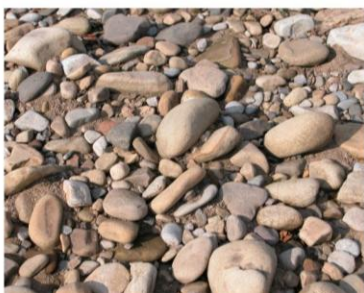


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Managing Landscape Change:

A multi-disciplinary approach to future mineral extraction in North Yorkshire

Stage 5 Final Report



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Authors:	Dr Alan Thompson, Director of Earth Sciences, Capita Symonds Jane Jackson, Senior Heritage Planner, Capita Symonds Jamie Quartermaine, Oxford Archaeology North Jayne Garbutt, Landscape Architect, Capita Symonds	
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	Dr. Alan Thompson Technical Director, Capita Symonds	
	Robin McCartney <i>Director, Capita Symonds</i>	

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Name	Organisation	Job Title	Role in this project
English Heritage - Project Sponsor			
Graham Fairclough	English Heritage	Head of Characterisation	Project steering group
Neil Redfern	English heritage	Team Leader, North Yorkshire and the City of York	Project steering group
Dave Went	English Heritage	Archaeological Investigator	Project assurance officer
North Yorkshire County Council - Project Sponsor			
Gail Falkingham	NYCC	Historic Environment Team Leader	Project Executive
Malcolm Barnett	NYCC	Principal Landscape Architect	Project steering group
Julia Casterton	NYCC	Principal Ecologist	Project steering group
Rob Smith	NYCC	Team Leader, plans and Technical Services	Project steering group
Graham Townsend	NYCC	Geographical Information Manager	Project steering group
Successful Tenderers - Capita Symonds Ltd, Carlisle (& East Grinstead)			
Jayne Garbutt	Capita Symonds Ltd	Environmental Design Consultant	Project Manager & Landscape Architect
Alan Thompson	Capita Symonds Ltd	Director of Earth Sciences	Technical Director
Jane Jackson	Capita Symonds Ltd	Senior Heritage Management Consultant	Technical Director
Katie Jackson	Capita Symonds Ltd	Geographic Information Consultant	GIS Consultant
Bruce Kerridge	Capita Symonds Ltd	Geographic Information Consultant	GIS Consultant
Lucinda Weymouth	Capita Symonds Ltd	Landscape Architect	Landscape Architect
Jamie Quartermaine	Oxford Archaeology North	Senior Project Manager	Archaeology & Historic Landscapes
Peter Schofield	Oxford Archaeology North	Project Officer	Archaeology & Historic Landscapes
Mairead Rutherford	Oxford Archaeology North	Environmental Project Officer	Archaeology & Historic Landscapes
Fraser Brown	Oxford Archaeology North	Project Manager	Archaeology & Historic Landscapes
Sam Griffin	Hesketh Ecology	Ecologist	Ecologist

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Contents

1. Introduction and Terms of Reference	8
2. Purpose of the Project.....	11
3. Methodologies and Data Sources	14
Identification of Mineral Resources (Stage 1).....	14
Identification and Analysis of Environmental Characteristics (Stage 1)	17
<i>Historic Environment Data Concordance</i>	<i>17</i>
Selection of Sample Areas (Stage 1).....	17
<i>Criteria for Selection</i>	<i>18</i>
Sample Area Investigations (Stage 2).....	21
Predictive Landscape Modelling (Stage 2)	21
Assessment of Environmental Sensitivities and Capacity (Stage 3).....	22
<i>Options Available.....</i>	<i>22</i>
<i>Methodology for implementing a scenario-based approach.....</i>	<i>23</i>
4. Mineral Deposits and Landscape Evolution	25
The Distribution and Geological Characteristics of Mineral Resources.....	25
<i>Geological Terminology and Overview of Commercial End Uses.....</i>	<i>26</i>
<i>Resource Information for Individual ASMRPs</i>	<i>28</i>
5. Landscape Evolution and Archaeological Potential.....	35
Introduction	35
<i>Timescales.....</i>	<i>35</i>
<i>Major River Valleys</i>	<i>37</i>
<i>The Vales of York and Mowbray, and the Magnesian Limestone Ridge.....</i>	<i>45</i>
<i>The Vale of Pickering and the Yorkshire Wolds.....</i>	<i>50</i>
<i>The Pennine Moors</i>	<i>56</i>
6. The Key Environmental Characteristics.....	62
Introduction	62
Environmental Designations	62
Wider Environmental Characteristics	63
7. Potential Impacts Associated with Mineral Extraction.....	67
Introduction	67
Types of impact.....	67
Differences relating to type of mineral and type of extraction	68
Cumulative and Combined Effects.....	70

Mitigation and Enhancement	70
8. Environmental Sensitivity and Capacity.....	72
<i>Introduction</i>	72
<i>Land Categories</i>	72
Assessment of Sensitivity.....	75
<i>Components of sensitivity</i>	75
<i>Implementation</i>	76
<i>Results</i>	78
Assessment of Capacity for future Mineral Extraction	93
9. Recommendations for Planning	96
Introduction & Key Principles	96
<i>Benefits of Adopting these Key Principles</i>	98
Overview of Recommendations.....	98
Recommendations for Spatial Planning.....	100
Recommendations for Pre-Application Information Requirements.....	100
<i>Key Environmental Research Questions</i>	101
Recommendations for Baseline Research and Monitoring	106
<i>Variations relating to specific minerals and/or geographical areas</i>	106
Recommendations for Environmental Impact Assessment.....	107
Recommendations for Quarry and Reclamation Design.....	107
<i>Variations relating to specific minerals and/or geographical areas</i>	108
Recommendations for Monitoring, Mitigation and Compensation Strategies	109
<i>Design of Operational Monitoring Strategies</i>	109
<i>Design of Mitigation Strategies</i>	110
<i>Design of Compensation Strategies</i>	111
<i>Variations relating to specific minerals and/or geographical areas</i>	111
Recommendations for the Operational Stage of Mineral Development.....	111
<i>Variations relating to specific minerals and/or geographical areas</i>	112
Recommendations for Reclamation and Long-term Management	112
<i>Variations relating to specific minerals and/or geographical areas</i>	113
10. Conclusions	114

Bibliography

Project Archive

Appendix One -

Figures showing the location of all Areas of Surface Mineral Resource Potential (ASMRP's) together with a plan showing each ASMRP; distribution of Land Categories together with a plan showing each Category

1. Introduction and Terms of Reference

1.1 In January 2011, North Yorkshire County Council (NYCC), with funding provided by English Heritage (EH), commissioned Capita Symonds Ltd (CSL) and sub-consultants, Oxford Archaeology North (OAN) to *‘develop an environmental evidence base and assess environmental sensitivities and capacity in North Yorkshire to inform a spatial planning strategy for the extraction of minerals’*.

1.2 The more detailed objectives of the contract were to:

- i. define mineral specific Areas of Surface Mineral Resource Potential (ASMRPs) within the overall minerals resource area for North Yorkshire through the identification of the relevant geologies and their spatial extent;
- ii. collate in GIS format available environmental data for the mineral resource areas to be studied, including historic environment, biodiversity and landscape data;
- iii. analyse the current state of knowledge about, and sensitivity of, the environment of each area of surface mineral resource potential;
- iv. undertake detailed environmental studies of indicative sample area(s) for each area of surface mineral resource potential, to include desk-based research, land-use study, landform classification and descriptions of environmental associations;
- v. assess the capacity for change within each ASMRP and provide a strategic assessment of the degree of impact that mineral extraction would have on each;
- vi. produce a short and focused research framework for each ASMRP to guide environmental evaluation and mitigation works associated with future minerals applications; and to
- vii. produce a report and prepare a digital archive resulting from the project results, suitable for web-access.

1.3 In order to meet these objectives, the work has been carried out by a team of environmental specialists including archaeology, geology, geomorphology, ecology, heritage planning and landscape architecture in order to provide an integrated, multi-disciplinary perspective. A similarly diverse group of specialists have represented the client in the form of a steering group comprising of representatives from both NYCC and EH. A series of workshops and review meetings between the consultants and steering group have taken place throughout the project in order to ensure that the objectives were met.

1.4 The Project has been delivered in five Stages:

Stage 1: Environmental mapping and characterisation

Task 1(i): Mapping of spatial extent of Areas of Surface Mineral Resource Potential (ASMRP) – reported in Stage 1, Chapter 2;

Task 1(ii): Historic environment data concordance – reported in Stage 1, Chapter 3;

Task 1(iii): Strategic environmental mapping – reported in Stage 1, Chapter 4;

Task 1(iv): Define key environmental characteristics of each ASMRP – reported in Stage 1, Chapter 5;

Task 1(v): Identify and describe relationships and interactions between key characteristics of each ASMRP at a strategic level – reported in Stage 1, Chapter 6;

Task 1(vi): Identify, map the spatial extent of, and describe/justify up to 12 sample areas from within the ASMRPs for further detailed study – reported in Stage 1, Chapter 7;

Task 1(vii): Production of updated project design – reported separately; and

Task 1(viii): Production of Stage 1 Highlight Report – reported separately.

Stage 2: Detailed environmental evidence gathering and assessment of sample areas

Task 2(i): Desk-based assessment and literature review - reported in the Stage 2 Technical Report on Sample Areas and within the separate Stage 2 Predictive Landscape Modelling report;

Task 2(ii): Site visits and walk-over surveys - reported in the Stage 2 Technical Report on Sample Areas;

Task 2(iii): Landform Element Classification - reported as above;

Task 2(iv): Land Use Mapping - reported as above;

Task 2(v): Detailed Landscape Character Assessment - reported as above;

Task 2(vi): Topographic Modelling - reported in the Stage 2 Predictive Landscape Modelling Report;

Task 2(vii): Predictive Landscape Models - reported as above; and

Task 2(viii): Production of Stage 2 Highlight Report - reported separately.

Stage 3: Analysis and environmental overview of each ASMRP

Task 3(ii): Review of methodologies used in Stages 1 and 2 - reported in Chapter 3 of the Stage 3 report;

Task 3(iii): Discussion of potential to generalise for whole of ASMRP - reported in Chapter 4 of the Stage 3 report;

Task 3(iv): Evaluation of the key characteristics of mineral development - reported in Chapter 6 of the Stage 3 report;

- Task 3(v):* Assessment of the sensitivities of each ASMRP - reported in Chapter 7 of the Stage 3 report;
- Task 3(vi):* Assessment of the capacity of each ASMRP - reported in relation to 'land categories' in Chapter 8 of the Stage 3 report;
- Task 3(vii):* Environmental research framework for each ASMRP - reported in the Stage 4 report (Chapter 5); and
- Task 3(viii):* Production of Stage 3 Highlight Report - reported separately.

Stage 4: Production of recommendations for planning

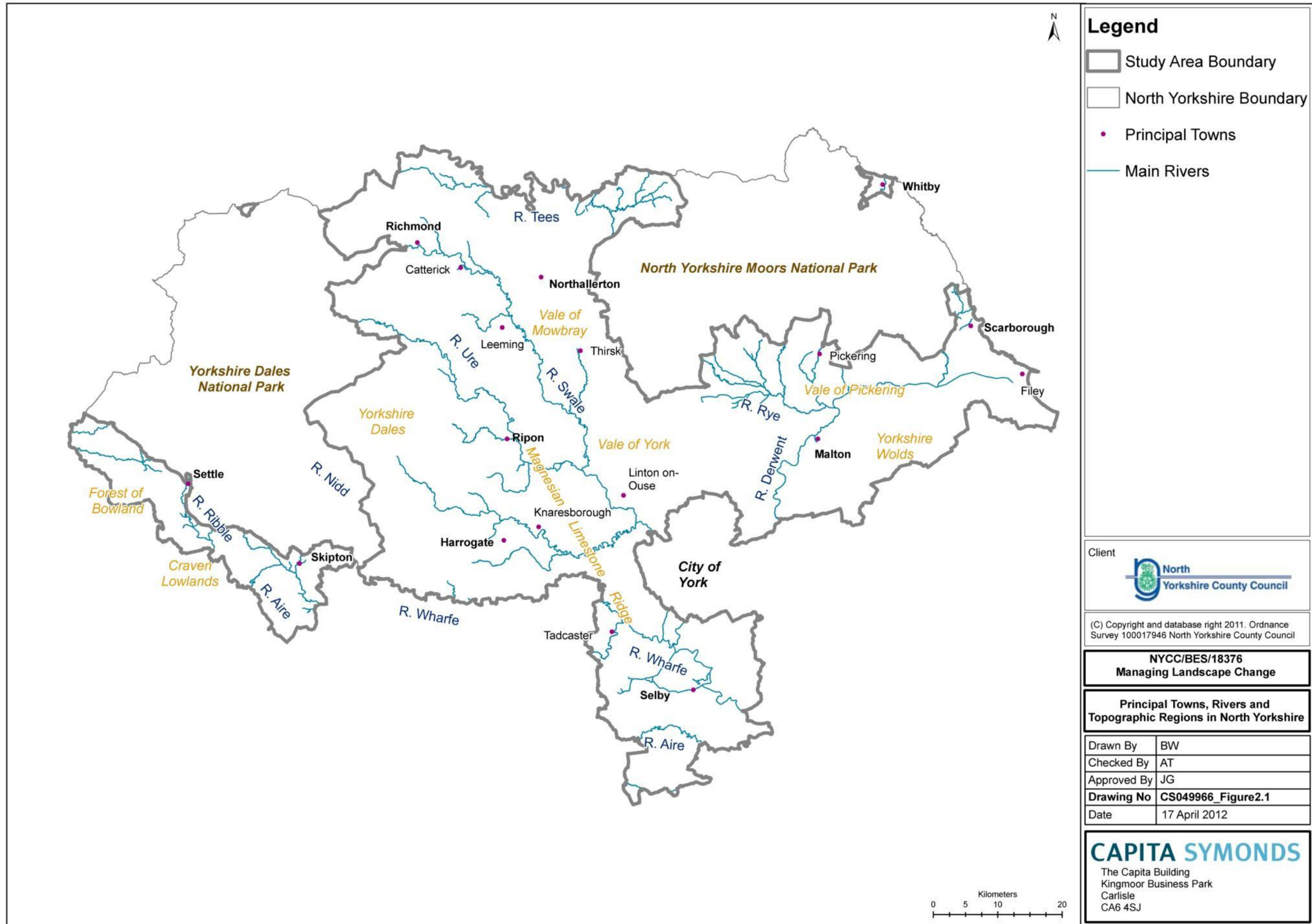
- Task 4(i):* Need/opportunities for mitigation and/or compensation - reported in Chapter 9 of the Stage 4 report and in Chapter 6 of the Stage 3 report;
- Task 4(ii):* Information requirements at pre-application stage - reported in Chapters 5, 6 and 7 of the Stage 4 report;
- Task 4(iii):* Restoration / long-term management - reported in Chapters 8 and 11 of the Stage 4 report;
- Task 4(iv):* Mitigation strategies - reported in Chapters 9, 10 and 11 of the Stage 4 report;
- Task 4(v):* Production of Stage 4 Highlight Report - reported separately.

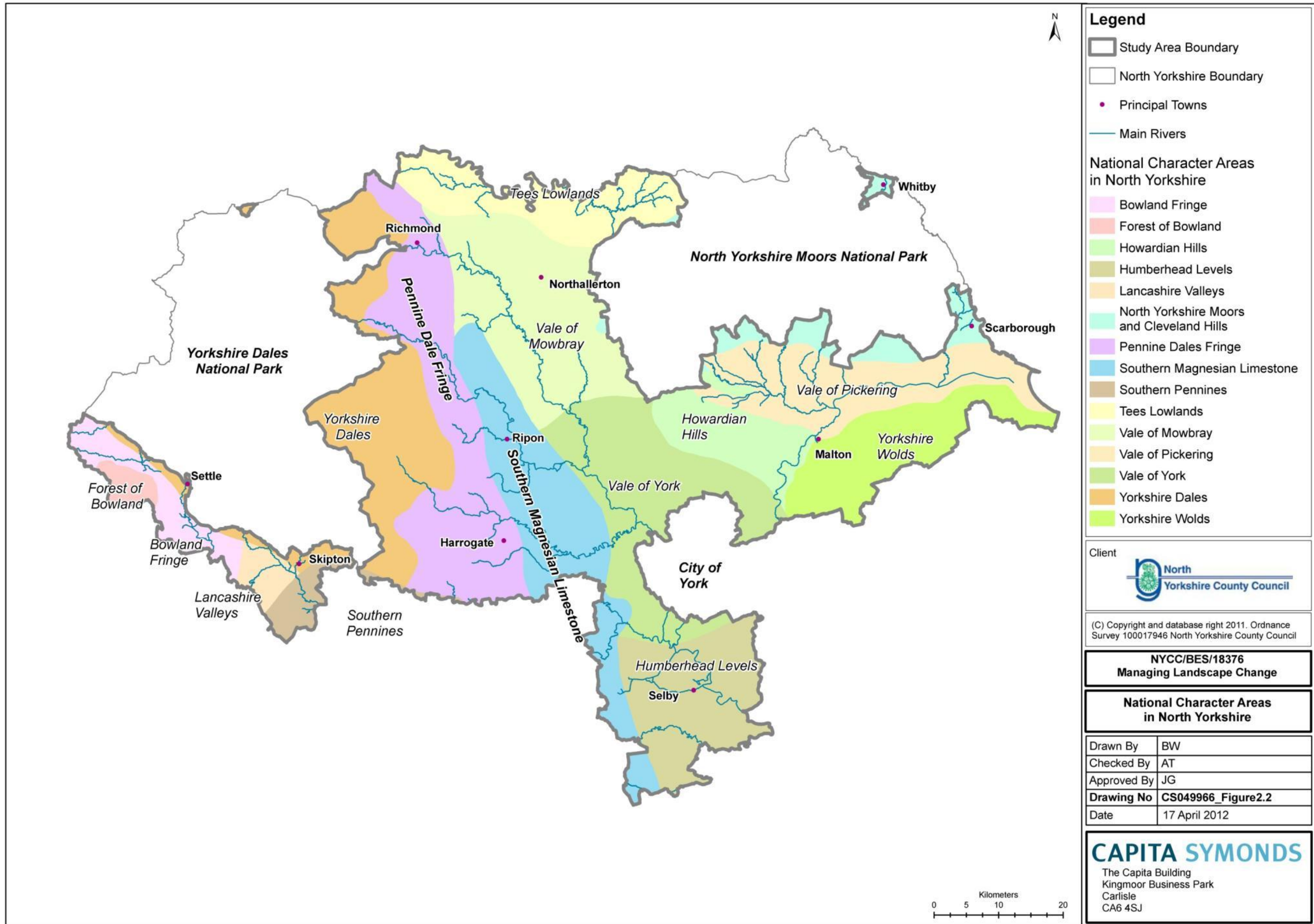
Stage 5: Reporting, archive and dissemination of project results

- 1.5 At the end of each stage, a technical report was produced, describing the objectives, methodology and outcomes of each discrete work phase. These reports and their associated appendices form part of a digital Archive, which is stored by ADS (Archaeology Data Service), part of the University of York and can be referenced by accessing the following link <http://dx.doi.org/10.5284/1012712>
- 1.6 This report, representing part of the output from Stage 5, summarises the main findings and recommendations of the project, bringing together the results from Stages 1 to 4.

2. Purpose of the Project

- 2.1 Pressure on the environment in North Yorkshire from the extraction of surface minerals, particularly aggregates, has created an urgent need for a high quality environmental dataset relating to environmental sensitivities and capacity, to underpin informed decision-making and management of the environmental resource in areas of past, present and future mineral extraction. Such management will help ensure that key environmental issues are factored into minerals strategy development in a balanced way alongside a range of economic and social considerations.
- 2.2 Understanding of the capacity of an asset to accept change and the possibility of mitigation against negative aspects of change are important tools for decision-making, particularly where there are competing demands for the preservation or development of an asset. The results of this study will inform new policy and decision-making and will also provide a case study of how such policies can be created and used in other areas where a multi-disciplinary approach can be used to address complex problems.
- 2.3 By addressing the objectives listed in Chapter 1, this project has sought to:
- provide an improved environmental evidence base for the development of the North Yorkshire Minerals Core Strategy and will help to ensure that environmental considerations can be considered on an equal basis with social and economic considerations;
 - inform the development of a spatial planning strategy for the extraction of minerals within North Yorkshire;
 - inform the assessment of environmental constraints and potential of areas and sites under consideration within the Minerals and Waste Development Framework (MWDF) for future mineral working;
 - inform the identification of appropriate development management policies relating to mineral extraction and the environment, including policies and approaches to mitigate the impacts of mineral working;
 - inform the preparation of potential Supplementary Planning Documents or other informal planning advice to guide implementation of environmental policy within the MWDF, including post-quarry restoration strategies; and to
 - enhance the understanding of the environment of areas of surface minerals resource potential within North Yorkshire amongst the minerals industry and the public.
- 2.4 Figures 2.1 and 2.2 below show some of the main geographical features of North Yorkshire, including the National Character Areas. The plans provide a guide to locations and areas which are referred to throughout this report.





3. Methodologies and Data Sources

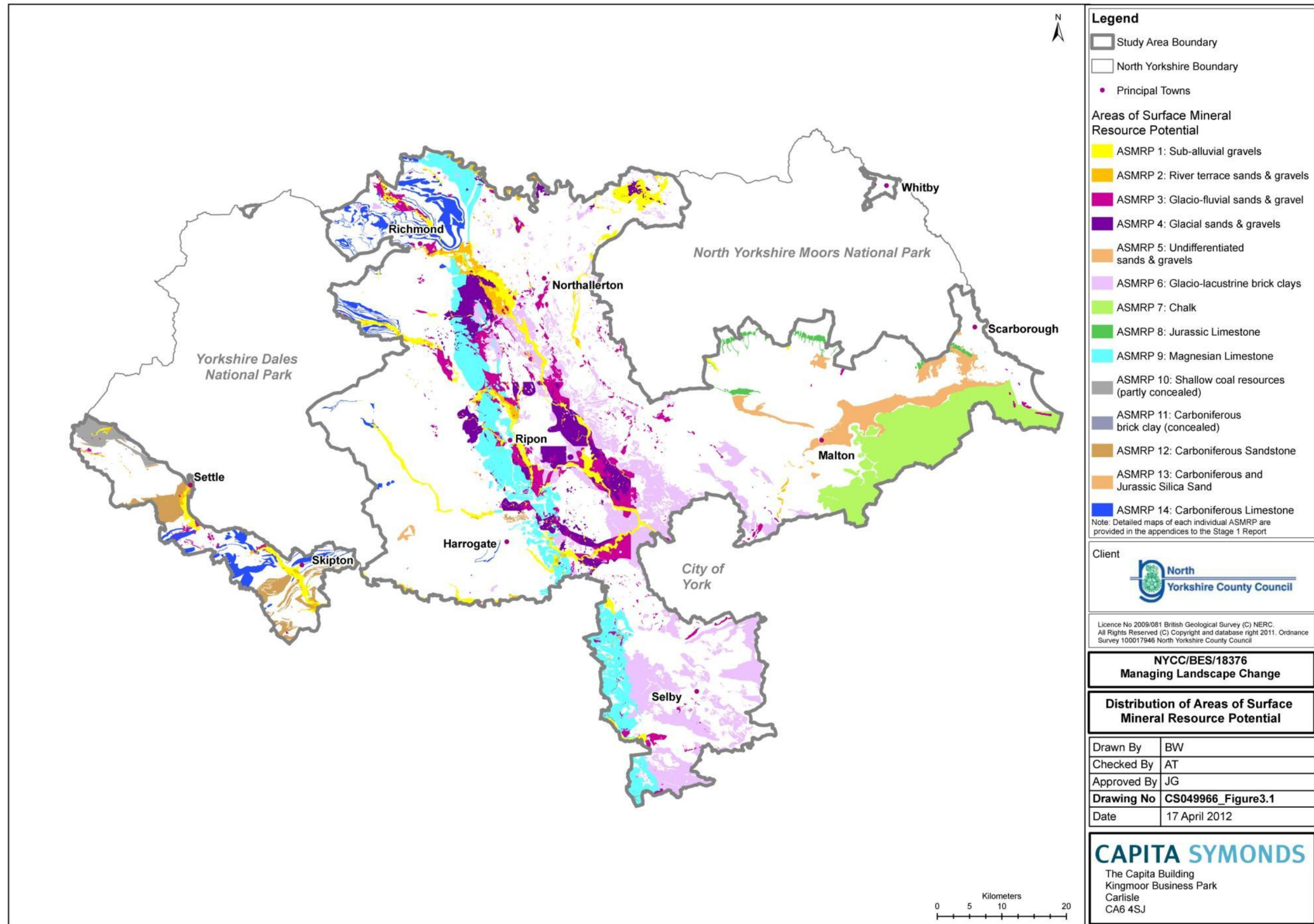
- 3.1 This chapter briefly summarises some of the main methodologies used in carrying out the research. More detailed explanations are provided in the relevant Stage reports.
- 3.2 A key aspect of the overall project is that it was conceived (by NYCC and English Heritage) as a multi-disciplinary and iterative programme of work which has allowed each Stage of the project to feed into the next, allowing for the progressive build-up of the evidence base. Stage 1 thus focused on assembling readily available GIS data to establish initial indications of the geological, environmental and landscape characteristics of each mineral resource area, and on the objective selection of sample areas for more detailed study. Stage 2 focused on the sample areas, allowing much more detailed information to be obtained for those areas, based on a combination of desk-based research and field investigation. It also included the development of conceptual 'predictive landscape models' of the main resource areas, based on a combination of desk study, field investigation and existing knowledge.
- 3.3 Stage 3 of the project consolidated the available information, considered the extent to which the sample area information might be representative of wider areas and provided tentative assessments of both the sensitivity and capacity of different areas with respect to future mineral extraction. In stage 4, all available information from Stages 1 to 3 was combined with a review of National planning policy to produce a series of recommendations for planning applicable specifically to future mineral extraction in North Yorkshire.
- 3.4 The following sections outline some of the key methodologies used in each Stage of the project.

Identification of Mineral Resources (Stage 1)

- 3.5 The various mineral resources potentially available for future extraction by surface quarrying within North Yorkshire have been identified as 'Areas of Surface Mineral Resource Potential' (ASMRPs). Separate ASMRPs were defined for 14 types of mineral resource and their outlines are taken directly from the digital, 1:50,000 scale mineral resource mapping produced by the British Geological Survey (BGS).
- 3.6 In sequential order of the age of the deposits (most recent first), these comprise:
- Quaternary Sand & Gravel Resources - *subdivided into*
 - sub-alluvial gravels (**ASMRP 1**),
 - river terrace deposits (**ASMRP 2**),
 - glacio-fluvial deposits (**ASMRP 3**),

- glacial deposits (**ASMRP 4**), and
- undifferentiated sand & gravel (**ASMRP 5**);
- Quaternary Brick Clay Resources (**ASMRP 6**), *comprising glacio-lacustrine clays and silts*;
- Cretaceous Chalk Resources (**ASMRP 7**);
- Jurassic Limestone (**ASMRP 8**);
- Permian 'Magnesian' Limestone (**ASMRP 9**);
- Carboniferous Shallow Coal Resources (**ASMRP 10**);
- Carboniferous Brick Clay Resources (**ASMRP 11**), *comprising mudstones and 'fireclay' seams associated with shallow coal*;
- Carboniferous Sandstone Resources (**ASMRP 12**);
- Carboniferous and Jurassic Silica Sand Resources (**ASMRP 13**); and
- Carboniferous Limestone Resources (**ASMRP 14**).

3.7 The extent and distribution of the ASMRPs are shown in Figure 3.1, below.



Identification and Analysis of Environmental Characteristics (Stage 1)

- 3.8 To facilitate a broad and strategic understanding of the key characteristics of each ASMRP, a number of spatial datasets pertaining to the natural and historical environment, along with the landscape character, were collated and organised within a GIS. By bringing together the data from a number of disparate sources, as detailed with Table 2 of the Stage 1 report, a multi-disciplinary evidence base was established, upon which the characteristics, interactions and relationships could be explored through a series of spatial analyses, as described in detail within the Stage 1 report.

Historic Environment Data Concordance

- 3.9 With the aim of providing a comprehensive and succinct overview of the heritage resource in North Yorkshire, a wide range of evidence relating to the historic environment was brought together in a process of Historic Environment Data Concordance. Spatial datasets were organised and queried in a Geographical Information System (GIS) to create a single, distilled data layer depicting Areas of Historic Environment Interest and Potential (AHEIP).
- 3.10 Historic Landscape Character (HLC) polygons were used as they provided groupings of present day land use that in general are of broadly comparable size. Within each HLC polygon the number of monuments; their date and their status was scored (as described in the Stage 1 report) to provide a combined assessment of the number and significance of the heritage resources within each HLC polygon. The method is a variation of one originally applied by the Lynher Valley project (Cornwall Archaeology Unit 2002 and subsequently during the Ribble ALSF project (OA North and University of Liverpool 2007; Cook et al 2008). The principles of the Archaeological Data Services Guide to Good Practice for creating GIS data (Gillings and Wise 1998) were adopted and the metadata were created using Version 2 of the UK Gemini Specification for Geographical Metadata (Walker 2010). This is a relatively broad brush approach to assessing the heritage resource but has the benefit of being straightforward and quick to apply. HLC is a key English Heritage programme for managing change to the 'historical and archaeological dimensions of the living landscape' (Aldred and Fairclough 2003) and, as such, is a suitable starting point for landscape-wide studies. However, experience in the North West Regional Landscape Characterisation Framework (OA North 2010) indicates that HLC data can be too detailed for county-wide assessment. To eliminate unnecessary granularity, the HLC was stripped of all unnecessary attribute data and was generalised within the GIS so that adjacent polygons with identical attributes were merged into single features.

Selection of Sample Areas (Stage 1)

Introduction

- 3.11 Sample areas were required by the Project Specification to be selected "in order to gain a representative sample of each surface mineral resource type and its different key

characteristics, covering elements of geology, landscape, biodiversity and historic environment. This may include more than one sample area for each ASMRP, particularly where the mineral resource type is present in disparate locations, and/or is particularly widespread, for example the areas of sands and gravels.”

3.12 The Specification further noted that “It is envisaged that a maximum of twelve sample areas will be selected, covering a maximum combined area of 360 hectares”.

3.13 Following discussions with the Client Team during the course of Stage 1, it was confirmed that the twelve selected areas should include representative samples of most, but not all, of the 14 ASMRPs. Those which were agreed to be excluded from the selection process were:

- **ASMRP 10** (Shallow Coal Resources) – on the basis that none of these resources is regarded as being likely to be exploited within the foreseeable future (see Chapter 2 for discussion);
- **ASMRP 11** (Carboniferous Brick Clay Resources) – on the basis that these are also very unlikely to be worked within North Yorkshire; and
- **ASMRP 13** (Silica Sand Resources) – on the basis that there are only two outcrops involved, each of which has extremely different geological and environmental characteristics, meaning that neither could be representative of the silica sand resource as a whole.

3.14 The exclusion of these three groups of resources allowed for one sample area to be allocated to each of the remaining eleven ASMRPs, with the twelfth sample area being available to be allocated as a second site in one of those areas.

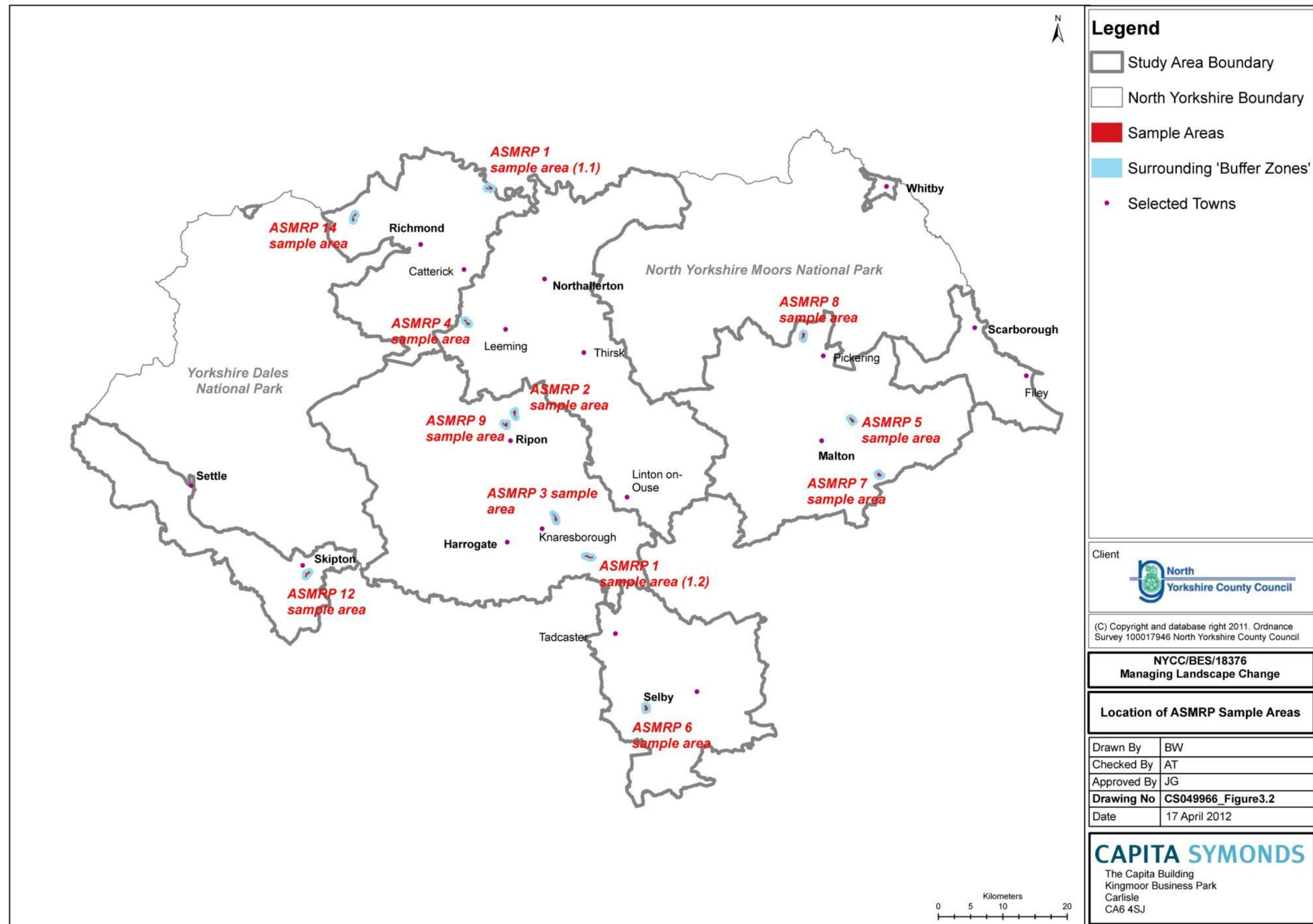
Criteria for Selection

3.15 The twin primary aims in selecting the twelve sample areas were to be as objective as possible (in order to avoid introducing bias) and to identify sites that were as representative as possible of the ASMRPs concerned.

3.16 The need for objectivity dictated a requirement for using sound and consistent criteria, drawn from the GIS evidence on key environmental characteristics and for using automated GIS processes, as far as possible, to avoid any subjective influences.

3.17 The need for identifying the most representative sites required the exclusion of areas within each ASMRP that were ‘uncharacteristic’ in terms of having very high or very low percentages of overlap with the key landscape, historic environment and natural environment constraints described in the Stage 1 report and then applying additional criteria to the resulting shortlist of ‘characteristic’ areas. Full details of the GIS methodology used are provided in the Stage 1 report.

- 3.18 After identifying the initial shortlists, the following additional selection criteria were applied, sequentially:
- i. identify candidate sample areas of approximately 30 hectares (e.g. 500m x 600m), wherever these will fit;
 - ii. exclude from the candidate sites those which have limited or no public access, and which would therefore be impractical for field investigation in Stage 2 of the project;
 - iii. use random numbers to identify four of the remaining sites for consideration by the Project Team and the Steering Group;
 - iv. discuss and agree the final selection of one preferred site from each group of four (plus one additional site), at the Project Review meeting at the end of Stage 1.
- 3.19 With the exception of the final step, the entire selection process was carried out objectively, using automated procedures within the GIS. The final step, whilst introducing an element of subjectivity, was included to allow for some degree of local knowledge to be taken into account in the final selection and to reach a consensus as to which ASMRP the twelfth sample area should be allocated.
- 3.20 At the Review meeting, preferred choices were agreed regarding the sample areas to be investigated, and a decision was made to allocate two sample areas to ASMRP 1, in order to capture the details of two different sites. The final selection of twelve sample areas is shown in Figure 3.2 below.



Sample Area Investigations (Stage 2)

- 3.21 For each of the selected sample areas, a series of desk studies were undertaken to gain background information on the area and its surroundings. These were carried out by a multi-disciplinary team of specialists covering mineral resources, geomorphology, ecology, landscape, archaeology and the historic environment in general. The same teams were then deployed in the field to examine each of the areas in greater detail. A key feature of the fieldwork was having the various specialists on site together, so that each could develop a more integrated understanding of the linkages and influences between the various different topics. The findings of these studies and field investigations are detailed in the Stage 2 technical report on sample areas.

Predictive Landscape Modelling (Stage 2)

- 3.22 The concept of predictive landscape modelling entails building up an understanding of the inter-relationships between the various facets of the modern landscape and how they have evolved over time, such that expectations regarding likely archaeological potential or environmental sensitivities (for example) can be developed for areas where substantive evidence is currently lacking.
- 3.23 In areas where there is scope to examine available evidence in great detail (for example in the case of individual planning applications), and in areas which have been subject to more comprehensive research programmes (such as the recent ALSF-funded studies of the Swale-Ure Washlands (Bridgland et al., 2011) and the Twill-Tweed catchment (Passmore et al., 2006)), this can be done with a reasonably high degree of confidence. In this case, however, where the requirement is to cover the whole of North Yorkshire, and where such detailed, site-specific analysis is not possible except within the very limited number of small sample areas, a more generalised approach has had to be taken. This draws primarily on the evidence base described in the Stage 1 report, supplemented by the additional desk study and field observations from the Stage 2 sample areas report and by existing knowledge within the project team.
- 3.24 The work firstly involved developing an understanding of the causal relationships between the underlying geology, the geomorphological evolution of the landscape, and changes in climate, natural vegetation, land use and human settlement throughout the Holocene period. This information is set out in Chapter 3 of the Stage 2 Predictive Landscape Modelling report, and is briefly summarised in Chapter 5 of this report. From this, although the details must inevitably be generalised, it has been possible to identify reasonably distinctive ‘profiles’ for some, though not all individual ASMRPs, which allow the prediction of broad environmental

characteristics and expectations. Again, these are detailed in the Stage 2 report and summarised in Chapter 5 herein.

Assessment of Environmental Sensitivities and Capacity (Stage 3)

- 3.25 Consideration was given to a range of potential options regarding the overall approach to be taken in the assessment of environmental sensitivity and capacity for future mineral development within North Yorkshire.

Options Available

- 3.26 For the purposes of this project, Section 2.3.5 of the Project Specification notes that ‘sensitivity’ shall be defined as “the degree to which a particular key environmental characteristic (using Stage 1 and Stage 3: 2.3.1) outputs) of an ASMRP is vulnerable to harm and/or change with potentially adverse effects upon its character”.
- 3.27 Section 2.3.6 of the Specification further defines ‘capacity’ as “a consideration of the sensitivity information (from Stage 3: 2.3.5 output) and judgement about the relative value of each key environmental characteristic, to guide minerals development to less sensitive or vulnerable areas. This judgement will be an interpretation of the significance of the key environmental characteristics; a subjective opinion, based upon professional, specialist synthesis and interpretation of relative importance”.
- 3.28 Sensitivity, as used in this study, is therefore required to deal with the intrinsic vulnerability of the natural and historic environments to potential impacts, irrespective of any mitigation measures that may be put in place through planning conditions to reduce or eliminate adverse impacts, or even to create positive long term environmental improvements through the eventual restoration and reclamation of surface mineral workings. The potential for long term improvement differs markedly between the natural and historic environments. In the former case, although biodiversity can be harmed in various ways by mineral extraction, in the longer term it can also be markedly enhanced through high quality restoration and aftercare. By comparison, damage to the historic environment is permanent (though it can be compensated to some degree by investigation, recording, analysis and dissemination/outreach activities). The focus required here, however, is very clearly on intrinsic vulnerability.
- 3.29 As noted by English Heritage (draft, 2011), techniques of assessing sensitivity to change are fast developing and the standard guidance on the subject, Topic Paper 6 of the Landscape Character Assessment (LCA) suite, published in 2002 by Scottish Natural Heritage and the former Countryside Agency (now Natural England) is currently under review. Despite the subsequent and rapid development of ideas in this area, however, the 2002 guidance made an

important distinction between overall landscape sensitivity, and sensitivity to a particular type of change.

3.30 For the purposes of the present study, three broad approaches to the assessment of sensitivity may be considered:

- **A quantitative approach based on assigning scores to various environmental features** (ancient monuments, cropmarks, historic parks, SSSIs, SINCs etc.), to reflect their intrinsic vulnerability, leading to the production of a map illustrating spatial variations in sensitivity (i.e. a 'traffic lights' map identifying three or more categories of sensitivity);
- **A quantitative or partly qualitative approach based on the varying types of sensitivity exhibited by individual receptors** (e.g. different types of heritage resource, different facets of landscape character or different habitats) to various types of impact. This would take account of the fact that any individual receptor will be sensitive, in varying degrees, to a range of different potential impacts. If it could be done this would again lead to some kind of spatial mapping of sensitivity;
- **A purely qualitative, scenario-based approach**, in which the generalised key characteristics of each ASMRP (or perhaps broad subdivisions of each ASMRP) are considered in terms of their sensitivity to the specific range of impacts likely to be associated with the kinds of mineral extraction that would be likely to take place in that ASMRP. This would lead directly to the development of policies or guidance applicable to each of these broad areas (e.g. guiding applicants to the particular types of sensitivity which they would need to address within their applications), and the differences between the ASMRPs (or parts thereof) could be illustrated on a map.

3.31 In order to decide on which overall approach should be used in this project, detailed consideration was given to the overall, generic pros and cons of each one, in relation to what this project needs to achieve. The findings of that exercise are given in full within the Stage 3 report. It was concluded that the qualitative, scenario-based approach was the only one which could realistically be applied.

Methodology for implementing a scenario-based approach

3.32 The following sequential steps were carried out, enabling information relating to landscape, the historic environment and the natural environment to be taken into account. This fitted in with iterative nature of the overall project, as described at the start of this chapter, allowing information from the earlier stages to be utilised in the assessments of sensitivity.

3.33 **Step A (Scenario development):** Identify the types of impact associated with each type of surface mineral working within each ASMRP (e.g. wet worked sand & gravel, dewatered dry working of sand & gravel, large scale aggregates extraction of Carboniferous and Magnesian

limestone, small scale and potentially large scale block stone working of Carboniferous sandstone and of Magnesian and Jurassic Limestone for use as building stone, opencast coal working, brick clay extraction etc.). This information is presented as part of the evaluation of the key characteristics of mineral development in Chapter 6 of the Stage 3 report.

- 3.34 **Step B (Identification of key environmental sensitivities):** Identify in broad, qualitative terms, the main environmental characteristics of each ASMRP that would give rise to sensitivities in relation to the potential impacts for that ASMRP identified in Step A. This is a natural extension of the Predictive Landscape Modelling work carried out in Stage 2 of the project and of the identification key environmental characteristics, as dealt with in Chapter 2 of the Stage 3 report. This has included consideration of multiple types of sensitivity for different types of landscape, historic environment and natural environment 'asset', but has not attempted to quantify these. The assessment, which incorporates professional judgement and logical expectations derived from the key characteristics, is presented in the form of tables for each ASMRP in Chapter 7 of the Stage 3 report. In all cases the sensitivities take account of the range of potential impacts associated with the type of mineral extraction likely to be involved for the ASMRP concerned, as detailed in Step A. Insofar as possible, differences in sensitivity have been identified for several subdivisions of each ASMRP, based on differences in Landscape Character Type. In some cases, significant variations were able to be identified between the different LCTs, whilst in others there were more similarities than differences, at least from a practical, qualitative point of view.
- 3.35 **Step C (Consider capacity for future mineral development):** Capacity is generally regarded as the inverse of sensitivity: the greater the sensitivity of a particular area to a specific type of development, the lower the capacity of that area will be to accommodate such impacts. However, whilst sensitivity has been considered in terms of the intrinsic vulnerability of an area or feature to potential impacts, irrespective of mitigation, it would be unrealistic for capacity to be judged on the same basis. A key tenet of the planning system is that conditions can be used to control development in such a way that it can be allowed to proceed, if it is needed, in situations where this might not otherwise be acceptable. For the purposes of this study, therefore, the assessment of capacity has been based on a consideration of both the intrinsic sensitivities, identified in Step B, and the potential for mitigation and enhancement.
- 3.36 **Step D (Develop generic guidance on addressing the sensitivities):** Without being too prescriptive, Stage 4 of the overall project has developed recommendations regarding approaches for dealing with the sensitivity and capacity issues identified. This information, detailed in the Stage 4 report and summarised in Chapter 9 of this report, includes generic recommendations for planning but also notes key differences between different minerals and geographical areas, taking particular account of the findings from Step C above. It highlights the need for particular forms of design, monitoring and mitigation in different circumstances.

4. Mineral Deposits and Landscape Evolution

The Distribution and Geological Characteristics of Mineral Resources

4.1 The various mineral resources potentially available for future extraction by surface quarrying within North Yorkshire have been identified as 'Areas of Surface Mineral Resource Potential' (ASMRPs). In sequential order of the age of the deposits (most recent first), these comprise:

- Quaternary Sand & Gravel Resources¹ - *subdivided into*
 - sub-alluvial gravels (**ASMRP 1**),
 - river terrace deposits (**ASMRP 2**),
 - glacio-fluvial deposits (**ASMRP 3**),
 - glacial deposits (**ASMRP 4**), and
 - undifferentiated sand & gravel (**ASMRP 5**);
- Quaternary Brick Clay Resources (**ASMRP 6**), *comprising glacio-lacustrine clays and silts*;
- Cretaceous Chalk Resources (**ASMRP 7**);
- Jurassic Limestone (**ASMRP 8**);
- Permian 'Magnesian' Limestone (**ASMRP 9**);
- Carboniferous Shallow Coal Resources (**ASMRP 10**);
- Carboniferous Brick Clay Resources (**ASMRP 11**), *comprising mudstones and 'fireclay' seams associated with shallow coal*;
- Carboniferous Sandstone Resources (**ASMRP 12**);
- Carboniferous and Jurassic Silica Sand Resources (**ASMRP 13**); *and*
- Carboniferous Limestone Resources (**ASMRP 14**).

4.2 The extent and distribution of the ASMRPs is shown in Figure 3.1, above, but a more detailed version of this which can be viewed alongside this chapter is provided in the Appendices to the Stage 1 report. More detailed plans showing the extent of each individual ASMRP are provided in Chapter 2 of the Stage 1 report.

¹ The work on sand & gravel resource distribution carried out for this study pre-dates the most recent BGS update set out in the North Yorkshire Sand and Gravel Assessment Minerals and Waste Programme Commissioned Report CR/11/133. As a consequence there are some minor differences in resource outlines compared with the most recent maps

- 4.3 In the case of the relatively recent ‘superficial deposits’ (those dating from or since the various ice ages of the Quaternary Period), the outlines correspond to the surface outcrops of potential resources, as mapped by the BGS. In the case of the older ‘bedrock’ geological formations, the outlines represent either surface outcrops or their positions beneath any overlying superficial deposits. For this reason, the two types of resource (superficial and bedrock) frequently overlap.
- 4.4 Each of the ASMRPs is described in further detail below but, first, it is useful to understand the geological terms which are necessary to distinguish between the different resources, and the links between these and the most common end uses for the materials concerned.

Geological Terminology and Overview of Commercial End Uses

- 4.5 The terms Quaternary, Cretaceous, Jurassic, Permian and Carboniferous refer to the specific periods of Earth history in which the deposits were laid down.
- 4.6 The Quaternary deposits (less than 2.6 million years old) are the youngest in this sequence. The most recent of these are the sub-alluvial gravels - sediments deposited by rivers, along with overlying silts and clays, during the process of creating the present-day floodplains over the last several hundred years. Slightly older than these are the sands and gravels of river terraces, dating from the last several thousand years, following the climatic improvement at the end of the last ice age. These are the valley-side remnants of older floodplains at higher levels, into which the present-day rivers have incised. Pre-dating the river terraces are the various deposits of the Quaternary ice ages, most of which (in North Yorkshire) relate to the last (‘Devensian’) glaciation, which peaked around 18,000 years ago. Those which are important in terms of mineral resources include sands and gravels laid down by glaciers (glacial deposits) and meltwater rivers (glacio-fluvial deposits), together with the finer-grained sediments which settled out in large glacial lakes at the margins of former glaciers and ice sheets (glacio-lacustrine deposits).
- 4.7 Sand and gravel deposits are capable of yielding a wide range of construction aggregate materials, from concreting gravels and ‘sharp’ concreting sands to finer-grained mortar and plastering sands. However, the suitability of each resource for these various end uses, and the ease (and therefore cost) of separating out the various size fractions depends to a large extent on the nature of the deposit and the proportion of unusable fines (silt and clay) within it. Sediments laid down by rivers are generally much better in this respect, than those laid down by former glaciers or their meltwater rivers, which tend to be less-well sorted in terms of grain size. After excavation, the deposits may need to be washed to remove excess fines and then screened into different size fractions. Typically, if the deposits have a fines content of more than about 10 to 15%, the cost of processing will be too high for them to be regarded as commercially viable resources. For this and other reasons (e.g. the thickness and extent of the deposit, the rock types of the gravels within it, the location of the deposit relative to potential

markets and a wide range of environmental factors), only some parts of the sand & gravel deposits shown on the BGS maps will be suitable for commercial exploitation.

