lifetime Cost	The lifetime cost for this option is estimated to be £92 million over a 40 year life. This is based upon 250 km of pipeline requiring eight PIGs trap facilities.
Overall Cost [Optional]: The option compares unfavourably with the other options in terms of both capital and lifetime cost, sufficiently so that this could potentially be a major consideration in the decision-making.	

Environment			
Sub Topics	**Summary Potential Effects (Adverse and Beneficial)**	**Summary Mitigation and Residual Effects**	**Summary Implications and Outcome**
Landscape & Visual	The route of this option will have to pass through eight NCAs, and whilst the scale and robustness of the NCAs would ensure that the impacts would not be significant, there will inevitably be some short-term localised adverse landscape effects due to the flat nature of the landform over the majority of the study area. The route is also likely to affect a National Trail and national cycle routes during construction. Settlement pattern is such that there is a potential for short-term localised adverse visual impacts during construction.	Adverse landscape and visual effects can be limited if key landscape features are avoided by appropriate routeing of the pipeline through suitable topography. The implementation of mitigation measures should also be able to minimise visual effects experienced by users of the National Trail and cycle routes and residents along the affected route.	It should be possible to avoid landscape effects during the construction period through careful routeing of the pipeline. Landscape and Visual should thus not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.
Ecology	The onshore Option 3 has the potential to impact the Humber Estuary which is designated as an SPA, SAC, Ramsar, IBA and SSSI, 13 other SSSIs and an RSPB reserve during the construction phase due to noise and vibration, pollution and disturbance. Given the international importance of the habitat, it will be necessary to demonstrate that any scheme does not have an adverse effect on the integrity of the constituent qualifying habitats and populations (most notably birds and fish).	With careful route alignment and suitable construction techniques under the Humber Estuary (i.e. non open cut techniques), it should be possible to avoid direct impacts on ecological sites.	At this stage it is assumed that impacts on ecological sites can be avoided through careful routeing or use of appropriate construction methods, therefore Ecological constraints would not be considered material in the selection of this as the Preferred Strategic Option at this stage. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.

Environment			
Sub Topics	**Summary Potential Effects (Adverse and Beneficial)**	**Summary Mitigation and Residual Effects**	**Summary Implications and Outcome**
Historic Environment	This option has the potential to impact upon 51 Scheduled Monuments and 72 listed buildings. There is also the potential for physical and setting impacts on non-designated heritage assets or previously un-recorded sites.	It is assumed that high value designated heritage assets can be avoided through careful route alignment avoiding significant physical or setting impacts.	At this stage it is assumed that any high value designated heritage assets can be avoided. Historic Environment should not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.
Other Environmental Issues	This option has the potential to impact four geological SSSIs. There is also the potential to effect flood defences, watercourses and Source Protection Zones.	Potential impacts to geological SSSIs may be avoided by careful routeing of the pipeline. Watercourses and flood defences should be avoided where possible. However, there are well developed techniques that can be applied to avoid, minimise and reduce adverse impacts. At this stage it should be possible to avoid Source Protection Zones.	At this stage it is assumed that receptors can be avoided. Therefore other environmental issues should not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.
Overall Environmental Implications [Optional]: The summary environmental implications for this option are that environmental issues will likely be manageable. However it is recognised that longer pipelines will result in a greater risk in terms of construction period and land take, and the likelihood of affecting more environmental features as this pipeline route is substantially longer than options 1a, 1b and 1c. It is likely that the length of the pipeline will be a factor to be considered in the decision-making.			

Socio-economics			
Socio-economics	This Option has the potential to impact upon existing pipelines and overhead powerlines, a national cycle route and a National Trail.	Potential impacts could be avoided with careful routeing and design.	It is not considered that socio-economic factors will be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.
Overall Socio-economic Impact [Optional]: At this stage of the process, socio economic issues can be adequately managed therefore will not be a major consideration in the decision-making.			