- 4.8 The glacio-lacustrine deposits, naturally winnowed-out from the coarser-grained glacial sediments by powerful meltwater rivers and discharged into large glacial lakes, provide concentrations of finer-grained silts and clays, but also sands and gravels in the form of beach deposits at some of the lake margins. Of these, the clays are sometimes used for the manufacture of bricks and tiles but, once again, this depends on a wide range of factors and not all of the glacio-lacustrine sediments shown on the BGS maps will be suitable for this purpose. Glacio-lacustrine beach deposits may sometimes provide viable resources of fine aggregate (sands) and are exploited for this purpose in parts of the Vale of Pickering (where they are mapped as '**undifferentiated sand & gravel**').
- 4.9 The terms Cretaceous, Jurassic, Permian and Carboniferous all relate to successively older time periods, extending from 65 to 359 million years before present. The deposits laid down at these times, within oceans, shallow seas and river systems, have been consolidated over time into rocks – the older rocks have generally become harder and stronger compared with those which are more recent.
- 4.10 The relatively young **Cretaceous Chalk** is generally too weak and too soluble to be used as either a construction aggregate or building stone, though it can be used, with care, as general fill material, as well as for agricultural lime and in the manufacture of cement.
- 4.11 **Jurassic** and **Permian Limestones**, being older, stronger and less soluble, are capable of being used as relatively low grade construction aggregate (that is, for relatively low specification uses, largely excluding concrete and asphalt products), but have also been used extensively as building stone, due to the ease with which they can be cut, compared with older rocks. Although the outcrops of these strata in many areas include old, disused quarries where building stone was formerly extracted for local use, modern building stone production tends to be focused primarily on those parts of the resource which exhibit the thickest 'beds' of rock, from which the largest blocks can be cut.
- 4.12 **Carboniferous Sandstones**, particularly those of the 'Millstone Grit Series', are similarly used for building stone and low grade aggregate. Unlike the younger limestones, which are made up almost entirely of calcium carbonate, the sandstones comprise grains of sand made up of harder and less soluble minerals, particularly quartz, feldspars and iron. This makes the sandstones more suitable for the production of paving stones and kerbs, as well as other types of building stone where strength and durability are more important than ease of production. Thinly-bedded sandstones have also been extensively used, in the past, as roofing stones, though they are rarely quarried for this purpose now.

- 4.13 **Silica sands** within both the Carboniferous and Jurassic sequences are sandstones in which the proportion of quartz is very high, making them suitable for a variety of specialist industrial uses where high purity is important. These range from glass production to a wide range of manufacturing, horticultural and leisure applications.
- 4.14 **Carboniferous Limestones**, the oldest rocks in the geological sequence exposed within North Yorkshire (excluding the National Parks), are also the hardest. In contrast to the younger limestones, the individual grains of calcium carbonate within these rocks have been consolidated to a much greater degree over a much longer period of time and in many cases have re-crystallised to produce a denser and much harder rock. As a consequence, they are important sources of relatively high grade construction aggregate - capable of being used in more demanding situations, including the manufacture of concrete and certain asphalt products (but not those used within wearing courses on the road surface itself, where a much higher degree of resistance to polishing and skidding is required).

Resource Information for Individual ASMRPs

ASMRP 1: Sub-Alluvial Gravels

- 4.15 As noted above, sub-alluvial gravels occur beneath the floodplains of present day rivers, and are naturally developed to the greatest extent within the main valleys and their principal tributaries.
- 4.16 In many of these areas, especially within the upstream sections of the valleys, the deposits are likely to be of limited commercial value because they are too thin; too limited in surface extent, or because the ratio of mineral to overburden and 'waste' (e.g. very silty or clayey layers) is too low. The upper sections of the valleys also tend to be more distant from potential markets, accessible only by relatively minor roads through numerous towns and villages and, in many cases, more sensitive in terms of landscape and environmental impacts (though this is to be the subject of further analysis later in the project). This combination of factors has influenced the current distribution of commercial extraction within these deposits, which occurs only to the East of Catterick, and around Ripon. In both cases, these locations are within a few miles of the A1, which allows good access to the markets of both Teeside, to the north, and West Yorkshire, to the south. For the same reasons, the most likely prospects for working sub alluvial deposits in future years are likely to be in similar areas, in terms of both distance from the A1 and distance upstream within the major valleys.

ASMRP 2: River Terrace Sands and Gravels

- 4.17 As explained above, river terraces are the remnants of older floodplains into which the present-day rivers have incised. They are therefore found, sporadically, along parts of the same major valleys, between the modern alluvium and the valley sides. In some cases they are also mapped along valleys where there are no significant alluvial deposits.

- 4.18 Existing gravel pits within these deposits occur only between Brompton on Swale and Catterick. Subject to further investigation, and taking account of location (including proximity to the A1), additional prospects for commercial exploitation are perhaps most likely to be found elsewhere within this part of the Swale Valley and within parts of the Tees and Ure Valleys.

ASMRP 3: Glacio-Fluvial Sands and Gravels

- 4.19 Glacio-fluvial sands and gravels are the deposits of meltwater streams and rivers which issued from former glaciers and ice sheets. In the last (Devensian) glaciation, valley glaciers occupied most of the major river valleys draining from the high ground of the Pennines and coalesced into a much broader ice sheet which extended across the Vale of York and down into South Yorkshire. A combined Scottish and Scandinavian ice sheet which flowed across the North Sea also impinged onto the coast of the North York Moors and East Yorkshire, extending inland from Filey across part of the Vale of Pickering. Meltwater from these various ice fronts generally followed the topography of the present-day valleys, often at a higher level, at the margins of the glaciers, and also extended across some of the 'interfluve' areas of higher ground between the valleys. The resulting deposits have been reworked in many places by subsequent (post-glacial) river activity, leaving behind a more sporadic pattern of glacio-fluvial sediments.
- 4.20 The deposits are only worked, at present, at three quarries (Marfield, Nosterfield and Ripon quarry), all of which are located in the Ure Valley. Subject to detailed investigation, however, opportunities for future resource development could potentially be found in any of the above-mentioned areas, especially those within reasonably close proximity to the A1.

ASMRP 4: Glacial Sands and Gravels

- 4.21 Glacial sands and gravels are those which were deposited directly at the margins of the former glaciers, following transportation by ice. Unlike glacial till deposits ('boulder clay'), which comprise a mixture of all grain sizes, including very large quantities of silt and clay, the glacial sands and gravels have been at least partially sorted by the action of meltwater within, beneath or on the surface of the glaciers. As a consequence, the deposits offer much greater potential for commercial exploitation, although they will often have greater proportions of both fines and 'oversize' cobbles and boulders, by comparison with the better-sorted glacio-fluvial and post-glacial river sediments. In reality, there is a complete gradation from glacial sand & gravel to various types of glacial till, and the distinction between the two is often somewhat arbitrary. The glacial sand & gravel resources, as mapped by the BGS, are located primarily within and at the margins of the Vale of York, indicating successive positions of the former Vale of York glacier, as it retreated back towards the higher ground of the Yorkshire Dales at the end of the last glaciation. Within this area the deposits are preserved as residual patches (following post-glacial erosion) both within the major valleys and across many of the intervening areas.

- 4.22 The deposits have previously been worked at two currently dormant quarries at Fairfield Farm and Leases Quarry West, to the north west of Leeming; at Myton Lane quarry, which is now closed; and at Allerton Park quarry. Once again, subject to detailed investigation, opportunities for future resource development could potentially be found in these and any of the other resource areas identified above, especially those within reasonably close proximity to the A1.

ASMRP 5: Undifferentiated Sands and Gravels

- 4.23 Undifferentiated sand & gravel resources are mapped within the Vale of Pickering and appear to correspond to (or at least to include) beach deposits formed at the margins of the former ice-dammed glacial lake which occupied the whole of this area during the Devensian glaciation. The deposits extend continuously along the foot of the Chalk escarpment of the Yorkshire Wolds, from Norton-on-Derwent in the west to Muston, near Filey in the east. They also occur along the northern margin of the former lake to the south and west of Seamer, Wykeham and Brompton, and to the south of Pickering. A further outcrop extends along the western margin of the former lake to the north west of Malton. The deposits are currently worked at the West Heselton sand pit in the first of these areas, and at Wykeham Quarry in the second area. A third active pit at Ings Farm Quarry near Yedingham also works similar deposits on a very small scale, though the outcrop here is not shown on the BGS resources map and is probably concealed by younger lake sediments and/or post-glacial peat and alluvium. Future prospects for working these deposits are likely to be limited by their distance from major markets, although local supplies to towns such as Scarborough, Eastfield, Filey, Malton, Norton and Pickering will continue to be needed.

ASMRP 6: Quaternary Brick Clay Resources

- 4.24 Fine-grained glacio-lacustrine sediments (clays and silts) accumulated on the beds of both large and small glacial lakes at the margins of the Vale of York glacier. Remnants of these deposits are widely preserved throughout this area, notably within the central and southern parts of Hambleton District, the eastern parts of Harrogate District, the south western part of Ryedale District and throughout much of Selby District. A succession of different lakes would have developed at different stages during the advance and subsequent retreat of the glacier, being trapped between the ice and adjoining higher ground. The suitability of individual deposits for brick-making depends once again on a wide range of factors including grain size distribution (uniform clays being preferred), organic content, colour, and proximity to markets.
- 4.25 The deposits are currently worked for brick-making at just one site within North Yorkshire: at Alne, to the south of Easingwold. Similar deposits are worked for pottery clay at Park Hill Quarry at Littlethorpe, near Ripon and as a component of concrete block products at Hemingbrough, to the east of Selby (the manufacturing taking place at Great Heck).

ASMRP 7: Cretaceous Chalk Resources

- 4.26 The Chalk deposits of the Yorkshire Wolds represent an extensive resource that has been used in the past as a source of both agricultural lime and (in neighbouring East Yorkshire and Humberside) for cement manufacture. Within North Yorkshire the Chalk has most recently been worked at Knapton Quarry, to the east of Norton and at Flixton Quarry to the north west of Hunmanby, but neither of these are currently active. Future workings are likely to be inhibited by the distance of these resources from principal construction markets, by comparison with the resources available at South Ferriby on the Humber Estuary, which are still used extensively for the production of cement.

ASMRP 8: Jurassic Limestone Resources

- 4.27 Jurassic Limestones occur within the southern part of the North York Moors, partly within the National Park and partly within North Yorkshire. The latter outcrops are found between Helmsley and Pickering in the west, and to the north of Seamer in the east. The quarry at Newbridge, to the north of Pickering, produces crushed rock aggregates from the Upper Calcareous Grit formation which directly overlies the limestone, but the limestone itself, formerly used as a local building stone, is no longer worked in this area, except on a very local scale from intermittently active quarries. Further south within Ryedale District, in areas which are not identified on the BGS resource maps, the Jurassic Limestone ('Malton Oolite') is, or recently has been, worked at four locations around Malton (Hovingham, Wath, Whitewall and Settrington quarries). The Hovingham site is not currently being worked, having been mothballed for several years. Again, these workings are primarily geared towards relatively low-grade crushed rock aggregate production, rather than building stone.

ASMRP 9: Permian 'Magnesian' Limestone Resources

- 4.28 The Magnesian Limestone is primarily a dolomite rather than a true limestone, as it is made up of magnesium carbonate as well as calcium carbonate. The difference allows it to be used for a variety of industrial applications, notably in steel and glass-making, and as a source of agricultural lime. The rock has also been used extensively in the past as a source of building stone for many prestigious architectural projects, within Yorkshire and elsewhere, and is still used for this purpose to some degree, but the primary use today is as a construction aggregate. The resource comprises two geological formations: the Cadeby Formation, which tends to be massively bedded, and the most suitable for building stone production (as well as aggregates) and the thinner and more thinly-bedded Brotherton Formation, which occurs higher in the Permian sequence, outcropping further east. The two outcrops run more or less parallel to each other in a narrow and almost unbroken belt which extends throughout North Yorkshire, from the area around Manfield in the north of Richmondshire to the area around Kirk Smeaton in the south of Selby District. The resource continues northwards into County Durham and southwards into South Yorkshire and Nottinghamshire.

- 4.29 Throughout its length, the Magnesian Limestone outcrop lies close to the A1 road, giving good access to major construction markets. For this reason, it has been extensively quarried. Although some parts of the resource (notably in South Yorkshire) are capable of yielding high quality aggregate that is suitable for use within concrete products, most of the Permian Limestone quarries within North Yorkshire produce relatively low grade aggregate that is used primarily as sub-base material in road construction and as general fill. Eleven separate quarries are currently operating. From north to south these are: Gebdykes near Masham; Potgate near Ripon; Jackdaw Crag near Tadcaster; Newthorpe near Sherburn in Elmet; Brotherton and Foxcliffe to the east of Castleford; Darrington, to the east of Pontefract; Went Edge near Wentbridge; and Barnsdale Bar / Long Lane near Kirk Smeaton.

ASMRP 10: Carboniferous Shallow Coal Resources

- 4.30 Shallow coal resources, potentially suitable for opencast extraction or shallow mining, occur within the Carboniferous coal measure sandstone outcrops between Ingleton and High Bentham in Craven District. They are classified by the BGS as being of secondary importance, comprising thin, widely-spaced coal seams. Around and to the north west of Ingleton itself, the coal is concealed by up to 50m of overburden, making it suitable only for underground mining. Whilst these resources have been worked in the past they are no longer viable, and their relatively small scale (compared to the extensive resources of both opencast and deep coal in other coalfield areas) is such that they are unlikely to be exploited in the foreseeable future.
- 4.31 Shallow coal, concealed by up to 50m of overburden (including the overlying Magnesian Limestone resources) is also shown on the BGS resource maps along the western boundary of Selby District, to the south of Tadcaster. These resources represent an easterly continuation of the exposed outcrops (including primary opencast resources) which occur immediately to the west, within West Yorkshire and South Yorkshire. The same resources also continue further east at greater depth, within the Selby Coalfield, where coal was extensively worked by deep mining until 2004. Given their proximity to these other resources, it is again considered unlikely that the shallow coal within Selby District will be exploited in the foreseeable future.

ASMRP 11: Carboniferous Brick Clay Resources

- 4.32 Seams of mudstone and 'fireclay' which occur within the Carboniferous coal measures have been extensively worked, as raw materials for brick and tile making, in most coalfield areas of the UK. Such resources occur, in close association with the shallow coal resources, along the western edge of Selby District. However, as noted above, the coal measures are concealed beneath a significant thickness of overburden, including Permian Limestone resources.
- 4.33 Fireclays, which occur in thin beds directly beneath individual coal seams, have always been extracted as a bi-product of coal production, and their future extraction is therefore intimately dependent on that of the coal. As explained above, the likelihood of future shallow coal extraction in North Yorkshire would seem to be very limited.

- 4.34 Other mudstones within the coal measure rocks, which occur in much thicker seams or beds, are capable of being worked separately, where they occur at or near the surface. Although clay pits of this type are to be found in neighbouring parts of West and South Yorkshire, the fact that the coal measure mudstones are not exposed in North Yorkshire means that there are no such pits in this area.

ASMRP 12: Carboniferous Sandstone Resources

- 4.35 Sandstones occur throughout the Carboniferous coal measure series and have been utilised in the past for walling stone but are no longer commercially exploited. Better quality building stone is obtained from some of the sandstones towards the top of the underlying Carboniferous Millstone Grit series, and it is these which are picked out on the BGS resources map and represented by ASMRP 12. It should be noted that these outcrops form only part of the Millstone Grit which, overall, has a much wider distribution across much of western moors of North Yorkshire. The identified resources crop out within parts of Craven District, primarily to the south-east of Settle and to the south of Skipton. A separate outcrop occurs directly to the north of Harrogate and Knaresborough. None of these outcrops are currently worked however, either for aggregates or building stone, although there may be intermittently worked quarries in some areas that are used as sources of stone for the repair of local historic buildings.
- 4.36 There are however, a number of sandstone quarries listed by the BGS in North Yorkshire, which fall outside the selected outcrops that are shown on their resource maps. These comprise Green Bank Farm, Carkin Moor and Gatherley Moor quarries, to the north of Richmond, which all work sandstones of the Alston Formation; Grey Yaud quarry, between Leyburn and Masham and Home Farm quarry, to the south of Harrogate, which both work the Follifoot Grit, and Killinghall quarry, to the north-west of Harrogate, which is now closed but formerly worked the Lower Plompton Grit. Both the Follifoot Grit and the Plompton Grit form part of the Millstone Grit Series, whilst the sandstones of the Alston Formation form part of the underlying Yoredale Series – an alternating sequence of sandstones, shales, limestones and occasional thin coal seams. In all cases these sandstones are worked primarily for use as local building stone.

ASMRP 13: Carboniferous and Jurassic Silica Sand Resources

- 4.37 Two separate, small areas of silica sand resources are identified on the BGS maps. The first of these, around the village of Blubberhouses, to the west of Harrogate, forms part of the Carboniferous sandstone sequence. The deposit has been worked in the past (c. 20 years ago) and the deposits there are capable of producing sand of sufficient quality for glass manufacture, subject to chemical processing, but is not currently active. The quarry lies within the Nidderdale Area of Outstanding Natural Beauty. The second area is located at Burythorpe, to the south of Malton in Ryedale District, and forms part of the Jurassic Scalby Formation. Silica sand is produced here for ceramic, construction, sports and leisure markets and for the

production of resin-coated sand for foundry applications. In both cases, the prospects for future resource development are extremely limited by the extent of the outcrops involved.

ASMRP 14: Carboniferous Limestone Resources

- 4.38 Carboniferous Limestone occurs within the central part of Craven District, between and to the south of Settle and Skipton and more extensively within Richmondshire District, primarily to the south and west of Leyburn and to the north and west of Brompton on Swale and Richmond. Smaller outcrops occur to the south west and north-west of Pateley Bridge in Harrogate District.
- 4.39 Given the importance of hard Carboniferous Limestone as a major source of construction aggregate, the deposits are quarried in all of these areas. In Craven, of the limestone has recently been worked at Skipton Rock, located to the north-east of Skipton, but that site is currently inactive. In Harrogate District, limestone is worked at Pateley Bridge Quarry. In the Leyburn area there are two quarries (Wensley and Leyburn) and in the north of Richmondshire there are a further five quarries (Forcett, Low Grange, Melsonby, Barton and Duckett Hill). As an indication of their importance, six of these ten quarries are operated by major aggregate companies (Tarmac, Hanson and Cemex UK) and a further two are operated by a regionally important independent firm (Sherburn Stone).
- 4.40 All of the resources described above provide both existing and potential future sources of high quality construction aggregate, with the possible exception of some of the thinner limestones within the Yoredale Series, which may not be economically viable.
- 4.41 In addition to the 'normal' varieties of Carboniferous Limestone, the area around Ingleton in Craven District includes small outcrops of high purity limestone (containing more than 97% calcium carbonate). Such deposits are valued for use in a range of industrial applications, and are extensively developed within both the Yorkshire Dales and Peak District National Parks, but are not currently worked in the Ingleton area. The prospects for such workings in future will be limited by the small outcrop size and their location immediately next to the National Park boundary, but might need to be considered in the longer term.

5. Landscape Evolution and Archaeological Potential

Introduction

- 5.1 This section, which forms an abridged version of Chapter 3 from the Stage 2 Predictive Landscape Modelling report, aims to provide a broad contextual understanding of the evolution of the modern landscape within North Yorkshire, over the last few hundred millennia, and especially over the last 12,000 years.
- 5.2 One of the most important aspects to consider in this respect is the relationship between Man and his changing environment within the **major river valleys** (including ASMRPs 1 and 2), throughout the post-glacial period. Here, in particular, there have been demonstrable cause and effect relationships between climate change, landform development, vegetation succession and human activity. The latter has both responded to, and increasingly influenced, the other factors.
- 5.3 Also important, primarily because of the mineral resources which they contain, are the **Vale of York** and the **Vale of Mowbray** (encompassing ASMRPs 1, 2, 3, 4 and 6) together with the adjoining **Magnesian Limestone Ridge** (ASMRP 9). Here, the available archaeological and palaeo-environmental evidence is patchier, and the distinctions which can be made between at least some of the different deposits are open to a number of alternative explanations.
- 5.4 A third area of importance, not least because of the immense richness of archaeological evidence available from successive periods throughout the Holocene period, are the relationships seen within the **Vale of Pickering** (including ASMRP 5) and the adjoining **Yorkshire Wolds** (ASMRP 7).
- 5.5 Finally, quite different relationships can be gleaned from sites within the upland areas of the **Pennine Moors**, including large parts of ASMRPs 12, 13 and 14).
- 5.6 Each of these broad areas is considered separately below, to provide a context in which the individual ASMRPs are subsequently examined.

Timescales

- 5.7 Throughout these accounts there are repeated references to periods of historical and geological time, particularly during the last 12,000 to 450,000 years Before Present (BP). For convenience, Table 5.1, below, summarises the sequences and approximate correlations involved.

Historical / Cultural period	Dates	Age (years BP) <i>(Calibrated radio-Carbon years Before Present, where 'Present'= 1950)</i>	Geological /Palaeo-environmental period		
Post-Medieval	Since 1540 AD	Less than 410 BP	Sub-Atlantic	Late Holocene	Holocene (= Flandrian)
Late Medieval	1066 – 1540 AD	884 – 410 BP			
Early Medieval	410 – 1066 AD	1,540 – 884 BP			
Roman	43 – 410 AD	1,907 – 1,540 BP			
Iron Age	BC 600 – 43 AD	2,550 – 1,907 BP			
Bronze Age	BC 2500 – 600	4,450 – 2,550 BP	Sub-Boreal	Mid Holocene	
Neolithic	BC 4000 – 2500	5,950 – 4,450 BP			
Mesolithic	BC 10000 – 4000	11,950 – 5,950 BP	Atlantic	Early Holocene	
			Boreal		
			Pre-Boreal		
Palaeolithic	Upper Palaeolithic	12,800 – 11,950 BP	Younger Dryas Stadial <i>(Late Glacial / Loch Lomond)</i>		Devensian glaciation
		26,000 – 12,800 BP	Dimlington Stadial <i>(includes the Bølling – Allerød (=Windermere) Interstadial, around 13,000 BP, and the Last Glacial Maximum (LGM) (=Oldest Dryas), around 23,000 BP)</i>		
		38,000 - 26,000 BP	Early Devensian		
	Middle Palaeolithic	110,000 - 38,000 BP			
		130,000 - 110,000 BP	Ipswichian Interglacial		
		200,000 - 130,000 BP	Wolstonian glaciation		
	Lower Palaeolithic	380,000 - 200,000 BP	Hoxnian Interglacial		
		455,000 - 380,000 BP	Anglian glaciation		
		Pre- 455,000 BP	Pre-Anglian		
					Middle and Upper Pleistocene

Important note: dates and age ranges shown in this table are based on the latest known information but are constantly changing as new dating evidence is obtained. For this reason there are differences between previously published studies

Table 5.1: Correlation of historical/ cultural and geological/palaeo-environmental periods, with corresponding dates / age ranges

Major River Valleys

- 5.8 The following account is based on an integrated analysis of geomorphological, archaeological and palaeo-environmental research, combined with the existing knowledge and observations of the multi-disciplinary project team. It draws extensively on the recently completed synthesis of work undertaken on the Swale-Ure Washlands project (Bridgland *et al.*, 2011), but also on a variety of other sources, as cited in the text.
- 5.9 Figure 5.1, below, uses an accurate cross section from the topographic modelling exercise to illustrate the relationship of river valley deposits (ASMRP 1, river floodplains and ASMRP 2, river terraces) to other ASMRPs within the surrounding landscape. Although precise details vary from one location to another, the section illustrates how these fluvial sediments form flat, low-lying areas which are often incised into older Quaternary glacial (ASMRP 4) and glacio-fluvial (ASMRP 3) sediments. This particular example (Section F) extends from south west to north east just to the north of Ripon. Although the surface profile and the surface positions of the ASMRP outcrops are accurate, the sub-surface detail and the distribution of glacial till (pale blue) are schematic (though informed by previous research carried out in this area – Thompson *et al.* 1996).

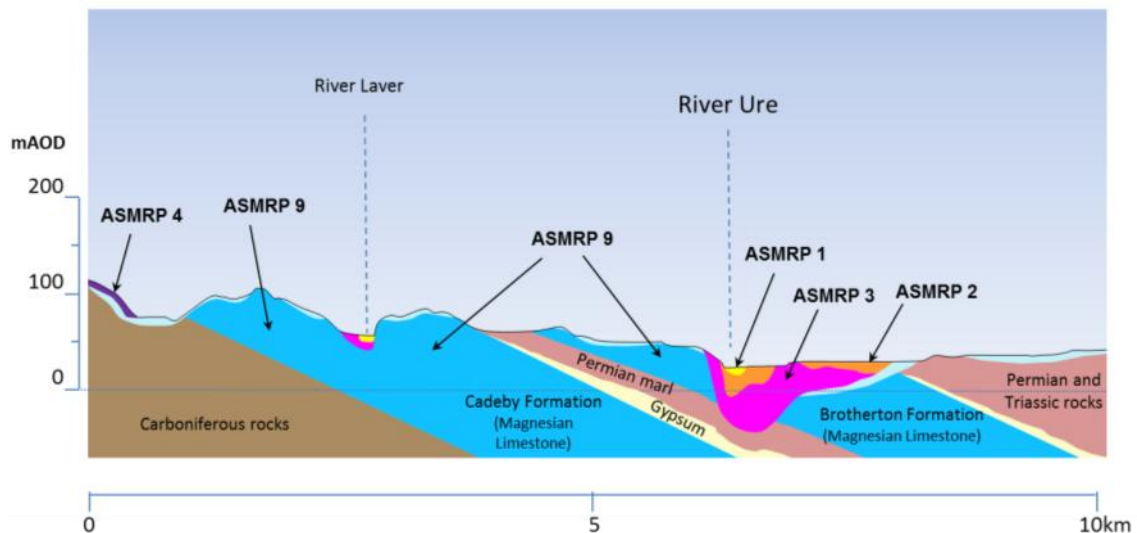


Figure 5.1: topographic profile (F) and schematic geological cross section to illustrate the relationship of ASMRPs 1 and 2 to the surrounding landscape

- 5.10 River deposits within the region accumulated at various stages during the post-glacial Holocene period, through the reworking of older glacial and glacio-fluvial sediments within high energy braided river environments. In some areas (Powell *et al.*, 1992; Cooper & Burgess, 1993; Thompson *et al.*, 1996; Frost, 1998) these deposits form part of a complex sequence of sedimentary infills within over-deepened palaeo-valleys. Such valleys were carved initially by Quaternary glaciers and sub-glacial rivers and the oldest sediments within them are overlain by

Late Devensian glacial tills, as illustrated in Figure 5.2, below. This cross section is entirely schematic, but is comparable to the eastern part of the profile shown in Figure 5.1, above.

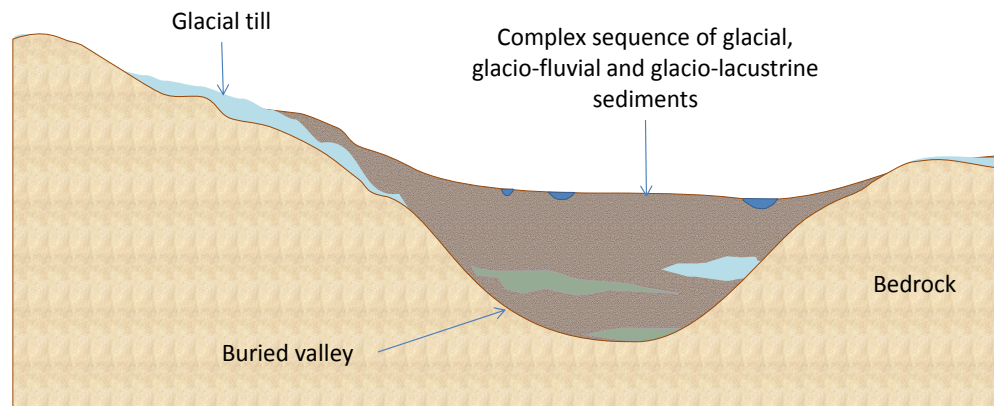


Figure 5.2: schematic cross section through a Pennine valley at the end of the Devensian glaciation

- 5.11 It seems likely, however, that the valleys were partially re-excavated by the river systems of the early Holocene period. At that time, the supply of sediment from upland areas was reduced by the retreat of the ice sheets and by the subsequent rapid growth of stabilising vegetation as climatic conditions improved. Woodland covered almost all the land surface of the Swale-Ure Washlands during the early and mid-Holocene (Innes, 2002).
- 5.12 Being relatively 'starved' of new sediment, the rivers were able to cut down into the older deposits and associated landforms – a process that is likely to have been enhanced by isostatic uplift of the land surface following the retreat of the ice sheets (Bridgland, 1999; Bridgland & Austin, 1999; Shennan & Andrews, 2000; Shennan *et al.*, 2006; Howard *et al.*, 2000a). Figure 5.3, below, provides a schematic illustration of this stage of landscape evolution during the early to mid-Holocene.

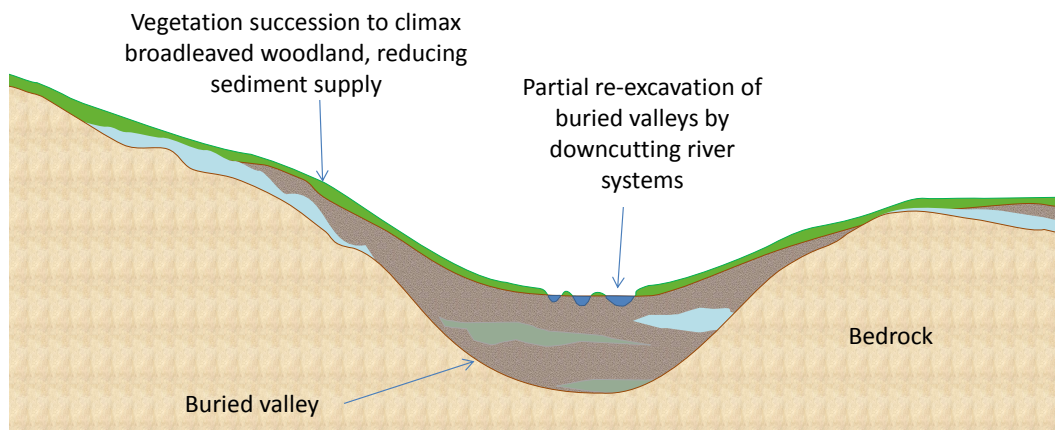


Figure 5.3: schematic cross section through a Pennine valley during the early Holocene

- 5.13 Evidence from other sources suggests that the subsequent accumulation of fluvial deposits within the re-excavated valleys was due, at least in part, to the progressive influence of humans on the landscape: in particular the clearance of trees to facilitate cultivation and grazing, which would have increased the supply of sediment once more.
- 5.14 From the Mesolithic period there is pollen evidence of a decline in upland tree species associated with the use of fire by hunter-gatherers, leading to the establishment of heath, bog and grassland over wide areas (Simmons and Innes, 1985). More widespread disturbance, through the permanent clearance of trees for animal husbandry and crop cultivation, occurred from the early Neolithic period onwards, around 5,000 years BP. Evidence for this is seen in the 'Elm Decline' a marked and widespread reduction in Elm pollen (*Ulmus sp.*) from around this time, accompanied by a rise in cereal pollen from arable farming. The process accelerated considerably, both in spatial extent and intensity, during the latter part of the Neolithic and into the mid Bronze Age (Bridgland *et al.* 2011). This was a time when the level of human settlement and activity in the area greatly increased – not least in response to a period of warmer and drier climate which allowed expansion of farming into previously unfavourable areas.
- 5.15 Throughout this period, from before 5,000 BP to around 3,000 BP, it is likely that river valleys would have experienced considerable net aggradation, i.e. the accumulation of sediment to higher levels than those of both pre-existing and present-day rivers (Figure 5.4, below). The sediments, being contemporaneous with Mesolithic to Bronze Age human activity, both incorporated and buried older archaeological evidence, whilst the depositional surfaces (remnants of which now form the highest river terraces), retain evidence of land use and settlement from these and subsequent periods.

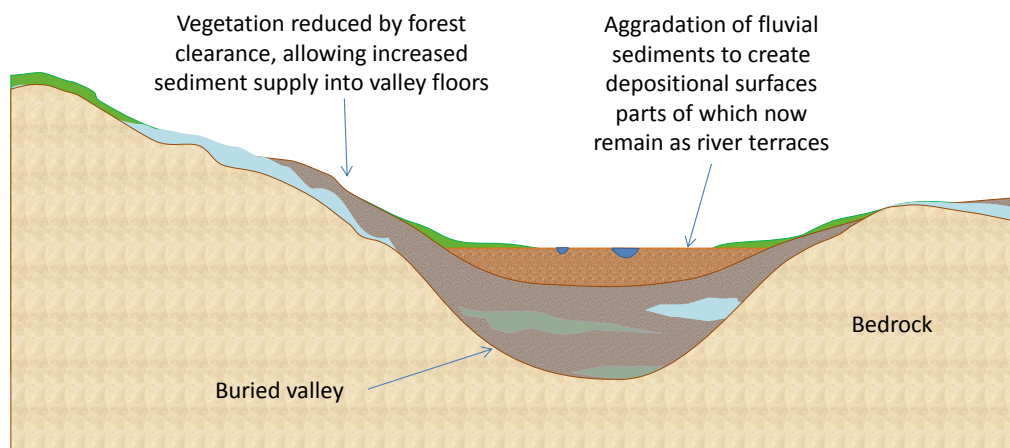


Figure 5.4: schematic cross section through a Pennine valley during the mid-Holocene

- 5.16 Within this period, as Neolithic settlers began to make their mark on the landscape, some of Yorkshire's most important prehistoric features were created. These included the three henges at Thornborough, which are almost perfectly aligned with the one at Nunwick, north of Ripon and also linked with the largely destroyed henge at Catterick, further north. The henges at Thornborough were constructed on ASMRP 3 sand & gravel deposits, slightly above the aggrading deposits of the Ure valley, whilst those at Nunwick and Catterick were built on slightly lower ASMRP 2 terrace surfaces.
- 5.17 Interestingly, all five of these henges, as well as being located close to major rivers, were also constructed very close to the narrow outcrops of Permian gypsum deposits and two more henges to the east of Ripon (Hutton Moor and Cana Barn) are not far from the same outcrops. Gypsum (alabaster) is known to have been used in covering the earthworks of at least the central henge at Thornborough (Burl, 1976), giving it a brilliant white sheen visible for miles around within the landscape, and comparable in many ways with the use of Chalk for similar purposes in parts of southern England. It is postulated here that the geological link with gypsum outcrops might form part of the explanation for the location of these henge monuments within North Yorkshire, and may help to provide a focus for future investigations of prehistoric remains within or close to other parts of the gypsum outcrop.

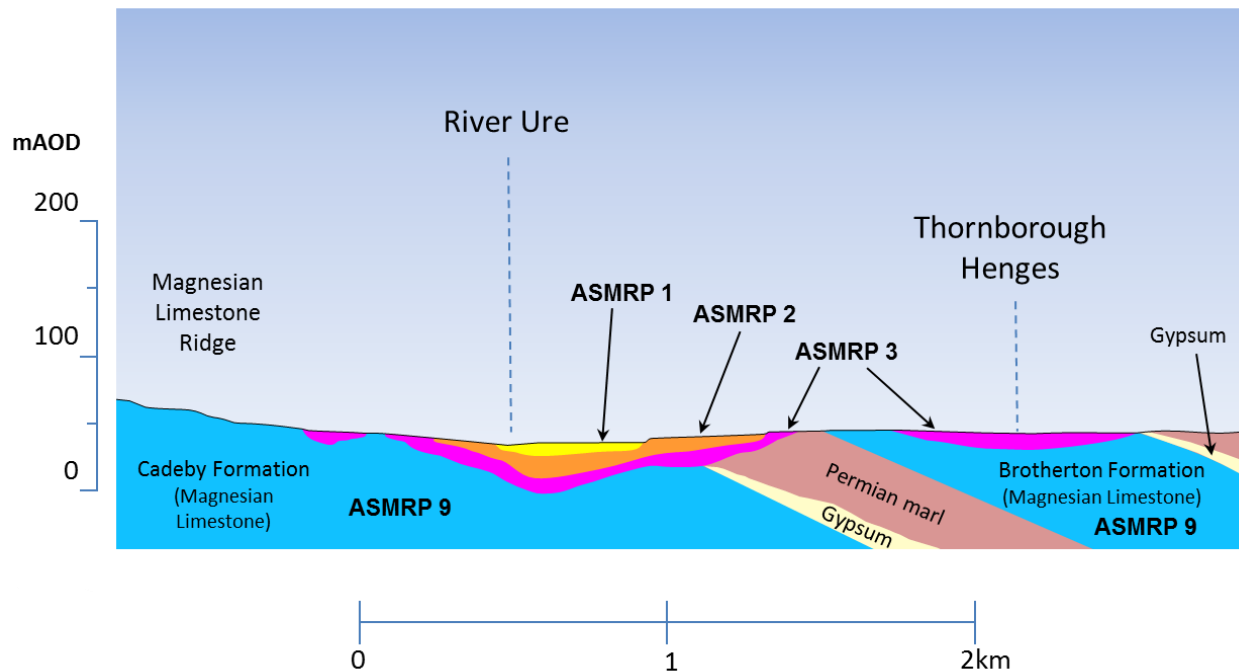


Figure 5.5: topographic profile (E) and schematic geological cross section to illustrate the relationship of ASMRPs 1, 2 and 3 to the Ure Valley and the Thornborough Henges complex

- 5.18 The conversion of the former depositional surfaces into the terrace features seen today resulted from subsequent downcutting by the rivers, interrupted by periods of renewed aggradation to produce complex 'cut and fill' sequences in many of the valleys, as illustrated

schematically in Figure 5.6, below. The incision was driven partly by continued isostatic rebound of the uplands, but the process was also strongly influenced by the effects of ongoing climate change – both directly, in relation to the hydrology and delivery of sediment from upland catchments, and indirectly through its effects on farming practices and tree clearances.

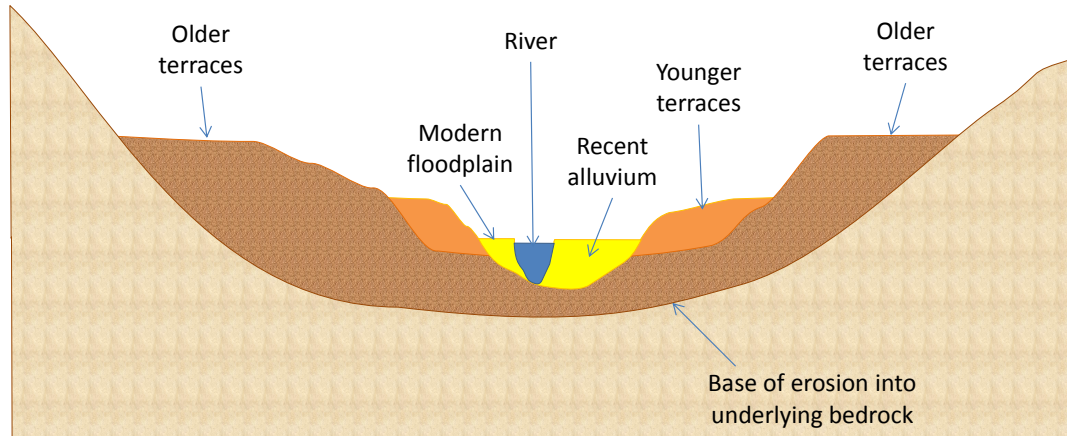


Figure 5.6: schematic illustration of the detail of Holocene cut and fill sequences within a river valley. In this example, the base of the Holocene sediments corresponds to the underlying bedrock surface but, elsewhere, these sediments may be underlain by older Quaternary deposits infilling much deeper valley systems (as illustrated in Figure 5.5, above).

- 5.19 Evidence from peat stratigraphy and other sources, summarised by Bridgland *et al.* 2011 (*Ibid.*), shows that there was a marked climatic deterioration towards the end of the Bronze Age, from about 3100 to 2500 ¹⁴C BP, with a particularly wet and cold phase near the end of that period, at around 2650 ¹⁴C BP. This is likely to have had a strong influence on the distribution and types of land use conducted by late Bronze Age and early Iron Age communities. Palaeo-environmental and archaeological evidence from the region (Bridgland *et al.* 2011) suggests that this led to the regeneration of woodland, the spread of wetland ecosystems within the valley floors and the near absence of forest clearance and agriculture within upland areas.
- 5.20 Initially, this change in climate may have combined with isostatic effects to allow for a period of incision into the older terrace deposits but this was subsequently replaced by a widespread episode of net deposition – particularly of fine-grained overbank flood deposits. As noted by Bridgland *et al.* 2011 (*Ibid.*), virtually all relevant studies of Yorkshire rivers record a major episode of alluvial deposition following the c. 2650 ¹⁴C BP climate event, from upper reaches, as in Wharfedale (Howard *et al.*, 2000b) to the Humber and Tees estuaries (Plater *et al.*, 2000; Rees *et al.*, 2000), as well as many stretches in between (Lewin *et al.*, 2005). It may be

conjectured that the presence of dense, wetland vegetation within the valley floors at this time would have helped to prolong flood events and to trap the fine grained sediment.

- 5.21 During the late Iron Age and Roman periods which followed, environmental and cultural conditions were profoundly different to the preceding wet phase of the early Iron Age. Climate studies suggest that a dry and warm phase began about 2400 ¹⁴C BP and lasted for several centuries. This greatly reduced the incidence of overbank flooding and alluviation (Macklin et al., 2005), so that much of the lowland in the Ouse system became drier and more stable and thus available for intensive agricultural exploitation. Environmental evidence also suggests that most areas experienced a high level of renewed forest clearance in the late Iron Age, and that this continued into and through the period of Roman control.
- 5.22 Thereafter, during the medieval period, there appears to have been a relaxation of human pressure on the landscape and a widespread regeneration of woodland. Throughout this time, from the late Iron Age to the early / mid-medieval period, human activity took place on what were then the valley floors, but which have since become low river terraces, following subsequent further incision to form the modern floodplains.
- 5.23 During the periods when the various terrace surfaces were active floodplains, their ecological characteristics would have reflected contemporary climatic conditions and the varying influence of human activity. The highest terraces, which were active depositional surfaces during the mid-Holocene, are likely to have been characterised, at that time, by willow and alder carr. In drier areas and on the woodland edge, species such as hazel and birch would dominate. A rich herbaceous ground flora would have existed within the floodplain with grass and sedge species thriving in seasonally inundated woodland.
- 5.24 The younger terraces, which were formed at lower elevations during and after the much colder and wetter period between around 3,100 and 2,500 BP, would originally have been characterised by extensive wetland environments and dense vegetation. Habitats such as this would have been extensively engineered by European Beaver (*Castor fiber*) until it was finally hunted to extinction in Britain in the sixteenth century. This would have resulted in a dynamic environment consisting of a mosaic of woodland, woodland edge and open water which would have been of high ecological value. Wetlands would have supported a wide biodiversity and provided habitat for species typical of the Euro-Siberian region of the Palearctic ecozone; these would include water voles, otters and water shrews. Waterside trees and shrubs (often naturally coppiced by beaver) would grow as dense belts which would provide cover for birds and other wildlife. Beaver dams would trap sediment and improve water quality; recharge groundwater tables and increase cover and forage for trout and salmon. Bats would have utilised the woodland edge and open water habitats and watercourses.
- 5.25 Subsequently, during the much drier and warmer climate which characterised the late Iron Age to the Roman era (around 2,400 to 1,500 BP), many of these areas would have been

progressively reclaimed for agriculture, a process assisted by the gradual further incision of the rivers down to their present levels, which left the terraces as higher surfaces of well-drained land, less frequently inundated by flooding. At this time grass, plantain, bracken, dandelion, thistle and nettle would have increased in association with an increasingly open arable and pastoral landscape. The presence of hazel and ash are indicative of opening-up of the forest cover and these species are likely to have become more widespread. Fields would have originally been enclosed by deep ditches, banks and fillets of pre-existing woodland. It is unclear when hedge planting became commonplace, but certainly by the tenth century hedges were used to enclose pasture.

- 5.26 Human occupation has progressively transformed the natural habitats through altering the fauna, felling forests, drainage, agriculture and built development. In places a good diversity of species still remains, including protected species such as water voles, otter, and great crested newts, but the residual habitats are much denuded resulting in fragmented (and consequentially fragile) populations.



Figure 5.7: the modern floodplain of the River Ure, immediately upstream of Ripon: remnants of formerly more extensive habitats survive within the Ripon Parks SSSI, seen in the far distance, but in the foreground the floodplain is dominated by improved pasture

- 5.27 Dating evidence from various sources suggests that most of the present-day floodplains are features of the last millennium and that, in many cases, they are of much more recent origin, having been reworked by the active migration of meandering rivers within the last few hundred years. This applies especially to the most active, gravel-bed rivers, such as the Swale upstream of Leeming, the Ure upstream of Boroughbridge, the Nidd upstream of Knaresborough and the Wharfe upstream of Harewood. Further downstream, lateral shifting

of the river channels has been more limited in historical times, and the modern floodplains are often narrow features constrained between higher river terraces, but overbank deposition of silts and clays on these surfaces during periodic major flood events is likely to have buried archaeological features. For this reason, the antiquity of archaeological evidence preserved on modern floodplain surfaces is typically limited to the last 200 to 1,000 years, depending on location.

- 5.28 In conclusion, although the understanding of alluvial (including terrace) sequences across North Yorkshire is continually improving through new research, the general pattern being revealed is one of complex response to a variety of different causal effects throughout the Holocene period. One implication of this is that the precise sequence and dates of origin of individual surfaces are likely to have varied from one river valley to another and even from one part of a particular valley to another.
- 5.29 More generally, however, the most important distinguishing features of all surviving fluvial deposits are that they post-date all other mineral deposits in the region, including glacial, glacio-fluvial and glacio-lacustrine sediments, and that they have developed in parallel with human occupation. Crucially, this means that each successive phase of fluvial deposition has buried and/or reworked and redistributed any evidence of earlier occupation or land use; and that any evidence preserved at the surface can only be expected to date from the time of the last reworking of the sediments by the shifting course of the river. In the case of the oldest post-glacial terraces this may be up to around 3,000 to 5,000 years ago (Neolithic to Bronze age), although the deposits beneath those surfaces may well contain or overlies evidence dating from much earlier periods, as far back as the early Holocene (Mesolithic), up to around 11,000 years ago. In the case of the present-day floodplains, the depositional surfaces date predominantly from the last few hundred years.
- 5.30 These features contrast with all other ASMRPs, where the deposits existed prior to any known human activity in the area, and where archaeological evidence can therefore only be expected to be found at or very near the surface (or in underground cave systems and mine workings in the case of the Carboniferous Limestone of ASMRP 14). In some other ASMRPs (notably 3, 4, 5, 6, 12, 13 and 14), archaeological features which were originally associated with the exposed surface of the associated mineral deposits have since been concealed by the accumulation of overlying soils, including windblown 'cover' sands and/or peat deposits (including lowland raised bog, valley mires and upland blanket bog). But in all of these cases, archaeological remains are most unlikely to occur within or beneath the mineral deposit themselves and, in terms of predictive landscape modelling, it is this which distinguishes all of them from the Holocene fluvial sediments of ASMRPs 1 and 2.

The Vales of York and Mowbray, and the Magnesian Limestone Ridge

- 5.31 Most of the major valley systems within North Yorkshire, other than those in the far west, which continue into Lancashire, and those in the north east which discharge into the North Sea, cut discordantly through the Magnesian Limestone Ridge and extend down into the Vale of Mowbray and/or the Vale of York. Here, along the lower reaches of the Ure, Nidd, Wharfe and Aire, eventually combining to form the River Ouse, the deposits associated with ASMRPs 1 and 2 continue, with similar characteristics to those described above.
- 5.32 However, these deposits form only a small part of a much wider range of Quaternary sediments distributed widely across a low-lying but complex landscape. Figure 5.8, below, uses an accurate cross section (D) from the topographic modelling exercise to illustrate the relationship of the various ASMRPs from west to east across the southern part of the Vale of Mowbray. Once again, whilst the surface profile and the surface positions of the ASMRP outcrops are accurate, the sub-surface detail and the distribution of glacial till (pale blue) are schematic.
- 5.33 Although the precise details vary substantially from one location to another, this cross section illustrates the typically complex arrangement of ASMRP 1 (sub-alluvial gravels), ASMRP 3 (glacio-fluvial sand & gravel), ASMRP 4 (glacial sand & gravel), ASMRP 6 (glacio-lacustrine clays) and the intervening outcrops of glacial till (shown in pale blue). It also shows the marked contrast between the low-lying Vale of York and the more elevated Magnesian Limestone Ridge (ASMRP 9) which characteristically demarcates the western edge of the Vale.

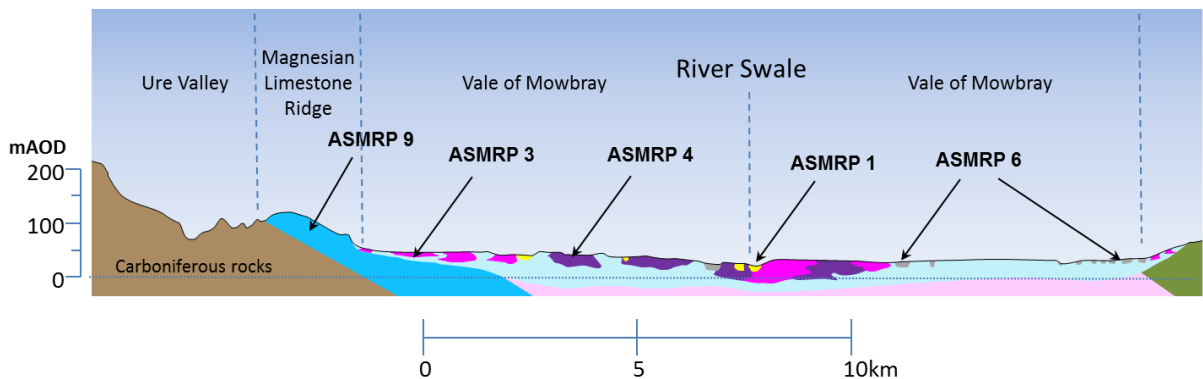


Figure 5.8: topographic profile (D) and schematic geological cross section to illustrate the relationship of ASMRPs 3, 4 and 6 to each other and to the surrounding landscape, across the Vale of Mowbray.

- 5.34 Within the Vale of Mowbray, and continuing southwards into the Vale of York, the areas of most prominent relief are generally those underlain by glacial till and, to a lesser extent, the ice-contact glacial sands and gravels of ASMRP 4. In places these deposits occur within moraine ridges or more complex areas of irregular, undulating ground.

5.35 The glacio-fluvial sediments of ASMRP 3, which were deposited contemporaneously with and after the glacial sediments as the ice sheet retreated, generally form areas of very limited relief, often contained between areas of moraine. Similarly, the glacio-lacustrine clays and silts deposited within former glacial lakes are usually intimately associated with, and often contained by, other glacial sediments.