Strategic Option 4: Offshore - Pipeline between Easington and Theddlethorpe, onshore pipeline between Theddlethorpe to Hatton and Compression (85 km)

Technical	
Technical Complexity	The construction methods used to install this option are well founded, however the offshore aspect would be new to National Grid and therefore external expertise would need to be sought. The construction method is considered to be low risk in terms of technical complexity.
Construction/Delivery issues	The technology is well established and straightforward to install and maintain. The offshore aspects may be seasonal/ weather dependent. However at this stage it is not expected that the construction method would have significant implications with regard to programme delivery.
Technology Issues	The compressor station will require on-going maintenance through-out its lifetime (approximately 40 years).
Capacity Issues	This option would increase the existing capacity.
Network Efficiencies/ Benefits	N/A
Overall Technical Consideration [Optional]: This option compares relatively favourably with the other options in terms of technical issues; however the installation of a compressor station would mean that this would be a consideration in the decision-making.	

Cost	
Capital Cost	The capital cost of this option is estimated to be 3.1 times more expensive than option 1b (excavated trench).
Lifetime Cost	The lifetime cost for this option is estimated to be £102 million over a 40 year life. This is based upon 85 km of pipeline requiring two PIG trap facilities and the installation and the life time cost of maintenance of one compressor station.
Overall Cost [Optional]: The option compares unfavourably with the other options in terms of both capital and lifetime cost, sufficiently so that this could potentially be a major consideration in the decision-making.	

Environment			
Sub Topics	**Summary Potential Effects (Adverse and Beneficial)**	**Summary Mitigation and Residual Effects**	**Summary Implications and Outcome**
Landscape & Visual	This option has the potential to impact upon two nationally designated landscapes: the Lincolnshire Wolds AONB and the Spurn Heritage Coast. The route of this option will also potentially have to pass through five NCAs, and whilst the scale and robustness of the NCAs would ensure that impacts would not be significant, there will inevitably be some short-term localised adverse landscape effects due to the flat nature of the landform over the majority of the study area. The settlement pattern is such that there is a potential for short-term localised adverse visual impacts during construction. The compressor associated with this option will also potentially cause operational effects on landscape character and visual amenity.	Adverse landscape and visual effects can be limited if key landscape features are avoided by appropriate routeing of the pipeline through suitable topography where this is applicable and careful siting and design of the compressor station. The Lincolnshire Wolds AONB can be avoided, however it should be noted that this would require a considerable re-route which would also cause landscape impacts. As impacts are likely to be limited to the construction phase, and with the implementation of appropriate mitigation to avoid permanent scarring of the landscape, it is likely that the pipeline could be routed through the AONB. Impacts on the Spurn Heritage Coast could be avoided by routeing the pipeline to make landfall north of the Heritage Coastline.	It should be possible to avoid landscape effects through careful routeing of the pipeline and the implementation of appropriate mitigation measures in the AONB. However, due to the potential effects on the AONB and the operational effects associated with the construction of the compressor station Landscape and Visual should be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles, but only after substantive mitigation'.

Environment			
Sub Topics	**Summary Potential Effects (Adverse and Beneficial)**	**Summary Mitigation and Residual Effects**	**Summary Implications and Outcome**
Ecology	The offshore option 4 has the potential to impact the Humber Estuary which is designated as an SPA, SAC, Ramsar, IBA and SSSI, the Saltfleetby-Theddlethorpe Dunes & Gibraltar Point SAC, 8 SSSIs and 2 NNRs during the construction phase due to noise and vibration, pollution and disturbance to birds and marine life (e.g. River Lamprey) associated with the designated sites using habitat outside of the designated area. Given the international importance of the Humber Estuary and the Saltfleetby-Theddlethorpe Dunes & Gibraltar Point SAC habitats, it will be necessary to demonstrate that any scheme does not have an adverse effect on the integrity of the constituent qualifying habitats and populations (most notably birds and fish).	With careful route alignment, it should be possible to avoid direct impacts on statutory designated sites. Standard mitigation measures should also reduce impacts on qualifying features outside the designated sites.	At this stage it is assumed that impacts on ecological sites can be avoided through careful routeing or use of appropriate construction techniques, therefore Ecological constraints would not be considered material in the selection of this as the Preferred Strategic Option at this stage. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.
Historic Environment	This option has the potential to impact upon 20 Scheduled Monuments and 15 listed buildings. There is also the potential for physical and setting impacts on non-designated heritage assets or previously un-recorded sites.	It is assumed that high value designated heritage assets can be avoided through careful route alignment avoiding significant physical or setting impacts.	At this stage it is assumed that any high value designated heritage assets can be avoided. Historic Environment should not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.
Other Environmental Issues	This option has the potential to impact one geological SSSI. There is also the potential to effect flood defences, watercourses and Source Protection Zones. As this option involves the construction and operation of a compressor station it is likely that there will be effects on air quality receptors as a result of compressor station emissions and impacts due to noise.	Potential impacts to geological SSSIs may be avoided by careful routeing of the pipeline. Watercourses and flood defences should be avoided where possible. However, there are well developed techniques that can be applied to avoid, minimise and reduce adverse impacts. At this stage it should be possible to avoid Source Protection Zones. It should be possible to avoid significant air quality and noise impacts through careful siting and design of the compressor station and regular monitoring and maintenance.	At this stage it is assumed that identified receptors can be avoided. However, due to the compressor station, air quality and noise should be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles, but only after substantive mitigation'.
Overall Environmental Implications [Optional]: The summary environmental implications for this option are that whilst Ecological and Historic Environment issues will likely be manageable, there is a risk of potential impacts upon Landscape and Visual, Noise and Air Quality receptors due to the construction of the compressor station. This pipeline route is also substantially longer that options 1a, 1b and 1c and it is recognised that a longer pipeline will result in a greater risk in terms of construction period and land take, and the likelihood of affecting more environmental features will increase. Therefore, the construction of the compressor station and the length of the pipeline is likely to be a factor to be considered in the decision-making.			

Socio-economics			
Socio-economics	This option has the potential to impact upon onshore and offshore pipelines, windfarm infrastructure, offshore platforms, submarine cables and licensed dredging activity. It also has the potential to be affected during construction by unexploded ordnance.	Potential impacts could be avoided with careful routeing and design. A full ordnance survey prior to construction and careful planning and design of the option to ensure the route avoids constraints.	It is not considered that socio-economic factors will be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.
Overall Socio-economic Impact [Optional]: At this stage of the process, socio economic issues can be adequately managed therefore will not be a major consideration in the decision-making.			

Strategic Option 5: Offshore - Easington to Bacton with compression, Kings Lynn to Peterborough onshore pipeline, high flow modifications and re-wheels (200 km)

Technical	
Technical Complexity	The construction methods used to install this option are well founded, however the offshore aspect would be new to National Grid and therefore external expertise would need to be sought. The construction method is considered to be low risk in terms of technical complexity.
Construction/Delivery issues	The technology is well established and straightforward to install and maintain. The offshore aspects may be seasonal/ weather dependent. However, at this stage it is not expected that the construction method would have significant implications with regard to programme delivery.
Technology Issues	The compressor station will require on-going maintenance through-out its lifetime (approximately 40 years).
Capacity Issues	This option would increase the existing capacity.
Network Efficiencies/ Benefits	N/A
Overall Technical Consideration [Optional]: This option compares relatively favourably with the other options in terms of technical issues; however the installation of a compressor station would mean that this would be a consideration in the decision-making.	

Cost	
Capital Cost	The capital cost of this option is estimated to be 6.8 times more expensive than option 1b (excavated trench).
Lifetime Cost	The lifetime cost for this option is estimated to be £124 million over a 40 year life. This is based upon 200 km of pipeline requiring four PIG trap facilities and the installation and life time maintenance of one compressor station.
Overall Cost [Optional]: The option compares unfavourably with the other options in terms of both capital and lifetime cost, sufficiently so that this could potentially be a major consideration in the decision-making.	