5.36 Figure 5.9, below, uses a further cross section (I) from the topographic modelling exercise to illustrate the distribution of the more extensive glacio-lacustrine clay deposits within the southern part of the Vale of York. Once again, whilst the surface profile and the surface positions of the ASMRP outcrops are accurate, the sub-surface detail and the distribution of glacial till (pale blue) are schematic. The western boundary of the Vale, defined by the Magnesian Limestone ridge (ASMRP 9), is clearly seen once again but the Vale itself has a very limited distribution of sand & gravel resources. Instead, in this area, it is characterised by the sporadic distribution of glaciolacustrine brick clay resources underlain and separated by extensive areas of glacial till. The modern course of the River Ouse has cut down into this low-lying plain and, in the eastern and northern-most parts of the profile, the till forms two prominent moraine ridges which mark the positions of the Vale of York glacier at different times during its gradual recession from the last glacial maximum: the Escrick Moraine, furthest south, and the York Moraine (the latter being outside the study area).

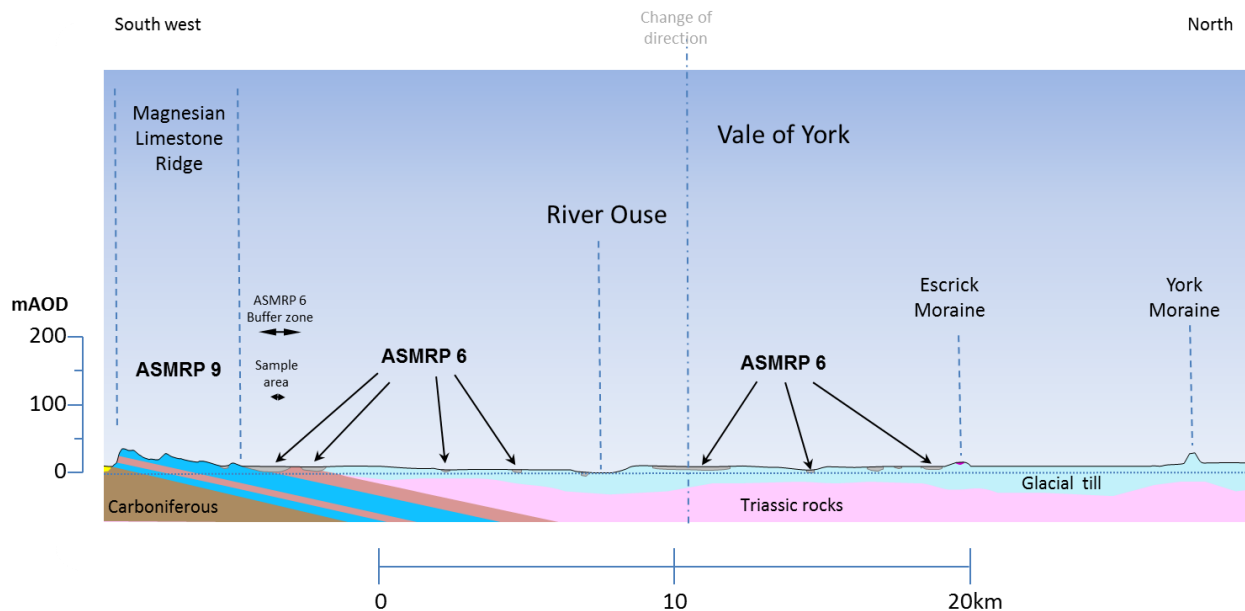


Figure 5.9: topographic profile (I) and schematic geological cross section to illustrate the relationship of ASMRP 6 to the surrounding landscape, across the southern part of the Vale of York.

Landscape evolution and archaeological potential within the Vale of York

- 5.37 In the Vale of York, many of the former glacial lakes are likely to have been gradually transformed, as climatic conditions improved during the early Holocene, into wetland areas including densely vegetated swamps and, in some cases, lowland raised bogs, sustained by incoming rainfall rather than groundwater. Evidence of this is found in the southern part of the Vale of York and the Humberhead levels, where there are extensive areas of peat, albeit severely degraded by historic peat extraction and drainage for agriculture which has taken place since medieval times. Although those areas are largely within South Yorkshire, and developed within areas which were formerly occupied by the extensive glacial Lake Humber, they serve as a model for smaller-scale former lakes which developed further north, within the central and northern parts of the Vale of York and the Vale of Mowbray, as the Devensian ice sheet retreated.
- 5.38 During the early Holocene, the ASMRP 6 areas would have been in transition from lakes to wetlands and, in some cases at least, to lowland raised bogs. By comparison with the slightly higher and therefore less waterlogged ground of the glacial deposits around them, they are therefore likely to have been unattractive areas for early Man, including both the hunter-gatherers of the Mesolithic period and the farmers and settlers of the succeeding Neolithic and Bronze Age periods. Some areas may have been transformed by forest clearances during the Bronze Age and used for agriculture, although direct evidence from that period is currently limited, as noted in the Stage 1 report.
- 5.39 As previously mentioned, there was a marked climatic deterioration towards the end of the Bronze Age, from about 3100 to 2500 ¹⁴C BP. Bridgland *et al.* (2011) have suggested that this probably led to the regeneration of woodland and the spread of wetland ecosystems, further limiting the likelihood of human activity during this period.
- 5.40 Although there is some evidence of later Iron Age and Roman activity within the ASMRP 6 deposits, corresponding to a long period of climatic improvement, this evidence is largely focused on areas close to the A1 route corridor. This is partly because of the historical importance of that route for communication and settlement but also because of the more extensive archaeological investigations that have been undertaken in connection with recent widening of the A1 to motorway standards.
- 5.41 Thus, whilst the lack of evidence of early human activity elsewhere within ASMRP 6 might support the notion that these areas were not conducive to either agriculture or settlement until they were artificially drained in the post-Medieval period, it might equally be due to the limited extent of recent development in this rural area (which has limited the recovery of artefacts), and problems with site visibility.

- 5.42 The National Mapping Programme in conjunction with the Vale of York Visibility Project (Howard *et al.*, 2008) has demonstrated that the visibilities of archaeological remains across the Vale of York are closely related to the underlying substrate. Cropmarks do not form well on clayey water-retaining soils, and geophysical surveys can yield unreliable results. For these reasons, the archaeological potential of the soils and organic sediments which overlie the ASMRP 6 deposits cannot be dismissed, and is worthy of further investigation.
- 5.43 As with the waterlogged organic deposits within the Vale of Pickering (see below), those which overlie the ASMRP 6 clays may also provide good conditions for the preservation of organic artefacts. Wetlands and peat soils have the ability to preserve a wide spectrum of organic archaeological evidence (particularly organic based materials such as wood, leather or bone) due largely to their saturated and anoxic nature (Corfield, 2007; Ward *et al.* 2009). Below the water table, the oxygen content of the burial environment can be very low, thereby limiting or preventing the rate of decay (oxidation), especially of organic remains. In waterlogged peatland (bog and fen) environments, the high organic carbon content of the topsoil and surface water further restricts the diffusion of oxygen into the soil and so creates ideal conditions for preservation (Thompson *et al.*, 2008).
- 5.44 The preservation potential within ASMRP 6 will have been diminished by the agricultural drainage which has taken place since medieval times. Whilst this has been a major cause for concern in the Vale of Pickering, where the organic sediments are underlain by (and perhaps intercalated with) the more permeable sand & gravel deposits of ASMRP 5, it might be less of a problem within ASMRP 6, where the underlying deposits (clays) are much less permeable. Nevertheless, there is an outstanding need to investigate the archaeological potential of ASMRP 6 in order to add detail to the palaeo-environmental record and to confirm whether or not these areas contain significant evidence of early (pre-Medieval) human activity.
- 5.45 Whilst the ASMRP 6 outcrops are distinguished by their low-lying, flat topography, their heavy clay soils and (perhaps) by their lack of early human activity, the other ASMRPs within the Vale of York, particularly ASMRPs 3 and 4, are much less easily distinguished from each other, or from the intervening outcrops of glacial till. The sand & gravel deposits are naturally better drained than the heavy, clay-rich soils associated with the outcrops of till, and will therefore have been more suited to arable cultivation from the Neolithic period onwards. But in practice, the distinction is not so clear: both the glacial sediments of ASMRP 4 and the glacio-fluvial deposits of ASMRP 3 are sometimes overlain by an irregular drape of 'flow till' – the result of saturated debris flows from the surface of the decaying ice sheets. It is these sediments, usually of very limited thickness, which conceal the surface expression of the sand & gravel deposits, and which thereby have a controlling influence on the nature of the topsoil.
- 5.46 In practice, however, the various types of deposit tend to grade into each other and it is highly doubtful whether the differences would have influenced the nature or patterns of early human activity. The same is true of more recent historical development and land use, with very little

generic distinction being possible between the landscapes associated with ASMRP 3, ASMRP 4 and the intervening outcrops of glacial till. Although there will have been more detailed variations in natural ecology between the various deposits, these distinctions are likely to have become blurred by the effects of human activity – especially the drainage and ‘improvement’ (for agriculture) of heavier clay soils.

- 5.47 Once again, there are differences in terms of visibility of archaeological evidence, with the heavier soils on glacial till deposits being less conducive to cropmarks than the lighter and better-drained soil elsewhere, but the variations appear to be less stark than those between these various deposits and ASMRP 6.
- 5.48 The overall conclusion to be reached for the Vale of York and Vale of Mowbray, in terms of predictive landscape modelling, is that there seems to be little prospect for differentiation between ASMRP 3, ASMRP 4 and intervening landscapes underlain by glacial till; but that, potentially at least, there could be a distinction between these areas and ASMRP 6, subject to further research.

The Magnesian Limestone Ridge

- 5.49 The Magnesian Limestone Ridge generally forms a quite separate and more distinctive part of the landscape, although less so in areas where it is mantled by glacial drift, and where its height above the Vale of York is reduced, in the northern part of its outcrop.
- 5.50 The western-most parts of the resource to the south of Knaresborough, and all of the resource to the south of Tadcaster, were ice-free during the Devensian glaciation. The implication of this is that all of these areas (except for those on the eastern edge of the resource which were submerged beneath glacial Lake Humber) would have been exposed to both vegetation development and (potentially) to human activity for a very long period of time.
- 5.51 Moreover, the elevation of the ridge, combined with the free-draining character of its soils, in areas where the limestone is at or very near the surface, will have made this an attractive landscape for early human occupation and cultivation, certainly by comparison with the lower ground and heavier soils which occur across much of the Vale of York. As detailed in the Stage 1 report, this is evidenced by the archaeological finds dating from the Mesolithic period onwards, by the presence of major Roman roads and forts, and by the post-medieval influence of wealthy land owners in creating extensive designed landscapes.
- 5.52 At the time of the Last Glacial Maximum (LGM) during the late Devensian period, around 23,000 years BP, these areas would have experienced a severe periglacial climate, with little more than arctic Tundra vegetation, and the prospects for human (Palaeolithic) activity would have been extremely slight.

- 5.53 Although conditions would have begun to improve during the Mesolithic period, with the climatic amelioration which heralded the onset of the Holocene, the earliest evidence of sustained human activity within ASMRP 9 dates from the much later Neolithic and Bronze Ages. By that time the natural vegetation would have progressed through sequential stages of succession to Celtic broadleaved forest and the human impact on this, through forest clearance for agriculture, would have been well advanced.
- 5.54 During the climatic deterioration which took place at the end of the Bronze Age, the spread of both settlement and agriculture withdrew from the high ground of the Pennines, North York Moors and Yorkshire Wolds, and also from the extensive wetlands which became re-established within river floodplains and other low-lying areas. It is probable, however, that the Magnesian Limestone ridge, being elevated and well-drained but much lower in height than the main upland areas, would have continued to function as an important area for both agriculture and settlement.
- 5.55 The fact that the Magnesian Limestone ridge is elevated above the former wetlands of the Vale of York also explains why it has been utilised throughout history as a major line of north-south communication, including the alignment of major Roman roads which subsequently became the Great North Road and now the A1(M) motorway. This has enabled the area, from at least the Iron Age onwards, to attract settlement, and to facilitate trade. Whilst the richness of archaeological evidence within ASMRP 9 has undoubtedly been highlighted by the investigations associated with upgrading the A1, for the reasons given above it is reasonable to expect that the archaeological potential should be high throughout most of the limestone outcrop and across all periods of human activity, from at least the Mesolithic period onwards. The archaeological resource is also likely to have been degraded by many centuries of ploughing within the extensive arable fields which characterise much of the limestone ridge, but this does not preclude the likelihood of further evidence being found in future investigations.

The Vale of Pickering and the Yorkshire Wolds

- 5.56 In marked contrast to most of the Vale of York and the Vale of Mowbray, the Vale of Pickering has been extensively investigated, in terms of archaeology, as detailed in both the Stage 1 report and the Stage 2 report on the sample areas. The following account does not attempt to repeat the detail provided in those reports or in the numerous previously published papers (notably Clark, 1954; Mellars & Dark, 1998; Powlesland, 2003; Powlesland *et al.*, 1997, 2006). Instead, it seeks to focus on the cause-and-effect relationships between human activity and environmental change within this area from the last glacial maximum to the present day.

Vale of Pickering

- 5.57 Throughout the Devensian Glaciation, most of the Vale of Pickering, together with the North York Moors to the north and most of the Yorkshire Wolds, to the south, were free of ice (Evans *et al.*, 2005, Catt, 2007). Scandinavian ice sheets impinged onto the coast of East Yorkshire, extending inland from Filey Bay and into the eastern part of the Vale of Pickering, whilst ice from the Lake District flowed into North Yorkshire across the Pennines via the Stainmore Gap to form the extensive Vale of York glacier. Drainage from the Vale of Pickering was therefore blocked both to the east and west by ice, and to the north and south by higher ground. As a consequence, a large glacial lake developed (Lake Pickering) and, as explained more fully in the Stage 1 report, the sand & gravel deposits of ASMRP 5 accumulated at the margins of this lake, through a combination of deltaic and beach sedimentation. The deposits extend continuously along the foot of the Chalk escarpment of the Yorkshire Wolds and, more sporadically, along the northern and western margins of the former lake. At the eastern end of the Vale of Pickering, between Staxton and Seamer (Figure 5.10, below), the ASMRP 5 deposits extend most of the way across the former lake floor. Further west, they are overlain in the centre of the Vale by lacustrine clays and postglacial organic sediments (Figure 5.11).



Figure 5.10: View across the eastern end of the Vale of Pickering, with the Wykeham Lakes (former and active sand & gravel workings) seen at the northern edge of the ASMRP 5 deposits.

- 5.58 Figure 5.11, below, uses an accurate cross section (J) from the topographic modelling exercise to illustrate the relationship of the various ASMRPs from north to south across the central part of the Vale of Pickering. Once again, whilst the surface profiles and the surface positions of the ASMRP outcrops are accurate, the sub-surface details are schematic. Although the precise details vary from one location to another (particularly regarding the extent of the ASMRP 5 deposits), these cross sections illustrate the general arrangement of the geology and topography of the area. They highlight the topographic contrast between the Vale of Pickering/ Vale of Rye and the higher ground to the north and south. Also evident is the marked contrast between the dip-slope of the Limestone Foothills, which form the southern

part of the North York Moors; the steep, north-facing scarp slope of the Yorkshire Wolds; and the detailed variations between rolling plateau and deeply incised dry valleys on the dip-slope of the Wolds.

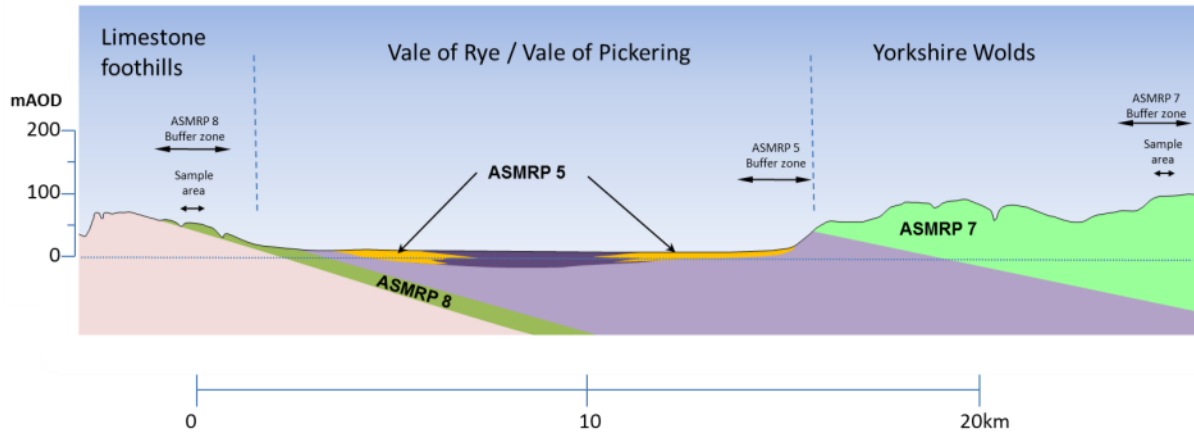


Figure 5.11: topographic profile (J) and schematic geological cross section to illustrate the relationship of ASMRPs 5, 7 and 8 to each other, across the central part of the Vale of Pickering and Vale of Rye

- 5.59 The earliest evidence of human activity within this area dates from the early Mesolithic period, soon after the rapid global warming which marked the Late Glacial / Holocene transition, approximately 11,500 years ago². An early phase of occupation at the Seamer Carr Site K had deposits associated with a hearth that dated to 11,000 +/- 130BP (HAR-5242) (Schadla-Hall 1989). Further evidence, relating to hunter gatherer activities from approximately 10,920 years ago, has been found at Star Carr (Clark, 1954; Mellars & Dark, 1998; Dark, 2000). Both of these are world-renowned archaeological sites located immediately adjacent to ASMRP 5.
- 5.60 It maybe conjectured that the reasons for such early human activity around the margins of the Vale of Pickering is not least because these areas were ice free during the last glaciation and relatively sheltered, by comparison with the adjoining, equally ice-free but higher landscapes of the Yorkshire Wolds and the North York Moors. They were also marginally elevated, compared with the areas submerged beneath the intervening Lake Pickering, and underlain by relatively free-draining sand & gravel. Another factor is likely to have been the location of this area at the western margins of Doggerland - part of the continental shelf which was occupied by Mesolithic people following the retreat of the Scandinavian ice sheet and which connected Britain to mainland Europe at that time (Coles, 2000). The area is now submerged beneath the North Sea, following the rise in sea level which accompanied global warming during the early

² The transition from the Devensian glaciation to the subsequent (post-glacial) Holocene period has traditionally been dated at about 10,000 years Before Present (BP), but recent evidence from the Mesolithic site at Star Carr in the Vale of Pickering has suggested a more accurate dating of 11,530+/-30 Calendar years BP (Dark, 2000).

to mid-Holocene, and a catastrophic tsunami event in 8,200BP, generated by a submarine landslide off the coast of Norway known as the Storegga Slide (Weninger *et al.* 2008).



Figure 5.12: The irregular surface of ASMRP 5 deposits adjacent to the Star Carr archaeological site

- 5.61 Even though the former lake drained and silted up during the Holocene, for much of that time (until reclamation for agriculture in the post-medieval period) it would have been a mosaic of open water and poorly-drained mire (Menuge 2003). The lake margins, by comparison, are likely to have been colonised by drier and more open vegetation, better able to support hunter-gatherer communities. Initially, and contemporaneously with the glacial lake, tundra and taiga habitats would have dominated.
- 5.62 Anthropogenic activity would have had some degree of impact on the vegetation from the Mesolithic period at the beginning of the Holocene. Birch trees were used to construct a platform at the early Mesolithic site of Star Carr and reed-swamps were burned around the edge of the shallow lake (“Lake Flixton”) (Atherden, 2003, Innes *et al.* 2012, in press). As the climate warmed rapidly during the early Holocene, there would have been a gradual succession towards boreal birch forest, coniferous forest and ultimately Celtic broadleaf forest. These habitats would have been occupied, at that time, by various species typical of the Palearctic ecozone including Brown Bear (*Ursus arctos*), Red Deer (*Cervus elaphus*), Reindeer (*Rangifer tarandus*), European Lynx (*Lynx lynx*) and European Wolf (*Canis lupus lupus*).
- 5.63 Optimum conditions during the mid-Holocene allowed the maximum development of closed forest ecosystems. The rise in alder pollen, which defines the mid-Holocene (Hibbert and Switsur 1976), has an early date at Star Carr (Day, 1996) in comparison with the dates for a more regional rise in north-east England (Bridgland *et al.* 1999).
- 5.64 During the Neolithic period, from approximately 5,500 to 3,700 years BP, human civilisation progressed from hunter gathering to farming and began to make a more permanent impact on the landscape. The closed forests began to give way, during this period, to open oak, hazel and birch forests of variable tree density, similar to modern pasture woodland. This habitat would have become prevalent as grazing increased. Large mature trees will have become less

prevalent as timber was felled for building purposes. Continued grazing will have gradually improved the soil changing the floral diversity and invertebrate assemblage which in turn will have affected the fauna of the area. The loss of young tree shoots to grazing animals results in the opening out of the forest cover. Natural habitats are likely to have rapidly given way to a man-made environment dominated by pastoral agriculture.

- 5.65 Earthen long barrows distributed across the Vale are a sign of occupation by Neolithic farmers and there is evidence elsewhere within ASMRP 5 of all subsequent periods of occupation. In particular, the well-investigated settlement site at West Heselton has revealed evidence of activity dating from the Mesolithic period through to the late Bronze Age. There is also evidence here of later Iron Age and Roman activity and it became an important early and late Anglo-Saxon settlement.
- 5.66 As explained more fully in the Stage 1 report and the Stage 2 sample areas report, the Heselton Parish Project has, over a period of 25 years, revealed both a continuum of activity throughout all periods of history and prehistory, and a previously unsuspected density of sites, demonstrating the major archaeological potential of this area - despite the seemingly bland characteristics of the modern agricultural landscape. The intensive geophysical research carried out as part of the Heselton Project has also demonstrated a rich complexity of features that have not been revealed as crop marks and highlights the limitations of aerial photography even on soils conducive to the formation of crop marks.
- 5.67 Within the Vale of Pickering, intensification of farming in medieval times led to a clearance of most of the remaining woodland (that hadn't already been cleared during the Bronze Age to Romano-British periods) and extensive land drainage (Atherden, 2003). Medieval farming included intensive cultivation on clay islands in the western end of the Vale with marsh and meadow areas being used for pastoral farming. During this period, the wooded areas were greatly outnumbered by those that were not. Even on the Jurassic outcrops, where woodland remained most pronounced, the landscape seems to have been predominantly open as early as the beginning of the fourteenth century (Wightman, 1968). The Vale of Pickering wetland project has documented changes to the environment in the historical past, including changes caused by drainage ditches and canals (Menuge, 2001, 2003).
- 5.68 In terms of predictive landscape modelling it can be concluded that much of the Vale of Pickering and at least parts of the Vale of Rye, and especially the well-drained marginal areas that are underlain by ASMRP 5 resources, are likely to be characterised by extremely high archaeological potential. It must also be noted, however, that (for the reasons explained earlier in relation to the ASMRP 6 deposits in the Vale of York), these areas are under threat from deep ploughing and there is also a potential for any waterlogged remains being affected by the reduction in groundwater levels associated with agricultural drainage and (potentially) any dewatering activities associated with nearby mineral extraction.

Yorkshire Wolds

- 5.69 As noted above, the high ground of the Yorkshire Wolds was also ice-free during the Devensian glaciation and, although it would have experienced a severe periglacial climate, with little more than sparse tundra vegetation, it is likely to have been one of the first parts of North Yorkshire to respond to the post-glacial climatic improvement.
- 5.70 Though perhaps lagging somewhat behind the more sheltered lower ground at the margins of Lake Pickering immediately to the north, the Wolds are likely to have moved through a similar succession of distinct habitats and plant communities - all typical of the Palearctic ecozone. Initially, tundra and taiga habitats would have dominated, followed by gradual succession towards boreal birch forest, coniferous forest and (in places at least) Celtic broadleaf forest.
- 5.71 Unfortunately, detailed palaeo-environmental evidence for the Wolds is restricted, by comparison with other parts of North Yorkshire, by the limited availability of organic and lake sediments which incorporate pollen. Evidence from Willow Garth (Bush and Flenley, 1987) shows that herbaceous plants were important elements in the mid-Holocene assemblages, and open grassland habitats appear to have been a continuous landscape element since the Lateglacial period, at least locally, although the species composition has changed greatly over time (Bush, 1993). The nature of the lithology (chalk) combined with the effects of altitude to limit the density of forest development through the mid-Holocene period.



Figure 5.13: Typical view of the rolling chalk farmland of the Yorkshire Wolds.

- 5.72 It is likely that human occupation of this high ground did not have as marked an impact on the natural habitat in this area as in the lower lying areas to the north and west. The woodland which is likely to have developed on such calcareous soil is likely to have contained species such as field maple (*Acer campestre*), bird cherry (*Prunus padus*), elder (*Sambucus nigra*) and other woody species frequently found on lime-rich soils.
- 5.73 The area is likely to have been used by Mesolithic hunter-gatherers but the earliest archaeological evidence dates from the Neolithic period. This includes high concentrations of stone axes originating from Langdale in the Lake District and substantial numbers of Neolithic monuments, including long barrows and the Duggleby Howe round barrow, located immediately north of the sample area. Iron Age/Romano-British field systems and associated ladder settlements have been identified, reflecting the settlement of this area during the climatic warm period at that time. During the late Holocene, much of the landscape of the Wolds became a “sheepscape” (Atherden, 1998). Deserted Medieval Villages (DMVs), particularly along the northern margins of the Wolds, testify not only to settlement during the Medieval period but also to the subsequent retreat from widespread cultivation during periods of poorer climate, including the so-called ‘Little Ice Age’ of the late 16th to late 19th Centuries.
- 5.74 The historic landscape character of the Wolds is thus, very broadly, a combination of medieval settlement around the margins and prehistoric remains across the upland areas. The present day site visibility is poor, however, and the archaeological remains have been mostly ploughed flat, reflecting the fact that the area has been subject to intensive cultivation throughout the twentieth century. This has primarily affected the higher parts of the slopes, however, where Chalk is now clearly visible at the surface, and has resulted in topsoil (and, potentially, disturbed artefacts) accumulating at the base of the slopes. Overall, the high identified resource reflects that, in the past, there was much improved site visibility by comparison with the present, and that the former earthwork features show up as crop marks only under certain conditions.

The Pennine Moors

- 5.75 In complete contrast to the Quaternary deposits of ASMRPs 1 to 6, and also to the pre-Quaternary bedrock deposits of ASMRPs 7 to 9, the moorlands associated with the much older Carboniferous rocks in the western parts of the study area (ASMRPs 12, 14 and part of ASMRP 13) require a very different model to explain their likely heritage potential. In these areas there has been little or no arable cultivation to degrade the evidence of earlier human activity, but there has been, to varying degrees, the development of blanket bogs, and the effects of historic mineral workings. Respectively, these have potentially obscured, modified and added to the natural and historic environment resources within the areas concerned.
- 5.76 Figure 5.14, below, combines accurate topographic data with a schematic geological cross section to illustrate the distribution and topographic features of the ASMRP 12 resources.

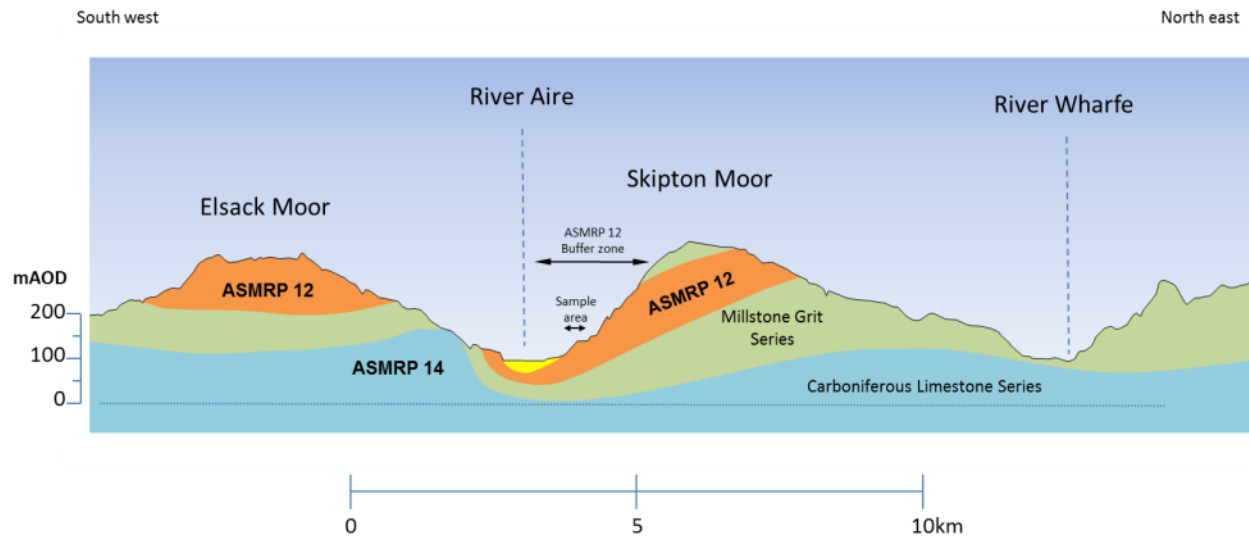


Figure 5.14: topographic profile (A) and schematic geological cross section to illustrate the relationship of ASMRP 12 (Carboniferous Sandstone) to the topography of the landscape around Skipton.

5.77 Figure 5.15, below, illustrates the present-day topography of the ASMRP 12 resource, looking from Skipton Moor, across the sample area and the industrialised Aire Valley below, to Elsack Moor in the distance.



Figure 5.15. Typical topography and landscape of the ASMRP 12 resource areas.

5.78 Figure 5.16, below, combines topographic data with a schematic geological cross section to illustrate the distribution and topographic features of the ASMRP 14 Carboniferous Limestone

resources. As indicated on the diagram, these resources comprise individual horizons within the Carboniferous Limestone sequence, each of which tends to form distinctive crags or steps where they crop out along the valley sides. The limestones are overlain in many places by strata of the succeeding Millstone Grit series, although in this area none of these correspond to ASMRP 12 resources. There is also a patchy distribution of Quaternary glacial till deposits and Holocene peat (blanket bog), but these are generally too thin to be represented on this diagram. Black vertical lines on the diagram schematically represent just some of the many geological faults shown on the 1:50,000 scale geological map. They are included in order to explain the overall geological structure and resulting outcrop pattern of the resources.

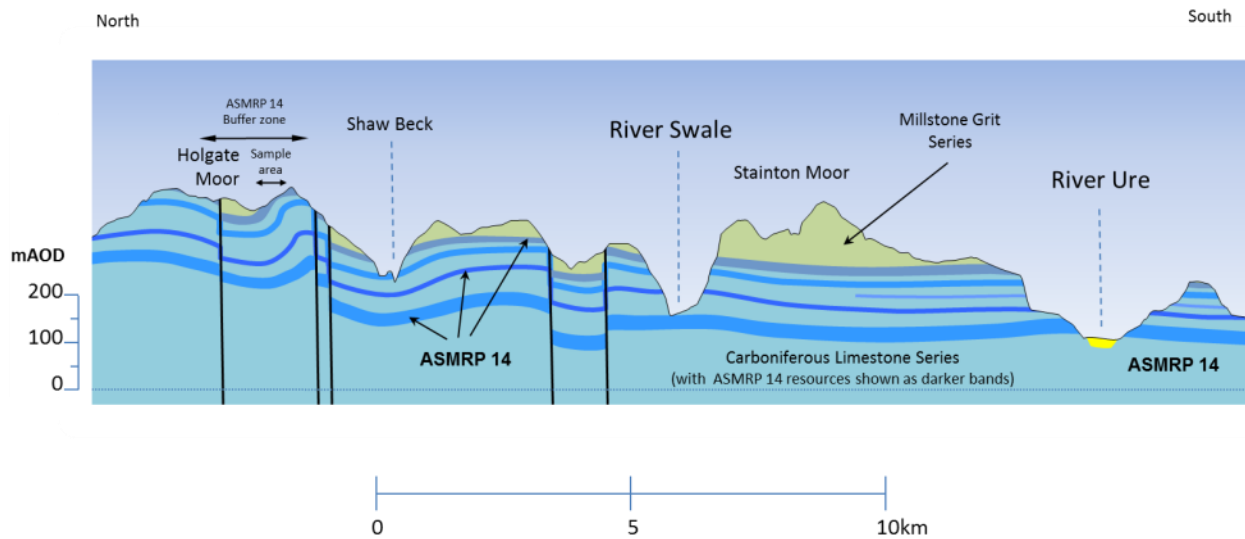


Figure 5.16: topographic profile (B) and schematic geological cross section to illustrate the relationship of ASMRP 14 (Carboniferous Limestone) to the topography of the landscape west of Richmond.

5.79 Figure 5.17, below, shows a typical example of a limestone scar on the side of a tributary valley, above the village of Marske in Swaledale, to the west of Richmond. In common with many other similar features in the area, the natural form of the outcrop has been extensively modified by historical small-scale quarrying activity. Larger quarries continue to operate on the northern side of the Ure valley, near the village of Wensley.



Figure 5.17: Clints Scar: a typical valley-side feature of the ASMRP 14 resources in Swaledale

- 5.80 In both of the above cases, (ASMRPs 12 and 14), the surface outcrops date from the end of the Devensian glaciation, when ice sheets melted and the effects of their erosion and deposition (generally patchy within these upland areas) became exposed for the first time. The underlying deposits, of course, are much older, dating from the Carboniferous era some 299 to 359 million years BP. As previously noted, there is no possibility of archaeological evidence being present within these deposits, except within limestone cave systems (potentially occupied by Palaeolithic people during interglacial cycles within the Pleistocene epoch – though no evidence of this has yet been recorded within the study area), and within more recent historical mining features (associated with the exploitation of lead and other mineral veins from at least Roman times until the late 19th or early 20th Centuries).
- 5.81 At the end of the last glaciation, all of these areas would have been characterised by a mosaic of bare rock outcrops and crags, with free-draining scree slopes below and with a patchy distribution of overlying glacial deposits. Topographic hollows would have supported upland lakes and ponds, whilst the areas mantled by glacial till or underlain by mudstones within the Carboniferous sequence would have been characterised by relatively poorly-drained, boggy ground.
- 5.82 With the advent of rapid global warming at the start of the Holocene period, a vegetation succession not dissimilar to that seen elsewhere in the county would have been predominant initially, leading to the development of coniferous and then broadleaved woodlands across much of the upland areas. Upland mixed Ash (*Fraxinus excelsior*) woodland is likely to have been abundant, particularly in wet valleys. Other tree species such as birch (*Betula pendula* and *B. pubescens*), rowan (*Sorbus aucuparia*), willow (*Salix europeus*), and alder (*Alnus glutinosa*) are also likely to have occurred in these base-rich flushes. The ground vegetation would have been herb-rich. Beyond the valleys, acidic grassland, mires and bracken would have been frequent. In parallel with the spread of woodlands, peat formation would initially

have been confined to the shallow lakes and wet hollows, as these gradually became infilled by sediment and vegetation.

- 5.83 From the Mesolithic period onwards there is evidence of a decline in upland tree species associated with the use of fire by hunter-gatherers, and more widespread disturbance occurred from the early Neolithic period onwards, from around 5,000 years BP (Simmons and Innes, 1985; Bridgland *et al.* 2011). During the late Neolithic and early Bronze Age periods, blanket bogs would have spread out from the original enclosed basins as trees were felled to open up wider areas for grazing, and as the climatic conditions became wetter. In the sandstone areas, and those mantled by glacial sediments, heavy rainfall contributed to this transformation by causing iron and other minerals to be leached out from the surface layers, allowing them to accumulate in sub-surface horizons known as ‘iron pans’, which further impeded drainage.
- 5.84 The poorly-drained areas would thus have been progressively transformed by the steady growth of vegetation communities dominated by heather (*Calluna vulgaris*), cross-leaved heath (*Erica tetralix*), cottongrasses (*Eriophorum spp.*), deergrass (*Trichophorum cespitosum*) and bog-mosses such as *Sphagnum papillosum*, *S. tenellum* and *S. capillifolium*. Even in the drier areas, particularly those within the surface outcrops of Carboniferous Limestone, it is likely that the habitats and associated plant communities would have been somewhat wetter in the past than at present. *Sphagnum spp* moss would have been far more extensive and dwarf shrub species such as creeping willow (*Salix repens*) would also have been abundant. Species such as Red Deer (*Cervus elaphus*) and European Wolf (*Canis lupus lupus*) are likely to have persisted here far longer than in the surrounding low lying areas.
- 5.85 Early human activity, not necessarily associated with settlement, is evidenced by the survival of round cairns and prehistoric rock art such as cup and ring marks – typical indicators of transient activity within upland landscapes.
- 5.86 In more recent times, fell gripping (open drainage ditches to improve conditions for sheep grazing), and moorland management practices associated with grouse moors (e.g. cutting and burning of heather) were widely adopted, resulting in drier conditions and reduced biodiversity, dominated by heather moorland and acidic grassland.
- 5.87 In the limestone areas there are numerous disused mine workings including shafts, rakes (open-cast workings), spoil heaps, and ancillary infrastructure, including chimneys, flues, hushing channels, leats and small dams. These relate to the mining of lead, and perhaps other vein minerals, within the limestone. Such activities are known to have taken place since Roman times, but are now long abandoned. They are, nevertheless, a key part of the historic character of the modern landscape.



Figure 5.18: Cobscar Rake: Relict chimney and flue features associated with former lead mining activity on the ASMRP 14 limestone moors above Redmire Scar, in Wensleydale

- 5.88 Within the same areas, natural dissolution features within the Carboniferous Limestone are frequently manifest at the surface as conical subsidence hollows and sink holes, known locally as ‘shake holes’. These can be seen directly on exposed limestone outcrops but, more commonly, on surfaces mantled by glacial drift and post-glacial peat (from which the drainage is more acidic).
- 5.89 More recent mineral extraction within the Carboniferous Limestone outcrops has focused on aggregate production from the limestone itself and is evident both as small-scale historical modifications to many natural outcrops as well as more industrial-scale ongoing quarrying activity. In the sandstone areas there are numerous small, disused quarries, used in the past for the production of local building, walling and roofing stone.

6. The Key Environmental Characteristics

Introduction

- 6.1 As indicated in the previous section, the environmental characteristics of the various mineral resources across North Yorkshire are extremely varied, and difficult to summarise concisely at a strategic level.

Environmental Designations

- 6.2 In Stage 1 of this project, attention was focused initially on the available GIS-based information relating to environmental designations. This gives a broad indication of the diversity and importance of different aspects of the landscape and its natural and cultural assets, but is unable to represent the much larger part of the landscape which, though undesignated, nevertheless has considerable environmental value.

- 6.3 To briefly summarise those findings:

- **Landscape designation** in total, apply to between 2% and 76% of the surface area of individual ASMRPs. The highest figure relates to ASMRP 13 which has a very small area of outcrop. More generally, the percentage cover is less than 20% and usually (in all but three cases) less than 10%.
- **Historic environment designations** generally cover a much smaller proportion of each ASMRP, ranging from 0.01% to 4.46%, though these sites represent just examples of a much more widespread, but largely undesignated, heritage resource.
- **Natural environment designations** also overlap with ASMRPs only to a small extent (in most cases less than 5% overall).

- 6.4 As the analysis has shown, there are certain areas within each ASMRP which are more heavily constrained, including some resources close to existing or recent areas of active mineral extraction. However, in quite a number of cases, the designated sites themselves are restored or disused areas of former mineral extraction and, where this is the case, are unlikely to have a major influence on the viability or environmental acceptability of future extraction on other land nearby. Of greater concern are the designations, whether local, national or international, which relate to areas of either semi-natural vegetation or ancient woodlands and meadows, together with the habitats and the fauna which they support. In all cases these are surviving fragments of habitats which were once far more extensive, and they provide vital refugia for rare and endangered species.

6.5 Further details of the nature of these designations are provided in the Stage 1 report but the key observation, overall, is that the formally designated areas account for only a very small percentage of the surface areas of each mineral resource. A direct implication of this (as noted in more detail in para 6.8 below) is that the designations alone cannot be used to characterise the environmental qualities of any given area. Moreover, the absence of formal designations cannot be taken to imply an absence of historical significance or scientific interest as there may well be sites that have not been previously recognised or recorded. Attention must therefore be turned to the overall wider environmental characteristics of each area in order to obtain a more complete picture.

Wider Environmental Characteristics

6.6 Detailed accounts of the more general characteristics, based on the investigation of the sample areas and the assessment of how representative these are of the corresponding ASMRPs, were provided in the Stage 2 Technical Report on the Sample Areas, and in Chapter 2 of the Stage 3 report. The descriptions of the characteristics of each sample area (from the Stage 2 Technical Report on Sample Areas) were compared with the wider characteristics of the corresponding ASMRP, as described in the Stage 1 Technical Report, and with observations from a range of other previous studies, as detailed in the Stage 3 Report. The comparisons were necessarily limited to those ASMRPs for which sample areas were investigated (that is, all except ASMRPs 10, 11 and 13, as explained in the Stage 1 report). The descriptions of the sample areas were placed within wider local, regional and national contexts through reference to a range of previous reports and through knowledge of both mineral characteristics and archaeological activity in areas with broadly similar geological resources elsewhere in the UK.

6.7 Table 6.1, below, attempts to summarise the key observations arising from those investigations, integrating the work done on the historic and natural environments and the landscape character and context. This holistic approach is essential to understanding the full range of inter-relationships and potential impacts when looking at the variations in sensitivities and potential capacity for change with respect to mineral extraction in North Yorkshire

6.8 It is particularly important to note that, even though these observations are necessarily very generalised, they create a very different impression to those which would be gained from an assessment of designations alone. This emphasises the importance of undertaking a thorough analysis of environmental conditions within and surrounding an area of proposed development, rather than relying on designated features alone. Whilst designations are, by definition, very important, and whilst they carry with them policy and/or statutory requirements in terms of their protection, they only provide a partial image of the environmental characteristics and sensitivities of the area involved. Moreover, protecting isolated designated sites has only limited benefit in terms of wider conservation and

sustainability objectives. There is a profound need to take account of the bigger picture so that optimum benefits can be gained by joining up ideas and restoring lost connections.

Table 6.1 Summary of the Key Environmental Characteristics of each ASMRP

ASMRP	Key Environmental Characteristics (drawn from Stage 1 and Stage 2 findings)	Additional observations
ASMRP 1 Sub alluvial sand and gravel	<ul style="list-style-type: none"> Watercourses are the most distinctive feature of the landscape and most surviving built structures relate to water use or water crossings as this ASMRP is characterized by frequency of flooding, The present day land use is predominantly modern improved fields and grazing The open, generally flat landform provides the <u>setting</u> for traditional, nucleated villages, There is great potential for deeply buried prehistoric deposits from earlier human activity concealed beneath more recent fluvial deposits Patch work of fen, flood meadows, floodplain mires, marsh and swamp, as well as the river channels and riparian vegetation which form vital wildlife corridors. 	Description is representative of the majority of ASMRP 1, except for those areas (mostly in Nidderdale) which fall within an AONB and those in upper Swaledale, Wensleydale and Craven which are visible from within parts of the Yorkshire Dales National Park,
ASMRP 2 River terrace sand and gravel	<ul style="list-style-type: none"> Older flood plains forming river terraces that developed in the post glacial period in parallel with human activity. Well drained and with reduced tendency to flooding presents a more mature landscape and intensive agricultural use Range of more recent land uses include historic houses and parks and gardens. Semi natural habitats are remnants of the former rich biodiversity which once characterized the river terraces 	Representative of the majority of ASMRP 2, except for very small areas of resource which fall within an AONB and those which are visible from within parts of the Yorkshire Dales or North York Moors National Parks and the settled industrial valleys of the Aire and the Wharfe
ASMRP 3 Glacio fluvial sand and gravel	<ul style="list-style-type: none"> Gently undulating or flat topography, some evidence of former rich habitats which have largely been displaced by modern agriculture This mineral resource was laid down prior to human activity so is unlikely to contain evidence of earliest human activity; however it is well drained and therefore likely to have been attractive for settlement from the early post glacial period and therefore contains significant evidence from the Mesolithic onwards. This includes the Neolithic Thornborough Henges 	Representative of the majority of ASMRP 3 where they overlie the Magnesian limestone, except for very small areas of resource which fall within an AONB or which are visible from within parts of the Yorkshire Dales or North York Moors National Parks.
ASMRP 4 Glacial sand and gravel	<ul style="list-style-type: none"> These areas have similar characteristics to ASMRP 3, land use is predominantly arable cultivation and semi improved grassland. There is limited biodiversity interest largely confined to mature hedgerows and small areas of woodland. Archaeological site visibility is poor largely due to the increase of clay sediment and the action of ploughing on surface features. Remnant ridge and furrow and HLC/ field evidence of early post medieval enclosure 	Representative of most of ASMRP 4, except for the resources around Galphay which fall within parts of the Nidderdale AONB
ASMRP 5 Undifferentiated sand and gravel	<ul style="list-style-type: none"> Low-lying open landscape with extensive views over the Vale of Pickering, Early post glacial human activity on the margins of the ice dammed Lake Pickering Enormous archaeological potential related to a continuum of activity since the Mesolithic, although site visibility is variable and an extensive range of techniques are being used by the Landscape Research Centre to record this. Deep ploughing and dewatering have affected areas of sub surface waterlogged remains The rich biodiversity which once characterized this area has been lost as a result of intensive agricultural activity since the late 18th century. Fragmented habitats survive, and small areas of plantation woodland and watercourses that are the result of more recent land management provide opportunity for other species. 	Representative of most of ASMRP 5 in the Vale of Pickering, except for the small area of resource which falls within the Howardian Hills AONB and to the north near Wykeham. Most areas are visible at a distance from within parts of the North York Moors National Park
ASMRP 6 Quaternary brick clay	<ul style="list-style-type: none"> Clay laid down within Quaternary glacial deposits in low lying areas of the Vales of Mowbray and York, and the Humberhead Levels Wetland marsh and mire characterized this landscape as the lakes silted and dried up in the post glacial period and would not have been attractive for human occupation. The modern agricultural landscape was the result of post medieval drainage and intensive cultivation. The landscape is characterized by medium sized hedged fields, but in the Humberhead Levels drainage ditches bound larger and more recent fields. Poor site visibility as a result of the heavy clay soils, and therefore potential for well-preserved archaeological deposits 	Representative of most of ASMRP 6 across North Yorkshire
ASMRP 7 Cretaceous chalk	<ul style="list-style-type: none"> 70% of this area is made up of the rolling Chalk Wolds, an open tranquil landscape in a relatively elevated position to the south of the Vale of Pickering. The area was ice free during the last glaciation and there is evidence of human activity from the Neolithic period onwards. The area has been continually but not intensively settled, with agricultural uses predominating. Deserted medieval villages (DMV) are a feature of this area – the result of population displacement by landowners to further large scale sheep grazing. The well drained nature of the landscape suits modern agriculture and the earlier natural habitats dominated by species rich calcareous grassland have given way to large scale intensive arable cultivation apart from the steeper slopes of the chalk foothills and narrow chalk valleys 	The northern edge is visible at a distance from within parts of the North York Moors National Park

<p>ASMRP 8 Jurassic limestone</p>	<ul style="list-style-type: none"> • A slightly undulating, well drained landscape on the dip slope of the North York Moors, facing south over the Vale of Pickering • The landscape is predominantly arable but there are important survivals of ancient woodlands from the past, particularly on steeper slopes in the foothills • Scattered Bronze Age cairns and potential for sub surface remains associated with Roman activity and settlement, the character of the landscape is largely post medieval with regularly spaced settlements and field enclosure. • The stone was widely used for housing and dry stone walling in the past and there are numerous remains of small stone working sites. 	<p>Representative of most of ASMRP 8, except for the western-most area of resource which falls within the Howardian Hills AONB.</p>
<p>ASMRP 9 Magnesian limestone</p>	<ul style="list-style-type: none"> • The Magnesian limestone resource is an extensive north–south orientated outcrop elevated above the adjoining and low-lying Vale of York and the Humberhead Levels to the east. • In many areas the limestone is overlain with glacial till • High archaeological potential because of the long association with a major communications route (now the A1) and settlement. • The rock weathers to form a light and friable soil and extensive arable cultivation has to some extent degraded this archaeological resource • Agriculture has also degraded the biodiversity of this ASMRP, but areas of semi-natural broad leaved woodland and calcareous grassland have survived, particularly on steeper valley sides 	<p>Representative of most of ASMRP 9, with some a typical features such as the gypsum related subsidence found in the sample site close to the River Ure near Ripon</p>
<p>ASMRP 10 Shallow Coal</p>	<ul style="list-style-type: none"> • Characteristic ‘drumlin’ topography in the Forest of Bowland AONB to south of Clapham, other deposits occur within the overlying Magnesian limestone ridge • High ecological sensitivity 	<p>This ASMRP was included within the resources described in the Stage 1 Report, but has not formed part of the more detailed sample site and characterisation process of Stages 2,3 and 4</p>
<p>ASMRP 11 Carboniferous brick clay</p>	<ul style="list-style-type: none"> • Occurs within the overlying Magnesian limestone ridge 	<p>This ASMRP was included within the resources described in the Stage 1 Report, but has not formed part of the more detailed sample site and characterisation process of Stages 2,3 and 4</p>
<p>ASMRP 12 Carboniferous sandstone</p>	<ul style="list-style-type: none"> • The sandstone is primarily found exposed in moorland areas where the glacial over burden is thinner or absent. • Natural and man-made (former quarries) outcrops of stone are a strong influence on the modern landscape. • Summit areas are largely unimproved acid grassland, with semi improved acid grassland and improved pasture on the sloping valley sides. There is little or no arable grazing • Early human activity is evidenced by ring cairns and rock art which are highly visible to those who look for them (see Stage 3 report references to 19th century antiquarians active in West Yorkshire) 	<p>Representative of most of ASMRP 12, except for the small areas of resource which fall within the Forest of Bowland AONB. Much of the resource is visible from within the Yorkshire Dales National Park</p>
<p>ASMRP 13 Silica Sand</p>	<ul style="list-style-type: none"> • Occurs as small outcrop in two locations within the project area at Blubberhouses in Nidderdale and Burythorpe in the Chalk Foothills of the Yorkshire Wolds. • Both have been exploited in the past 	<p>This ASMRP was included within the resources described in the Stage 1 Report, but has not formed part of the more detailed sample site and characterisation process of Stages 2,3 and 4</p>
<p>ASMRP 14 Carboniferous limestone</p>	<ul style="list-style-type: none"> • Within the North Yorkshire study area, the limestone outcrops occur in the west, linked to more extensive out crops in the Yorkshire Dales National Park. The limestone underlies extensive upland plateau and also occurs as scars on the dale sides • Shake holes created by natural dissolution occur on upland surfaces • Extensive upland forests were succeeded by blanket bog. Drainage of these upland areas for sheep grazing has led to a mosaic of acid grassland and dry heath, with isolated woodlands confined to the valley sides • Strong historic land use pattern with dry stone walls and hedgerows. • There are extensive remains of former lead mining activity, past and current stone extraction and evidence of early human activity • There is potential for subsurface remains beneath peat deposits • This landscape is of generally high ecological value for both bogs, mires and moors, and species rich meadows and pastures 	<p>In ASMRP 14 the underlying limestone forms part of a succession of underlying rock types including sandstone and chert. The sample site was typical of Gritstone Moorland, but this mineral resource occurs more extensively within the Moors Fringe (LCT 13) and farmed valleys and dales.</p>

7. Potential Impacts Associated with Mineral Extraction

Introduction

- 7.1 Mineral extraction inevitably gives rise to localised environmental impacts and often to other impacts over the wider landscape, particularly where the impacts are cumulative and/or on a large scale. The excavation and removal of mineral unavoidably changes the shape of the land and removes existing landscape features, habitats and archaeological material. In doing so, it also creates noise, dust, traffic and carbon emissions which otherwise would not exist. Quarrying may also disrupt the natural flows of groundwater and surface water, both physically and in terms of water quality, and this, in turn, may have impacts on habitats and ecosystems in the areas which surround the quarry.

Types of impact

- 7.2 Listed below are the main categories of potential impact which may be associated with mineral development. Detailed information relating to each of these is provided in Chapter 6 of the Stage 3 report.
- Landscape and Visual Impacts
 - Archaeological Impacts
 - Biodiversity Impacts
 - Geodiversity impacts
 - Air Quality impacts
 - Environmental Noise and Vibration
 - Traffic impacts
 - Water Environment impacts, including groundwater, surface water and associated habitats and ecosystems
- 7.3 All types of impact are a function of both the intrinsic features of the **operation** (e.g. the level of noise, the amount of traffic, the depth of the void etc.) and the nature and sensitivity of the **receptors** within and around the location involved. ‘Receptors’ in this sense range from people, fauna and flora to habitats, water resources, landscapes and various facets of the historic environment. For certain types of impact, which are directly related to the intrinsic type and amount of activity within the quarry (e.g. dust, noise, vibration, traffic), it is easier to identify generic distinctions between different types of working. For other types of impact, however, (e.g. on landscape, archaeology, habitats and species), it is the receptors which

actually define the impact, and which are therefore far more important in determining the likely scale of potential adverse effects. For example, the effects of a large sand & gravel pit with open water restoration, located within an area of highly valued historic landscape, may have greater impacts than a crushed rock quarry located in an area which has little in the way of landscape, historic environment or biodiversity interest. In such cases it becomes virtually impossible to generalise regarding the 'typical' levels of impact associated with particular types of working. In between these two groups are the various types of impact on the water environment, where both the nature of the operations and the characteristics of existing groundwater and surface water features (including their links to habitats and ecosystems) are more closely balanced in terms of their importance in determining the scale of impact.

Differences relating to type of mineral and type of extraction

- 7.4 Most of the above-mentioned types of impact will need to be at least considered in relation to all types of surface mineral working. Differences between them are largely a matter of scale, duration and location. For the most part, such differences need to be considered on a site-specific basis, but there are some generalisations which can be made regarding the intrinsic characteristics of different types of extraction, irrespective of location and environmental setting.
- 7.5 At this level, differences can be considered in terms of:
- the typical size and location of the quarry void (crushed rock and opencast coal operations generally being larger and more visible than other types of working, although some large sand & gravel workings can also cover large areas - although this usually relates to the cumulative impacts of successive extensions and new permissions within a given area - which need to be considered as a separate issue);
 - whether or not the quarry extends beneath the water table and, if so, whether dewatering is required or whether the mineral can be worked under water (*which is possible for sand & gravel, where necessary, although dry working is generally preferred for optimum efficiency*);
 - whether or not the mineral deposits are likely to contain important water resources (especially likely for limestone and chalk quarries and for sand & gravel pits, but may also be true for sandstone);
 - the method of working, including whether or not high explosive blasting is required (generally applies only to crushed rock quarries but may also be required to some extent in opencast coal and in in some chalk quarries);
 - the nature of any mineral processing carried out, including whether or not crushing and screening is required (again, crushing is generally applicable only in hard rock quarries, but

screening is required in all types of aggregate production. Saw mills may be present at building stone quarries, to produce sawn blocks, slabs, paving stones and other products, but more commonly these facilities are sited elsewhere and already exist);

- the likely presence or absence of ancillary manufacturing processes within the site, such as asphalt coating plant, concrete batching plant and concrete block production (*any or all of these are commonly found at the site of crushed rock quarries but may sometimes also be present at large sand & gravel sites*);
- the typical rate of production and output, since these will influence the magnitude of certain impacts (e.g. noise, blasting vibration, traffic impacts) and the duration and frequency with which they are experienced (*once again, crushed rock and opencast coal units are likely to be the most prominent, on account of their high volume production*);
- the likely nature of quarry restoration, including opportunities for 'rolling' restoration which help to limit the area of active workings at any given time, and whether or not the restoration is likely to result in a substantial change of landscape character (*as will usually be the case where part or all of the site is restored to open water*).

7.6 Some generic distinctions can therefore be made, particularly between major crushed rock quarries (which tend to have high levels of potential impact); sand & gravel quarries (which tend to have more modest potential impacts, except when working below the water table, and excluding cumulative impacts): and building stone quarries (which, because of their small size, lack of blasting and very limited output tend to have low levels of impact in most categories). Shallow clay pits are likely to have low levels of impact in some categories but medium levels in others. Chalk pits are also likely to be associated with different levels of impact in different categories, depending on methods of working. Many modern chalk pits which are used for cement manufacture are wet-worked below the water table, but those in North Yorkshire are generally on higher ground, above the water table, and would be more likely to be worked dry. Such quarries may or may not require the occasional use of blasting.

7.7 Opencast coal extraction has much in common with hard rock quarries, except that blasting is only required, if at all, to loosen the bands of rock between the coal seams and not to induce complete fragmentation of the rock face. The environmental impacts of reclamation and after-use may also be less for coal extraction because of the relatively poor baseline conditions that are sometimes found in coalfield areas. Further south, within the main part of the Yorkshire, Derbyshire and Nottinghamshire coalfield (and in similar industrialised coalfields elsewhere), modern opencast extraction has often been seen as a mechanism for improving the derelict and contaminated landscapes left behind by former industrial activity.

Cumulative and Combined Effects

- 7.8 Cumulative effects can be a major issue where two or more quarries are located in close proximity to each other, either simultaneously, during the operational phase, or sequentially.
- 7.9 In the first case, problems may arise from the compound effects of such things as noise, dust, traffic and the drawdown of water tables associated with dewatering from multiple locations. The effects are both increased in overall magnitude and spread out over a wider area. Whilst the effects from any one of the sites may be considered acceptable (subject to mitigation and/or compensatory measures) the cumulative effects of two or more sites within the same area might not.
- 7.10 In the second case, where adjoining sites are developed sequentially, as is often the case with sand & gravel extraction within wide floodplains or river terraces, the operational impacts may be capable of adequate mitigation and management, but the consequences of working in terms of reclamation schemes and their relationship to the surrounding landscape might not be. This is especially likely where reclamation is partly or wholly to open water: the original landscape can become transformed into a disjointed pattern of isolated, water-filled holes, resulting in a complete change of character. Whether or not this is acceptable, or has the potential to be acceptable, will depend on the sensitivity (see Chapter 7) of the original landscape including its historic and natural environment characteristics. In some cases, the progressive creation of a new, water and wetland-dominated landscape may have biodiversity, amenity and visual benefits which, if developed sensitively and as an integral part of appropriate landscape measures and vision, might outweigh any adverse impacts. But in other cases the changes will be more finely balanced or, in some cases, completely unacceptable.
- 7.11 In-combination effects relate to situations where different types of impact combine to create much greater problems than might otherwise be expected, based on the assessment of individual issues. In the case of large, crushed rock aggregates extraction on open hillsides, for example, high levels of visual intrusion are likely to combine with high levels of noise and dust, potentially giving rise to more complaints than small-scale sand or clay pits on lower ground.
- 7.12 Understanding these various combinations highlights a key part of the rationale behind this project i.e. taking an integrated look at landscape, biodiversity and heritage issues.

Mitigation and Enhancement

- 7.13 Many potential adverse effects can be mitigated, in one way or another, and managed within acceptable limits through the use of good practice techniques (enforced, where necessary, through the use of planning conditions, Section 106 obligations and/or environmental permits). An outline of the techniques available to mitigate specific types of impact is provided along with the discussion of the impacts themselves in Chapter 6 of the Stage 3 report.

- 7.14 In some circumstances, other effects may be more difficult or impossible to mitigate, however, and it cannot be assumed that there will always be an acceptable solution. In such cases a balance needs to be struck between the need for the mineral and the acceptability or otherwise of the residual impacts (i.e. those which would still be likely to occur after mitigation), which will be strongly influenced by importance and significance of the historic or natural assets being put at risk.
- 7.15 In other cases, however, it is increasingly being demonstrated that certain impacts can be managed in such a way as to create positive environmental benefits in the longer term. This includes certain impacts on biodiversity and geodiversity, where quarrying often provides opportunities for substantial enhancement, compared with existing, 'baseline' conditions, including the reconnection rather than fragmentation of existing habitats. Quarrying frequently provides opportunities for large scale changes to the physical form of the landscape. Whilst this can be damaging where the existing landscape is highly valued, in other cases, through sympathetic landform design, high quality implementation and effective long-term management of agreed reclamation schemes, it can also lead to the creation of harmonious and imaginative new landscape features which, in turn, may become highly valued in their own right.

8. Environmental Sensitivity and Capacity

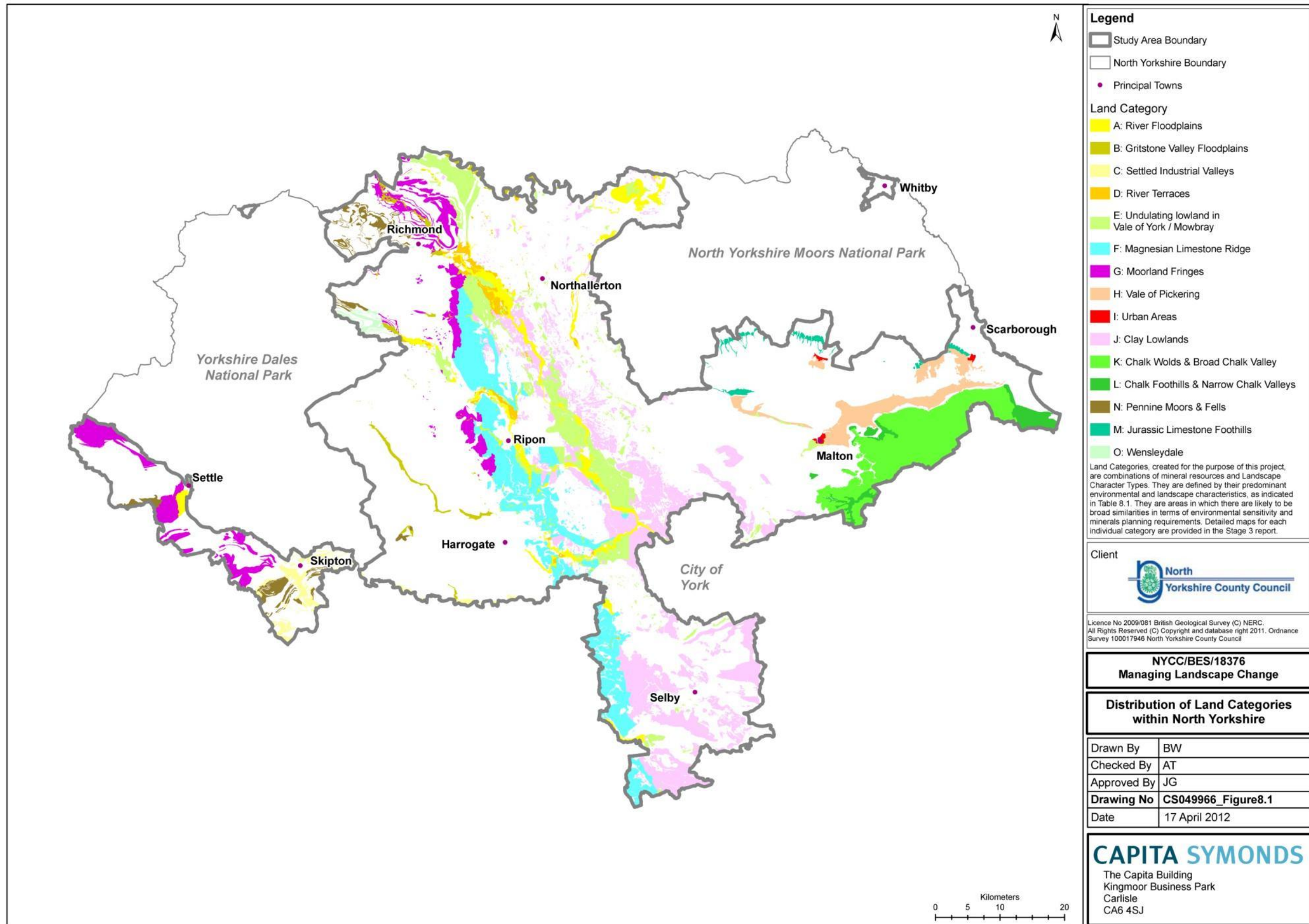
Introduction

- 8.1 This Chapter outlines the findings of the sensitivity and capacity assessments carried out in Stage 3 of the project, but begins with an explanation of the identification of ‘Land Categories’ which were used in this work, and carried through to the recommendations for planning that are presented in Chapter 9.

Land Categories

- 8.2 Taking account of the varying degrees of similarity, in terms of environmental characteristics, within *and between* different ASMRPs, certain geographical groupings begin to emerge which may provide a more useful basis for future policy development than the ASMRP boundaries themselves. Although some of the ASMRPs, such as the Vale of Pickering (ASMRP 5) and the Yorkshire Wolds (ASMRP 7), have strong internal homogeneity, there are also differences, as reflected in their component LCTs. For other ASMRPs, where there is a more complex interplay of different landscape types, this is not the case. Equally, however, there is not always consistency within individual LCTs, which occur across many different types of resource. Even in the Vale of York, where many similarities exist across the areas of ASMRP 3 and ASMRP 4 resources, there are important differences associated with the ASMRP 6 clay resources and the ASMRP 1 floodplains within the same general areas. Table 8.1, below identifies a total of 15 categories, each of which is considered to have a greater degree of homogeneity than either the ASMRPS or the LCTs, and thus provides a potential basis for developing planning recommendations. The categories are utilised in the analysis of environmental sensitivity and capacity, below, and their geographical distribution is illustrated in Figure 8.1.

Table 8.1: Definition of Land Categories and their predominant characteristics			
Category	ASMRPs	LCT Subdivisions (in order of decreasing area within each ASMRP)	Dominant feature(s) in terms of environmental characteristics
Category A	ASMRP 1 (including areas superimposed on ASMRPs 9, 10, 11)	LCTs 24, 27, 6 & 25 plus Tees Valley part of LCT 36	ASMRP 1 - Modern River Floodplains
	ASMRP 12	LCT 11	Floodplain of the River Ribble
Category B	ASMRP 1, 2 & 13	LCT 36 except Tees Valley & LCT 13	Gritstone Valley Floodplains
Category C	ASMRPs 1, 2, 12 & 14	LCT 31	Settled Industrial Valleys
Category D	ASMRP 2	LCTs 24, 25, 27, 13, 6	ASMRP 2 - River Terraces
Category E	ASMRP 3	LCTs 28, 24, 25, 23	Mixed features within general lowland topography, predominantly within the Vale of York & Vale of Mowbray - all dominated by modern agriculture
	ASMRP 4	LCTs 25, 28, 24, 27	
	ASMRP 5	LCT 5	
	ASMRP 9	LCTs 27, 25	
	ASMRP 14	LCT 27	
Category F	ASMRPs 3, 4 & 9 (including areas superimposed on ASMRPs 10 & 11, but excluding areas overlain by ASMRP 1)	LCT 6	Magnesian Limestone ridge, including areas overlain by glacial and glaciofluvial sediments
Category G	ASMRPs 3, 4 & 9	LCT 13	Moors Fringe or Drumlin Valleys or Rolling Upland Farmland
	ASMRPs 10 & 12	LCT 32	
	ASMRP 12	LCT 14	
	ASMRP 14	LCTs 13, 14 & 32	
Category H	ASMRP 5	LCTs 30 & 26	ASMRP 5 - sand & gravel outcrops at the margins of the Vale of Pickering
	ASMRP 5	LCT 22	Open Carr Vale Farmland within the Vale of Pickering
Category I	ASMRP 5	LCT 1	Urban Landscapes
Category J	ASMRP 6	LCTs 23, 28, 25, 24, 6, 27	ASMRP 6 - low-lying, flat agricultural landscape with poor visibility
	ASMRP 9	LCT 23	levels farmland
Category K	ASMRP 7	LCTs 18 & 20	Chalk Wolds & Broad Chalk Valley
Category L	ASMRP 7	LCTs 19 & 21	Chalk Foothills & Narrow Chalk Valleys
	ASMRP 13	LCT 19	
Category M	ASMRP 8	LCTs 4 & 30	Limestone Foothills
Category N	ASMRP 12	LCTs 38, 37, 35	Siltstone, Sandstone & Gritstone Moors and Fells
	ASMRP 13	LCTs 34 & 35	
	ASMRP 14	LCT 33	
Category O	ASMRP 14	LCT 9	Farmed Dale



Assessment of Sensitivity

- 8.3 As explained in Chapter 3 above the selected approach to the assessment of environmental and landscape sensitivity within this project is based on qualitative analysis, and focuses on the specific scenario of future mineral extraction.
- 8.4 The starting point for this assessment was to recognise that most forms of potential impact associated with surface mineral working will apply to all geographical areas and environmental settings, and that policies relating to the control of these impacts will therefore largely be generic across all areas.
- 8.5 The analysis presented below therefore attempts to identify the ‘special’ sensitivities (whether higher or lower than ‘normal’) that may be associated with particular areas, either because of the intrinsic characteristics of the landscape, historic environment or natural environment in those areas (as summarised above and detailed within in Chapter 2 of the Stage 3 report), and/or because of the type of mineral extraction likely to be involved, and its associated potential impacts (as detailed in Chapter 6 of the Stage 3 report).
- 8.6 In order to do this, some initial concept is needed of what is ‘normal’ and how this can be differentiated from what is ‘special’. This would be extremely difficult and controversial to establish in any quantitative way, even for individual issues, but an attempt can be made to provide more general, qualitative definitions that can be used to guide professional judgement. Across all three of the topic areas under consideration, we suggest that this would need to encompass the concepts of **quality, uniqueness, significance** and **vulnerability**.

Components of sensitivity

- 8.7 Features of exceptional **quality** (such as nationally or internationally important designations) would clearly fall into the ‘special’ rather than ‘normal’ category. However, in this respect it must be remembered that, for historic and natural environment features, such designations only attempt to deal with a representative sample of special features and that other features of equal ‘national’ importance may also be present.
- 8.8 Consideration also needs to be given to the concept of **uniqueness**: a feature which is the only one of its kind and which adds to our understanding of the landscape, past cultures or the changing natural environment over time can be regarded as ‘special’ whether or not it has any kind of designation. Equally, where there are multiple examples of a particular feature in a given area, not all of these may need to be preserved, even if they are all of a similar quality. In the field of archaeology, for example, if there are multiple tumuli within a given area, the loss of some of these, in exchange for a greater understanding of what they contain, may be seen as an acceptable outcome - though this may not apply to the loss of individual elements

from a larger group of connected features (such as an alignment of henges). In the field of biodiversity, the preservation of European-designated sites which are refugia for rare or endangered species is of paramount importance, and is backed by European Law. This applies whether or not the sites concerned are unique. More generally, care needs to be taken with uniqueness since (to a specialist, in particular) no two things are exactly alike: this applies equally to particular landforms, rock outcrops, habitats, vegetation communities and to individual historic monuments. To qualify as 'special' in this sense, the uniqueness must be important in some way, at a level which is relevant to planning policy.

8.9 **Significance** is therefore the third vital component in distinguishing between what is normal and what is special, and is perhaps the most difficult for specialists to agree upon. English Heritage (2008b) has noted that *"significance is a word used to summarise what is important about a building or place or any type of historic asset. It can be defined as the sum of the heritage values of a place"*. More generally, a feature may have special significance to a local community, for example in providing or contributing to a 'sense of place'. In other circumstances a feature may have national or international significance, for example because of its importance to scientific or cultural knowledge (including sites that are important for the historical development of scientific ideas). In between, there are features which are significant at a regional or sub-regional level including, for example, wildlife corridors which connect similar habitats and thereby help to protect species and to maintain a healthy natural environment. The severance of such corridors by mineral workings (or other forms of development) can be of much greater significance than might otherwise be expected from the loss of a small area of habitat. It must also be recognised that well-designed mineral operations can be used to re-establish habitat connections that have previously been lost (e.g. through the spread and intensification of agriculture). This, however, will be considered in the following Chapter on capacity, rather than here.

8.10 The fourth and final aspect of whether or not something has 'normal' or 'special' sensitivity relates to its **vulnerability** to change. Certain features, such as non-finite geological exposures, which can be replaced with similar (or better) new exposures as a result of mineral extraction can be regarded as fairly robust and therefore non-sensitive. By comparison, the habitat of a species which depends for its survival on the integrity and continuity of that habitat over a given area or distance would be highly vulnerable to its partial removal or severance. Similarly, certain landscapes may be vulnerable to development which disrupted the continuity of a given landform or field pattern.

Implementation

8.11 Bringing all four of these concepts together is not an exact science and, in the case of this project, can only be done on the basis of limited information. It is necessarily a strategic-level exercise informed by a broad-brush desk study and GIS-based analysis (Stage 1 report); more

detailed investigations of very small sample areas (Stage 2 sample areas report); and an attempt to create a wider synthesis of understanding (as expressed in the Stage 2 Predictive Landscape Modelling report and in Chapter 2 of this report). Nevertheless, the general concepts outlined above have informed the views of the project team in identifying ‘special’ sensitivities.

8.12 These considerations have been applied to subdivisions of each ASMRP, based on Landscape Character Type (LCT), as defined in the North Yorkshire County Landscape Assessment (Chris Blandford Associates, 2011). These subdivisions were used because the landscape character assessment process, on which they are based, incorporated the consideration of landscape, historic environment and natural environment issues, and thus provided a sound basis for differentiation.

8.13 Table 8.2 below shows the issues that have been considered under the headings of landscape; the historic environment; and the natural environment.

Landscape	Historic Environment	Natural Environment
Landscape Quality (AONB)	Predominant HLC Categories	Environmental designations
Geology	Archaeological Deposits	Existing Habitats
Topography & Drainage	Earthworks	Semi-Natural Vegetation
Land Cover	Historic Buildings	Protected species
Enclosure / Field Pattern	Other Historic Structures	Water Environment
Settlement Pattern	Groups of Monuments (including historic settlements, field patterns etc.)	Biodiversity Opportunities
Visible Historic Features		Green Infrastructure
Built Environment & Materials	Designed Landscapes including Registered Parks & Gardens	Geodiversity features (landforms, exposures, active geomorphological processes - all linked to landscape)
Tranquillity		
Access	Registered Battlefields	
Views	Other Features	Other Features
Other Features		

Table 8.2: key issues taken into account in the assessment of sensitivities to mineral extraction in each land category

8.14 It must be emphasised however, that it is only the issues which are considered by the project team to give rise to ‘special sensitivities’ which are noted in the body of the subsequent tables. It is also important to reiterate that the absence of a special sensitivity does not mean that it does not exist, just that it is not publicly known about (at least to the project team), or that it

awaits discovery. Any proposed minerals development will still require a specific site-based data search and watching brief as part of a basic investigation, in accordance with current policy.

Results

- 8.15 The results are presented below, for each individual ASMRP, in Tables 8.3 to 8.16. Within each table, the component LCT subdivisions are presented in order of their percentage cover within the ASMRP. This is in order to give some indication of 'weighting' for the sensitivities involved (those associated with larger areas being likely to have a much greater influence on the development of area-specific policies).
- 8.16 In each table the LCT subdivisions are colour-coded to reflect the broad Land Categories identified in Table 8.1, above.
- 8.17 Although differences in sensitivity have been identified in these tables, between at least some of the LCT subdivisions, these often relate to localised features rather than to the whole subdivision. Moreover, areas which have high sensitivity with respect to the historic environment do not necessarily have high sensitivities in other categories, and vice-versa. This is not surprising, given that the issues involved are very different, but it does mean that variations in overall sensitivity cannot easily be mapped: to do so would create a misleading impression and would not provide a sound basis for the future development of policy.

LCT Subdivisions: (in order of decreasing percentage area)	LCT 24 River Floodplain	LCT 27 Vale Farmland and Dispersed Settlements	LCT 36 Gritstone Valley	LCT 31 Settled Industrial Valleys	LCT 6 Magnesian Limestone ridge	LCT 13 Moors Fringe	LCT 25 Settled Vale Farmland	LCTs 1, 3, 4, 9, 11, 26, 28, 29, 32
Percentage of ASMRP within each subdivision:	38.97%	13.01%	9.51% <i>(note, the descriptions below exclude the areas of floodplain within the Tees Valley which are more akin to LCT 24)</i>	8.84%	7.20%	6.06%	5.18%	<5% each
Key Sensitivities, with respect to potential mineral extraction, that may be associated with:	<p>Watercourses are the most distinctive feature of the landscape, presenting special sensitivities in terms of landscape character, active geomorphological processes, water resources and both aquatic and riparian habitats and ecosystems</p> <p>The open, generally flat landform which provides the setting for traditional, nucleated villages, is sensitive to the visual effects of mineral operations</p> <p>The SSSI Hell's Kettles is the only site in the county where open water fed by calcareous springs occurs and is sensitive to water level change caused by extraction</p> <p>The present day land use is predominantly modern and has a low sensitivity.</p> <p>Potential for deeply buried prehistoric deposits from earlier human activity concealed beneath more recent fluvial deposits. There is therefore poor site visibility of early archaeology, which gives a precautionary higher sensitivity to these areas</p> <p>High ecological sensitivity as a result of the patchwork of fen, flood meadows, floodplain mires, marsh and swamp, as well as the river channels and riparian vegetation which form vital wildlife corridors. These wetland environments and ecosystems are especially vulnerable to the effects of watercourse diversions, floodplain excavations and dewatering.</p>	<p>Watercourses again are a distinctive feature of these areas, presenting the same special sensitivities as in LCT 24.</p> <p>Dispersed settlement pattern and pockets of historic parkland are sensitive to visual effects of mineral extraction</p> <p>The present day land use is predominantly modern and has a low sensitivity.</p> <p>However, historic parklands occur in this open rolling landscape.</p> <p>High sensitivity within true floodplain areas, as noted for LCT 24. Elsewhere, away from the rivers, moderate ecological sensitivity in areas of improved agricultural land, including bat roosts in mature trees and built structures and foraging / commuting habitat along hedges / woodland edge.</p>	<p>Watercourses again are a distinctive feature of these areas, presenting the same special sensitivities as in LCT 24.</p> <p>Largely within the Nidderdale AONB which is a long, majestic dale along the River Nidd; internationally important for wildlife and a popular recreational area for walkers to admire the natural beauty.</p> <p>Recreational use, as a gateway to Nidderdale AONB, is sensitive to impacts of mineral operations, such as new roads and change to landscape character through removal of field boundaries.</p> <p>High visual sensitivity as a result of strong visual connectivity with adjacent Moors and Fells.</p> <p>Strong historic landscape/land use pattern that could be diluted by mineral extraction and inappropriate restoration.</p> <p>The heritage value score is high which reflects a large amount of lead mining related features in the valley, and includes communication features and water powered lead processing sites which used to exploit the river.</p> <p>High sensitivity within true floodplain areas, as noted for LCT 24. Elsewhere, away from the rivers, moderate ecological sensitivity in areas of improved agricultural land - as for LCT 27 areas</p>	<p>Watercourses again are a distinctive feature of these areas, presenting similar sensitivities to those in LCT 24 but with increased scope for environmental enhancement.</p> <p>A very small part of this area falls within the Howardian Hills AONB; soft rolling hills with historic parklands which are sensitive to the visual effects of mineral operations.</p> <p>Major communication routes and influence of the West Yorkshire conurbation have resulted in greater urbanisation and industrial activity.</p> <p>The heritage value scoring defines a typically low level of resource. To an extent this reflects the fact that older heritage resources are likely to be buried beneath the alluvium, but also reflects that the area has not been subject to targeted archaeological investigation</p> <p>Relatively low ecological sensitivity, but heightened need/opportunities for biodiversity enhancement in areas of degraded industrial watercourses</p>	<p>Watercourses again are a distinctive feature of these areas, where major valleys cut through the limestone ridge.</p> <p>The setting of historic country houses and designated landscapes on adjoining higher ground may be sensitive to mineral extraction within this LCT.</p> <p>Proximity to A1 M corridor may heighten the sensitivities associated with cumulative impacts (from multiple extraction sites and from HGV traffic)</p> <p>The present day land use is predominantly modern arable agriculture and has a low sensitivity.</p> <p>Historically, these parts of ASMRP 1 have been within an important communications corridor - that of the present-day - A1/M1 giving a locally heightened heritage value and thus greater sensitivity; otherwise these areas have a low Heritage Value Score.</p> <p>High sensitivity within true floodplain areas, as noted for LCT 24.</p> <p>Heightened sensitivities for groundwater resources may occur where gravel is in hydraulic contact with the limestone aquifer</p>	<p>A small part of this area falls within the Nidderdale AONB ; a popular recreational area for walkers to admire the natural beauty of the landscape and hence sensitive to visual effects of mineral operations</p> <p>Predominantly rural landscape with associated sense of tranquillity; sensitive to noise and disturbance caused by minerals operations.</p> <p>Strong historic landscape/land use pattern, reflecting that it is on the moorland fringe. The historic landscape could be diluted by mineral extraction and inappropriate restoration</p> <p>High sensitivity within true floodplain areas, as noted for LCT 24.</p>	<p>Watercourses again are a distinctive feature of these areas, presenting the same special sensitivities as in LCT 24.</p> <p>In places, modern development has fragmented historic landscape patterns and hedgerows are gappy. Remaining parkland landscapes are more sensitive to mineral operations.</p> <p>No particular features of special historic sensitivity</p> <p>High sensitivity within true floodplain areas, as noted for LCT 24. Other features of high ecological sensitivity may result from the patchwork of habitat types and the abundance of features such as mature parkland trees.</p>	

Table 8.4: ASMRP 2 (River Terrace Sand & Gravel): Summary of special environmental sensitivities within LCT subdivisions

LCT Subdivisions: (in order of decreasing percentage area)	LCT 24 River Floodplain	LCT 25 Settled Vale Farmland	LCT 36 Gritstone Valley <i>(Note: most of this subdivision of ASMRP 2 falls within the Tees Valley where the landscape is more akin to LCT 24. The descriptions below relate only to the Nidd Valley)</i>	LCT 31 Settled Industrial Valleys	LCT 27 Vale Farmland with Dispersed Settlements	LCT 13 Moors Fringe	LCT 6 Magnesian Limestone Ridge	LCTs 9, 32, 1, 11, 28, 12, and nine others
Percentage of ASMRP within each subdivision:	28.70%	20.65%	10.02%	8.76%	6.60%	3.79%	3.65%	<3.60% each
<p>Key Sensitivities, with respect to potential mineral extraction, that may be associated with:</p> <ul style="list-style-type: none"> landscape, the historic environment and the natural environment 	<p>High visual sensitivity as a result of the predominantly open and flat landform, facilitating long distance open views and visual connectivity between landscape character areas.</p> <p>Historic sites, listed buildings, designed landscapes and views, and the settings of all of these would have a high degree of landscape sensitivity to all but very small scale mineral operations</p> <p>Strong historic landscape/land use pattern that could be diluted by mineral extraction and inappropriate restoration</p> <p>Association with Roman road (now A1) and well drained means a strong association with older settlement – particularly Roman (Roman fort and vicus at Catterick are in this ASMRP). This makes these areas potentially of greater sensitivity with respect to mineral extraction.</p> <p>Henges at Nunwick and Catterick are on ASMRP 2, and are part of wider ritual landscape associated with adjacent ASMRP 3 at Thornborough. These associations provide a prehistoric context which may increase the sensitivity of other parts of these deposits nearby</p> <p>Locally high ecological sensitivity where terrace deposits adjoin semi-natural riparian habitats along river banks. These form important wildlife corridors and are host to a wide range of both aquatic and terrestrial species.</p> <p>Locally high ecological sensitivity also associated with the wider patchwork of fen, flood meadows, floodplain mires, marsh and swamp, inland bare ground and calcareous grassland habitats, where these occur. Several of these habitats are designated as SSSI and Ramsar sites.</p>	<p>Some historic landscape patterns are evident and these may be sensitive to disturbance and damage from mineral operations. Former WWI airfields are of interest but relatively low sensitivity to minerals development</p> <p>Significant historic landscapes, including ancient piecemeal enclosure and historic parkland. The survival of historic boundaries and features associated with past activity makes this LCT/ASMRP sensitive to extraction damage and need appropriate mitigation/landscape restoration measures to be considered</p> <p>Locally high sensitivity associated with parkland trees where these are used by roosting bats, and with associated hedgerows and other foraging areas.</p> <p>Ancient and semi-natural mixed woodland is also of high ecological importance and therefore sensitive to removal and indirect impacts.</p>	<p>Setting of historic parkland and designed view is sensitive to mineral operations.</p> <p>Significant survival of old landscapes where considerations are similar to LCT 24 and 25.</p> <p>Designated sites with high sensitivity include the Roman bridge and fort at Piercebridge</p> <p>Otherwise there is low level of historic environment (designated and undesignated) resource.</p> <p>Locally high sensitivity associated with parkland trees where these are used by roosting bats, and with associated hedgerows and other foraging areas.</p>	<p>Remnant drystone walls are a special landscape feature and would be sensitive to removal as a result of mineral operations</p> <p>No special sensitivities with regard to impacts of extraction on the historic environment.</p> <p>There is generally a low level established and potential historic environment resource, although the proportion of ornamental parkland is higher than usual</p> <p>Locally high sensitivity associated with parkland trees where these are used by roosting bats, and with associated hedgerows and other foraging areas.</p>	<p>Remnant drystone walls are a special landscape feature and would be sensitive to removal as a result of mineral operations</p> <p>High visual sensitivity as a result of open landscape; strong intervisibility with adjacent landscape types</p> <p>There is a good survival of historic villages within this landscape, and therefore associated potential for archaeological sites. Sensitivity is therefore moderate to high</p> <p>Locally high sensitivity associated with built structures within villages, where these are used by roosting bats.</p> <p>Sensitive BAP habitats may include Traditional Orchards.</p>	<p>Vernacular features which contribute to the landscape character, such as drystone walls, would be sensitive to removal as a result of mineral operations</p> <p>High visual sensitivity as a result of strong intervisibility with adjacent landscape types</p> <p>High sensitivity associated with the site of Anglian cemetery and earlier Roman fort at Bainesse near Catterick</p> <p>Potential for reptiles and breeding birds on less intensively managed land may present local sensitivities.</p>	<p>The setting of historic country houses (such as Nunwick House) and designed landscapes such as Norton Conyers would be sensitive to mineral operations</p> <p>Parts of this area, around Nosterfield, have a high archaeological resource and high sensitivity because of their location close to the Thornborough Henges and associated ritual landscape</p> <p>Calcareous grassland BAP habitat, 'Special' hedgerows and BAP Hedgerows may present local sensitivities.</p>	

LCT Subdivisions: (in order of decreasing percentage area)	LCT 6 Magnesian Limestone ridge	LCT 28 Vale Farmland with Plantation Woodland & Heathland	LCT 24 River Floodplain	LCT 25 Settled Vale Farmland	LCT 13 Moors Fringe	LCT 23 Levels Farmland	LCTs 1, 12, 32, 27, 11, 19, 9, and sixteen others
Percentage of ASMRP within each subdivision:	24.08%	18.67%	18.60%	15.87%	8.10%	2.57%	<2% each
<p>Key Sensitivities, with respect to potential mineral extraction, that may be associated with:</p> <ul style="list-style-type: none"> landscape, the historic environment and the natural environment 	<p>Special sensitivities in this area include scattered mature veteran trees which are a strong element in this landscape and are reminiscent of past, associated designed landscapes. The agricultural landscape is predominantly intact with a comprehensive, mature hedgerow network, pockets of deciduous woodland and several estates.</p> <p>Gently undulating landscape allowing views between farmsteads and historic estates is a special characteristic of this landscape, such as views between Castle Farm and Alterton Park Mansion.</p> <p>The present day land use is predominantly modern, which would suggest low historic environment sensitivity.</p> <p>However, the area has a high Heritage Value Score, and notably includes the area of Thornborough where there is a very significant prehistoric resource, including round barrows, a cursus and pit alignments.</p> <p>In the area around Snape, there are Roman buildings, field systems and Snape Castle</p> <p>Generally moderate ecological sensitivity due to intact hedgerows and mature trees.</p> <p>Great crested newts are likely to be abundant throughout due to presence of subsidence hollows and ponds. Meta-populations of GCN are highly sensitive to severance of dispersal routes, e.g. removal of hedgerows etc. Calcareous grassland BAP habitat is likely to occur on unmanaged or lightly grazed land.</p>	<p>There are no areas of high landscape sensitivity in these areas: patches of plantations disrupt views to adjoining landscapes so visual sensitivity is reduced; some historic landscape patterns have been compromised by modern developments and infrastructure; and hedgerows are gappy.</p> <p>The cumulative effects of additional development, including mineral operations could, however, reduce the quality of the landscape</p> <p>The present day land use is predominantly modern and has a low sensitivity.</p> <p>Low ecological sensitivity due to prevalence of improved grassland and plantation woodland.</p>	<p>Open views to adjoining areas may be sensitive to disruption associated with mineral development</p> <p>A generally flat, low-lying landscape which is fairly tranquil and sensitive to the cumulative effects of further mineral extraction, including increased noise and visual effects of additional structures in the landscape</p> <p>Setting of nucleated villages is sensitive to large scale mineral operations where the surrounding landscape is flat, open and visually connects one landscape type to another</p> <p>The present day land use is predominantly modern and has a low sensitivity.</p> <p>High ecological sensitivity due to semi-natural riparian habitats which form important wildlife corridors and are host to a wide range of both aquatic and terrestrial species.</p> <p>Particularly sensitive species include water-vole and otter.</p>	<p>Some historic landscape patterns are evident and these may be sensitive to disturbance caused by mineral operations</p> <p>The present day land use is predominantly modern and has a low sensitivity.</p> <p>The area has a generally low Heritage Value Score, but there are localised areas to the south of Northallerton where there is a high score and therefore higher sensitivity to change. These include the Money Hill Motte and bailey castle at Pickhill.</p> <p>Low ecological sensitivity due to prevalence of improved grassland and plantation woodland. Built structures offer potential for roosting bats.</p>	<p>Partly within the Nidderdale AONB, this area forms a transition between the high moors and fells to the west and the lower Magnesian Limestone ridge to the east. Strong intervisibility with adjacent LCTs and high sensitivity to change</p> <p>Predominantly intact historic features within the landscape, such as walls and hedgerows are sensitive to change</p> <p>Relatively strong historic land use pattern reflecting the survival of old fields on elevated land and on the edge of moors.</p> <p>Some areas have a low Heritage Value Score, but an area to the east of Richmond is crossed by Scots Dyke and includes Easby Abbey. At Ravensworth is a Motte and Bailey fortification. These areas will have a higher sensitivity to change.</p> <p>High ecological sensitivity in higher areas due to non-intensive agricultural management of heath and moorland.</p> <p>Transition between the high moors and fells to the west and the lower magnesium limestone ridge to the east is likely to be occupied by reptiles and of significance to breeding birds.</p>	<p>High visual sensitivity as a result of the predominantly open character and flat landform, which facilitates long distance open views across the landscape and promotes strong intervisibility with adjacent landscape types</p> <p>Moderate landscape and cultural sensitivity as a result of the presence of a patchworks of historic drainage features (ditches and dykes), moated sites and grange sites</p> <p>No special sensitivities with regard to impacts of extraction on the historic environment. For the most part this area has a Heritage Value Score that is low, and there are no scheduled monuments in association.</p> <p>Low ecological sensitivity, resulting from the fact that much of this LCT encompasses improved agricultural land.</p>	

LCT Subdivisions: (in order of decreasing percentage area)	LCT 6 Magnesian Limestone ridge	LCT 25 Settled Vale Farmland	LCT 28 Vale Farmland with Plantation Woodland & Heathland	LCT 13 Moors Fringe	LCT 24 River Floodplain	LCT 27 Vale Farmland with Dispersed Settlements	LCTs 36, 1, 31
Percentage of ASMRP within each subdivision:	36.50%	28.28%	10.81%	9.04%	9.00%	3.99%	<2% each
<p>Key Sensitivities, with respect to potential mineral extraction, that may be associated with:</p> <ul style="list-style-type: none"> landscape, the historic environment and the natural environment 	<p>Part of the outcrop of ASMRP 4 within this LCT falls within the Nidderdale AONB and thus has heightened landscape sensitivities.</p> <p>Elsewhere, special landscape sensitivities include historical features such as the Wensleydale railway line (carrying steam trains) and examples of mature hedgerows.</p> <p>The gently undulating topography within historic estates and scattered mature trees are special features of this area which are sensitive to development.</p> <p>The tranquillity of this landscape type is sensitive also to change</p> <p>Strong historic land use pattern that could be diluted by mineral extraction.</p> <p>The Heritage Value Score is generally low but includes a localised area centred on Boroughbridge that is associated with the A1 historic communication route and the Aldborough Roman town and has a locally high Heritage Value Score.</p> <p>Moderately high ecological sensitivity where there are well-established wildlife corridors such as railway lines and hedgerows. These features specifically are likely to be used by reptiles and breeding birds.</p>	<p>The settings of nucleated villages, such as Crakehall would be sensitive to the introduction of mineral operations</p> <p>The present day land use is predominantly modern and has a low sensitivity.</p> <p>Mixed Heritage Value Score across the area, but higher sensitivities occur in an area just north of Boroughbridge and in the environs of Aldborough Roman town. To the south-east of Topcliffe is the historically important Maiden Bower motte and bailey, formerly domiciled by the Earls of Northumberland.</p> <p>Generally low ecological sensitivity due to high prevalence of improved grassland.</p> <p>Higher sensitivities may be associated with hedgerows, many of which are species-rich and old, are abundant as fields are generally small.</p>	<p>The landscape is generally open and flat with no obvious special landscape sensitivities</p> <p>The present day land use is predominantly modern and has a low sensitivity</p> <p>Generally low ecological sensitivity due to high prevalence of improved grassland.</p> <p>Higher sensitivities may be associated with hedgerows, many of which are species-rich and old, are abundant as fields are generally small.</p>	<p>The main outcrop of ASMRP 4 within this LCT falls within the Nidderdale AONB and thus has heightened landscape sensitivities.</p> <p>More generally, there is high visual sensitivity as a result of strong intervisibility with adjacent higher and lower landscapes.</p> <p>Strong historic land use pattern that reflects that it is on the margins of Nidderdale uplands.</p> <p>The Heritage Value Score is generally moderate, and includes the Mowbray Motte and Bailey Castle.</p> <p>High ecological sensitivity due to the amount of non-intensively managed land likely to be of high significance to breeding birds and reptiles</p>	<p>Open views to adjoining areas are sensitive to disruption by new development</p> <p>Mature vegetated river banks are special features within this landscape</p> <p>Because of the focus of past and ongoing gravel extraction within valley floors, these areas are especially sensitive to the cumulative effects of mineral extraction</p> <p>The present day land use is predominantly modern and has a low sensitivity.</p> <p>High ecological sensitivity due to semi-natural riparian habitats which form important wildlife corridors and are host to a wide range of both aquatic and terrestrial species.</p> <p>Particularly sensitive species include water-vole and otter.</p>	<p>Strong vegetation pattern adjacent to rivers which meander through farmed landscape</p> <p>Scattered trees and hedgerows create a mature, unified landscape pattern which would be sensitive to disturbance by mineral extraction</p> <p>The present day land use is predominantly modern and has a low sensitivity.</p> <p>High ecological sensitivity in areas of riparian habitat.</p>	

Table 8.7: ASMRP 5 (Undifferentiated Sand & Gravel in Vale of Pickering): Summary of special environmental sensitivities within LCT subdivisions

LCT Subdivisions: (in order of decreasing percentage area)	LCT 30 Sand and Gravel Vale Fringe	LCT 22 Open Carr Vale Farmland	LCT 26 Enclosed Vale Farmland	LCT 5 Limestone Ridge	LCT 1 Urban Landscapes	LCTs 19, 4, 12 and 18
Percentage of ASMRP within each subdivision:	43.88%	36.12%	8.89%	3.79%	3.48%	<2.5% each
<p>Key Sensitivities, with respect to potential mineral extraction, that may be associated with:</p> <ul style="list-style-type: none"> landscape, the historic environment and the natural environment 	<p>High landscape sensitivity as a result of the striking settlement pattern of villages located along the spring line, and designed landscapes</p> <p>Special sensitivities include traditional buildings constructed using vernacular materials including chalk.</p> <p>Field patterns are striking: regular strip patterns are a special feature and sensitive to removal.</p> <p>Very high sensitivity relating to the known or potential richness of the concealed archaeological resource, with evidence of all periods of human activity from the Mesolithic onwards, and the survival of an older landscape which had isolated villages and associated historic field systems.</p> <p>Generally low ecological sensitivity resulting from the fact that this landscape predominantly consists of improved agricultural fields</p>	<p>Linear ditches and small watercourses are a special feature of this landscape and are sensitive to extraction practices</p> <p>Surviving hedgerows associated with strip farming are sensitive to removal as so many have already been removed.</p> <p>Some landscape features, including historic landmarks and vertical elements such as Wykeham Abbey provide which focal points in the flat landscape have higher sensitivity to change</p> <p>Potentially high sensitivities associated with buried archaeology but this land is lower lying and less well drained than LCT 30, and would not have been attractive for human occupation during early periods of history.</p> <p>There is a large amount of parliamentary enclosure, reflecting the fact that a large proportion of this area was previously waste land, enclosed late.</p> <p>Locally high ecological sensitivity associated with the prevalence of deep ditches and streams. These create an important network of wildlife corridors with increasing connections to biodiversity enhancement schemes in peatland areas.</p>	<p>Partly within the Howardian Hills AONB: soft rolling hills with historic parklands which are sensitive to the visual effects of mineral operations</p> <p>High sensitivity likely to be associated with concealed archaeological resources along this narrow strip of better-drained land which extends across the southern edge of the Vale of Rye. The strip formed an historic communication route between Malton and Slingsby and was occupied by villages spread out along the route. Around the villages are the fossilised remains of former open fields (Strip Fields). The area includes Iron Age cemeteries.</p> <p>Generally low ecological sensitivity resulting from the fact that this landscape predominantly consists of improved agricultural fields</p>	<p>ASMRP 5 resources overlap only with the low ground at the northern edge of this LCT, so the high sensitivities which apply to the more elevated parts of the ridge do not apply here</p> <p>The proportion of Unknown planned enclosure reflects a degree of survival of old agricultural systems. The area has a high sensitivity associated with the underlying resource and with Slingsby Castle.</p> <p>Moderately high ecological sensitivity as a result of the patchwork of high quality limestone grassland (mainly linked to grass banks), mature parkland, woodland trees and species-rich grass road verges</p>	<p>Most of the ASMRP 5 resource within this LCT is sterilised by existing built development, including housing estates, industrial estates and the historic core of Malton.</p> <p>Locally high sensitivity associated with the historically significant medieval core of Malton and its Roman fort.</p> <p>Low ecological sensitivity.</p>	