Environment			
Sub Topics	**Summary Potential Effects (Adverse and Beneficial)**	**Summary Mitigation and Residual Effects**	**Summary Implications and Outcome**
Landscape & Visual	This option has the potential to impact upon two nationally designated landscapes; the Norfolk Coast AONB and the Spurn Heritage Coast. The route will potentially have to pass through eight NCAs, and whilst the scale and robustness of the NCAs would ensure that impacts would not be significant, there will inevitably be some short-term localised adverse landscape effects due to the flat nature of the landform over the majority of the study area. The route is also likely to affect national cycle routes during construction. The settlement pattern is such that there is a potential for short-term localised adverse visual impacts during construction. The compressor station associated with this option will also potentially cause operational effects on landscape character and visual amenity.	Adverse landscape and visual effects can be limited if key landscape features are avoided by appropriate routeing of the pipeline and siting and design of the compressor station. Impacts on the Norfolk Coast AONB and Spurn Heritage Coast could be avoided by routeing the pipeline to make landfall either north or south of their boundaries. The implementation of mitigation measures should also be able to minimise visual effects experienced by users of the national cycle routes and residents along the affected route.	It should be possible to avoid landscape effects during the construction period through careful routeing of the pipeline. However, due to the potential operational effects on landscape and visual from the construction of the compressor station, Landscape and Visual should be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles, but only after substantive mitigation'.

Environment			
Sub Topics	**Summary Potential Effects (Adverse and Beneficial)**	**Summary Mitigation and Residual Effects**	**Summary Implications and Outcome**
Ecology	The offshore option 5 has the potential to impact Inner Dowsing, Race Bank and North Ridge Candidate Marine SAC, the Humber Estuary which is designated as an SPA, SAC, Ramsar, IBA and SSSI, Norfolk Valley Fens SAC and 4 SSSIs and a NNR during the construction phase due to noise and vibration, pollution and disturbance. Given the international importance of these habitats, it will be necessary to demonstrate that any scheme does not have an adverse effect on the integrity of the constituent qualifying habitats and populations (most notably birds and fish).	With careful route alignment and suitable construction techniques, it should be possible with this option to avoid direct impacts to the onshore ecological designated sites. There is a risk that the scheme could have an adverse effect on the integrity of the constituent qualifying habitats and populations of the designated sites, and the potential exists for significant ecological impacts onshore. With careful route alignment to avoid the Candidate Marine SAC it should be possible to avoid direct impacts on the site.	At this stage it is assumed that direct impacts on ecological sites can be avoided through careful routeing, therefore Ecological constraints would not be considered material in the selection of this as the Preferred Strategic Option at this stage. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.
Historic Environment	This option has the potential to impact upon 24 Scheduled Monuments, 52 listed buildings and 1 Registered Parks and Garden. There is also the potential for physical and setting impacts on non-designated heritage assets or previously un-recorded sites.	It is assumed that high value designated heritage assets can be avoided through careful route alignment avoiding significant physical or setting impacts.	At this stage it is assumed that any high value designated heritage assets can be avoided. Historic Environment should not be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.
Other environmental issues	This option has the potential to impact four geological SSSIs. There is also the potential to effect flood defences, flood storage areas and watercourses. As this option involves the construction and operation of a compressor station it is likely that there will be effects on air quality receptors as a result of compressor station emissions and impacts due to noise.	Potential impacts to geological SSSIs may be avoided by careful routeing of the pipeline. Watercourses and flood defences should be avoided where possible. However, there are well developed techniques that can be applied to avoid, minimise and reduce adverse impacts. It should be possible to avoid significant air quality and noise impacts through careful siting and design of the compressor station and regular monitoring and maintenance.	At this stage it is assumed that identified receptors can be avoided. However, due to the compressor station, air quality and noise should be considered to be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles, but only after substantive mitigation'.
Overall Environmental implications [Optional]: The summary environmental implications for this option are that whilst Ecological and Historic Environment issues will likely be manageable, there is a risk of potential impacts upon Landscape and Visual, Noise and Air Quality receptors due to the construction of the compressor station. This pipeline route is also substantially longer that options 1a, 1b and 1c and it is recognised that a longer pipeline will result in a greater risk in terms of construction period and land take, and the likelihood of affecting more environmental features will increase. Therefore, the construction of the compressor station and the length of the pipeline is likely to be a factor to be considered in the decision-making.			