LCT Subdivisions: (in order of decreasing percentage area)	LCT 23 Levels Farmland	LCT 28 Vale Farmland with Plantation Woodland & Heathland	LCT 25 Settled Vale Farmland	LCT 24 River Floodplain	LCT 6 Magnesian Limestone ridge	LCT 27 Vale Farmland with Dispersed Settlements	LCTs 12, 33, 1, 3, 29, 36, 19 and 13
Percentage of ASMRP within each subdivision:	32.68%	30.83%	14.47%	9.62%	8.01%	2.48%	<1% each
<p>Key Sensitivities, with respect to potential mineral extraction, that may be associated with:</p> <ul style="list-style-type: none"> landscape, the historic environment and the natural environment 	<p>High visual sensitivity due to flat, openness of the landscape allowing long distance views to adjoining areas</p> <p>Hedgerows have been removed to increase field sizes; making remaining hedgerows sensitive to further change</p> <p>The present day land use is predominantly modern and has a low sensitivity.</p> <p>The Heritage Value Score is general low but higher sensitivities are associated with isolated pockets of high scores and include Drax Augustinian Priory and Castle Hill mooted site.</p> <p>Possibility exists of unknown buried archaeology with poor visibility on heavy clay soils</p> <p>Low ecological sensitivity due to most of the landscape being improved farmland.</p>	<p>Whilst most of the landscape is open and flat, patches of woodland are a feature and can provide screening and/or break continuous views to adjoining areas. Visual sensitivity is therefore low</p> <p>The present day land use is predominantly modern and has a low sensitivity.</p> <p>Possibility exists of unknown buried archaeology with poor visibility on heavy clay soils</p> <p>Low ecological sensitivity due to most of the landscape being improved farmland.</p>	<p>Large field sizes and modern farming practices make this area sensitive to further removal of hedgerows</p> <p>Large structures such as power stations, pylons in the low-lying landscape detract from the otherwise rural landscape, thereby reducing the sensitivity to new elements associated with mineral development</p> <p>The present day land use is predominantly modern and has a low sensitivity.</p> <p>Possibility exists of unknown buried archaeology with poor visibility on heavy clay soils</p> <p>Low ecological sensitivity due to most of the landscape being improved farmland.</p>	<p>Open views to adjoining areas are sensitive to disruption by development</p> <p>The present day land use is predominantly modern, but includes the survival of some historic fields which have a higher sensitivity.</p> <p>Generally the Heritage Value Score is moderate, but within this LCT is a small part of the Aldborough Roman town, which has a locally high score and higher sensitivity.</p> <p>Possibility exists of unknown buried archaeology with poor visibility on heavy clay soils</p> <p>Generally low ecological sensitivity due to most of the landscape being improved farmland, but riparian habitats offer significant wildlife corridors and these would be sensitive to any severance.</p>	<p>Views across gently undulating agricultural land are sensitive to the introduction of tall, vertical elements on higher ground (skyline)</p> <p>These are relatively undeveloped areas, characterised by established farm buildings made of local materials; sensitive to the introduction of modern development</p> <p>Scattered mature trees within fields are vulnerable to change</p> <p>The present day land use is predominantly modern, but includes the survival of some historic fields which have a higher sensitivity</p> <p>Possibility exists of unknown buried archaeology with poor visibility on heavy clay soils</p> <p>Low ecological sensitivity due to most of the landscape being improved farmland.</p>	<p>Pockets of historic parkland would be sensitive to the effects of minerals operations</p> <p>The present day land use is predominantly modern, but includes the survival of some historic fields which have a higher sensitivity</p> <p>The Heritage Value Score is low, but higher sensitivities are associated with isolated pockets of high scores, that include South Cowton DMV and Little Smeaton medieval village.</p> <p>Possibility exists of unknown buried archaeology with poor visibility on heavy clay soils</p> <p>Generally low ecological sensitivity overall. Much of this landscape type comprises improved agricultural fields or improved grassland, however there are patches of deciduous woodland and pockets of species rich floodplain meadows which provide key habitats and locally higher sensitivities</p>	

Table 8.9: ASMRP 7 (Cretaceous Chalk Resources): Summary of special environmental sensitivities within LCT subdivisions					
LCT Subdivisions: (in order of decreasing percentage area)	LCT 18 Chalk Wolds	LCT 20 Broad Chalk Valley	LCT 19 Chalk Foothills	LCT 21 Narrow Chalk Valley	LCTs 30, 22 and 17
Percentage of ASMRP within each subdivision:	69.99%	11.88%	11.11%	3.14%	<3% each
<p>Key Sensitivities, with respect to potential mineral extraction, that may be associated with:</p> <ul style="list-style-type: none"> landscape, the historic environment and the natural environment 	<p>The Wolds are currently not within any AONB but the area has special landscape sensitivities due to its distinctive topography and its connectivity to adjacent landscapes</p> <p>The exceptionally tranquil landscape has a sense of remoteness due to its relatively high elevation above the Vale of Pickering, its lack of modern development and scattered shelterbelts of trees. These characteristics represent high sensitivities to the physical effects of mineral operations. The open landscape would also have particular visual sensitivity to the creation of new, large exposures of chalk and to the introduction of new vertical elements associated with mineral workings</p> <p>Further cultural sensitivities associated with the predominantly intact pattern of parkland landscapes, and particular settlement pattern of historic villages in lower valleys with associated management of grazing on higher slopes.</p> <p>Land use is largely modern fields and intensive agriculture; however this ASMRP subdivision has the largest density of scheduled monuments, predominantly prehistoric burial monuments, and for this reason the historic environment sensitivity will generally be high.</p> <p>Locally high ecological sensitivity in some areas, associated with surviving areas of species-rich chalk grassland which are a key habitat.</p> <p>There is also localised geodiversity interest associated with a number of small disused chalk quarries, several of which are designated SSSIs.</p>	<p>High visual connectivity with the Chalk Wolds and Chalk Foothills. As a continuous landscape, this area is sensitive to fragmentation caused by the introduction of man-made, vertical elements</p> <p>The valley sides connecting the foothills to the Wolds serve to enclose views of the valleys</p> <p>Especially tranquil area sensitive to the effects of mineral operations</p> <p>This area also has a large density of scheduled monuments, predominantly settlements of all periods, together with potential archaeological evidence of human activity concealed beneath redeposited top soil. For this reason the historic environment sensitivity will generally be high.</p> <p>Locally high ecological sensitivity in some areas, associated with surviving areas of species-rich chalk grassland which are a key habitat.</p> <p>There is also localised geodiversity interest associated with a number of small disused chalk quarries, several of which are designated SSSIs.</p>	<p>High visual sensitivity as a result of the long views that can be gained from the escarpment and strong intervisibility with the Chalk Wolds, Broad and Narrow Chalk Valleys.</p> <p>High landscape and cultural sensitivity as a result of the striking landscape pattern of the chalk escarpment/foothills and the scattered settlement coupled with pockets of parkland around country houses at Birdsall, Settrington and Place Newton (Scragglethorpe)</p> <p>This area also has a large density of scheduled monuments, including round barrows, settlement sites and the Hunmanby Motte and Bailey, and for this reason the historic environment sensitivity will generally be high.</p> <p>High ecological sensitivity in many areas, associated with swathes of species-rich chalk grassland which are a key habitat.</p> <p>There are also numerous small patches of semi-natural woodland</p>	<p>Forms an integral part of the Chalk Wolds landscape and as such is sensitive to noise, traffic and fragmentation caused by the introduction of development</p> <p>The Heritage Value Score in this area is generally high and the scheduled monuments comprise early cross dykes and round barrows. Sensitivity is therefore generally high</p> <p>High ecological sensitivity in many areas, associated with swathes of species-rich chalk grassland which are a key habitat.</p> <p>There is also localised geodiversity interest associated with a number of small disused chalk quarries, several of which are designated SSSIs.</p>	

Table 8.10: ASMRP 8 (Jurassic Limestone Resources): Summary of special environmental sensitivities within LCT subdivisions

LCT Subdivisions: (in order of decreasing percentage area)	LCT 4 Limestone Foothills and Valleys	LCT 30 Sand and Gravel Vale Fringe	LCTs 1, 22 and 26
Percentage of ASMRP within each subdivision:	77.14%	15.67%	<5% each
<p>Key Sensitivities, with respect to potential mineral extraction, that may be associated with:</p> <ul style="list-style-type: none"> • landscape, • the historic environment and • the natural environment 	<p>The southern part of this resource falls within the Howardian Hills AONB: soft rolling hills with historic parklands which are sensitive to visual effects of mineral operations, particularly on the higher ground.</p> <p>More generally there is high landscape sensitivity due to strong landscape and settlement pattern which could be disturbed by mineral operations</p> <p>The Heritage Value is varied and incorporates very low, to high scores, representing opposite extremes of sensitivity</p> <p>High ecological sensitivity within the numerous linear belts of ancient woodland lining the dale sides, many of which have national or local designations for their ecological interest</p> <p>Intervening areas encompass a patchwork of ecological habitats with varying sensitivity to change</p>	<p>High landscape sensitivity as a result of the striking settlement pattern of villages located along the spring line, and designed landscapes</p> <p>High landscape sensitivity due to strong visual connectivity with adjacent LCT</p> <p>There are no known areas of special historic environment sensitivity in this part of the ASMRP</p> <p>Locally high ecological sensitivity associated with old hedgerows and small agricultural fields with a prevalence of ancient woodland and mature trees.</p>	

LCT Subdivisions: (in order of decreasing percentage area)	LCT 6 Magnesian Limestone Ridge	LCT 27 Vale Farmland with Dispersed Settlements	LCT 13 Moors Fringe	LCT 24 River Floodplain	LCT 23 Levels Farmland	LCT 25 Settled Vale Farmland	LCTs 36, 1, 29, 28 and 31
Percentage of ASMRP within each subdivision:	64.73%	8.35%	8.03%	5.74%	4.37%	3.41%	<3% each
<p>Key Sensitivities, with respect to potential mineral extraction, that may be associated with:</p> <ul style="list-style-type: none"> landscape, the historic environment and the natural environment 	<p>Long distance and open views are a special consideration within this area, and these would be sensitive to the visual impacts of quarry development (although older limestone quarries are a feature of the landscape)</p> <p>Mixed land use in some areas (such as the outskirts of Ripon) has put pressure on the retention of hedgerows and scattered mature trees; remnant features would be sensitive to removal, if necessitated by mineral operations</p> <p>The Heritage value score is varied but includes localised areas of higher sensitivity, notably the Thornborough Henges, where ASMRP 9 resources underlie the superficial sands & gravels currently being exploited. More generally, the highest scoring areas are in the vicinity of Ripon, Bedale and Wetherby.</p> <p>Locally high ecological sensitivity, particularly in areas of nationally important, species-rich limestone grassland, and in several pockets of semi-natural ancient woodland scattered along the ridge. There are also a number of SSSIs relating to various ecological habitats that are sensitive to changes in land management.</p>	<p>Strong presence of scattered trees and hedgerows create a mature, unified landscape pattern. The area would be sensitive to the removal of these features, if necessitated by mineral operations</p> <p>The Heritage Value Scores are generally low, but locally high scores occur near Piercebridge Roman fort, and Manfield settlement and field system, which have relatively large numbers of designated monuments. These areas are likely to have higher historic environment sensitivities.</p> <p>High ecological sensitivity in areas of riparian habitat wildlife corridors, and in ponds that are known to support meta-populations of great crested newts.</p>	<p>High visual sensitivity as a result of strong visual connectivity with adjacent areas</p> <p>Strong historic land use patterns that could be diluted by (and are therefore sensitive to) mineral extraction.</p> <p>The area includes high Heritage Value Scores near to Ripon and includes Fountains Abbey and a substantial number of designated monuments. These areas will have high sensitivity with respect to the historic environment</p>	<p>Open views to adjoining areas of limestone outcrop would be sensitive to disruption and fragmentation caused by indirect impacts of mineral operations in those areas</p> <p>Some of these areas have been subject to previous and/or ongoing sand and gravel extraction and would therefore be sensitive to the cumulative effects of mineral extraction</p> <p>Strong vegetation pattern adjacent to rivers which meander through this landscape is a special feature which would be sensitive to the effects of mineral operations</p> <p>The present land use pattern is predominantly modern and has a low sensitivity</p> <p>These areas include high Heritage Value Scores (and thus higher sensitivities) near to Ripon (including Nunwick Henge), near to Thornborough Henges, and around Knaresborough. They also include the Tanfield DMV, and a Roman villa near Tadcaster.</p> <p>High ecological sensitivity in areas of riparian habitat wildlife corridors, and in ponds that are known to support meta-populations of great crested newts.</p>	<p>High visual sensitivity due to flat, openness of the landscape allowing long distance views to adjoining areas</p> <p>Hedgerows have been removed to increase field sizes; and those which survive are therefore sensitive to further change</p> <p>The mixture of land uses, coupled with poor pasture management fragments the existing field pattern; and the landscape is therefore sensitive to further fragmentation</p> <p>The present land use pattern includes substantial areas of parliamentary enclosure and older relict field systems which may be particularly vulnerable to erosion if not considered as part of HLC analysis</p> <p>The Heritage Value Scores are generally low, but there are a small number of scheduled monuments with higher sensitivity, including the Norton Manor House and associated features.</p> <p>Low ecological sensitivity due to prevalence of improved grassland.</p>	<p>Visually sensitive to new development due to strong sense of openness within much of the farmland areas</p> <p>Hedgerows are often gappy and sensitive to change in farming practices and removal for development</p> <p>No known aspects of special sensitivity with regard to the historic environment</p> <p>Species-rich hedgerows are likely to be of some significance and may therefore be of high sensitivity. Similarly, mature trees are likely to be sensitive if used by roosting bats.</p>	

Table 8.12 ASMRP 10 (Shallow Coal Resources): Summary of special environmental sensitivities within LCT subdivisions

LCT Subdivisions: (in order of decreasing percentage area)	LCT 32 Drumlin Valleys	LCT 6 Magnesian Limestone Ridge	LCT 24 River Floodplain	LCTs 8 and 31
Percentage of ASMRP within each subdivision:	56.73%	39.15%	3.62%	<1% each
<p>Key Sensitivities, with respect to potential mineral extraction, that may be associated with:</p> <ul style="list-style-type: none"> landscape, the historic environment and the natural environment 	<p>The easternmost part of this area, to the south of Clapham, falls within the Forest of Bowland AONB, and thus has heightened landscape sensitivities.</p> <p>More generally, the characteristic 'basket of eggs' (drumlin) topography is a special feature of this area and would be sensitive to disruption by surface mineral extraction</p> <p>Additional sensitivities relate to the presence of other special landscape features, including stone walls and archaeological sites on the drumlins which are vulnerable to disturbance</p> <p>This area has a strong historic land use pattern that could be diluted by surface mineral extraction.</p> <p>The area generally has a low heritage value score, but this reflects a lack of investigation rather than a confirmed absence of heritage.</p> <p>Two areas of higher score (and therefore known higher sensitivity) are centred on Clapham and Burton in Lonsdale, which has a motte and bailey fortification.</p> <p>Locally high ecological sensitivity, associated with pockets of species-rich grassland and remnant mires, developed on the overlying superficial deposits. Some of these are designated as SSSIs for the key habitats that they provide.</p>	<p>The tranquillity in some parts of these areas, afforded on the higher ground away from the A1 (M) where there is little development, is sensitive to change. (Although, more generally, the close proximity of the A1 (M) already negates the tranquillity found in other parts of LCT 6).</p> <p>This area has a strong historic land use pattern, which includes relict parkland, associated with high sensitivity; The historic landscape could be diluted by surface mineral extraction.</p> <p>More generally, the area has a mixture of low and high heritage scores, and therefore both low and high sensitivities, in different areas. Higher sensitivities include the Aberford Dyke System and a Roman road. A significant number of Iron Age / Roman crop mark sites have also been identified from aerial photography.</p> <p>Locally high ecological sensitivity, particularly in areas of nationally important, species-rich limestone grassland, and in areas of semi-natural ancient woodland (both developed on the overlying Magnesian Limestone of ASMRP 9)</p>	<p>Almost all of the ASMRP 10 resources within this area lie beneath the Fairburn and Newton Ings lakes, formed by subsidence associated with former deep coal mining and now protected as an ecological SSSI (see below). The resulting landscape would be highly sensitive to any opencast mining of shallower coal, since this would require the removal of these lakes.</p> <p>As noted above, almost all of this area is occupied by the Fairburn and Newton Ings lakes. The area therefore has some post-industrial heritage significance but only low historic environment sensitivity.</p> <p>High ecological sensitivity associated directly with the SSSI status of the Fairburn and Newton Ings lakes.</p>	

LCT Subdivisions: (in order of decreasing percentage area)	LCT 6 Magnesian Limestone Ridge	LCT 24 River Floodplain
Percentage of ASMRP within each subdivision:	92.42%	7.58%
<p>Key Sensitivities, with respect to potential mineral extraction, that may be associated with:</p> <ul style="list-style-type: none"> • landscape, • the historic environment and • the natural environment 	<p>The tranquillity in some parts of these areas, afforded on the higher ground away from the A1 (M) where there is little development, is sensitive to change. (Although, more generally, the close proximity of the A1 (M) already negates the tranquillity found in other parts of LCT 6).</p> <p>This area has a strong historic land use pattern, which includes relict parkland, associated with high sensitivity; The historic landscape could be diluted by surface mineral extraction.</p> <p>More generally, the area has a mixture of low and high heritage scores, and therefore both low and high sensitivities, in different areas. Higher sensitivities include the Aberford Dyke System and a Roman road. A significant number of Iron Age / Roman crop mark sites have also been identified from aerial photography.</p> <p>Locally high ecological sensitivity, particularly in areas of nationally important, species-rich limestone grassland, and in areas of semi-natural ancient woodland (both developed on the overlying Magnesian Limestone of ASMRP 9)</p>	<p>Part of the ASMRP 11 resources within this area lie beneath the Fairburn and Newton Ings lakes, formed by subsidence associated with former deep coal mining and now protected as an ecological SSSI (see below). The resulting landscape would be highly sensitive to any opencast mining of shallower coal, since this would require the removal of these lakes.</p> <p>As noted above, almost all of this area is occupied by the Fairburn and Newton Ings lakes. The area therefore has some post-industrial heritage significance but only a low historic environment sensitivity</p> <p>High ecological sensitivity associated directly with the SSSI status of the Fairburn and Newton Ings lakes.</p>

LCT Subdivisions: (in order of decreasing percentage area)	LCT 31 Settled Industrial Valleys	LCT 38 Siltstone and Sandstone Low Moors and Fells	LCT 32 Drumlin Valleys	LCT 37 Siltstone and Sandstone High Moors and Fells	LCT 11 Broad Valleys	LCT 14 Rolling Upland Farmland	LTC 35 Gritstone Low Moors and Fells	LTCs 1, 36, 6, 13 and 8
Percentage of ASMRP within each subdivision:	23.78%	20.8%	17.81%	9.25%	8.90%	8.84%	4.68%	<3% each
<p>Key Sensitivities, with respect to potential mineral extraction, that may be associated with:</p> <ul style="list-style-type: none"> landscape, the historic environment and the natural environment 	<p>Strong pattern of industrial buildings and associated infrastructure, such as canals and factories made from local sandstone. Where these occur there is strong historic integrity within industrial-related development and the remnants of industrial revolution era workings are special features in the landscape. These are increasingly compromised by more recent development and are therefore sensitive to any new development (including large scale mineral extraction) which would add to the fragmentation of this landscape.</p> <p>As in LCT 37, there would be much less sensitivity to small scale building stone extraction</p> <p>Strong historic land use pattern, reflecting an upland terrain; the historic landscape could be diluted by mineral extraction.</p> <p>The heritage value score is relatively high in the area of Airedale, and includes a substantial number of designated examples of rock art.</p> <p>Low ecological sensitivity as a result of heavily modified habitats.</p>	<p>High visual sensitivity as a result of the open skylines and extensive panoramic views across surrounding lower landscapes from higher locations and strong intervisibility with adjacent Landscape Character Types.</p> <p>High landscape and cultural sensitivity, resulting from the predominantly intact landscape pattern of moorland summits, small plantations and scattered, isolated stone barns and farmsteads.</p> <p>The area would, however, be less sensitive to small scale extraction of building stone associated with the repair of existing buildings or the construction of new buildings in the local, vernacular style.</p> <p>This is predominantly moorland which has seen little modern improvement, and has a significant relict character with high sensitivity to change. The historic landscape could be diluted by mineral extraction.</p> <p>High ecological sensitivity, particularly in the unimproved moorland areas, as a result of the patchwork of key ecological habitats, including blanket bog, dwarf shrub habitats and semi-natural gill woodlands. Many of these habitats are designated as SSSI, SPA and SAC</p>	<p>Parts of this area falls within the Forest of Bowland AONB and thus has heightened landscape sensitivities</p> <p>High visual sensitivity as a result of the predominantly open character and strong intervisibility with adjacent landscape character types including long distance views to the three peaks of Ingleborough, Whernside and Pen-y-ghent</p> <p>Strong pattern of landscape features, including stone walls, hedgerows and pockets of woodland, coupled with the presence of archaeological sites on the drumlins are special landscape sensitivities</p> <p>Strong historic land use pattern, reflecting an upland terrain; the historic landscape could be diluted by extraction.</p> <p>The LCT has a low heritage value score, but this reflects a lack of investigation rather than an absence of heritage, so sensitivity could be higher.</p> <p>Locally high ecological sensitivity, associated with pockets of species-rich grassland and remnant mires, developed on the overlying superficial deposits. Some of these are designated as SSSIs for the key habitats that they provide.</p>	<p>All of this subdivision falls within the Forest of Bowland AONB and thus has heightened landscape sensitivities</p> <p>High level, relatively undisturbed, tranquil and exposed moorland with expansive views across hilltops. This is a 'remote' and rugged landscape which is highly sensitive to development due to the intact pattern of moorland summits, small plantations and scattered, isolated stone barns and farmsteads.</p> <p>The area would, however, be less sensitive to small scale extraction of building stone associated with the repair of existing buildings or the construction of new buildings in the local, vernacular style.</p> <p>Strong historic land use pattern, reflecting an upland terrain on the edge of the Forest of Bowland; the historic landscape could be diluted by extraction.</p> <p>The LCT has a low heritage value score, but this probably reflects a lack of investigation rather than an absence of heritage, so sensitivity could be higher</p> <p>High ecological sensitivity as a result of the patchwork of key ecological habitats, including blanket bog, dwarf shrub habitats and semi-natural gill woodlands. Many of these habitats are designated as SSSI, SPA and SAC</p>	<p>The Ribble Valley in this area forms a striking flat, open floodplain which is overlooked by adjoining LCTs. The area thus has high visual sensitivity as a result of the predominantly open character and strong intervisibility with adjacent landscape character types</p> <p>The heritage value scores are low in this area, but to a great extent this reflects an absence of investigation, rather than an absence of heritage, so sensitivity could be higher.</p> <p>Recent LiDAR surveys have revealed significant medieval field systems around Rathmell</p> <p>Locally high ecological sensitivity associated with riparian vegetation and wetland areas adjacent to the River Ribble (some of which form part of the Long Preston Deepes SSSI) and the patchwork of interconnected semi-natural ancient woodlands and areas of grassland</p>	<p>All of the ASMRP 12 resources in this area fall within the Forest of Bowland AONB and thus have heightened landscape sensitivities</p> <p>Features, such as drystone walls constructed of local sandstone are a strong visual element of this landscape and help to create a coherent landscape pattern: these are sensitive to change</p> <p>Strong historic land use pattern, reflecting an upland terrain; the historic landscape could be diluted by extraction.</p> <p>Its heritage value scores are low, but to a great extent this reflects an absence of investigation, rather than an absence of heritage, so sensitivity could be higher.</p> <p>No specific features of high ecological sensitivity</p>	<p>High visual sensitivity due to the elevation of this area above the adjoining valleys and visual connectivity with adjacent areas</p> <p>This is predominantly moorland which has seen little modern improvement, and has a significant relict character with high sensitivity to change. The historic landscape could be diluted by extraction.</p> <p>The upland unimproved character has allowed the preservation of monuments and the Heritage Value Score is locally high. These include designated rock art and round and long cairns on Black Hill.</p> <p>High ecological sensitivity as a result of the distinctive patchwork of blanket bogs and heather moorland which provide key habitats for plants and birds and are designated as part of the North Pennine Moors SPA, SSSI and SAC</p>	<p>Most of the small area of LCT 13 in this ASMRP falls within the Forest of Bowland AONB</p>

Table 8.15: ASMRP 13 (Carboniferous and Jurassic Silica Sand Resources): Summary of special environmental sensitivities within LCT subdivisions

LCT Subdivisions: (in order of decreasing percentage area)	LCT 34 Gritstone High Moors and Fells (Blubberhouses outcrop only)	LCT 36 Gritstone Valley (Blubberhouses outcrop only)	LCT 19 Chalk Foothills (Burythorpe outcrop only)	LCT 35 Gritstone Low Moors and Fells (Blubberhouses outcrop only)
Percentage of ASMRP within each subdivision:	37.66%	31.29%	23.06%	7.98%
<p>Key Sensitivities, with respect to potential mineral extraction, that may be associated with:</p> <ul style="list-style-type: none"> landscape, the historic environment and the natural environment 	<p>High visual sensitivity as a result of elevated, open nature of this landscape, which facilitates panoramic views across adjacent landscapes. There is strong intervisibility with surrounding areas</p> <p>High landscape and cultural sensitivity, resulting from the predominantly intact landscape pattern of blocky gritstone outcrops, predominantly rural character and strong sense of remoteness and tranquillity throughout, with associated dark night skies</p> <p>This is predominantly moorland which has seen little modern improvement, and has a significant relict character which represents high sensitivity to change. The historic landscape could be diluted by extraction.</p> <p>The area has a high heritage value score reflecting large numbers of rock art features across the Summerscales area. Although there are no designated monuments within the LCT, the sensitivity is nevertheless high.</p> <p>High ecological sensitivity as a result of the distinctive patchwork of blanket bogs and heather moorland which provide key habitats for plants and birds and are designated as part of the North Pennine Moors SPA, SSSI and SAC</p>	<p>High visual sensitivity as a result of strong intervisibility with adjacent moors and fells</p> <p>High landscape and cultural sensitivity as a result of the pattern of narrow valleys, each with their own strongly recognisable landscape pattern and sense of place, coupled with strong historic integrity, numerous historic features and overall sense of tranquillity within this predominantly rural landscape</p> <p>This is predominantly moorland and has a significant relict character. The historic landscape could be diluted by extraction.</p> <p>The area has a high heritage value score reflecting large numbers of rock art features across the Summerscales area. Although there are no designated monuments within the LCT, the sensitivity is nevertheless high.</p> <p>Moderate ecological sensitivity associated with the patchwork of deciduous woodland which provide key habitats</p>	<p>High visual sensitivity as a result of the long views that can be gained from the escarpment and strong intervisibility with the Chalk Wolds, Broad and Narrow Chalk Valleys</p> <p>High landscape and cultural sensitivity as a result of the striking landscape pattern of the chalk escarpment/foothills and the scattered settlement coupled with pockets of parkland around country houses at Birdsall, Settrington and Place Newton</p> <p>The present land use pattern is predominantly modern and in this respect has a low sensitivity</p> <p>However, the area has a high heritage resource and includes the designated Roman site of Kennythorpe (in Burythorpe Parish), which represents locally heightened sensitivity to change</p> <p>Mount Ferrant - the earthwork remains of a timber Motte and Bailey Castle - is close to this ASMRP, in Burythorpe, and the setting would be visually sensitive to mineral operations</p> <p>High ecological sensitivity as a result of the swathes of species rich chalk grassland which are a key habitat and numerous small patches of semi-natural ancient woodland</p>	<p>High visual sensitivity as a result of elevated, open nature of this landscape, which facilitates panoramic views across adjacent landscapes. There is associated strong intervisibility with surrounding areas</p> <p>High landscape and cultural sensitivity, resulting from the predominantly intact landscape pattern of blocky gritstone outcrops, predominantly rural character and strong sense of remoteness and tranquillity throughout, with associated dark night skies</p> <p>This is moorland, which has seen little modern improvement, and has a significant relict character which represents high sensitivity to change. The historic landscape could be diluted by extraction.</p> <p>The area has a high heritage value score reflecting large numbers of rock art features across the Summerscales area. Although there are no designated monuments within the LCT, the sensitivity is nevertheless high.</p> <p>High ecological sensitivity as a result of the distinctive patchwork of blanket bogs and heather moorland which provide key habitats for plants and birds and are designated as part of the North Pennine Moors SPA, SSSI and SAC</p>

LCT Subdivisions: (in order of decreasing percentage area)	LCT 13 Moors Fringe	LCT 32 Drumlin Valleys	LCT 33 Gritstone High Plateau	LCT 9 Farmed Dale	LCT 31 Settled Industrial Valleys	LCT 27 Vale Farmland with Dispersed Settlements	LCT 14 Rolling Upland Farmland	LCTs 36, 1, 34, 11, 29, 38, 24, 8, & 7
Percentage of ASMRP within each subdivision:	29.98%	20.87%	18.35%	9.43%	5.65%	4.86%	3.84%	<2% each
<p>Key Sensitivities, with respect to potential mineral extraction, that may be associated with:</p> <ul style="list-style-type: none"> landscape, the historic environment and the natural environment 	<p>Strong pattern of hedgerows and drystone walls as field boundaries, which are predominantly intact and which represent a high sensitivity to change.</p> <p>Patchwork of historic designed landscapes, predominantly rural character and relatively strong sense of tranquillity are all further special sensitivities</p> <p>Strong seasonal colour provided by heather moorland is a special feature of this landscape</p> <p>Strong historic land use pattern which could be diluted by mineral extraction.</p> <p>The Heritage Value Score is low to moderate, but includes the Iron Age hill fort of Stanwick Camp, and part of Scots Dyke, which represent areas of higher sensitivity.</p> <p>Locally high ecological sensitivity associated with numerous small woodlands, hedgerows and open moors, which provide key habitats. These have, however, been depleted in many places by agricultural improvement</p>	<p>the characteristic, undulating 'basket of eggs' (drumlin) topography with clumps of trees is a special feature in parts of this area and would be sensitive to disruption by surface mineral extraction</p> <p>Additional sensitivities relate to the strong intervisibility with adjacent areas including long distance views to the three peaks of Ingleborough, Wharfedale and Pen-y-ghent</p> <p>Strong historic land use pattern which could be diluted by mineral extraction.</p> <p>Locally high ecological sensitivity associated with pockets of species-rich grassland and remnant mires, some of which are designated SSSI for the key habitats they provide.</p>	<p>High visual sensitivity as a result of elevated, open nature of this landscape, which facilitates panoramic views across adjacent landscapes.</p> <p>High landscape and cultural sensitivity, resulting from the predominantly intact landscape pattern of blocky gritstone outcrops, predominantly rural character and strong sense of remoteness and tranquillity throughout, with associated dark night skies</p> <p>Strong seasonal colour provided by heather moorland is a special feature of this landscape</p> <p>Strong historic land use pattern, which includes large areas of parliamentary enclosure and could be diluted by extraction.</p> <p>The Heritage Value Score is high, and includes designated rock art and prehistoric round cairns, in the area of Kirkby Hill / Gayles. These features represent high sensitivities, as do the relicts of former lead mining in this area.</p> <p>High ecological sensitivity as a result of the distinctive patchwork of blanket bogs and heather moorland which provide key habitats for plants and birds and are designated as part of the North Pennine Moors SPA, SSSI and SAC</p>	<p>High visual sensitivity as a result of strong intervisibility with adjacent moors and fells, and key views to the three peaks of Ingleborough, Wharfedale and Pen-y-ghent</p> <p>High landscape and cultural sensitivity as a result of the diverse pattern of dales, each with their own strongly recognisable landscape pattern and sense of place, coupled with strong historic integrity, numerous historic features (including drystone walls, field barns, hedgerows and prehistoric monuments) and overall sense of tranquillity within this predominantly rural landscape</p> <p>Strong historic land use pattern which could be diluted by mineral extraction.</p> <p>The Heritage Value Score is moderate to high, including designated round cairns, the Roman fort at Wensley, the Keld Heads lead smelt mill and Middleham castle. All of these represent localised areas of heightened sensitivity to change.</p> <p>High ecological sensitivity as a result of the patchwork of species rich meadows and pastures, mosaics of rush and managed pastures on hill sides and swathes of calcareous grassland on limestone, many of which are of national importance for their landscape and biodiversity value</p>	<p>High visual sensitivity associated with strong intervisibility with adjacent higher landscapes</p> <p>High landscape and cultural sensitivity as a result of the diverse pattern of dales, each with their own strongly recognisable landscape pattern and sense of place, coupled with strong historic integrity, numerous historic features (including drystone walls, field barns, hedgerows and prehistoric monuments) and overall sense of tranquillity within this predominantly rural landscape</p> <p>Strong historic land use pattern which could be diluted by mineral extraction.</p> <p>Low ecological sensitivity overall, resulting from the predominance of urban development and improved agricultural fields</p>	<p>Strong vegetation pattern adjacent to rivers which meander through farmed landscape</p> <p>Scattered trees and hedgerows create a mature, unified landscape pattern. The area is sensitive to the removal of these features.</p> <p>The present land use pattern is predominantly modern and has a low sensitivity</p> <p>The LCT includes some areas of very high Heritage Value scores and therefore higher sensitivities. These include the area centred upon Middleton Tyas, near Scotch Corner, and designated monuments here which include an eighteenth century copper mine and an area of medieval cultivation.</p> <p>Generally low ecological sensitivity overall. Much of this landscape type comprises improved agricultural fields or improved grassland, however there are patches of deciduous woodland and pockets of species rich floodplain meadows which provide key habitats with higher sensitivities</p>	<p>High visual sensitivity as a result of strong intervisibility with adjacent higher and lower landscapes</p> <p>High landscape and cultural sensitivity as a result of the intact network of limestone drystone walls which contribute to coherent pattern; and predominantly rural character, strong sense of remoteness, tranquillity and dark night skies</p> <p>Strong historic land use pattern which could be diluted by mineral extraction.</p> <p>Localised ecological sensitivity associated with trees and pockets of ancient woodland which provide local habitat and wildlife corridors</p>	

Assessment of Capacity for future Mineral Extraction

- 8.1 Environmental capacity is generally regarded as the inverse of sensitivity: the greater the sensitivity of a particular area to a specific type of development then, other things being equal, the lower the capacity of that area will be to accommodate further impacts from such development.
- 8.2 However, capacity is also affected by a number of other factors: the specific nature of the sensitivities compared with the likely impacts of the proposed development; the size of the area compared with the scale of potential impacts; the extent to which the area has already been affected by previous extraction and associated reclamation schemes; and the potential to mitigate the likely effects of future mineral extraction, including cumulative effects within a given area. The potential complexity of interactions between these factors makes it difficult to define capacity with any degree of confidence in any particular case, particularly within the context of a strategic level study such as this. The approach set out in this Chapter is therefore intended to represent a starting point for the consideration of capacity and the discussion herein is, of necessity a broad generalisation. Pre-application discussions with NYCC will always be an important factor in gathering information which will help to determine the capacity of a particular area with much greater precision.
- 8.3 After assessing sample areas within each mineral resource in Stage 2, the potential to generalise these findings over the whole of each mineral resource was assessed in Stage 3. One of the outcomes of this exercise was to define fifteen 'land categories' across North Yorkshire which had similarities in terms of overall topography, predominant environmental characteristics and sensitivities. These categories (as defined in Table 8.1 and illustrated in Figure 8.1) have been used as a basis for the assessment of capacity for further mineral extraction.
- 8.4 Various assumptions were made as part of the capacity assessment, as outlined below. A Land Category covering a large area is more likely to provide greater scope to identify locations of lower sensitivity which may have potential for future mineral working, than one which covers a small area. Likewise, Land Categories, or parts thereof, which have already experienced mineral extraction, will have reduced capacity for further extraction, compared with areas of unworked resources elsewhere. However, in many cases, the extension of existing sites may be preferable to opening up new 'greenfield' sites. The location for future minerals working is a matter which requires detailed, site-specific consideration, and cannot be fully addressed in a broad-scale assessment such as this. **For this and other reasons of site-specific detail, the findings identified below can only be regarded as very general indications.**
- 8.5 Consideration of mitigation is also a factor in determining capacity. Mitigation can allow a proposal which is initially regarded as being potentially harmful to the landscape, natural

environment and/or historic environment to go ahead after the potential impacts have been adequately addressed and collaborative agreement has been reached on reclamation, management, monitoring proposals and wider landscape benefits. This may require the use of Section 106 legal agreements (Planning Obligations) in order to secure the necessary commitments to delivering the required mitigation, if these cannot be achieved through the use of normal planning conditions (see Stage 4 report, Chapter 8, for further details).

- 8.6 In this study, the assessments of capacity, which have resulted in low/medium/high, or a combination of 2 levels being applied to each Land Category, are qualitative judgements based upon our interpretation of the sensitivities and character of the areas involved, and developed from the extensive evidence base created for this project. It is important to note that, as well as being generalised, these judgements are **relative** to the other categories, rather than being absolute. The implication of this is that 'high' capacity does not necessarily equate to a green light for mineral development. Nor does 'low' capacity mean that future mineral extraction cannot be contemplated. In all cases there is an overriding need for site-specific assessment in much more detail than has been possible in this high-level, strategic study.
- 8.7 Some objective information has, however, been used to develop the qualitative judgements: various datasets have been created in order to inform the spatial capacity of each Land Category and to provide details on the extent of each mineral resource and Landscape Character Type (LCT) present within each of the categories (see Tables 8.1, 8.2 and 8.3 in the Stage 3 report). **The assessments are, nevertheless, broad generalisations relating to the whole area of each Land Category and should not be applied to any specific location within a Category.** The results are summarised in Table 8.17, below, which provides an overview of the general capacity assessments.
- 8.8 *It should be noted that the data on the extent of existing and former minerals development used in this assessment is sourced from records held by North Yorkshire County Council as mineral planning authority and reflects the position up to 2008. It indicates the total area covered by applications for minerals extraction and therefore does not necessarily reflect the total extent of areas permitted or actually worked, which will be less.*
- 8.9 The assessment shows that nine of the fifteen Land Categories have Low capacity for extraction as opposed to one Land Category (J) resulting in High Capacity. This has happened because of the different size/extent of each Land Category (Land Category J has the highest distribution across the county compared to other Land Categories: Category F has the second highest distribution but this is approximately 33% lower in terms of hectares coverage than J) but is also due to the environmental sensitivities of the mineral resources which make up Land Category J. There are comparatively less sensitivities in J as the landscape has been substantially changed over the years through settlement and modern day activities.

- 8.10 In Land Categories with Low capacity, such as K, the area of coverage is 50% less than Land Category J (which is still comparatively high when considered in relation to all other Land Categories) but it covers the Yorkshire Wolds and has overall, high environmental sensitivities due to the particular archaeological, historical and landscape characteristics with expansive views across the landscape.
- 8.11 The capacity assessment is a starting point in the process of selecting areas for mineral extraction but due to the generalisation of this assessment, developers should always discuss particular sites with the Planning Authority. Pre-applications discussions with the authority are an important part of the site selection process and will be more reliable in terms of defining capacity of a particular area or proposed site. Further research and detailed investigation, will identify specific areas within each land Category where landscape, ecology, archaeology or geology are more significant than others.

Land Category	Capacity Assessment rating	Comment re considerations for specific sites
A	Medium	Particular issues: green infrastructure - riparian habitats, deep buried archaeology
B	Low	Industrial archaeology and high amenity value of the Nidderdale AONB
C	Medium	Settled nature of valleys and existing land use limits mineral development options
D	Low	High ecological value and history of human activity. Cumulative impact of further minerals development
E	Medium to High	Identified areas of high value but likely mineral opportunities within large area of mineral resource currently unexploited
F	Medium	Mature landscape, evidence of long history of human activity will limit opportunities
G	Low to Medium	Tranquil historic landscape and ecological value. Good crop mark visibility
H	Low	Significant known archaeological resource, potential for extraction linked to management of the archaeological landscape
I	Low	Urban/suburban fringes of towns.
J	High	Opportunities for landscape restoration, but low archaeological site visibility means may conceal potential sites
K	Low	Open landscape and high archaeological sensitivity across this category
L	Low	High ecological and landscape sensitivity
M	Low	High archaeological and ecological value within this limestone landscape
N	Low	Open and remote moorland – an archaeological landscape of great antiquity with high ecological value
O	Low	High landscape value

Table 8.17 Summary showing relative general capacity of each Category for mineral extraction

9. Recommendations for Planning

Introduction & Key Principles

9.1 This chapter briefly covers the main recommendations arising from this 12-month study. It forms an abridged version of Chapters 3 to 11 of the Stage 4 report which, provide the contextual explanations and justifications for the recommendations set out below.

9.2 Through the work carried out in Stages 1 to 3 of this project, including the detailed appreciation that has been gained of the complex inter-relationships between all aspects of the landscape, the natural environment and the historic environment, the varying degree and nature of the environmental sensitivities involved, and the wide range of potential impacts and corresponding mitigation and monitoring techniques which may need to be applied, a number of key principles have been identified as being important components of a successful strategy for managing landscape change. These comprise:

- **Integrated Understanding** (the development of a comprehensive awareness of the wider landscape surrounding the site of a development proposal or in the general area of potential future site allocations, including the historic environment and natural environment components, and their interactions over time. At the detailed level of specific proposals this can be expressed in the form of a conceptual '***predictive landscape model***'³ which is then used to focus pre-application research to inform the location and design of the proposal);
- **Spatial Planning** (the need to integrate the spatial requirements for current and future minerals development with those of other relevant factors, including the distribution of mineral resources, the occurrence and significance of environmental and other planning constraints (including existing and planned development); the geographical distribution of likely future demand; and alternative sources of supply. These are issues which need to be considered in the formulation of policies, strategies and plans, but also in relation to the consideration of alternatives for individual proposals);
- **Long-term Vision** (this is in relation to the development proposal, the landscape and environment involved and to the successive involvement of relevant personnel. This includes the need to consider mineral development as part of a continuum of landscape change, not only within the timescale of an individual Development Plan or planning application, but over a much longer period of time, in order to recognise and fit in with

³***Predictive landscape modelling*** involves building up an understanding of the evolution of a particular part of the landscape over time, so that associations between landscape, landform, ecology, historical land use and climate change can be adequately reflected in the design of any new proposals for development. In both cases the essence is to develop a sound and comprehensive understanding of the processes, interactions and features involved, so that any impacts on these processes and features can properly be anticipated, assessed and mitigated as an integral part of the proposal.

other environmental, climatic and land use changes that are likely to occur. To include the concept of '*dynamic baseline monitoring*⁴);

- **Environmental Impact Assessment** (a normal requirement of most minerals planning applications, this should form an integral part of the design process, informed by a sound, integrated understanding of the environment and of the ecosystem services provided by the various components of the landscape - both now and on completion of quarrying and reclamation).
- **Imaginative Design and the Creation of Environmental Benefits** (designing to ensure that adverse impacts are avoided or mitigated, that the proposal fits in with and (where possible) enhances the surrounding landscape, and that opportunities for creating environmental benefits during final reclamation are optimised through the imaginative design of the excavation itself. This process can benefit from the use of an *ecosystems approach*⁵ and the balanced consideration of individual *ecosystem services*);
- **Monitoring** (planned strategies to ensure that progress and potential impacts are adequately and efficiently monitored, and that monitoring results are properly assessed so that, where necessary, they can trigger mitigation measures or changes in implementation, aftercare and management, and also the design of further extraction);
- **Mitigation Measures** (designed on the basis of a good, integrated understanding of the wider landscape (see above) and using demonstrably effective mitigation methods. Where uncertainty exists, staged or tiered mitigation strategies, linked to ongoing monitoring which provides early warning of impending impacts, allow the *precautionary principle*⁶ to be used); and
- **Compensatory Measures** (used where there is an over-riding need for mineral extraction and where certain impacts cannot be avoided and adequate mitigation cannot be achieved).

⁴ The concept of *dynamic baseline monitoring*, in which the long-term impacts of mineral development are monitored against the observed, changing background of other, ongoing and independent aspects of environmental change, rather than just in relation to pre-operational baseline data, has been proposed within guidance relating to the control of impacts of surface mineral workings on the water environment (Thompson *et al.*, 2007, 2008). In principle, it also has much wider applicability to other aspects of the natural environment and land use change, and allows for sensible adaptation of long-term reclamation plans.

⁵ See paragraphs **Error! Reference source not found.** *et seq.* for an explanation of the *Ecosystems Approach* and *Ecosystem Services*.

⁶ The *Precautionary Principle* is a basis for adopting a cautious approach to regulating development which may otherwise cause damage to the natural environment. The concept was first defined as Principle 15 of the Rio Declaration, 1992, which states: “Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation”. This can be reflected in a number of different approaches. Planning permissions may be subject to incremental stages (e.g. one bench at a time for deep hard rock quarries), whereby each stage is subject to the satisfactory performance of mitigation measures in the previous stage and to the review of operational monitoring data. Alternatively, or in addition, where the likelihood of the risk is low but cannot be ruled out, this could be reflected in a staged mitigation strategy which requires certain measures to become mandatory in the event that the assessed likelihood of serious impact is increased through the results of routine operational monitoring. In such cases, the relevant thresholds or trigger levels need to be agreed prior to the grant of planning permission or other development consent and need to provide an adequate early warning of any serious or irreversible risk. The details will usually need to be reflected in legally binding Section 106 planning obligations.

9.3 These suggestions have arisen in part from this study and in part from existing good practice within North Yorkshire and elsewhere. They are compatible with the overarching principles of sustainable development, as set out within the National Planning Policy Framework.

Benefits of Adopting these Key Principles

9.4 There are numerous benefits to be gained by following the key principles outlined above and by adopting pro-active, front-loaded requirements for information to enable more informed decision making based on understanding and valuing landscape as a whole. This helps both mineral operators and the planning authority to manage landscape change in a positive way. The potential benefits to operators include:

- Opportunity to identify potential problems and resolve issues prior to submission of a planning application;
- Identification at an early stage what and where specialist advice is necessary (e.g. landscape, ecology or archaeology);
- Early consultation and archaeological evaluation can minimise the risk of non-designated heritage assets coming to light later on;
- The local planning authority will give advice that can help the applicant prepare a better planning application, so that it may be processed more quickly; and
- Greater confidence in planning the long-term development of available reserves in the less sensitive parts of a given resource outcrop. .

Overview of Recommendations

9.5 Detailed recommendations are set out in the following sections with respect to each stage of quarry development, as summarised below:

- **Spatial Planning** (noting the importance of this in focusing plans, strategies and individual proposals for future mineral development on areas which contain suitable mineral resources but which also avoid the more sensitive landscapes and environmental features, as far as possible);
- **Pre-Application Information Requirements** (highlighting the importance of developing a good, holistic understanding of the wider landscape and environment surrounding the proposed application site through a sequential and iterative⁷ process of investigation.

⁷ Throughout this document there are references to the need for an '*iterative*' process of gathering and utilising information. This is considered to be a vital aspect of the process of managing landscape change. In the broadest sense it refers to the need to understand what has gone before, and to reflect this understanding in what happens next. More specifically, it applies to the gathering of information, both during the pre-application stage and throughout the lifetime of the operational and post-operational stages. Such information will sometimes necessitate changes to previously-conceived ideas, whether this be the design of further information gathering, the location and design of the proposed excavation, or the design and implementation of the reclamation and long-term management phases.

This includes an indicative series of key **Environmental Research Questions** which should assist applicants in fulfilling these requirements);

- **Pre-Application Research and Baseline Monitoring** (noting the methods likely to be required in obtaining the necessary pre-application information, supported by more detailed guidance within Appendix 1 of the Stage 4 report);
- **Environmental Impact Assessment** (noting the need for this to be an integral and iterative part of the design process, and therefore carried out in parallel with the stages outlined below, making use of the comprehensive information and integrated understanding built-up throughout the pre-application stage);
- **Quarry Design** (noting the generic aspects of design philosophy which should help to achieve more sustainable mineral extraction, to enhance the potential for creating environmental benefits, and to optimise the overall benefits in terms of ecosystem services. This includes recommendations relating to the development of a **Long-term Vision** - focusing on the benefits to all parties of long-term planning - both for minerals and for the landscape itself, including adaptation to more general environmental and climate change);
- **Design of Operational Monitoring, Mitigation and Compensation Strategies** (detailed guidance, highlighting the importance of these being designed in advance and used as effectively as possible to monitor and control impacts throughout the operational and post-operational stages of mineral development);
- **The Operational Phase of mineral extraction and processing** (highlighting the need for design concepts and strategies to be implemented, or adapted where necessary, with the continued advice of relevant specialists, and with ongoing dialogue with North Yorkshire County Council, including the monitoring, enforcement and periodic review of agreed planning conditions and obligations)
- **The Reclamation and Long-term Management Phases of mineral development** (again, highlighting the importance of implementing or adapting the agreed design concepts with the continued advice of relevant specialists and ongoing dialogue with the planning authority)

9.6 Each of the following sections focuses on the key, generic recommendations which apply to all areas and all types of mineral extraction. Additional or more specific recommendations relating to specific minerals and/or geographical areas are provided in the Stage 4 report, along with more detailed information to explain the justification for the recommendations.

Recommendations for Spatial Planning

- 9.7 NYCC should develop a spatial strategy for future minerals development within the County. This should take account of the availability and distribution of mineral resources (informed by the latest available information from the British Geological Survey); environmental sensitivities and capacity (informed in part by Stage 3 of this project); wider sustainability issues relating to mineral transportation; and the prospects for mineral extraction and reclamation to contribute to other initiatives for maintaining and enhancing the existing landscape and natural/historic environment.
- 9.8 Mineral operators should be expected to develop their proposals in the light of a more detailed analysis of potential alternative sites within their area(s) of interest, demonstrating in each case how their preferred location has been selected in such a way as to avoid potential impacts to features of particular sensitivity within that general area.

Recommendations for Pre-Application Information Requirements

- 9.9 In all cases, the information required from prospective applicants should demonstrate a good, holistic understanding of all aspects of the landscape and environment within and surrounding their proposed application site. This should include an appreciation of how the various elements of the landscape, historic environment and natural environment relate to each other, and how these have interacted to create the present-day landscape since pre-historic times. This will provide a basis for understanding and for the evaluation of distinctiveness, significance, sensitivity and capacity. It could also lead to more informed and appropriate mitigation strategies. It could also provide a context for understanding both future interactions and opportunities for environmental enhancement.
- 9.10 This information should cover a wide area, defined in each case through pre-application discussions, to take account of local environmental characteristics and sensitivities. It should demonstrate how the proposed site was selected, based on a rigorous analysis of the need for extraction, the availability and distribution of commercially exploitable resources, and the sensitivity and significance of all landscape and environmental assets within that area. It should show how the proposal can play a positive role within this wider natural and historic landscape, with a minimum of adverse consequences.
- 9.11 The information should cover all aspects of the proposal, so that it is able to inform each stage of development from initial preparatory works through to mineral extraction, reclamation and long-term management.
- 9.12 The information should be based on a clear sequential and iterative procedure, beginning with a desk-based assessment of the wider area and progressively focusing down to more detailed

assessments and investigations which are sufficient to address the issues identified for the site in question, including the identification of effective mitigation strategies.

- 9.13 In order to identify the relevant issues pertaining to a particular site, a number of key environmental research questions need to be asked as part of the iterative process. The suggestions outlined below should enable prospective applicants to gather information that will help them to prepare a suitably informed development proposal. It is recommended that all questions are at least considered even though some of them may be less relevant than others for a particular location.