Socio-economics			
Socio-economics	This option has the potential to impact upon offshore pipelines, windfarm infrastructure, offshore platforms, submarine cables and licensed dredging activity during construction of the pipeline. Onshore pipelines, overhead powerlines, and national cycle routes may also be affected. It also has the potential to be affected during construction by unexploded ordnance.	Potential impacts could be avoided with careful routeing and design. A full ordnance survey prior to construction and careful planning and design of the option to ensure the route avoids constraints.	It is not considered that socio-economic factors will be material in the selection of this Preferred Strategic Option. This option should therefore be recorded as 'complies with the guiding principles with no substantive concern'.
Overall Socio-economic Impact [Optional]: At this stage of the process, socio economic issues can be adequately managed therefore will not be a major consideration in the decision-making.			

Appendix 5 Consultee Response Summary

Consultee	Comments	Action
AB Ports		
ISpikings@abports.co.uk (Ian Spikings)	"Option 1a would seem to be the best option from our Harbour Authority point of view because it is not invasive and therefore unlikely to disrupt navigation"	Navigation will be further considered when assessing the route options at Stage 2 and Stage 3.
Natural England		
consultations@naturalengland.org.uk (James Walsh)	1a 1b 1c will all require Appropriate Assessment	Appropriate Assessment will be undertaken once the preferred route is identified.
Environment Agency		
sam.kipling@environment-agency.gov.uk	Flood defences, and managed realignment sites, protect people and property from flooding	Flood defences will be further considered when assessing the route options at Stage 2 and Stage 3.
	Sole gateway for migratory fish such as lamprey, salmon, sea trout and eel	Fish impacts will be further considered when assessing the route options at Stage 2 and Stage 3.
	Recovering salmon fishery and vulnerable to impacts. Likely that no works in spring and late summer.	Fish impacts will be further considered when assessing the route options at Stage 2 and Stage 3.
	Don't like open cut option	Impacts of open-cut techniques against non-open cut techniques will be further considered when assessing the route options at Stage 2 and Stage 3.
	Works must robustly safeguard integrity of flood defences etc	Flood defences will be further considered when assessing the route options at Stage 2 and Stage 3.
	Managed realignment site at Goxhill	Further details of Goxhill managed realignment have been obtained from susan.manson@environment-agency.gov.uk and will be further considered when assessing the route options at Stage 2 and Stage 3.
	Estuary sediments disturbance and redistribution	Estuary sediments will be further considered when assessing the route options at Stage 2 and Stage 3.
	Water quality and sediments	Water quality will be further considered when assessing the route options at Stage 2 and Stage 3.
	Marine Ecology	Marine ecology will be further considered when assessing the route options at Stage 2 and Stage 3.
	Water Framework Directive	Water Framework Directive will be further considered when assessing the route options at Stage 2 and Stage 3.
	SPZs and sources of potentially contaminated ground	SPZs and contamination will be further considered when assessing the route options at Stage 2 and Stage 3.
	Contact Stephanie Walden at Yorkshire Water for their experiences of tunnelling the Humber	stephanie.walden@yorkshirewater.co.uk - tel 01274 692349. A copy of the Stage 2 RCIS will be sent for comments.
English Heritage		
ian.smith@english-heritage.org.uk	WSI needed once route chosen	WSI will be provided once preferred route is identified.
	Marine Archaeological Reporting Protocol required	Marine Archaeological Reporting Protocol will be provided once preferred route is identified.
	Need to expand assessment to Grade II Listed Buildings and Conservation Areas	Stage 1 Assessment is necessarily high level. Stage 2 RCIS will further consider Listed Buildings and Conservation Areas.
	Also Registered Historic Parks and Gardens	Stage 1 Assessment is necessarily high level. Stage 2 RCIS will further consider Registered Historic Parks and Gardens.
	Also Non Desginated Assets (buildings, historic open space, historic features, wider historic landscape.	Stage 1 Assessment is necessarily high level. Stage 2 RCIS will further consider Non Desginated Assets.
	Historic Environment Record from LPAs	Historic Environment Record will be further considered when assessing the route options at Stage 2 and Stage 3.
	Cumulative effect of impacts on longer routes needs to be included	Cumulative effects will be further considered when assessing the route options at Stage 2 and Stage 3.
	100m buffer between route and scheduled monuments	A buffer zone will be placed around all SAMs and this will be further developed during Stage 2 and Stage 3 in consultation with English Heritage.
	Spatial data records held by UK Hydrographic Office and English Heritage for non designated wrecks	Stage 1 Assessment is necessarily high level. Stage 2 RCIS will further consider spatial data records.
	MoD for any ships/planes Protection of Military Remains Act 1986	MoD assets will be further considered when assessing the route options at Stage 2 and Stage 3.
	Marine Policy Statement for non designated sites	Marine Policy Statement for non designated sites will be further considered when assessing the route options at Stage 2 and Stage 3.
	HMS Umpire and HMS Vortigern not mapped - Protection of Military Remains Act 1986	Wreck sites will be further considered when assessing the route options at Stage 2 and Stage 3. HMS Umpire and HMS Vortigern are outside of the search area for Option 1 taken forward.
Marine Management Organisation		
jonathan.peters@marinemanagement.org.uk	Marine Licence will be required (NSIP project can be part of DCO)	Marine License will be applied for once a preferred route is identified. If the project is deemed NSIP then the DCO will suffice.
	Potential impacts upon commercial fish species and the fishing industry in Socio section	Fish and fisheries impacts will be further considered when assessing the route options at Stage 2 and Stage 3.
	Options 4 and 5 well known potting areas	Options 4 and 5 have not been carried forward to Stage 2 assessment and will not be considered further.
	Humber Estuary crossing needs to reference East Inshore draft vision and objectives for future marine plan	East Inshore draft vision and objectives for future marine plan will be further considered when assessing the route options at Stage 2 and Stage 3.