Key Environmental Research Questions

- 9.14 A series of primary research questions are set out below, each with a number of secondary questions that should help to address the main issue. Primary questions 1 to 3 form the first part of an iterative sequence leading to the identification of a preferred location within a wider potential resource area. The subsequent questions should then enable more detailed information to be gathered in the areas of greatest relevance to the proposal, as the application develops. In most cases, those additional questions will lead to a refinement of the proposal before it is submitted, and in some cases may lead to a changed location.
- 9.15 **It must be emphasised that the questions are not intended to be a definitive checklist or to impose unnecessary burdens, but are suggested as a guide to achieving optimum environmental benefits. They should be drawn upon as relevant to any specific development proposal.**
- 9.16 Primary Question 1: what is the wider context for the proposed development site? (NB. Pre-application discussions will clarify the extent of the area to be included within this preliminary phase of research. The following subsidiary questions are intended to be indicative rather than exhaustive).
- Does any part of this area fall within or close to nationally or internationally-designated sites or to heritage assets of national significance, whether designated or not?
 - Is the area covered by any relevant previous or ongoing studies or surveys (e.g. on landscape character, biodiversity, geodiversity, water environment, archaeology or other aspects of the historic environment?)
 - What planning policies, relevant to the proposed development, are applicable to the area?
 - What other strategies, initiatives or masterplans are applicable to the area (e.g. biodiversity opportunity areas, 'green' or 'blue' infrastructure corridors; Biodiversity Action Plans (BAPs), Geodiversity Action Plans (GAPs)?)
 - What defines the existing landscape character within this wider area at national and local level, and how has this evolved over the centuries?

- What important features of the natural environment exist within this area (including habitats, species and wildlife corridors, features of geodiversity interest and all aspects of the water environment such as lakes, ponds, surface watercourses, floodplains, wetlands, aquifers and water resources)?
- What is the significance of the heritage assets within this area, including known heritage assets (designated and non-designated) and archaeological potential?
- What is the broad relationship between the geology, topography, hydrology, hydrogeology, natural vegetation, land use and present day landscape character of the area?
- How sensitive is the area to physical change (in terms of intrinsic vulnerability, irrespective of the precise nature of any proposed development) and what is the nature of the main sensitivities involved (including landscape, historic environment and natural environment)?
- To what extent are these sensitivities likely to be able to be addressed by careful location of the proposal within this wider area, or by appropriate mitigation, and what are the implications of this for the area being able to accommodate change?

9.17 Primary Question 2: Are there important local interests to be considered?

- How is the area currently used?
- How is the area valued by local people and how important is it to them (e.g. in terms of landscape character or quality, cultural interest, nature conservation or as a recreational resource)?
- Are there any local designations, such as Sites of Importance for Nature Conservation, Local Geological Sites, locally listed buildings or conservation areas or Areas of Great Landscape Value within the area?
- Would the local community like to be involved in the development of the proposal and/or in future management of the site following reclamation?

9.18 Primary Question 3: Has other development taken place in this wider area in the past or is any such development being planned?

- If so, what is the potential for generating further cumulative effects on habitats, heritage assets, landscape character or visual impact?
- What is the scope for such effects to be avoided or mitigated through the production of a contextual landscape plan, area action plan or other long-term masterplan to enhance the area?
- Is there potential for generating positive effects through extension of habitat restorations or restoration to agricultural land for example?

- Taking account of this, what are the implications in terms of capacity for further minerals development?

9.19 **Primary Question 4: Taking account of the information gained from Questions 1 to 3, and after discussion with the MPA and other specialist consultees, what would seem to be the preferred location for the proposed mineral development within the wider area?**

9.20 The following questions, intended to inform the more detailed evidence base relating to the proposal, are applicable to the operator's preferred location and to the area surrounding this which might be affected by one or more potential impacts. This 'zone of potential influence' is likely to be different for each type of impact, and will be informed by the preliminary investigations outlined above.

9.21 **Primary Question 5: What would be the basic form of the proposed development**, including the intended size and shape of the void, the method of excavation, whether or not dewatering would be required, and the intended reclamation plan? *(NB these and other more detailed aspects of the design will need to be revisited as an iterative process, as the following questions are addressed, so as to minimise impacts, incorporate mitigation and optimise the potential for environmental enhancement. In some cases, this iterative process might lead to a change of preferred location).*

9.22 **Primary Question 6: What aspects of the water environment could be affected by the proposal?**

- What is the likely zone of influence of the proposal on all aspects of the water environment?
- What sensitive features of the water environment are present within this area (including watercourses, lakes, ponds, floodplains, wetlands, aquifers and water resources), and what is the nature of their sensitivity?
- What are the baseline conditions of each of these receptors, including the typical range of seasonal variations and any evident longer-term trends?
- What potential impacts might the proposed development have on each of these receptors?
- How can each of these impacts be avoided or mitigated?

9.23 **Primary Question 7: What habitats, vegetation communities and species are present within the area, how are they inter-connected, and how could they be affected by the proposal?**

- What is the ecological zone of influence of the proposal, including foraging areas for BAP and other protected species, and including water-dependent ecosystems which could be affected by impacts on the water environment

- What ecological surveys are required? (See appendix A for further details of statutory and other requirements following this preliminary scoping stage).
- What are the baseline conditions for each of these habitats and species, including the typical range of seasonal variations and any evident longer-term trends?
- What potential impacts might the proposed development have on each of these receptors?
- How can each of these impacts be avoided or mitigated?
- How can the proposed development ultimately enhance these and/or other sustainable priority habitats through reclamation, including re-establishing connections between previously fragmented habitats and wildlife corridors?

9.24 **Primary Question 8: What topographic and geodiversity features are present within the area, and how could they be affected by the proposal?**

- What are the characteristic landforms within the area and how do these relate to the wider landscape character?
- What active geomorphological processes are operating within the area?
- What geological exposures are present within the area and what is their significance?
- What potential adverse impacts might the proposed development have on each of these features?
- How can each of these impacts be avoided or mitigated?
- How can the proposed development enhance or add to the geodiversity interest of the area, including links with wider landscape and biodiversity features?

9.25 **Primary Question 9: what is the Historic Landscape Character of the proposed development site and its wider landscape setting?**

- What is its historic landscape character and is it sensitive to changes as a result of development?
- How has the historic landscape character changed over the centuries and are there opportunities for restoration or enhancement?

9.26 **Primary Question 10: Does the site sit within, adjacent to, or within the landscape setting of a designed landscape or registered Park and Garden?**

- How will the development impact on the site and its setting?
- Does the development affect the significance of the designed landscape?
- Can the landscape be protected through screening or other mitigation?

- Is there scope for restoration or enhancement?

9.27 **Primary Question 11: Is there a designated heritage asset or the setting of a heritage asset (such as a listed building or other structure) that could be affected by the development?**

- What is the significance of the asset and its setting?
- Will impacts be temporary or long-term?
- Is there a possibility of mitigation, including the wider landscape setting?
- Is there scope for restoration or enhancement of the setting?

9.28 **Primary question 12: How sensitive is the archaeological resource at the site or environs?**

- Are there waterlogged deposits within the development site or environs that could be affected by impacts on the water environment (particularly, but not only the effects of dewatering)?
- To what extent have the archaeological remains at the site and environs been impacted by earlier disturbance, such as ploughing or dewatering?
- To what extent could the identified heritage resource be affected by the proposed development, and can these impacts be mitigated by an adjustment of the proposed excavation or reclamation design or by recording?
- How will the proposed development affect the visual setting of the archaeological landscape, and any designated monuments within the wider landscape?
- What would be the cumulative effect of the proposal upon the wider archaeological landscape?

9.29 **Primary question 13: What archaeological remains will be directly or indirectly impacted by the mineral extraction?**

- What is the documented archaeological resource within the proposed development area and within the wider environs?
- How visible are archaeological remains within the environs of the proposed development and how is site visibility affected by the local soils and underlying geology. To what extent is the documented resource likely to correspond with the actual resource?
- How does the anthropogenic activity within the development relate to the wider man-made landscape, and how does the identified resource relate to the surrounding topography and geology? In particular, are there early archaeological deposits preserved beneath layers of fluvial sediment.
- How was the landscape formed over time and to what extent is the present day landscape a product of anthropogenic activity. What was the historic landscape at the time that the

principal archaeological activity established?

- What is the actual archaeological resource within the proposed development area and within the wider environs?
- What is the condition of the archaeological remains?
- How might the above questions be answered? What is the appropriate archaeological evaluation strategy to use in the particular location? Would the production of a landscape model be a useful tool to aid understanding?

9.30 Primary question 14: What is the significance of the archaeological remains?

- How rare and significant are the identified remains within the development site and wider environs?
- How significant is that part of the archaeological landscape within the development footprint, by comparison with that of the wider landscape?
- Does the landscape at the site and wider environs reflect a palimpsest of different episodes of activity, and does the significance of the site reflect this long-term development of the landscape?

Recommendations for Baseline Research and Monitoring

9.31 **In order to compile the detailed information needed to support the iterative development of a planning application for mineral extraction in North Yorkshire, based on an integrated understanding of the environment and landscape within and surrounding their proposed development, prospective applicants will need to undertake or commission a range of specialist research and baseline monitoring. The precise requirements will vary from one location to another but will be informed by the findings of initial desk-based assessments, including reference to the key environmental characteristics and special sensitivities identified in the Stage 3 report.**

9.32 **The research needs to be carried out, in accordance with professional standards and guidance, by competent professional specialists who are able to judge what is required in order to deliver suitably robust and credible evidence at each iterative stage of developing the application and the accompanying Environmental Statement.**

Variations relating to specific minerals and/or geographical areas

9.33 As indicated above, the detailed research and baseline monitoring requirements for any particular site or area will need to reflect the landscape and environmental characteristics of the locality involved. The information provided in the Stage 3 report offers a starting point for

identifying the key issues which are likely to be of particular relevance in certain parts of each resource outcrop, and which may therefore need special attention, but it must be emphasised that those characteristics and sensitivities are neither limiting nor exclusive. In each case the research topics of particular significance will emerge from the initial desk-based assessments and from the development of a conceptual model which reflects the natural and historic environment and landscape character of the area involved. Further guidance on particular issues that are likely to require attention within each of the 'Land Category' areas is provided in the Stage 4 report.

Recommendations for Environmental Impact Assessment

- 9.34 In most cases, proposals for mineral extraction are likely to be subject to Environmental Impact Assessment (EIA) and, where this is the case, the information must be sufficient to support a comprehensive Environmental Statement.
- 9.35 The EIA should be based on a detailed, holistic understanding of the existing environment within and around the application site, prepared by competent experts through an integrated, multi-disciplinary approach, and supported by a strong evidence base.
- 9.36 The basic scope and applicability of the EIA process will apply equally across all areas. However, the particular sensitivities identified in Tables 7.2 to 7.15 of the Stage 3 report, together with the general capacity indicators shown in Table 8.4 of that report, will help to refine the EIA scope in particular areas and to identify the likely areas in which detailed assessments will be required.
- 9.37 It is therefore recommended that NYCC should make use of the Stage 3 report to inform their screening and scoping opinions and to guide their requirements for pre-application information.

Recommendations for Quarry and Reclamation Design

- 9.38 The scheme design submitted with any planning application for mineral extraction should cover all aspects of the proposal, from preparatory works such as soil stripping and initial landscaping through to mineral extraction, restoration, aftercare, after-use and long-term management.
- 9.39 The design should be informed by a good, integrated understanding of the existing landscape, natural environment and historic environment surrounding the site and of the linkages between them, including an understanding of how the landscape has changed over time and how it is likely to change within the lifetime of the proposed development. This provides the

context for the development of the extraction proposal and a long term vision for the reclamation of the site.

- 9.40 Designs should incorporate preliminary reclamation plans, incorporating both restoration and aftercare proposals. These should be prepared in parallel with the excavation design as an integral part of the proposed scheme, and should be sufficiently detailed to demonstrate how benefits will be created, but should allow for some flexibility to accommodate changes in design that may be needed during the lifetime of the scheme, not least to allow for adaptation to climate change. Such changes would be subject to agreement during Periodic Reviews of any planning permission obtained.
- 9.41 Reclamation designs should aim to fit in with, and (as far as possible) enhance the natural environment, historic environment and the wider landscape in which the proposed extraction is intended to take place. The design, including that of the excavation itself, should seek to optimise the delivery of ecosystem services, balancing the economic benefits of mineral extraction with the wider benefits associated with other services. These may include benefits associated with the intended after-use of the site and those associated with off-site benefits (as may be achieved, for example by re-connecting previously fragmented habitats in adjoining areas). Consideration should also be given to cumulative effects where there would be two or more active or restored quarries in close proximity, seeking to minimise the adverse impacts and optimise the environmental benefits through complementary design.
- 9.42 It is crucial that, at the design stage, clear objectives are set out, long-term visions are developed and delivery and long-term management mechanisms are clearly established, in discussion with the Mineral Planning Authority.
- 9.43 The proposal should also show how the development would fit into a longer-term strategy for mineral extraction in the surrounding area, whether this is the operator's own internal strategy or one developed by (or in conjunction with) NYCC. This should include an indicative assessment of potential or likely cumulative effects.
- 9.44 NYCC, in turn, should consider developing integrated long-term strategies for minerals development within particular areas where there are likely to be high levels of ongoing demand and/or high levels of environmental sensitivity.

Variations relating to specific minerals and/or geographical areas

- 9.45 Quarry and reclamation design will always be a site-specific matter, to which the foregoing generic principles and recommendations can be applied. However, there are also specific additional observations which can be made relating to individual types of minerals, types of landscape and types of natural and historic environment settings. Further guidance on this is provided in the Stage 4 report.

Recommendations for Monitoring, Mitigation and Compensation Strategies

- 9.46 Throughout the operational stage of mineral development, and continuing into and beyond the final reclamation stage, there will be a need for detailed monitoring of potential impacts and of the effectiveness (or otherwise) of the planned mitigation works. Strategies for both monitoring and mitigation, as well as any compensation works that may be necessary to justify planning permission being granted, need to be developed at the pre-application stage, as an integral part of the design and EIA processes relating to the planning application.
- 9.47 Monitoring results may need to be linked in to the implementation of particular mitigation requirements, through the use of thresholds or trigger levels. Further details and corresponding recommendations are set out in each of the following sections.

Design of Operational Monitoring Strategies

- 9.48 A scheme of monitoring needs to be put forward by the applicant at the time of submitting a planning application. It is important that the scheme is specific to the site in question and that standard conditions are avoided.
- 9.49 In general, the following basic principles should be followed:
- The objectives of the monitoring plan should be defined before the start of mineral operations;
 - The design should be based on the best conceptual understanding at that time;
 - Allowance should be made for the plan to change (e.g. reduction in monitoring points or frequency) as understanding is improved with new information over time;
 - The design (monitoring point location, data parameters and frequency of collection) should be risk based (i.e. targeted, fit-for-purpose monitoring rather than precautionary blanket monitoring);
 - The function of each monitoring point and type of data collected should be clearly defined;
 - Quality control measures should be incorporated into the monitoring plan, together with regular calibration of all monitoring instrumentation (e.g. automated data loggers, *in-situ* water quality monitoring equipment); and
 - Monitoring data should be reviewed, interpreted and reported on by a competent person, on a regular basis (e.g. monthly or quarterly, as appropriate) to identify any trends or breaches in trigger levels.

- 9.50 NYCC should encourage and facilitate the sharing and coordinated use of monitoring data, including records of the success or otherwise of mitigation and reclamation schemes, so as to enhance future development proposals and decision-making.
- 9.51 An overview of minerals consents over the past 30 years should include an examination of the original reclamation plan and the outcome, including current condition. This will then inform future minerals-related landscape restoration projects and assist in the process of managing landscape change.

Design of Mitigation Strategies

- 9.52 Mitigation should be considered as an integral part of the design processes, so that its effectiveness can be optimised, and it should be informed by (and feed back into) the EIA process.
- 9.53 Landscape-scale mitigation strategies may be needed where significant effects would otherwise be likely to extend over wide areas and/or where there are likely to be significant cumulative effects from incremental expansion or from two or more sites in close proximity.
- 9.54 Where development is justified, unavoidable impacts may be agreed subject to mitigation measures which ensure that a site or place is fully understood and recorded and the information enhances public knowledge.
- 9.55 Mitigation measures involving the development of replacement or enhanced habitats, or the translocation of species must recognise the length of time needed for these to become properly established. This needs to be balanced against the significance of the habitats which would be lost through the proposed extraction.
- 9.56 Measures relating to the natural environment may need to respond to changing conditions and circumstances as the excavation is developed. In view of the uncertainties involved, the mitigation strategy should reflect the precautionary principle by incorporating staged or tiered mitigation measures linked to operational and post-operational monitoring by suitable thresholds (trigger levels) which provide an adequate early warning of the need for action. These should allow for the cessation of operations in exceptional cases if unexpected and unacceptable impacts are found to occur.
- 9.57 The effectiveness of the mitigation strategy should be demonstrated within the proposal, by reference to previous successful examples and, if accepted by the planning authority, will need to be enshrined within planning conditions or obligations.
- 9.58 It should be recognised that adequate mitigation may not always be possible and that, where this is the case, planning permission may be refused.

Design of Compensation Strategies

- 9.59 Where there is an over-riding need for mineral extraction but where the planning authority has concerns about certain impacts which cannot be avoided, and where adequate mitigation cannot be achieved, opportunities for appropriate compensation should be discussed with the operator, in order to justify planning permission being granted.

Variations relating to specific minerals and/or geographical areas

- 9.60 Detailed variations on the foregoing generic requirements for monitoring, mitigation and compensation will be specific to each individual site, taking account of the local sensitivities within the area concerned. There are, however, some broad generalisations which can be made regarding variations in emphasis on appropriate types of monitoring or mitigation in each of the Land Categories, in recognition of the differences in their predominant characteristics. Further details are provided in the Stage 4 report.

Recommendations for the Operational Stage of Mineral Development

- 9.61 Whether or not all aspects of the agreed design are reflected in planning conditions and obligations it is important that they are all implemented with the same attention to detail as was used in creating the design. This requires the ongoing involvement of competent specialists who share responsibility with the operator for the implementation of critical design features, including monitoring and mitigation strategies.
- 9.62 Preparatory landscape operations which will benefit the long-term landscape design objectives should be carried out at the earliest phase of site possession. These should be informed by a holistic understanding of the landscape and environment.
- 9.63 Measures relating to the historic environment may be outside the immediate footprint of extraction but should be planned to protect the significance and fabric of heritage assets that might otherwise be damaged by operational works and traffic movements.
- 9.64 Measures relating to the natural environment may need to respond to changing conditions and circumstances as the excavation is developed. In view of the uncertainties involved, the mitigation strategy should reflect the precautionary principle by incorporating staged or tiered mitigation measures linked to operational and post-operational monitoring by suitable thresholds (trigger levels) which provide an adequate early warning of the need for action. To allow for a worst case scenario, these should allow for the cessation of operations if exceptional and unacceptable impacts are found to occur.

- 9.65 Regular liaison meetings should be organised between the site operator and specialists within NYCC to ensure that good working relationships continue throughout the operational stage and that monitoring results are jointly reviewed on a frequent basis.

Variations relating to specific minerals and/or geographical areas

- 9.66 At this stage of development, it must be assumed that planning permission has been obtained and that detailed variations to the generic requirements outlined above will have been set out in site-specific planning conditions and legal agreements (obligations). Variations appropriate to specific minerals and geographical locations / land categories, will have been addressed at the design stage (see above).

Recommendations for Reclamation and Long-term Management

- 9.67 Reclamation Plans should allow for flexibility to accommodate changes in design that may be needed during the lifetime of the scheme, not least to allow for adaptation to climate change. Such changes would be subject to agreement during Periodic Reviews of any planning permission obtained, or at other times where justified.
- 9.68 Improvements in knowledge during the lifetime of the scheme, including information obtained from routine operational monitoring and from archaeological and geodiversity discoveries should be taken into account to refine the final reclamation design.
- 9.69 Reclamation designs should integrate with and (as far as possible) enhance the natural environment, historic environment and wider landscape and should be informed by an understanding of the development of the landscape over time. The design, including that of the quarry excavation itself, should seek to optimise the delivery of ecosystem services, balancing the economic benefits of mineral extraction with the wider benefits associated with other services. These may include benefits associated with the intended after-use of the site and those associated with off-site benefits (as may be achieved, for example by re-connecting previously fragmented habitats in adjoining areas).
- 9.70 Cumulative effects associated with quarry reclamation and long-term management should be considered at the outset of the application process, with a view to minimising adverse impacts and optimising potential benefits. Where such effects (whether positive or negative) are likely to be significant over wide areas, a landscape-scale, area-based approach to the design and management of mitigation and enhancement is likely to be required, rather than one which focuses on an individual site.
- 9.71 Insofar as possible, reclamation works should take place in parallel with ongoing excavation (for example through 'rolling' restoration of a shallow excavation or through the early

landscaping and treatment of the upper, completed faces and benches in a deep excavation), so that the associated benefits can be realised at the earliest opportunity.

- 9.72 Where reclamation schemes are intended to create or restore habitats for nature conservation, or to create land for public access and recreation, these must be demonstrably achievable (e.g. supported by clear evidence and by a firm commitment by the operator to provide the specialist expertise and long-term management required). Such schemes should also aim to be as sustainable as possible (by virtue of being well designed and adapted to the site conditions) but provision should also be made for effective and appropriate long-term management, to ensure that the benefits are fully delivered and maintained.
- 9.73 Where heritage assets are restored or reinstated as part of the reclamation of an operational site, the works should form part of a maintenance plan which sets out how the significance of the heritage asset will be preserved and maintained in its setting.
- 9.74 Mineral operators are encouraged, where appropriate, to develop relationships with conservation and/or voluntary organisations in order to secure long-term management and monitoring of restored sites.

Variations relating to specific minerals and/or geographical areas

- 9.75 At this stage of development, it must be assumed that planning permission has been obtained and that detailed variations to the generic requirements outlined above will have been set out in site-specific planning conditions and legal agreements (obligations). Variations appropriate to specific minerals and geographical locations / land categories, will have been addressed at the design stage (see above).

10. Conclusions

- 10.1 North Yorkshire has a considerable wealth of mineral resources, the exploitation of which can help to support economic growth. It also has a very rich diversity of high quality landscapes; significant heritage assets relating to millennia of human occupation; fragmentary remains of very diverse and formerly more extensive natural and semi-natural habitats; and considerable opportunities for enhancement in all of these areas. It is therefore of paramount importance that the ongoing need for mineral extraction is properly balanced against the need for environmental protection and that all opportunities for enhancement associated with the reclamation of mineral sites are harnessed to optimum effect. In this context, and throughout the report, the term 'environmental' is used to refer to both the natural and the historic environment.
- 10.2 With this in mind, the Managing Landscape Change research project has sought to develop a multi-disciplinary environmental evidence base and to provide a broad assessment of landscape and environmental sensitivities and capacity in North Yorkshire, with a view to informing a spatial planning strategy for the future extraction of minerals.
- 10.3 The evidence gathered in this project is primarily of a strategic nature, but this has been complemented by more detailed assessments of small but broadly representative sample areas in each of the main types of mineral resource within the county. Together with desk-based research into the origins and evolution of the physical and cultural landscape over many thousands of years, this has enabled a broad understanding to be gained of the key environmental and landscape characteristics associated with each type of mineral resource.
- 10.4 The work has brought together evidence relating to landscape, the historic environment and the natural environment and has demonstrated how all of these are inextricably linked together. This, in particular, has strongly influenced the identification of key principles relating to the way in which a more sustainable approach to future mineral extraction might be developed, and the over-arching need for an integrated, multi-disciplinary approach, rather than dealing with individual issues in isolation. It has also highlighted the importance of adopting a long-term vision which allows the design of mineral extraction sites and their eventual reclamation to be integrated as fully as possible with existing landscape character and environmental assets, allowing for the likely influence of future climatic and environmental change.
- 10.5 All of this can help to optimise the generation of long-term benefits associated with the reclamation of mineral sites (incorporating cultural, aesthetic and economic benefits as well as those associated with the natural environment). This is a vital component of minerals planning, but of greater importance still is the need for the avoidance and/or adequate mitigation of impacts associated with mineral extraction itself. Whilst many impacts can be

minimised through the adoption of best practice mitigation and monitoring techniques, it should not be assumed that this will always be possible. For this reason, seeking to avoid adverse impacts through well-informed spatial planning is of paramount importance.

- 10.6 As a starting point, this project has attempted to provide a broad, strategic assessment of sensitivities relating to the historic and natural environments and to the wider landscape, and the resulting capacity for further mineral extraction. Whilst this provides some degree of guidance, focusing on the 'special sensitivities' of different areas as indicated by known aspects of their landscape character and environmental features, it also recognises that most sensitivities will require site-specific detail in order to be properly assessed. This is reflected in recommendations for detailed pre-application research by mineral operators, for areas surrounding their proposed extraction sites, so that conflicts with highly sensitive features can be avoided.
- 10.7 The broad sensitivity assessments carried out within this study have been applied to subdivisions of each Area of Surface Mineral Resource Potential (ASMRP), divided on the basis of Landscape Character Type. They have also been applied to groupings of areas (referred to here as Land Categories) which have similar, predominant, topographic and environmental characteristics, and to which common planning approaches might be developed. These categories, which sometimes incorporate two or more different mineral types within a particular topographic or environmental setting, have been used as the basis for the broad assessment of capacity.
- 10.8 Environmental capacity is generally regarded as the inverse of sensitivity: the greater the sensitivity of a particular area to a specific type of development then, other things being equal, the lower the capacity of that area will be to accommodate further impacts from such development. However, capacity is also affected by a number of other factors: the specific nature of the sensitivities compared with the likely impacts of the proposed development; the size of the area compared with the scale of potential impacts; the extent to which the area has already been affected by previous extraction and associated reclamation schemes; and the potential to mitigate the likely effects of future mineral extraction, including cumulative effects within a given area. The potential complexity of interactions between these factors makes it difficult to define capacity with any degree of confidence within a strategic level study such as this. The approach used here is therefore intended to represent only a starting point for the more detailed consideration of capacity by individual applicants within their particular areas of interest.
- 10.9 Thus, whilst these qualitative judgements provide a very broad indication of areas which may be more capable than others of accommodating future mineral extraction, they are not definitive and should be used only as a general guide. It is also important to emphasise that the judgements are *relative* to the other categories, rather than being absolute. Moreover, a high, medium or low rating for any given category does not imply that all areas within that

category are assessed at that level of capacity: there will always be significant variations from one location to another. High capacity overall does not mean there would be no sensitivities to address, either within the category as a whole or at any individual site. Equally, low capacity does not mean that there are no prospects for future extraction.

- 10.10 As indicated above, the appreciation that has been gained of the complex inter-relationships between all aspects of the landscape, the natural environment and the historic environment, and of the varying degree and nature of the environmental sensitivities involved, has enabled a number of key principles to be identified as important components of a successful strategy for managing landscape change. Whilst these key principles are largely strategic, the recommendations which flow from them have, in many cases, been able to incorporate variations between different mineral resource areas and landscape types, based on the more detailed, area-specific information obtained throughout the study.
- 10.11 The recommendations relate to each stage of the development of a minerals operation from pre-application considerations through formal application and on to the operational stage of quarrying, implementation of reclamation schemes and the long-term management of a site post extraction.
- 10.12 Emphasis throughout the recommendations is placed on the integration of knowledge relating to all different aspects of the landscape and the environment. This is needed in order to build understanding and to engender high quality, imaginative designs and mitigation measures which enable potential adverse impacts to be avoided or adequately controlled, and which allow for optimum enhancement of existing features. In this way, future mineral extraction will be able to contribute as fully as possible to the delivery of ecosystem services and to the goal of sustainable development.
- 10.13 The recommendations are deliberately front-loaded, in line with the requirements of the planning system itself. Particular emphasis is therefore placed on the importance of pre-application research and investigation to ensure that development proposals are brought forward in the most suitable locations, and to facilitate the creation of sympathetic designs which are compatible with the surrounding landscape and environment.

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Project Archive

A digital Archive of the project has been created by ADS (Archaeology Data Service), part of the University of York and can be referenced by accessing the following link <http://dx.doi.org/10.5284/1012712>

The Archive contains the following files:

Folder	Filename	File type	Projection	Description	Source	Attribute Tables – codes used
Contract reference: NYCC/BES/18376 English Heritage project reference 5590 MAIN Managing Landscape Change – A multi- disciplinary approach to future mineral extraction in North Yorkshire	Stage 1 Technical Report (with appendices) – Rev 4 28-10-12	pdf				
	Stage 2 Technical Report on Sample Areas FINAL 19-04-12	pdf				
	Stage 2 Technical Report on Sample Areas - Appendices Only 03-02-12	pdf				
	Stage 2 Technical Report on Predictive Landscape Modelling 02-02-12	pdf				
	Stage 3 Technical Report Rev 11 18-04-12	pdf				
	Stage 4 Recommendations for Planning 17- 04-12	pdf				
	Stage 5 Final Report 19-04-12	pdf				
	Stage 5 Appendix One 19-04-12	pdf				
Phase1_Habitat	CSL_Phase1Habitat_Point_01.shp	Point	British National Grid	Phase 1 habitat information for 12 ASMRP sample sites (point)	Heads up digitising from site survey notes, snapped to OS Mastermap	Id Cat_1 Cat_2 Cat_3 Label ASMRP
Phase1_Habitat	CSL_Phase1Habitat_Polygon_01.shp	Polygon	British National Grid	Phase 1 habitat information for 12 ASMRP sample sites (Polygon)	Heads up digitising from site survey notes, snapped to OS Mastermap	Id Cat_1 Cat_2 Cat_3 Label ASMRP

Folder	Filename	File type	Projection	Description	Source	Attribute Tables – codes used
Phase1_Habitat	CSL_Phase1Habitat_Polyline_01.shp	Polyline	British National Grid	Phase 1 habitat information for 12 ASMRP sample sites (Polyline)	Heads up digitising from site survey notes, snapped to OS Mastermap	Id Cat_1 Cat_2 Cat_3 Label ASMRP
Landform_Element Landform_Element	CSL_LandformElement_Point_01.shp	Point	British National Grid	Geomorphology and topography features for the 12 ASMRP sample sites (point)	Heads up digitising from site survey notes, snapped to OS Mastermap	Id Cat_1 Cat_2 Label ASMRP Rotation
Landform_Element	CSL_LandformElement_Polygon_01.shp	Polygon	British National Grid	Geomorphology and topography features for the 12 ASMRP sample sites (polygon)	Heads up digitising from site survey notes, snapped to OS Mastermap	Id Cat_1 Cat_2 ASMRP
Landform_Element	CSL_LandformElement_Polyline_01.shp	Polyline	British National Grid	Geomorphology and topography features for the 12 ASMRP sample sites (polyline)	Heads up digitising from site survey notes, snapped to OS Mastermap	Id Cat_1 Cat_2 ASMRP
Landform_Element	CSL_LandformElement_Text_01.shp	Text	British National Grid	Geomorphology and topography features for the 12 ASMRP sample sites (anno)	Heads up digitising from site survey notes, snapped to OS Mastermap	Id Text Size
LandscapeCharacter	CSL_LandscapeCharacter_Point_01.shp	Point	British National Grid	Landscape Character assessment data for the 12 ASMRP sample sites (point)	Heads up digitising from site survey notes, snapped to OS Mastermap	Id Category Type VPNo Rotation ASMRP Label
LandscapeCharacter	CSL_LandscapeCharacter_Polygon_01.shp	Polygon	British National Grid	Landscape Character assessment data for the 12 ASMRP sample sites (polygon)	Heads up digitising from site survey notes, snapped to OS Mastermap	Id Category Type ASMRP
LandscapeCharacter	CSL_LandscapeCharacter_Polyline_01.shp	Polyline	British National Grid	Landscape Character assessment data for the 12 ASMRP sample sites (polyline)	Heads up digitising from site survey notes, snapped to OS Mastermap	Id Category Type ASMRP Code

Folder	Filename	File type	Projection	Description	Source	Attribute Tables – codes used
CrossSections	Cross_Sections_01.shp	Polyline	British National Grid	Created for Topographical modelling task (Stage 2) Used to extract information from DTM model	Heads up digitising	Id CS_Ref Length
CrossSections	Buffer_of_Cross_Sections_01.shp	Polygon	British National Grid	Created for Topographical modelling task (Stage 2) Used to define area which OS Profile data would be extracted and hence DTM built for.	Application of buffer function	FiD BufferDist
CrossSections	CrossSections_A_01.shp	Point	British National Grid	Created for Topographical modelling task (Stage 2). Spot heights (Z values) provided at 10m intervals along cross section and intersections with ASMRPs and sample areas detailed.	Cross sections applied to Ordnance Survey Profile	Id M Z Easting Northing CS Ref Notes ASMRPAreas
CrossSections	CrossSections_B_01.shp	Point	British National Grid	Created for Topographical modelling task (Stage 2). Spot heights (Z values) provided at 10m intervals along cross section and intersections with ASMRPs and sample areas detailed.	Cross sections applied to Ordnance Survey Profile	Id M Z Easting Northing CS Ref Notes ASMRPAreas
CrossSections	CrossSections_C_01.shp	Point	British National Grid	Created for Topographical modelling task (Stage 2). Spot heights (Z values) provided at 10m intervals along cross section and intersections with ASMRPs and sample areas detailed.	Cross sections applied to Ordnance Survey Profile	Id M Z Easting Northing CS Ref Notes ASMRPAreas
CrossSections	CrossSections_D_01.shp	Point	British National Grid	Created for Topographical modelling task (Stage 2). Spot heights (Z values) provided at 10m intervals along cross section and intersections with ASMRPs and sample areas	Cross sections applied to Ordnance Survey Profile	Id M Z Easting Northing CS Ref

Folder	Filename	File type	Projection	Description	Source	Attribute Tables – codes used
				detailed.		Notes ASMRPAreas
CrossSections	CrossSections_E_01shp	Point	British National Grid	Created for Topographical modelling task (Stage 2). Spot heights (Z values) provided at 10m intervals along cross section and intersections with ASMRPs and sample areas detailed.	Cross sections applied to Ordnance Survey Profile	Id M Z Easting Northing CS Ref Notes ASMRPAreas
CrossSections	CrossSections_F_01.shp	Point	British National Grid	Created for Topographical modelling task (Stage 2). Spot heights (Z values) provided at 10m intervals along cross section and intersections with ASMRPs and sample areas detailed.	Cross sections applied to Ordnance Survey Profile	Id M Z Easting Northing CS Ref Notes ASMRPAreas
CrossSections	CrossSections_G_01.shp	Point	British National Grid	Created for Topographical modelling task (Stage 2). Spot heights (Z values) provided at 10m intervals along cross section and intersections with ASMRPs and sample areas detailed.	Cross sections applied to Ordnance Survey Profile	Id M Z Easting Northing CS Ref Notes ASMRPAreas
CrossSections	CrossSections_H_01.shp	Point	British National Grid	Created for Topographical modelling task (Stage 2). Spot heights (Z values) provided at 10m intervals along cross section and intersections with ASMRPs and sample areas detailed.	Cross sections applied to Ordnance Survey Profile	Id M Z Easting Northing CS Ref Notes ASMRPAreas
CrossSections	CrossSections_I_01.shp	Point	British National Grid	Created for Topographical modelling task (Stage 2). Spot heights (Z values) provided at 10m intervals along cross section and intersections with ASMRPs and sample areas	Cross sections applied to Ordnance Survey Profile	Id M Z Easting Northing CS Ref

Folder	Filename	File type	Projection	Description	Source	Attribute Tables – codes used
				detailed.		Notes ASMRPAreas
CrossSections	CrossSections_J_01.shp	Point	British National Grid	Created for Topographical modelling task (Stage 2). Spot heights (Z values) provided at 10m intervals along cross section and intersections with ASMRPs and sample areas detailed.	Cross sections applied to Ordnance Survey Profile	Id M Z Easting Northing CS Ref Notes ASMRPAreas
CrossSections	CrossSections_K_01.shp	Point	British National Grid	Created for Topographical modelling task (Stage 2). Spot heights (Z values) provided at 10m intervals along cross section and intersections with ASMRPs and sample areas detailed.	Cross sections applied to Ordnance Survey Profile	Id M Z Easting Northing CS Ref Notes ASMRPAreas
HLC_Extract	HLC_extraction_region34.shp	Polygon	British National Grid	Historic Landscape Character Polygons with AHIEP Scoring analyses, complete dataset for whole of study area	Various scoring analyses applied - To confirm with OAN	FID Shape HLCUID BRQADTYPE1 BRAODTYPE2 HLCTYPEC HLCTYPED FULLTYPE NAME PERIOD ATTRIBUTE1 ATTRIBUTE2 ATTRIBUTE3 ATTRIBUTE4 ATTRIBUTE5 ATTRIBUTE6 ATTRIBUTE7 ATTRIBUTE8 ATTRIBUTE9 ATTRIBUTE10 ATTRIBUTE11 ATTRIBUTE12 ATTRIBUTE13

Folder	Filename	File type	Projection	Description	Source	Attribute Tables – codes used
						ATTRIBUTE14 ATTRIBUTE15 ATTRIBUTE16 BROADTYPE HLCTYPE SUMMARY CONFIDENC EXGCREATED EXEDITED Mine_in_hi MUN_RES MIN_ABBR MINE_PERCE BATTLEFIEL WHSITES PANDG HERROM MERMENE HERBAIA HEREMED HERMPM HERMOD HERUNKN SAMTOTAL HERTOTAL AREA_SQ_M Area_SQ_KM DEBATTLEF DEWHSITES DEPANDG DEHERROM DEMERMEN DEHERBAI DEHERME DEHERMED DEHERMPM DEHERMOD DEHERUNK DESAMTOT MINEXTR SCBATTLEFI

Folder	Filename	File type	Projection	Description	Source	Attribute Tables – codes used
						SCWHSITES SCPANGD SCHERROM SCHERMENE SCHHERBAIA SCHHEREMED SCHERMED SCHEREMED SCHERNPM SCHERMOD SCHERUNKN SCSSAMTOT SCORE_TOT HER_Densit
Topo_Modelling	NY_TIN_02	TIN	British National Grid	Triangulated Irregular Network for North Yorkshire Area (excluding National Parks). Clipped to study area boundary.	Create TIN from vector feature. Clip to study extent	n/a
Topo_Modelling	NY_DEM_02	DEM	British National Grid	Digital Elevation Model for North Yorkshire Area (excluding National Parks). Clipped to study area boundary. 20m resolution.	Conversion of NY_TIN_02 to raster dataset	n/a
Topo_Modelling	nycc_profile_03	DEM	British National Grid	Digital Elevation Model created for topographical modelling task (stage 2). Coverage falls within 5km of cross sections. 10m resolution.	Create TIN from vector feature. Convert TIN to Raster	
Topo_Modelling	Contour_ClipSA_01.shp	Contours	British National Grid	5m contour data clipped to the study extent boundary	Clip vector feature	-
MineralResource	YorksHum_BClay_Clip.shp	Polygon	British National Grid	Boulder Clay clipped to NYCC	BGS Mineral Resource Layer	MIN_RES MIN_ABBREV
MineralResource	YorksHum_Chalk_Clip.shp	Polygon	British National Grid	Boulder Clay clipped to NYCC	BGS Mineral Resource Layer	MIN_RES MIN_ABBREV
MineralResource	YorksHum_Chalk_Clip.shp	Polygon	British National Grid	Chalk clipped to NYCC	BGS Mineral Resource Layer	MIN_RES MIN_ABBREV
MineralResource	YorksHum_Coal_shallow_Clip.shp	Polygon	British National Grid	Coal clipped to NYCC	BGS Mineral Resource Layer	MIN_RES MIN_ABBREV
MineralResource	YorksHum_Lmst_Clip.shp	Polygon	British National Grid	Limestone clipped to NYCC	BGS Mineral Resource Layer	MIN_RES

Folder	Filename	File type	Projection	Description	Source	Attribute Tables – codes used
						MIN_ABBREV
MineralResource	YorksHum_Sandst_Clip.shp	Polygon	British National Grid	Limestone clipped to NYCC	BGS Mineral Resource Layer	MIN_RES MIN_ABBREV
MineralResource	YorksHum_SG_Clip.shp	Polygon	British National Grid	Sand Gravel clipped to NYCC	BGS Mineral Resource Layer	MIN_RES MIN_ABBREV
MineralResource	YorksHum_Silica_Clip.shp	Polygon	British National Grid	Silica clipped to NYCC	BGS Mineral Resource Layer	MIN_RES MIN_ABBREV
ASMRP	ASMRP_SG_SubAlluvial.shp	Polygon	British National Grid	Sub-alluvial (indicated and inferred) sand and gravel mineral resources. Produced as part of task 1i.	Exported from Sand and Gravel layer based upon 'MIN_RES' field properties	MIN_RES MIN_ABBREV Area
ASMRP	ASMRP_SG_RiverTerrace.shp	Polygon	British National Grid	River terrace and concealed river terrace sand and gravel mineral resources. Produced as part of task 1i.	Exported from Sand and Gravel layer based upon 'MIN_RES' field properties	MIN_RES MIN_ABBREV Area
ASMRP	ASMRP_SG_Glacial.shp	Polygon	British National Grid	Glacial and concealed glacial sand and gravel mineral resources. Produced as part of task 1i.	Exported from Sand and Gravel layer based upon 'MIN_RES' field properties	MIN_RES MIN_ABBREV Area
ASMRP	ASMRP_SG_Glaciofluvial.shp	Polygon	British National Grid	Glacio-fluvial and concealed glacio-fluvial sand and gravel mineral resources. Produced as part of task 1i.	Exported from Sand and Gravel layer based upon 'MIN_RES' field properties	MIN_RES MIN_ABBREV Area
ASMRP	ASMRP_SG_Undifferentiated.shp	Polygon	British National Grid	Undifferentiated sand and gravel mineral resources. Produced as part of task 1i.	Exported from Sand and Gravel layer based upon 'MIN_RES' field properties	MIN_RES MIN_ABBREV Area
ASMRP	ASMRP_Bclay_QuaternaryGL.shp	Polygon	British National Grid	Brick Clay: Quaternary, glacio-lacustrine deposits resources. Produced as part of task 1i.	Exported from Brick Clay layer based upon 'MIN_RES' field properties	MIN_RES MIN_ABBREV Area
ASMRP	ASMRP_Chalk_ExConcealed.shp	Polygon	British National Grid	Chalk resources (retaining the subdivision into higher purity and lower purity, but excluding the concealed resources) Produced as part of	Exported from Chalk layer based upon 'MIN_RES' field properties	MIN_RES MIN_ABBREV Area

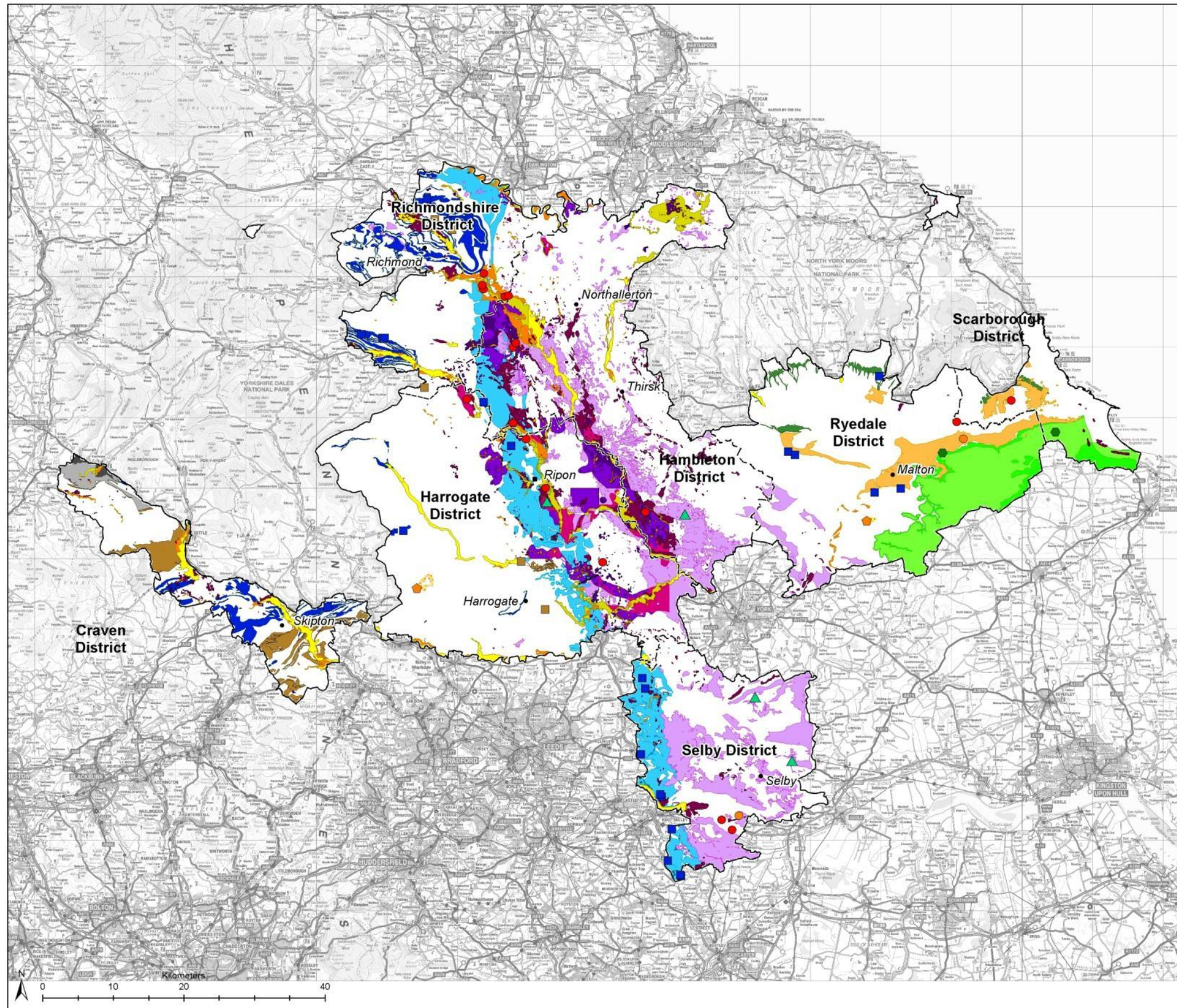
Folder	Filename	File type	Projection	Description	Source	Attribute Tables – codes used
				task 1i.		
ASMRP	ASMRP_Lmst_Jurassic.shp	Polygon	British National Grid	Jurassic Limestone resources. Produced as part of task 1i.	Exported from Limestone layer based upon 'MIN_RES' field properties	MIN_RES MIN_ABBREV Area
ASMRP	ASMRP_Lmst_Permian.shp	Polygon	British National Grid	Permian Limestone resources. Produced as part of task 1i.	Exported from Limestone layer based upon 'MIN_RES' field properties	MIN_RES MIN_ABBREV Area
ASMRP	ASMRP_Coal_Shallow_ExTertiary.shp	Polygon	British National Grid	Shallow Coal resources (retaining the subdivisions shown in the BGS data, but excluding the 'tertiary' opencast resources) Produced as part of task 1i.	Exported from Shallow Col layer based upon 'MIN_RES' field properties	RESOURCE ZONE SURFACE DESCRIP MIN_RES MIN_ABBREV Area
ASMRP	ASMRP_Bclay_Carboniferous.shp	Polygon	British National Grid	Brick Clay: Carboniferous Coal Measure mudstone mineral resources. Produced as part of task 1i.	Exported from Brick Clay layer based upon 'MIN_RES' field properties	MIN_RES MIN_ABBREV Area
ASMRP	ASMRP_Silica.shp	Polygon	British National Grid	Silica Sand resources (retaining the subdivision into Carboniferous and Jurassic deposits). Produced as part of task 1i.	Exported from Silica layer based upon 'MIN_RES' field properties	MIN_RES MIN_ABBREV Area
ASMRP	ASMRP_Sandst.shp	Polygon	British National Grid	Sandstone mineral resources. Produced as part of task 1i.	Exported from parent layer based upon 'MIN_RES' field properties	MIN_RES MIN_ABBREV Area
ASMRP	ASMRP_Lmst_Carboniferous.shp	Polygon	British National Grid	Carboniferous Limestone resources (retaining the subdivision into higher purity and lower purity). Produced as	Exported from Limestone layer based upon 'MIN_RES' field properties	MIN_RES MIN_ABBREV Area

Folder	Filename	File type	Projection	Description	Source	Attribute Tables – codes used
				part of task 1i.		
ASMRP	ASMRP_1_to_14_All_MLC_layers_02.shp	Polygon	British National Grid	Merging of individual layers for York Humbs, data as above(E9 to E22)	Merging of individual layers for York Humbs, data as above	MIN_RES MIN_ABBREV Area
ASMRP_Intersect_LCT_HLC_04.shp	ASMRP01_Intersect_LCT_HLC_01_Dissolved_by_Category_04.shp	Polygon	British National Grid	ASMRP layer intersected with Land scape Character Types (LCT) and Historic Landscape Character Types, then dissolved by character type	ASMRP, LCT and HLC data	Cat2 Area Hectares

Appendix One

Contains figures showing the location of all Areas of Surface Mineral Resource Potential (ASMRP's) together with a plan showing each ASMRP and distribution of Land Categories together with a plan showing each Category.

These plans form part of the Stage 1 and Stage 3 reports which can be accessed via the project archive (referenced above).