Consultee	Comments	Action
North Lincolnshire Council william.hill@northlincs.gov.uk		
	TRANSPORT	
	Construction Management Plan including Transport Assessment	Construction Management Plan including Transport Assessment will be provided once a preferred route has been identified.
	Seeking financial contribution for local highway network per South Humber Bank Transport Study	Impacts upon local highways networks will be assessed once a preferred route has been identified.
	South Humber Gateway guidance document supplied re transport assessment	South Humber Gateway guidance document will be further considered when assessing the route options at Stage 2 and Stage 3.
	HERITAGE	
	EIA process should be in accordance with NPPF and planning policies	NPPF and Planning Policies will be further considered when assessing the route options at Stage 2 and Stage 3.
	Not all scheduled monuments identified	Stage 1 Assessment is necessarily high level. Stage 2 RCIS will further consider Scheduled Monuments.
	ECOLOGY	
	Likely significant effect on Humber Estuary SAC/SPA/Ramsar - Appropriate Assessment required	Appropriate Assessment will be undertaken once the preferred route is identified.
	Ecology surveys required (list provided along with detailed spec)	Phase 2 Ecology Surveys will be undertaken when assessing the route options at Stage 3.
	Biodiversity enhancement required as per NPPF	Biodiversity enhancement will be considered following the Phase 2 Ecology Surveys undertaken when assessing the route options at Stage 3.
	Hydrogen Pipeline and Able Logistics Park ecological mitigation needs to be tied-in. Both have ESs.	The hydrogen pipeline and Able Park (plus associated sites) will be further considered when assessing the route options at Stage 2 and Stage 3.
	Data searches from Humber Environmental Data Centre and Lincolnshire Environmental Records Centre	Data searches from Humber Environmental Data Centre and Lincolnshire Environmental Records Centre will be obtained when assessing the route options at Stage 2 and Stage 3.
Crown Estates		
	No response received	Not applicable.
East Riding of Yorkshire Council beverley.dc@eastriding.gov.uk		
	Planning permission will be required and a screening opinion should be sought.	Planning permission and EIA will be undertaken at Stage 3.
	POLICY AND PRINCIPLE OF DEVELOPMENT	
	Summary of applicable planning policies.	Planning policies will be further considered when assessing the route options at Stage 2 and Stage 3.
	A comprehensive scheme will be required to accompany significant estuary related proposals.	A Route Corridor Investigation Study will be provided at Stage 2 and a full Environmental Statement will be provided at Stage 3.
	Development could meet the threshold of a NSIP submitted to Planning Inspectorate.	NSIP Screening will be undertaken once the preferred route is identified.
	FACTORS INFLUENCING ROUTE SELECTION	
	Desktop surveys should be undertaken to allow adequate route selection.	Desktop surveys will be undertaken when assessing the route options at Stage 2 and Stage 3.
	NOISE, VIBRATION, DUST AND LIGHTING	
	Need to identify all sensitive receptors and assess impacts of all aspects of construction and operation.	Noise Assessment will be undertaken when assessing the route options at Stage 2 and Stage 3.
	Advantages and disadvantages to all options.	Comparison of all options will be undertaken when assessing the route options at Stage 2 and Stage 3.
	Further information would need to be submitted.	A Route Corridor Investigation Study will be provided at Stage 2 and a full Environmental Statement will be provided at Stage 3.
	Option 1 would be less likely to impact on local residents.	Comparison of all options will be undertaken when assessing the route options at Stage 2 and Stage 3.
	Noise mitigation methods, particularly at AGIs, should be included.	Noise Assessment will be undertaken when assessing the route options at Stage 2 and Stage 3.
	HIGHWAYS	
	Highways Agency will need to be consulted for Options 2 and 3 regarding the A63.	Options 2 and 3 have not been carried forward to Stage 2 assessment and will not be considered further.
	Highways issues should be considered.	Traffic and Transport Assessment will be undertaken when assessing the route options at Stage 2 and Stage 3.
	CONSERVATION	
	Options 1, 4, 5 are the favoured options. Option 1 most viable choice.	Comparison of all options will be undertaken when assessing the route options at Stage 2 and Stage 3.
	Avoid direct conflict with designated assets on banks of Humber, including SAMs.	Designated sites, including SAMs, will be further considered when assessing the route options at Stage 2 and Stage 3.
	DRAINAGE, WATER QUALITY AND RESOURCES	
	Assessment of impacts required as part of any application.	A Route Corridor Investigation Study will be provided at Stage 2 and a full Environmental Statement will be provided at Stage 3.
	Mitigation measures may be required.	Water and Drainage will be further considered when assessing the route options at Stage 2 and Stage 3.