Key

- ASMRP 1: Sand and Gravel - Sub-alluvial deposits**
 - Sub-alluvial: indicated resources (only in areas assessed by BGS)
 - Sub-alluvial: inferred resources
- ASMRP 2: Sand and Gravel - River Terrace Deposits**
 - River terrace deposits
- ASMRP 3: Sand and Gravel - Glaciofluvial**
 - Glaciofluvial deposits
 - Glaciofluvial deposits: concealed (only in areas assessed by BGS)
- ASMRP 4: Sand and Gravel - Glacial deposits**
 - Glacial deposits
 - Glacial deposits: concealed (only in areas assessed by BGS)
- ASMRP 5: Sand and Gravel - Undifferentiated**
 - Undifferentiated sand and gravel
- ASMRP 6: Brick Clay - Quaternary**
 - Brick clay: Quaternary, glaciolacustrine deposits (clay and silt)
- ASMRP 7: Chalk - excluding concealed**
 - Higher purity chalk (>97% CaCO₃)
 - Lower purity chalk (93-97% CaCO₃)
- ASMRP 8: Limestone - Jurassic**
 - Limestone: Jurassic, Lincolnshire Limestone / Malton Oolite
- ASMRP 9: Limestone - Permian**
 - Dolomite and dolomitic limestone: Permian, Cadeby and Brotherton formations (Magnesian Limestone)
- ASMRP 10: Coal (shallow) - excluding tertiary**
 - Secondary opencast coal resource area
 - Buried coal resource overlain by up to 50m overburden
- ASMRP 11: Brick Clay - Carboniferous**
 - Brick clay: Carboniferous, Coal Measures mudstones (coincident with shallow coal)
- ASMRP 12: Sandstone**
 - Sandstone: Carboniferous, Millstone Grit and Coal Measures
- ASMRP 13: Silica**
 - Silica sand: Carboniferous, Millstone Grit (Blubberhouses only)
 - Silica sand: Jurassic, Osgoby Formation (Burythorpe area only)
- ASMRP 14: Limestone - Carboniferous**
 - Limestone: Carboniferous
 - Limestone: Carboniferous, high purity (>97% CaCO₃)

● Chalk Quarries ● Silica Quarries
▲ Clay Quarries ● Sand & Gravel Quarries
■ Limestone Quarries ● Sand Quarries
■ Sandstone Quarries

Client



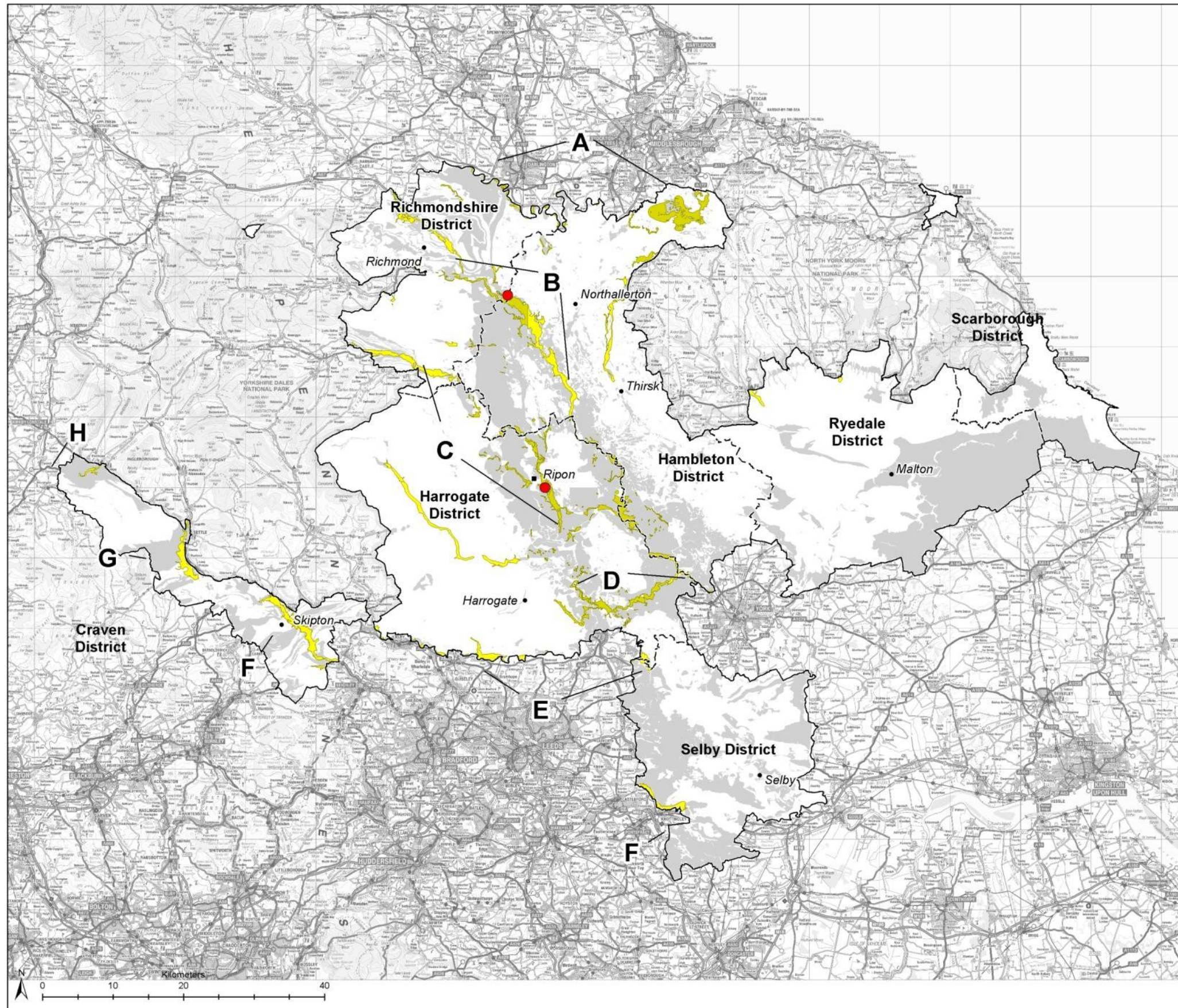
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**AREAS OF SURFACE MINERAL
 RESOURCE POTENTIAL**

Drawn By	KJ
Checked By	AT
Approved By	JG
Drawing No	CS049966_Figure1.0_All_ASMRP
Date	19 April 2012

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Key

- ASMRP 1 - Active Pits
- ASMRP 1: Sand and Gravel - Sub-alluvial deposits**
- Sub-alluvial: indicated resources (only in areas assessed by BGS)
- Sub-alluvial: inferred resources
- Study Area

Client



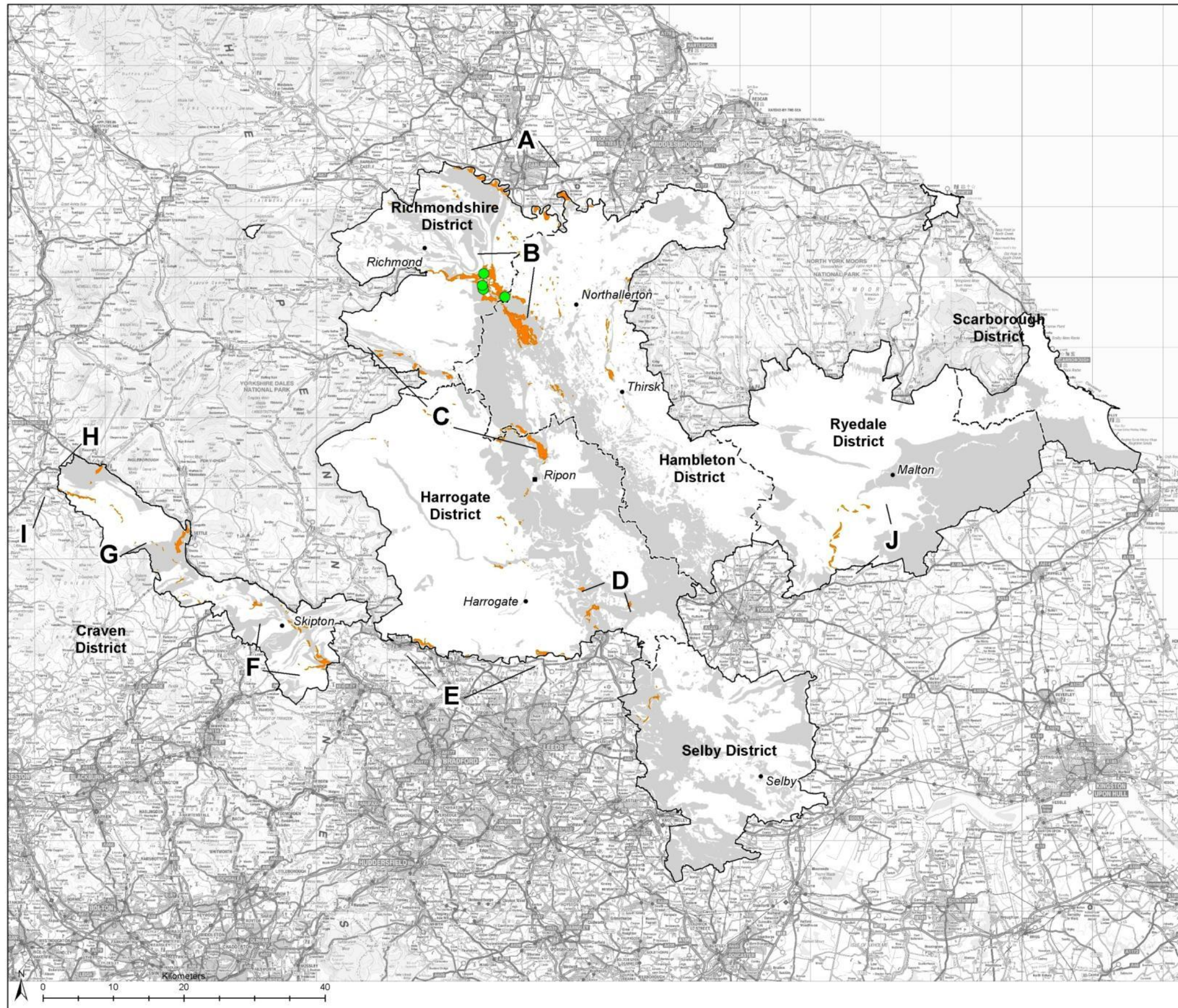
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**ASMRP 1: SAND AND GRAVEL
 - SUB-ALLUVIAL DEPOSITS**

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Drawing No	CS049966_Figure1.1_ASMRP1
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Key

- ASMRP 2 - Active Pits
- ASMRP 2: Sand and Gravel - River Terrace Deposits
- River terrace deposits
- Study Area

Client

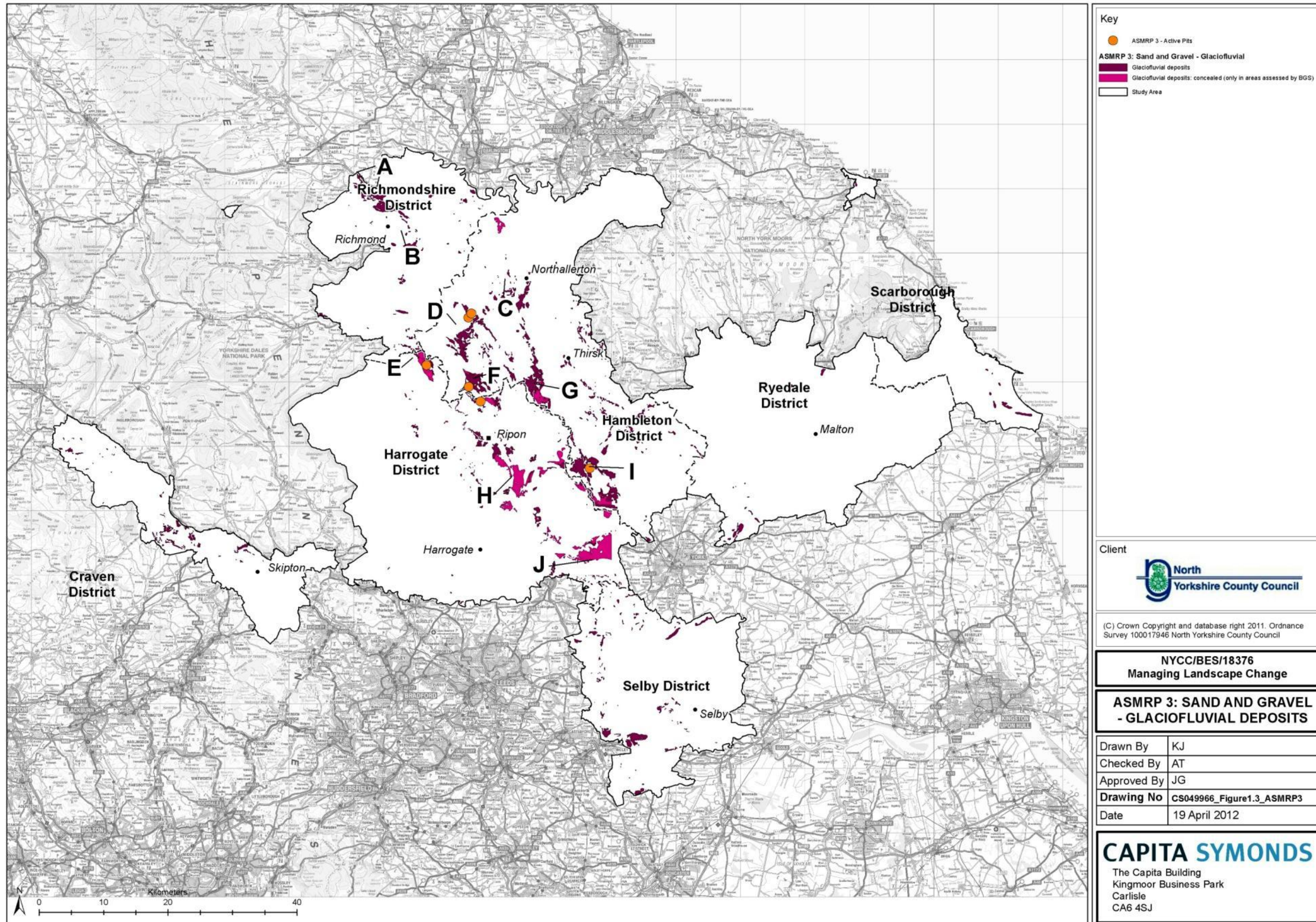
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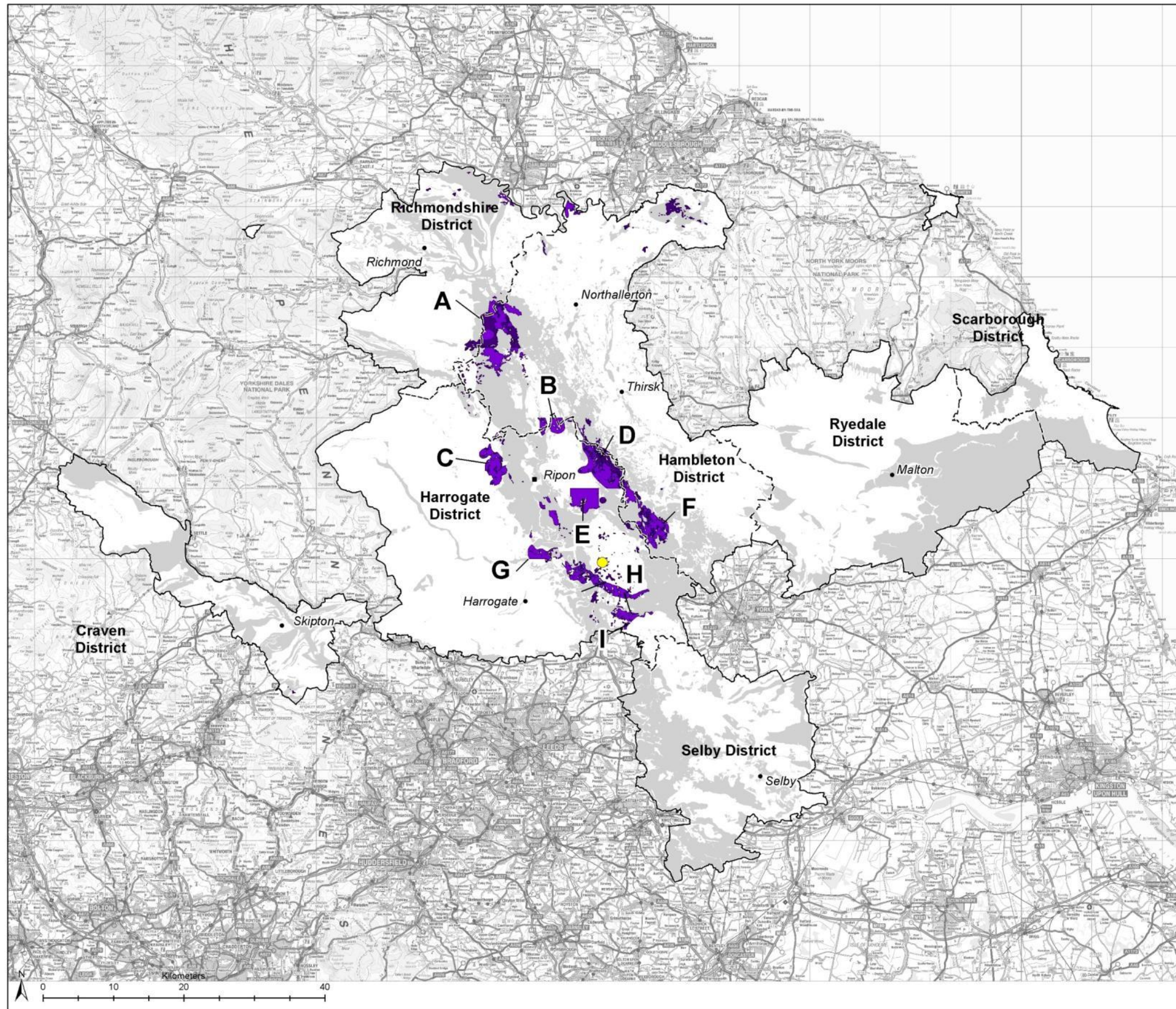
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**ASMRP 2: SAND AND GRAVEL
 - RIVER TERRACE DEPOSITS**

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Approved By	JG
Drawing No	CS049966_Figure1.2_ASMRP2
Date	19 April 2012

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Key

- ASMRP 4 - Active Pits
- ASMRP 4: Sand and Gravel - Glacial deposits**
- Glacial deposits
- Glacial deposits: concealed (only in areas assessed by BGS)
- Study Area

Client



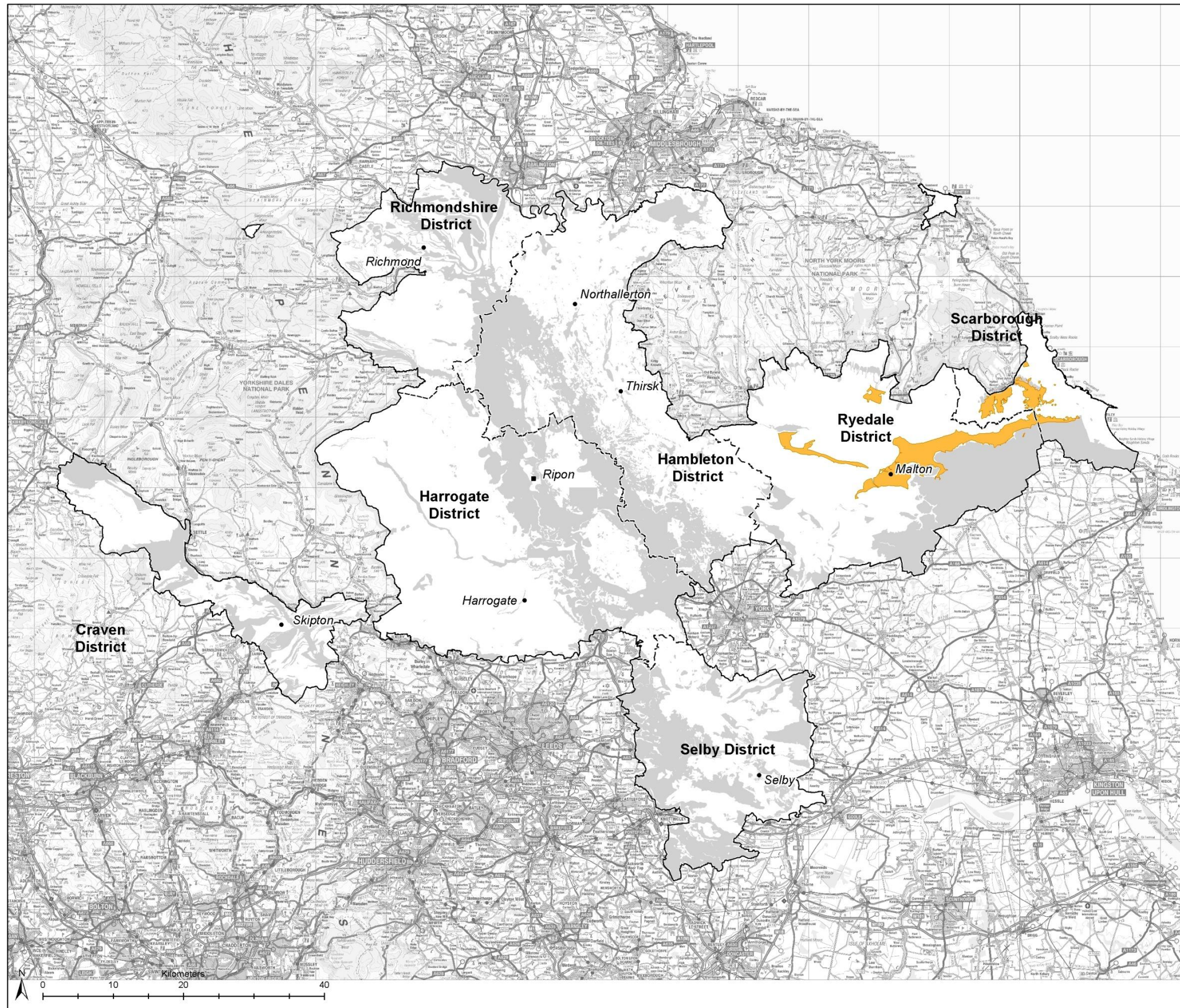
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**ASMRP 4: SAND AND GRAVEL
 - GLACIAL DEPOSITS**

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Drawing No	CS049966_Figure1.4_ASMRP4
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Key
ASMRP 5: Sand and Gravel - Undifferentiated
 Undifferentiated sand and gravel
 Study Area

Client

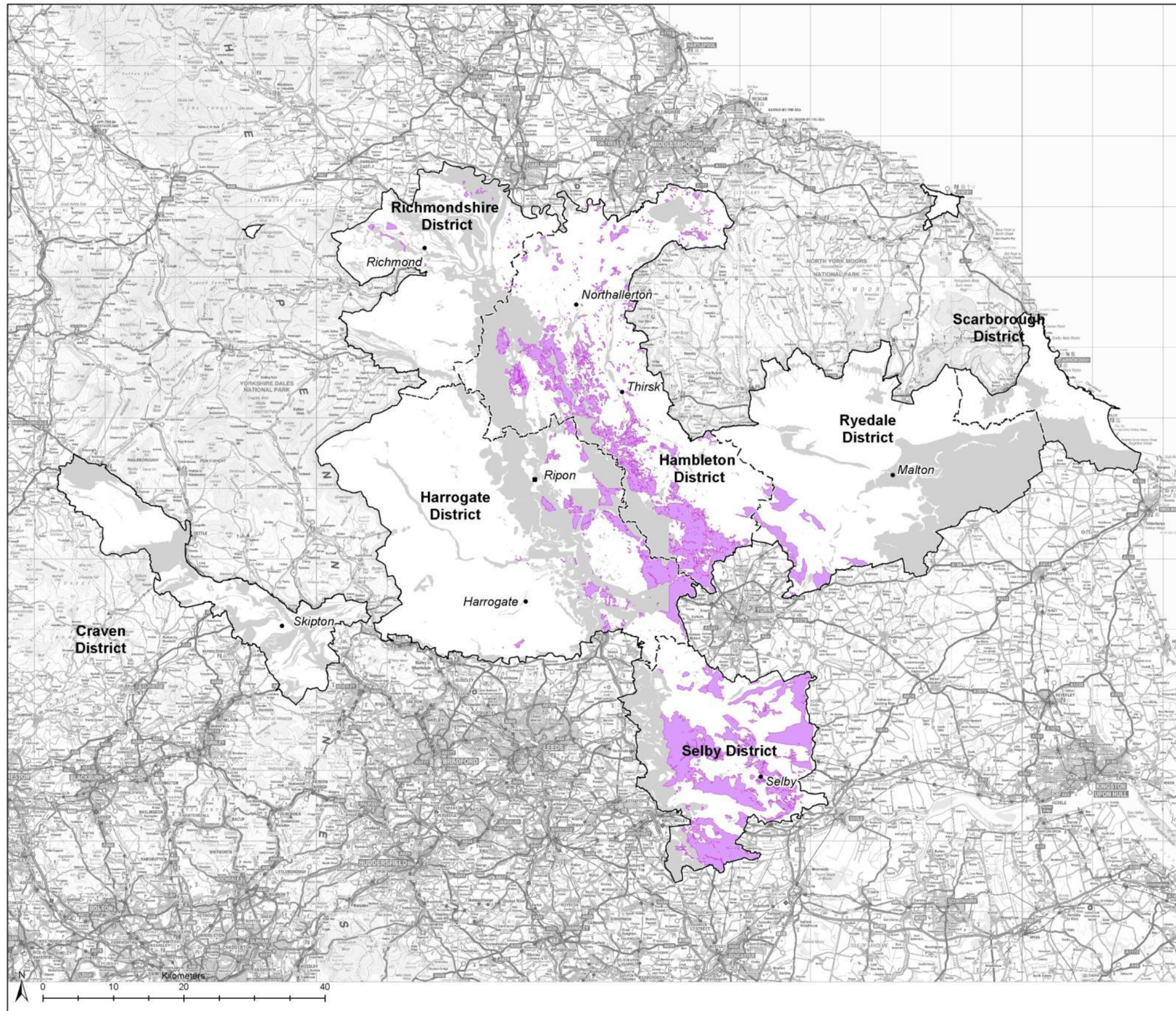

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ASMRP 5: SAND AND GRAVEL
- UNDIFFERENTIATED

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Approved By	JG
Drawing No	CS049966_Figure1.5_ASMP5
Date	19 April 2012

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Key

ASMRP 6: Brick Clay - Quaternary

Brick clay: Quaternary, glaciolacustrine deposits (clay and silt)

Study Area

Client



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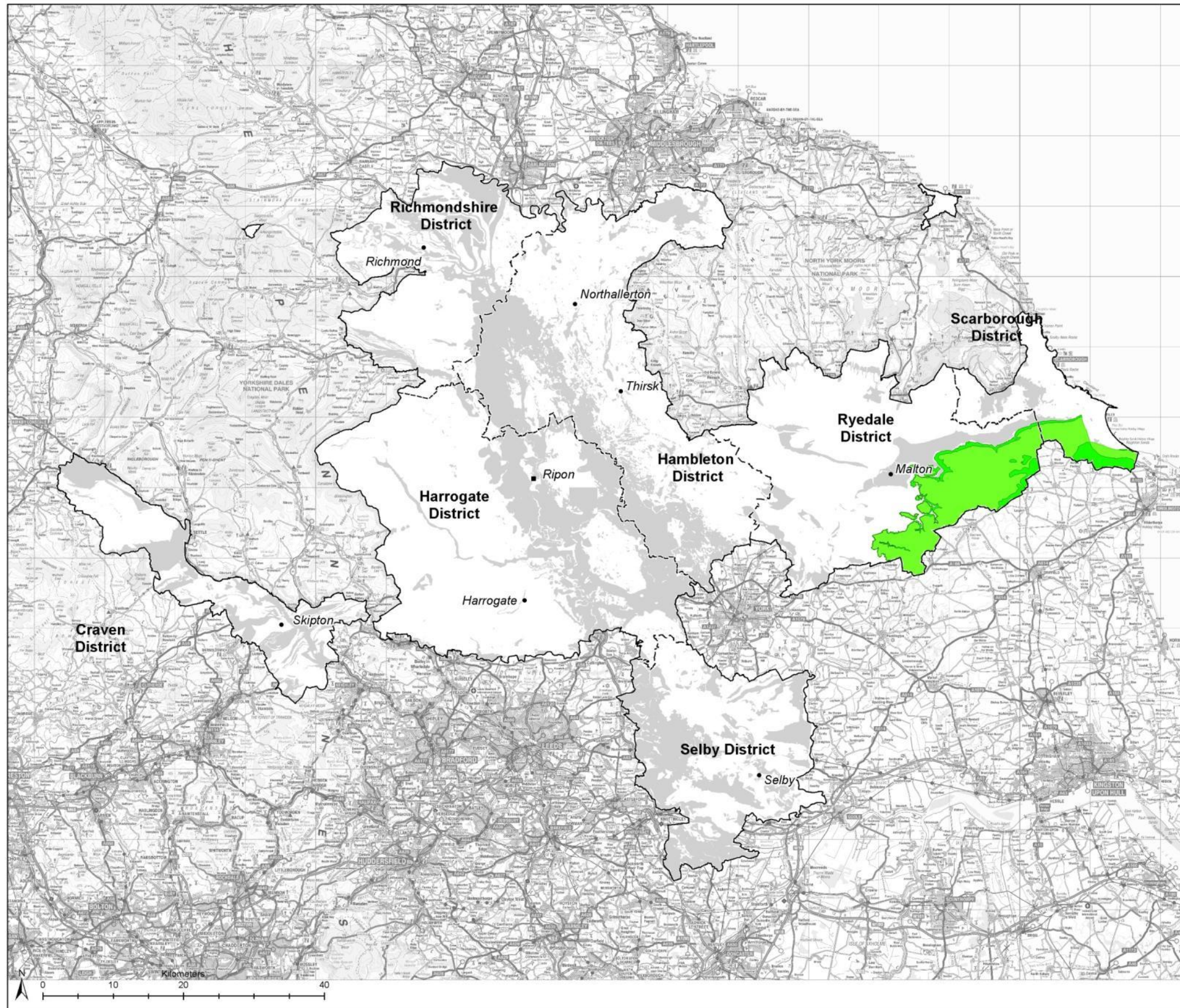
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ASMRP 6: BRICK CLAY
- QUATERNARY

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Approved By	JG
Drawing No	CS049966_Figure1.6_ASMP6
Date	19 April 2012

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Key

ASMRP 7: Chalk - excluding concealed

- Higher purity chalk (>97% CaCO₃)
- Lower purity chalk (93-97% CaCO₃)
- Study Area

Client



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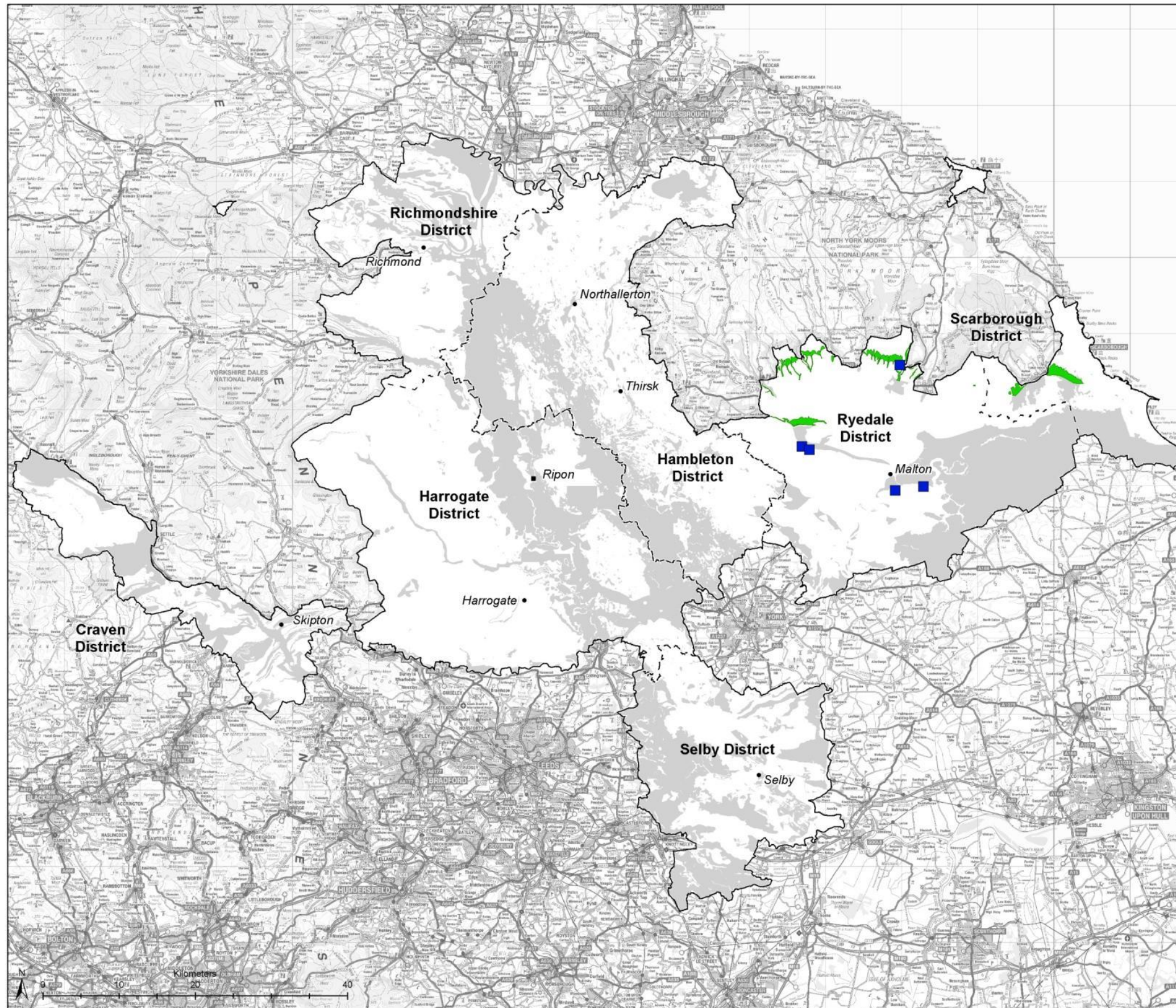
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ASMRP 7: CHALK
- EXCLUDING CONCEALED

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Approved By	JG
Drawing No	CS049966_Figure1.7_ASMRP7
Date	19 April 2012

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Key

- ASMRP 8 - Active Pits
- ASMRP 8: Limestone -Jurassic
- Limestone: Jurassic, Lincolnshire Limestone / Malton Oolite
- Study Area

Client

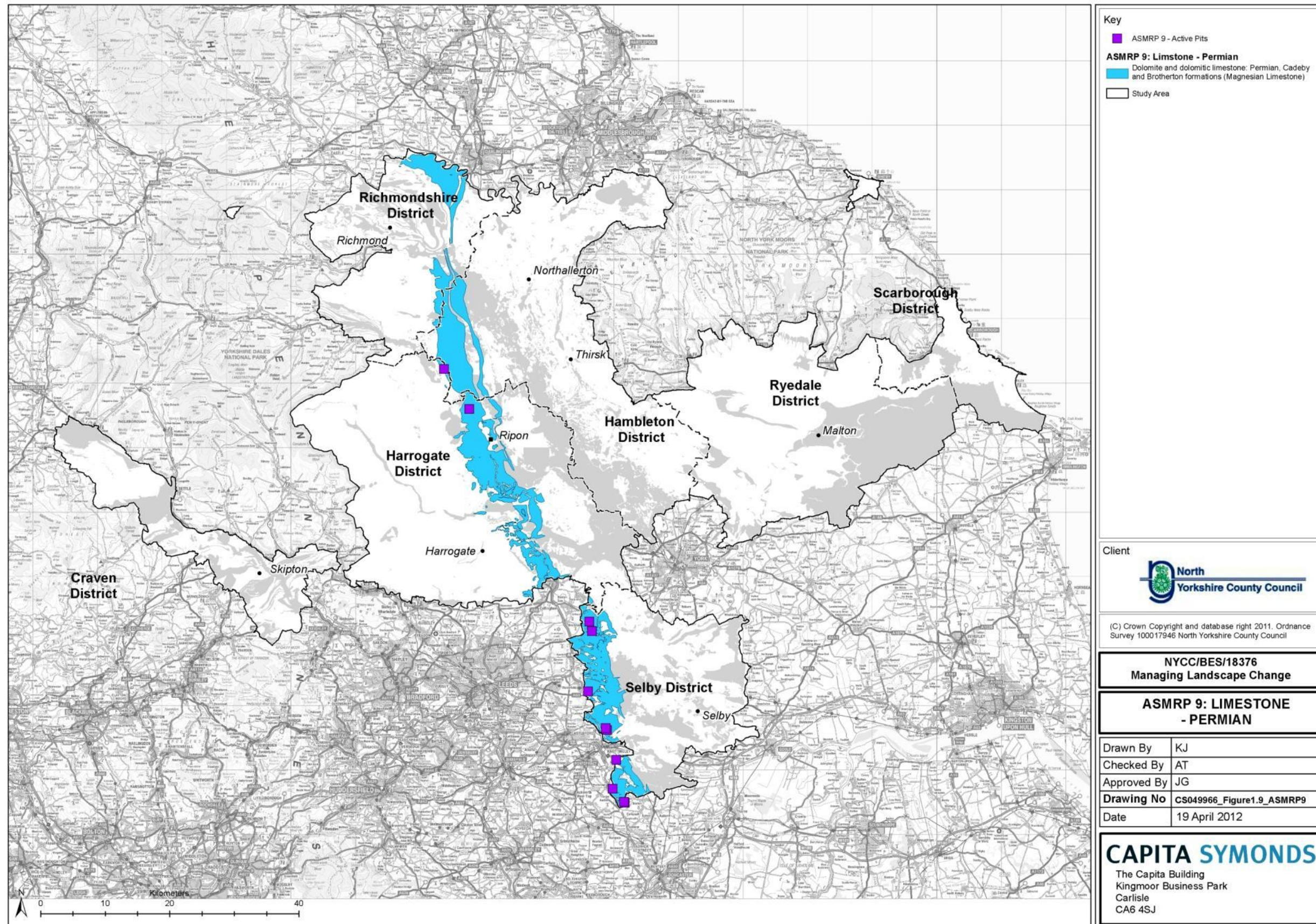
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**ASMRP 8: LIMESTONE
 - JURASSIC**

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Drawing No	CS049966_Figure1.8_ASMRP8
Date	19 April 2012

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Key

- ASMRP 9 - Active Pits
- ASMRP 9: Limestone - Permian**
■ Dolomite and dolomitic limestone: Permian, Cadeby and Brotherton formations (Magnesian Limestone)
- Study Area

Client

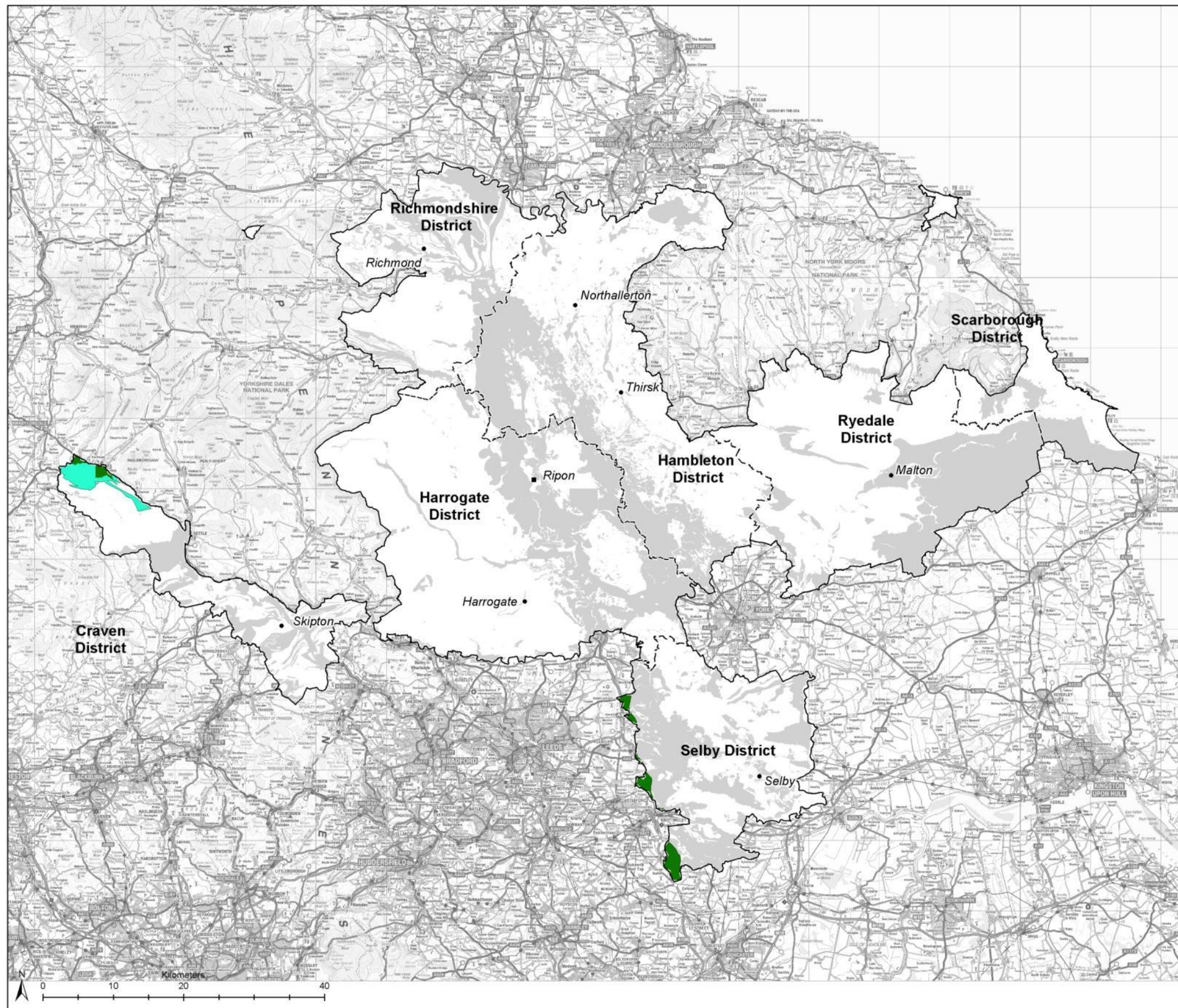

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**ASMRP 9: LIMESTONE
 - PERMIAN**

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Approved By	JG
Drawing No	CS049966_Figure1.9_ASMRP9
Date	19 April 2012

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Key

- Study Area
- ASMRP 10: Coal (shallow) - excluding tertiary**
- Buried coal resource overlain by up to 50m overburden
- Secondary opencast coal resource area

Client



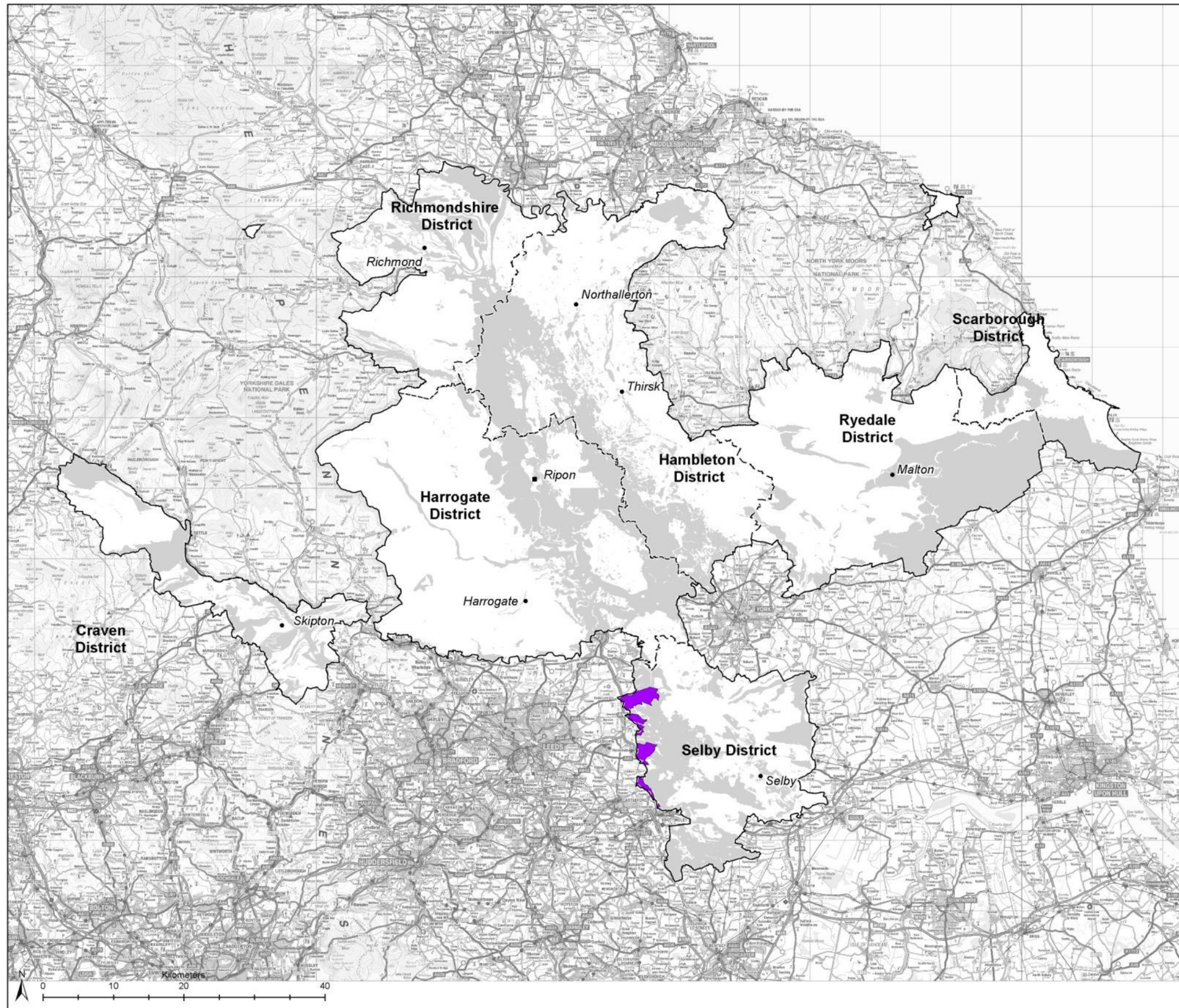
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**ASMRP 10: COAL (SHALLOW)
 - EXCLUDING TERTIARY**

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Approved By	JG
Drawing No	CS049966_Figure1.10_ASMP10
Date	19 April 2012

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Key

Study Area

ASMRP 11: Brick Clay - Carboniferous
 Brick clay: Carboniferous. Coal Measures mudstones (coincident with shallow coal)

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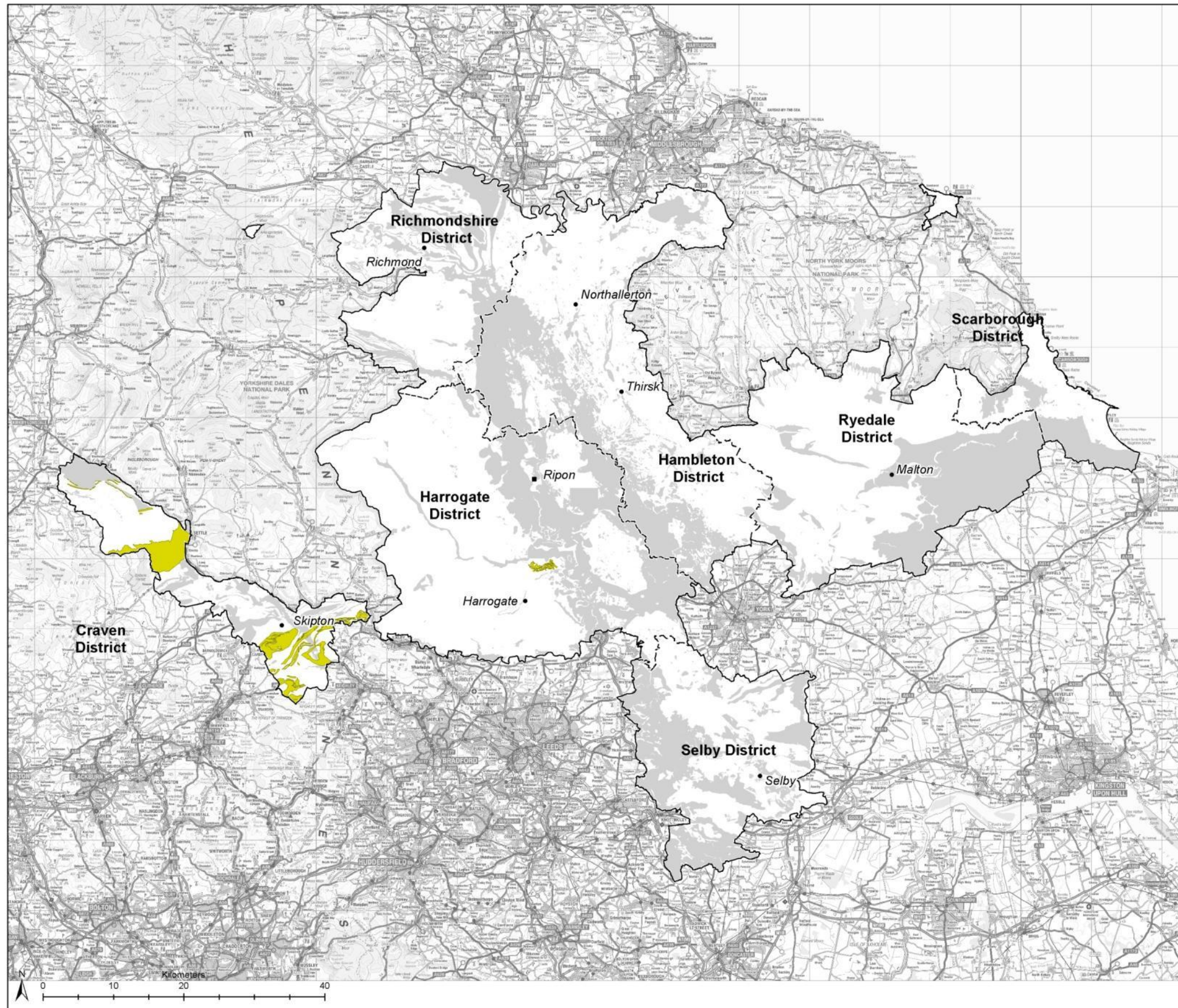
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**ASMRP 11: BRICK CLAY
 - CARBONIFEROUS**

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Approved By	JG
Drawing No	CS049966_Figure1.11_ASMRP11
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Key

- ASMRP 12: Sandstone**
- Sandstone: Carboniferous, Millstone Grit and Coal Measures
- Study Area