Consultee	Comments	Action
East Riding of Yorkshire Council (continued)	**BIODIVERSITY, LANDSCAPE AND VISUAL IMPACT**	
	Option 1 is supported as this would result in fewest landscape and visual effects.	Comparison of all options will be undertaken when assessing the route options at Stage 2 and Stage 3.
	Application should include an assessment of the biodiversity and landscape and visual effects.	Biodiversity and landscape and visual effects will be further considered when assessing the route options at Stage 2 and Stage 3.
	Reinstatement and mitigation measures should be addressed.	Mitigation measures will be further considered when assessing the route options at Stage 2 and Stage 3.
	Non open cut techniques should be considered at woodland, TPO and protected hedges.	Construction techniques will be further considered when assessing the route options at Stage 2 and Stage 3.
	No reference to TPOs or Conservation Areas.	Stage 1 Assessment is necessarily high level. Stage 2 RCIS will further consider TPOs and Conservation Areas.
	SOIL AND GEOLOGY IMPACTS	
	Important to understand the soil types and underlying strata.	Soil and Geology will be further considered when assessing the route options at Stage 2 and Stage 3.
	Assessment of impacts required as part of any application.	A Route Corridor Investigation Study will be provided at Stage 2 and a full Environmental Statement will be provided at Stage 3.
	New boreholes may be required.	Borehole requirement will be further considered when assessing the route options at Stage 2 and Stage 3.
	Assessment should consider whether HDD is suitable and alternative plan if fails.	The technical considerations for HDD technique has ruled-out this option and only Tunnel and Open-Cut techniques are to be taken forward to Stage 2.
	Mitigation measures may be required.	Mitigation measures will be further considered when assessing the route options at Stage 2 and Stage 3.
	PUBLIC RIGHT OF WAY	
	Proposal, particularly Options 2 and 3, could affect PROWs. Contact council for info.	PROW team on 01482 395203 will be contacted when assessing the route options at Stage 2 and Stage 3.
	HUMBER / NORTH SEA	
	Proposal, particularly Options 1,4,5 could affect inshore fishing. Contact council for info.	David McCandless, Chief Inshore Fishery and Conservation Officer on 01482 393690 will be contacted when assessing the route options at Stage 2 and Stage 3.