Client



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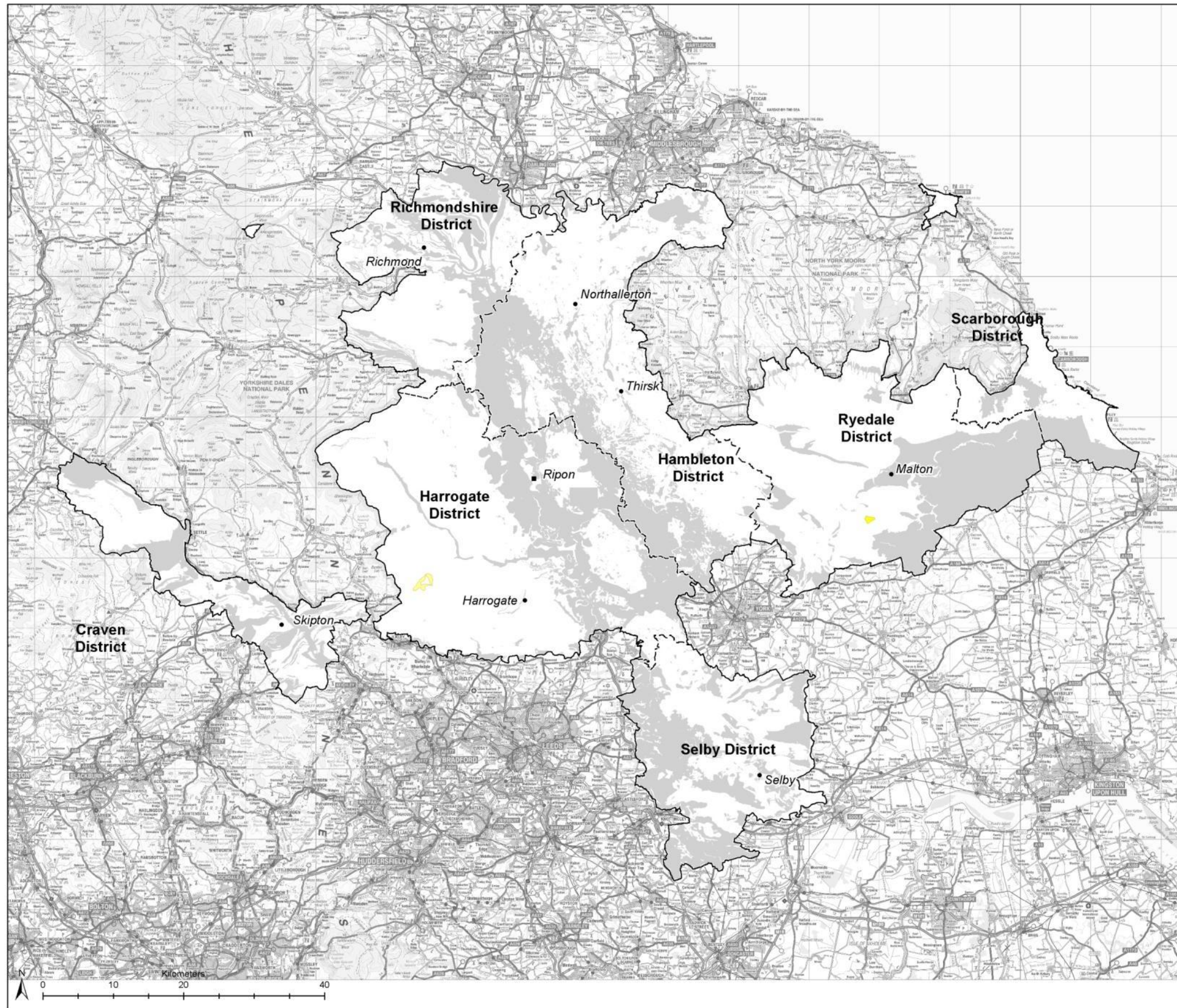
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ASMRP 12: SANDSTONE

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Approved By	JG
Drawing No	CS049966_Figure1.12_ASMP12
Date	19 April 2012

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Key

ASMRP 13: Silica

- Silica sand: Carboniferous, Millstone Grit (Blubberhouses only)
- Silica sand: Jurassic, Osgodby Formation (Burythorpe area only)
- Study Area

Client



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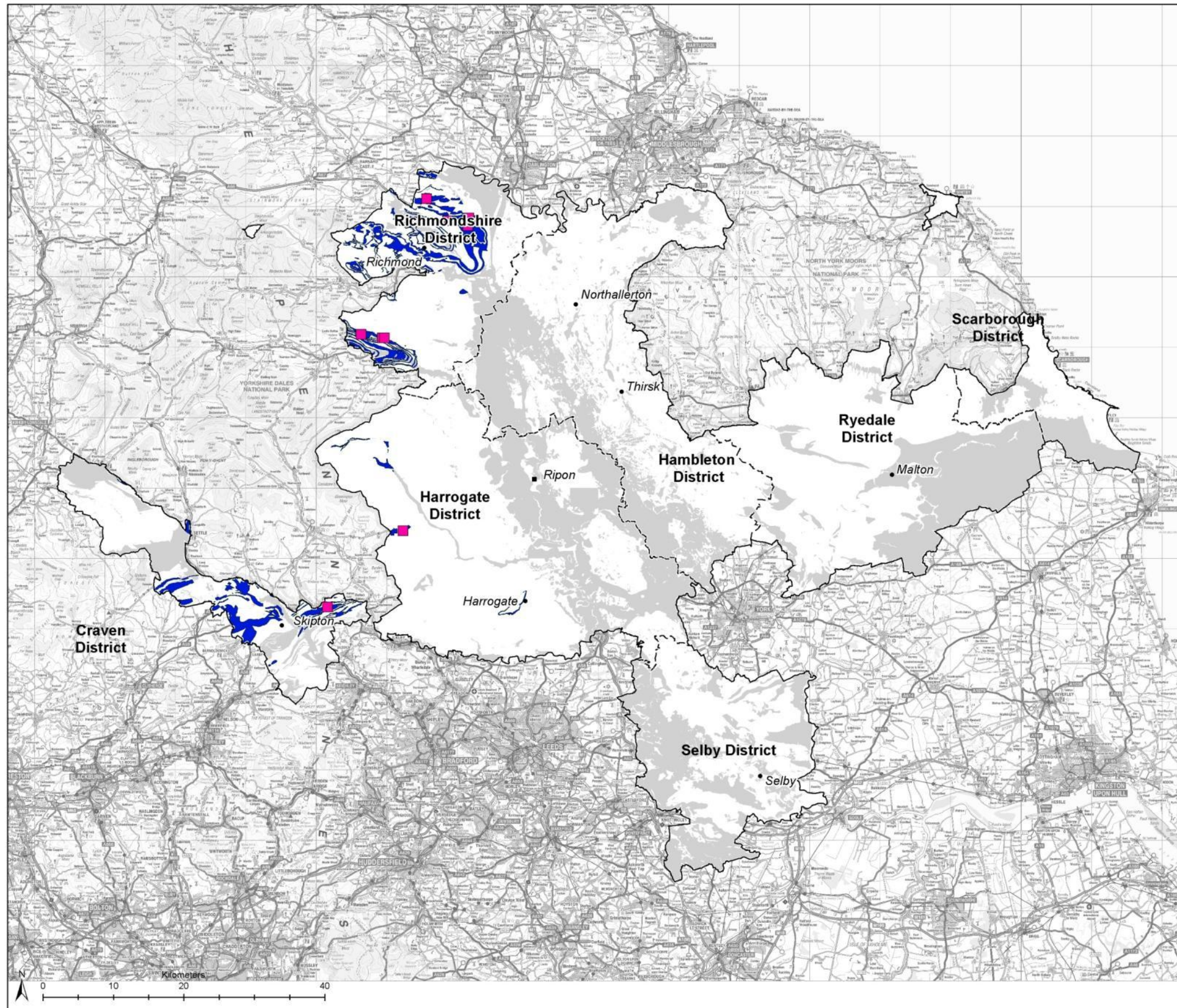
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ASMRP 13: SILICA

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Key

- ASMRP14 - Active Pits
- ASMRP 14: Limestone - Carboniferous**
- Limestone - Carboniferous
- Limestone - Carboniferous, high purity (>97% CaCO₃)
- Study Area

Client



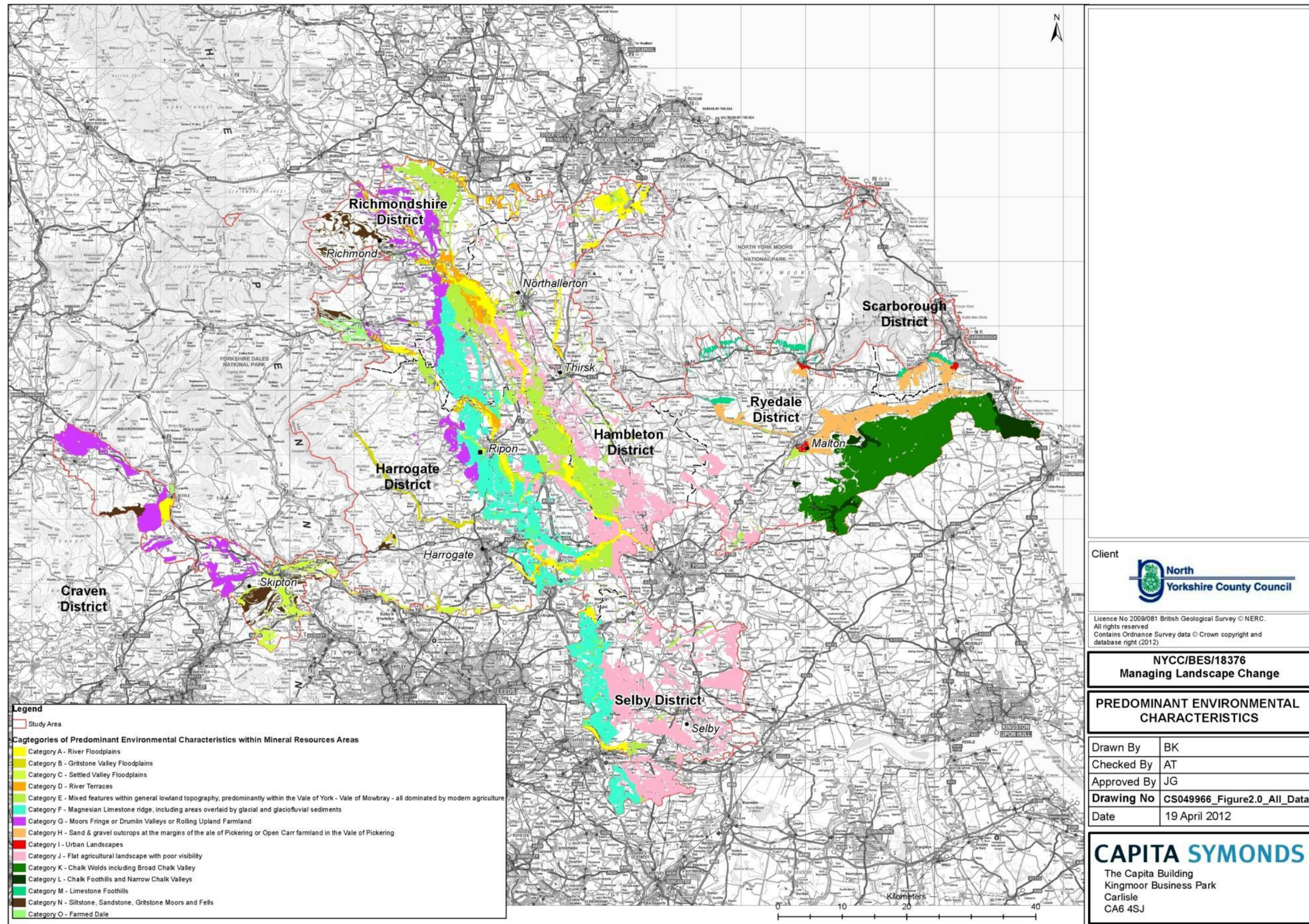
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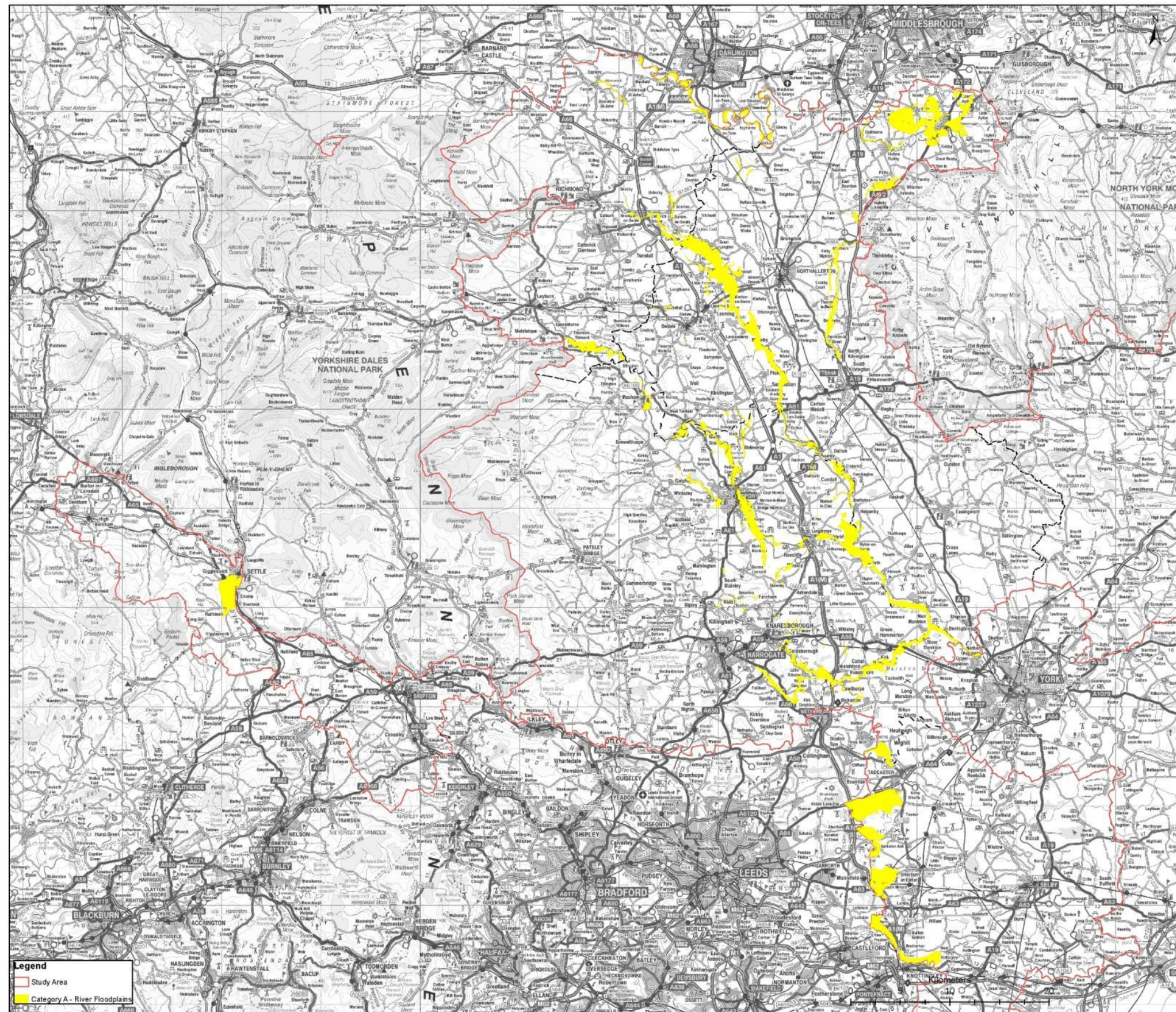
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**ASMRP 14: LIMESTONE
 - CARBONIFEROUS**


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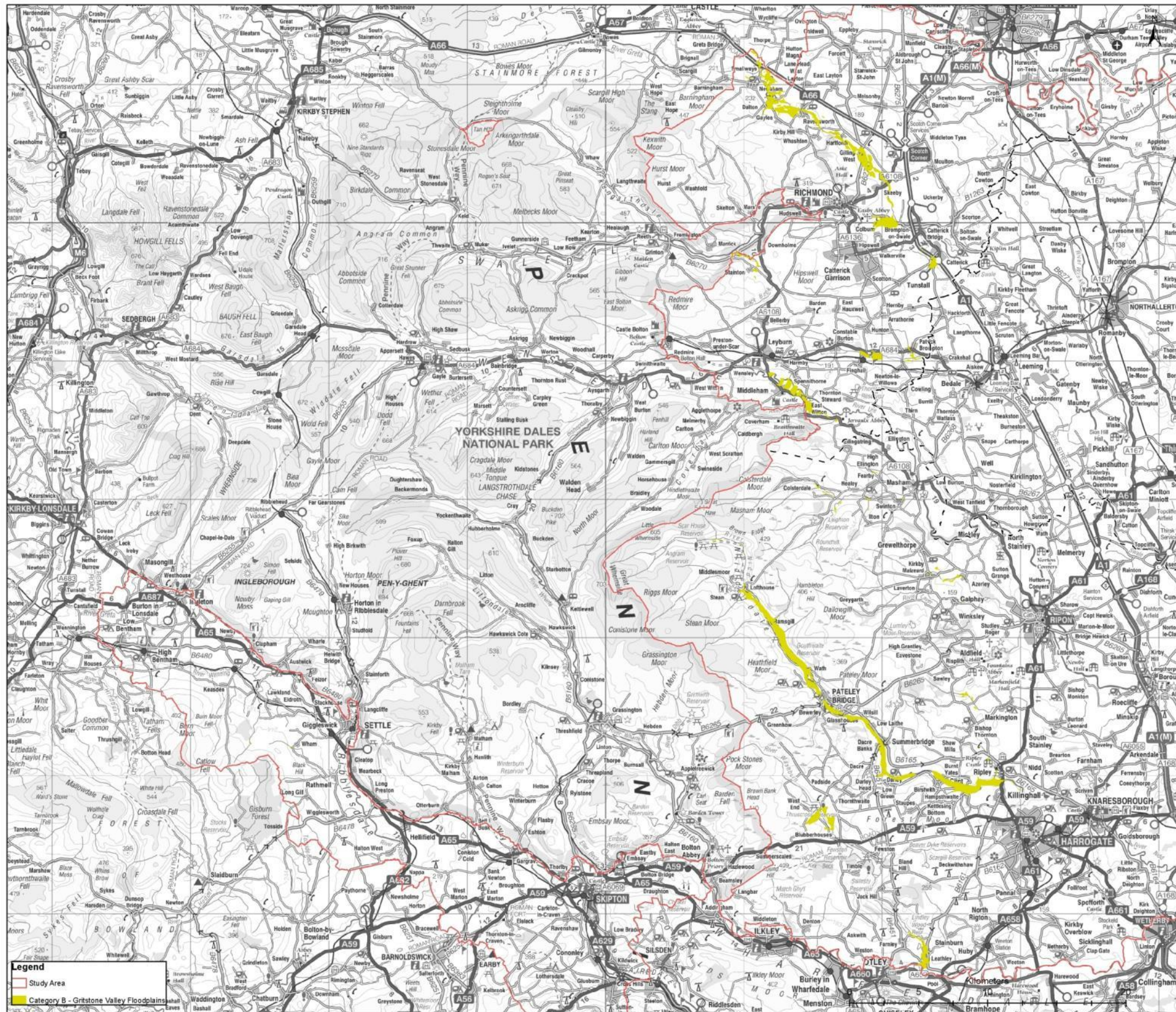
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Drawing No	CS049966_Figure2.1_CatA
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PREDOMINANT ENVIRONMENTAL CHARACTERISTICS, CATEGORY B

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Legend
 Study Area
 Category D - River Teraces



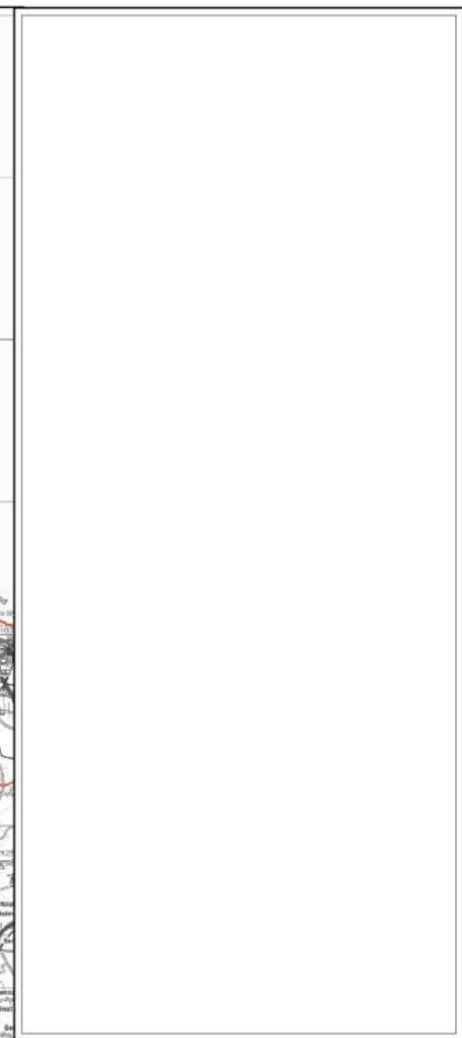
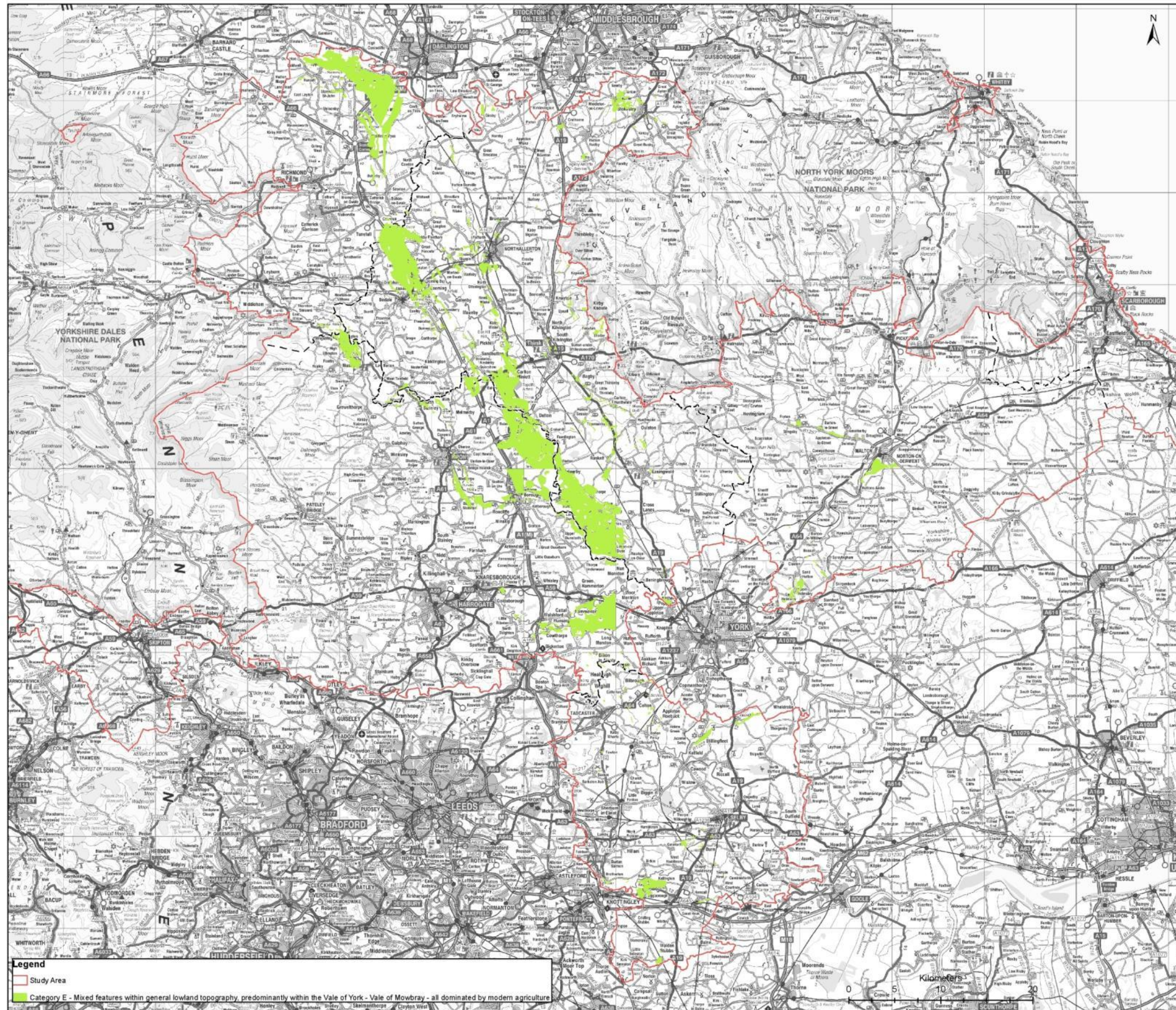
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**PREDOMINANT ENVIRONMENTAL
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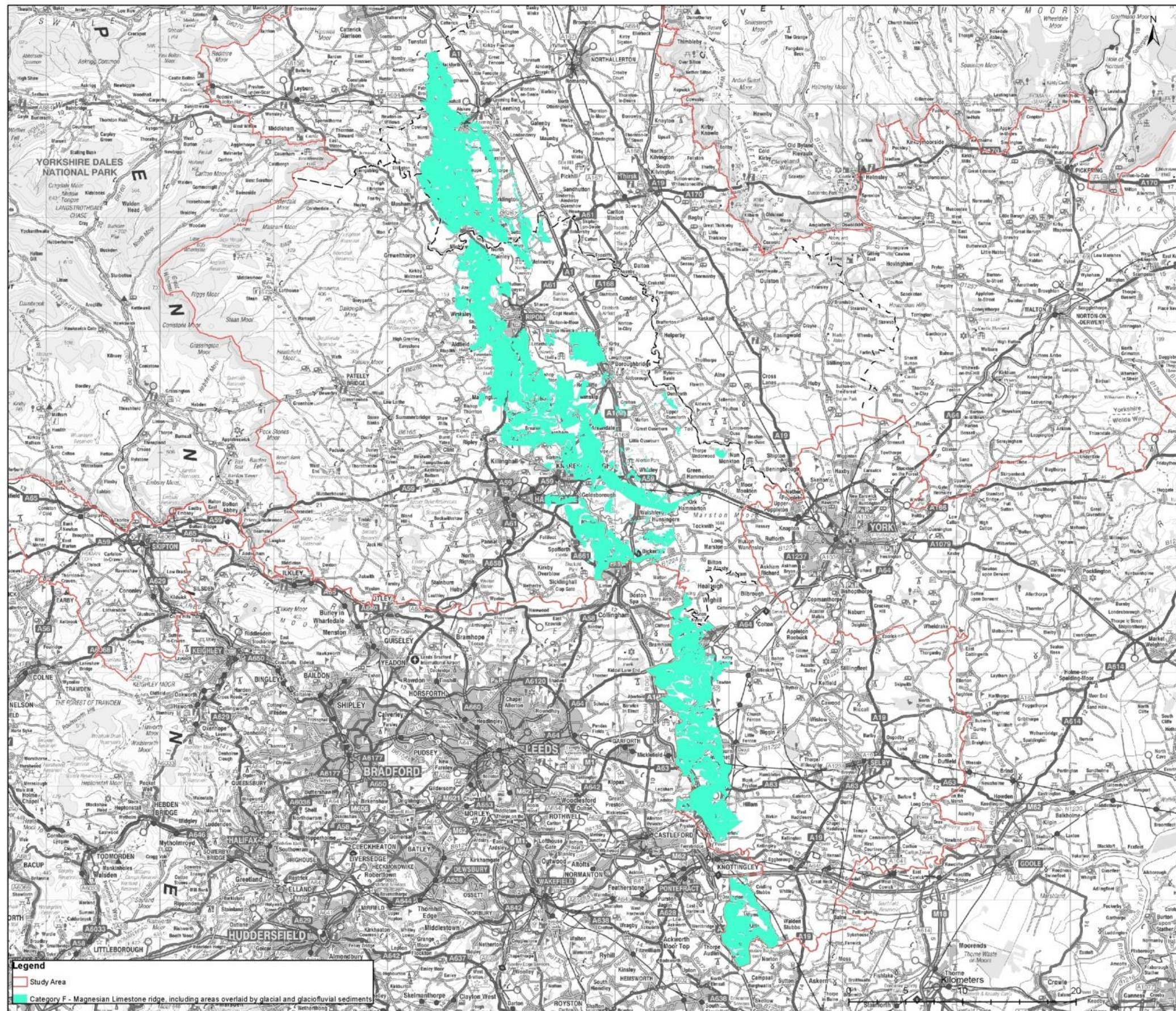
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**PREDOMINANT ENVIRONMENTAL
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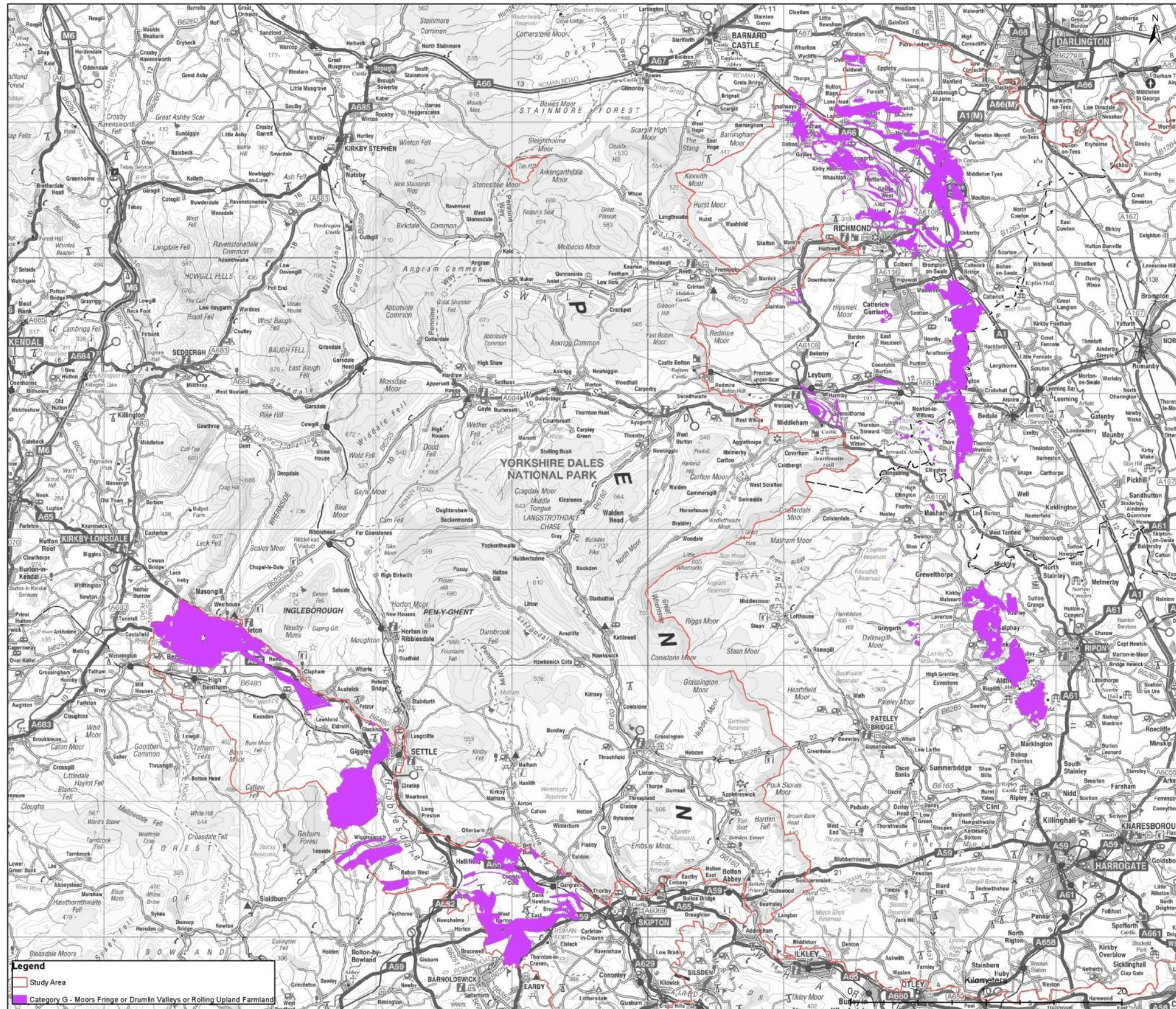
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**PREDOMINANT ENVIRONMENTAL
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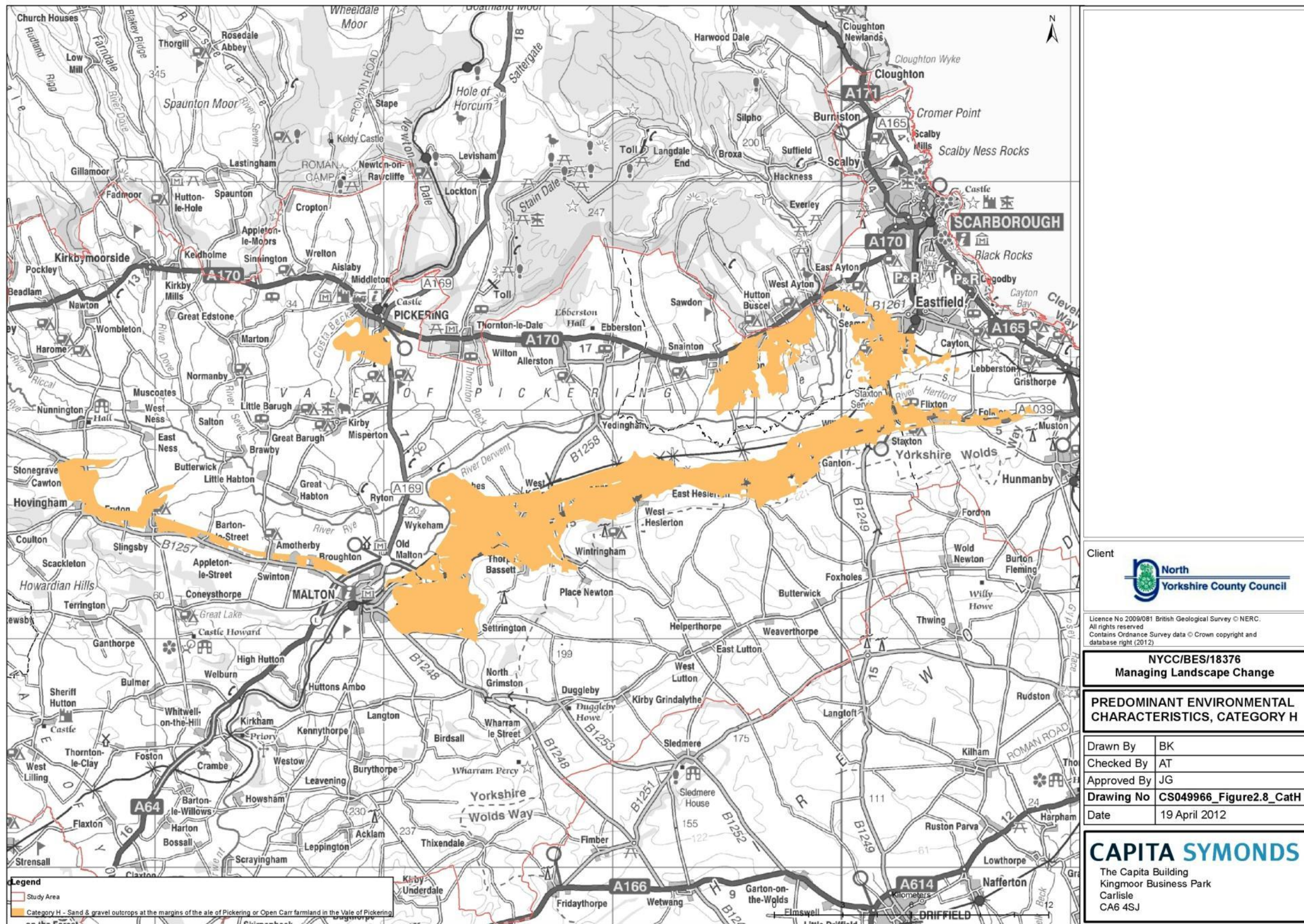
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**PREDOMINANT ENVIRONMENTAL
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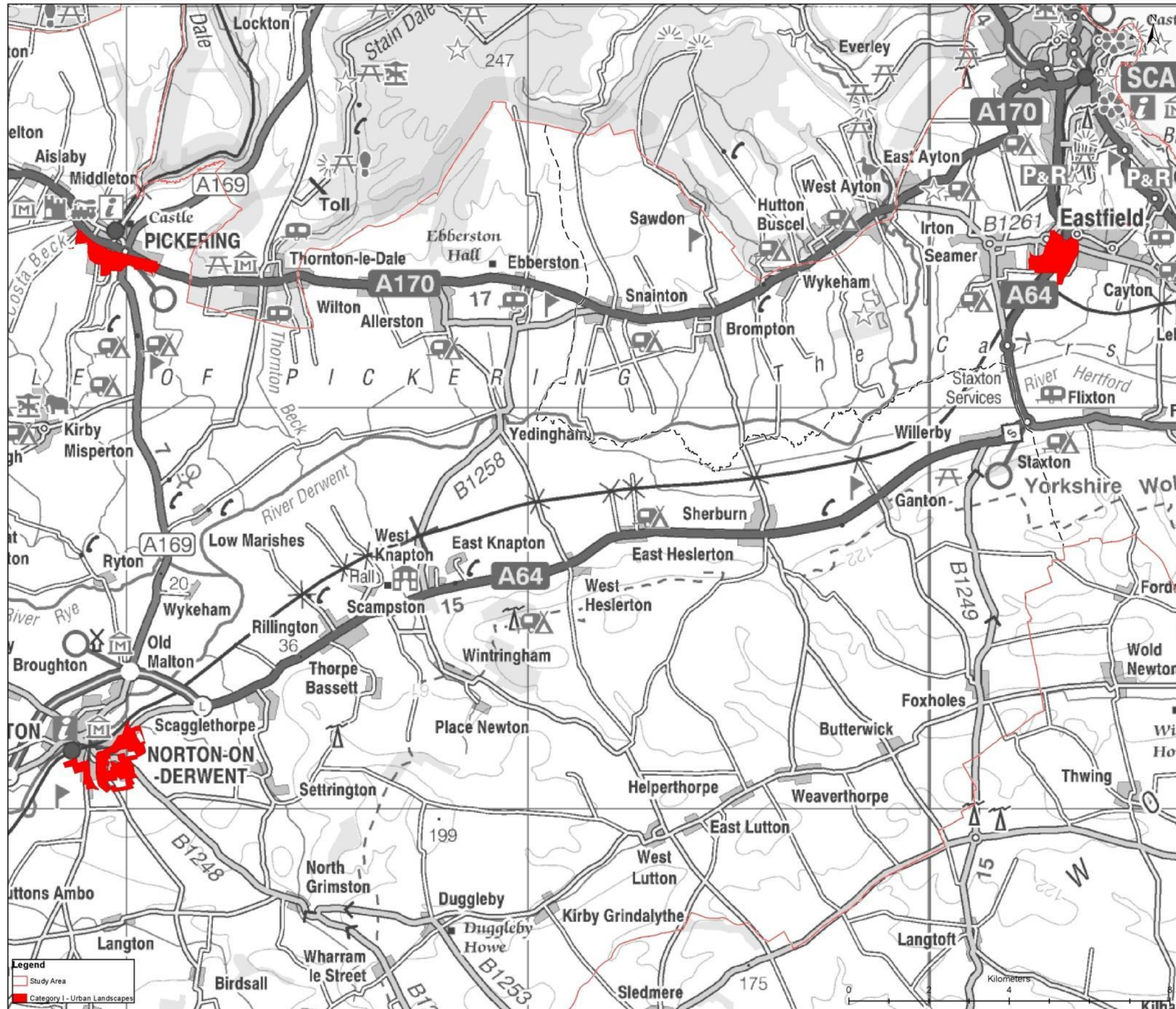
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Legend
 Study Area
 Category I - Urban Landscapes

Client

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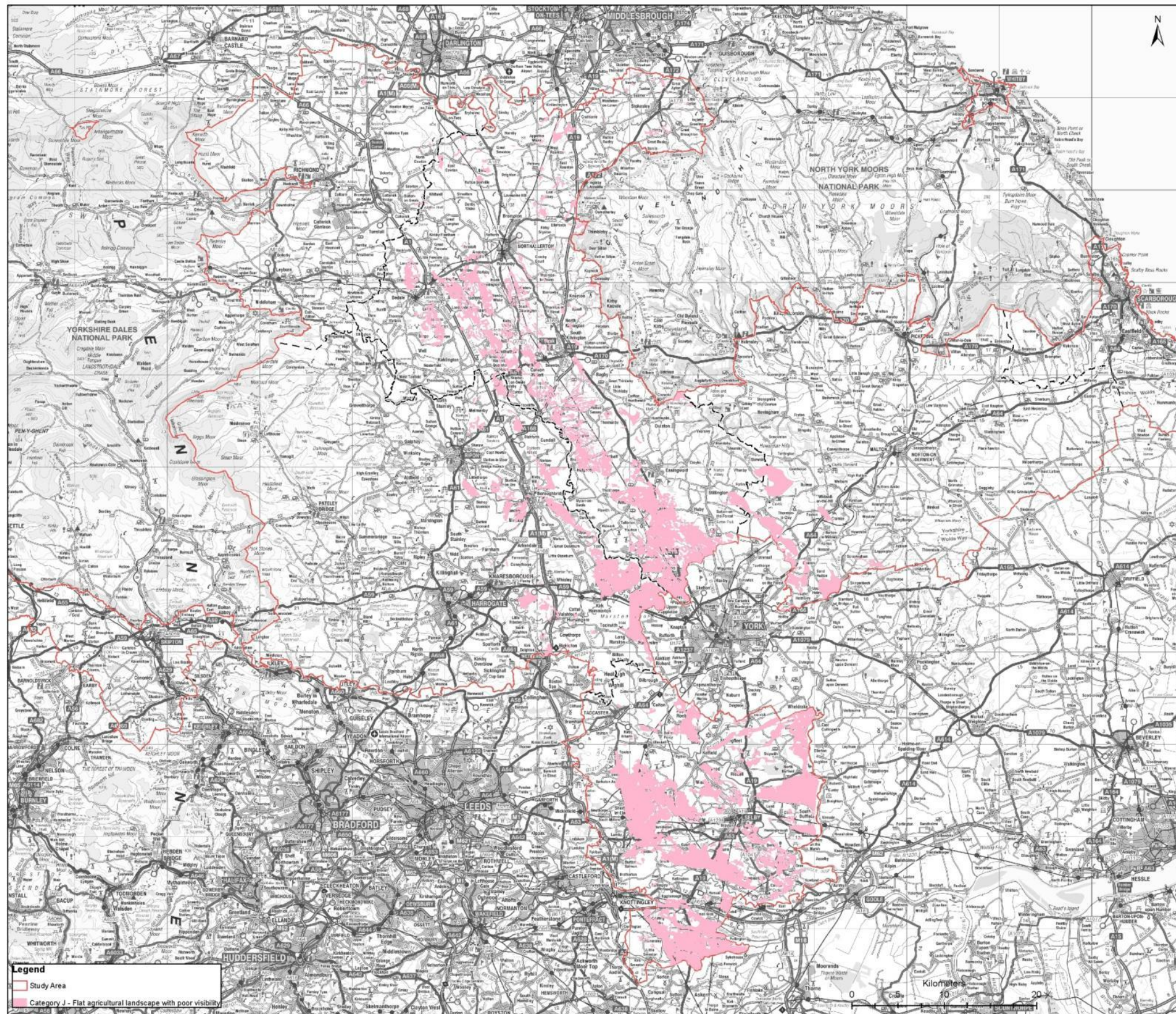
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**PREDOMINANT ENVIRONMENTAL
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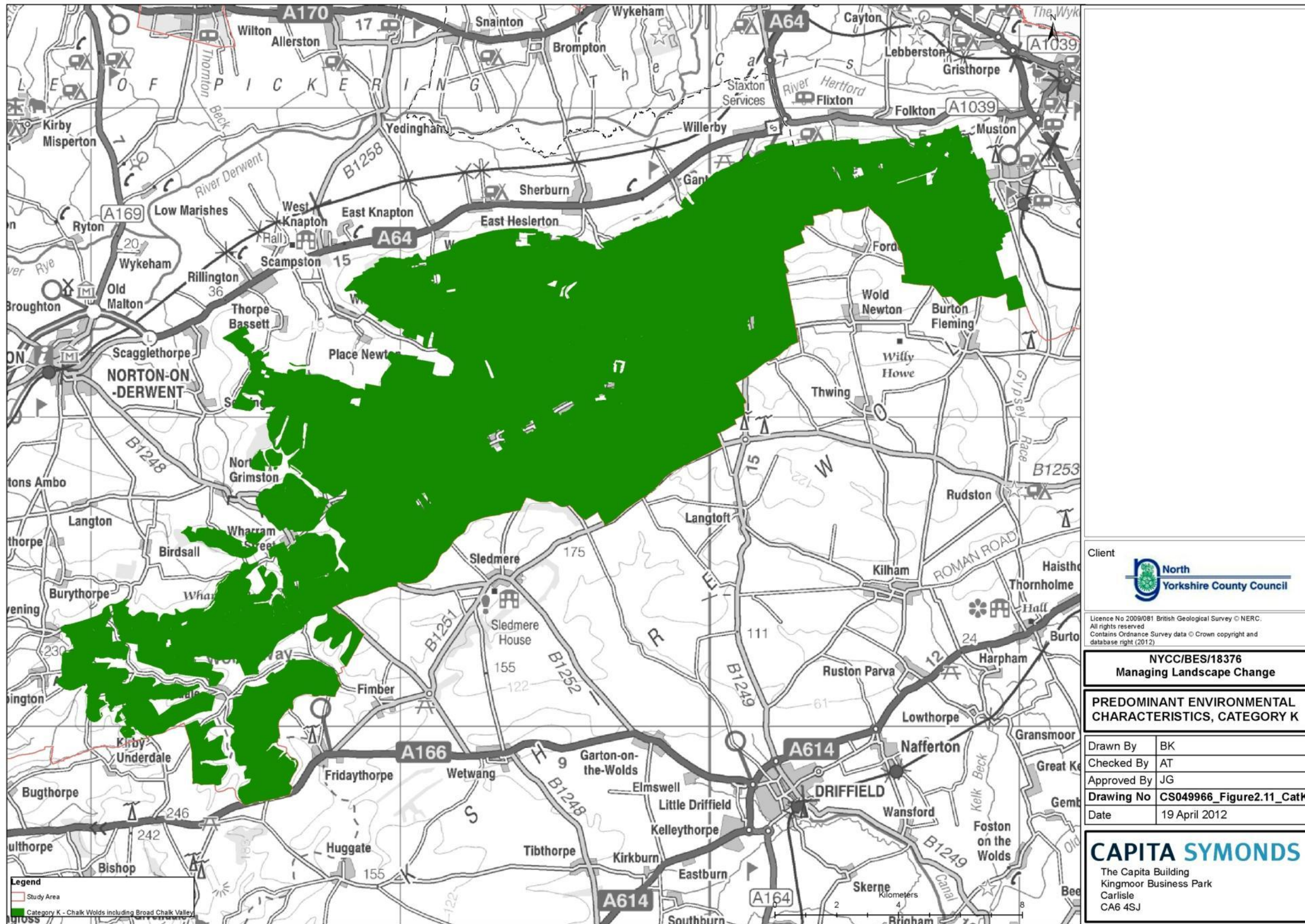
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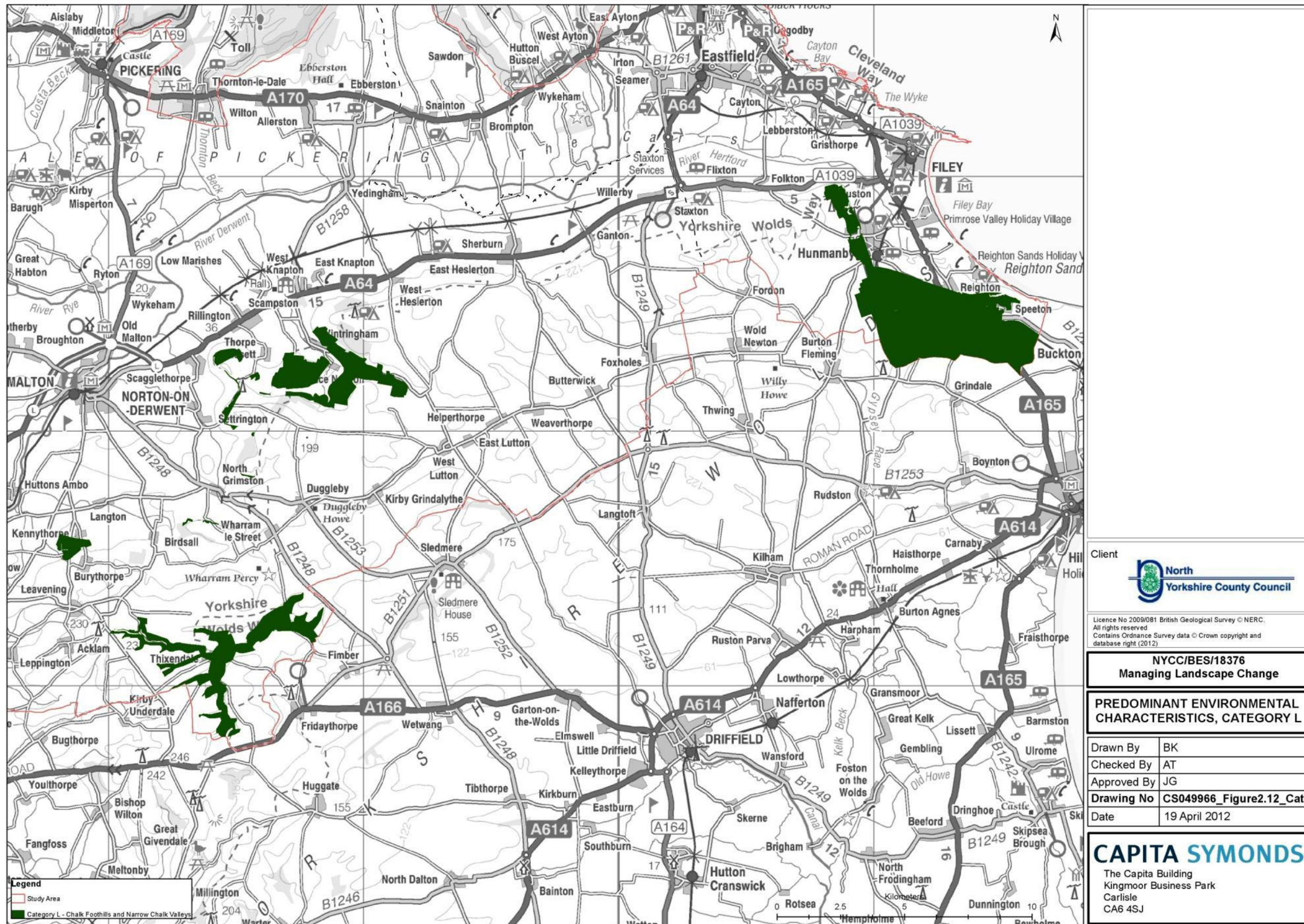
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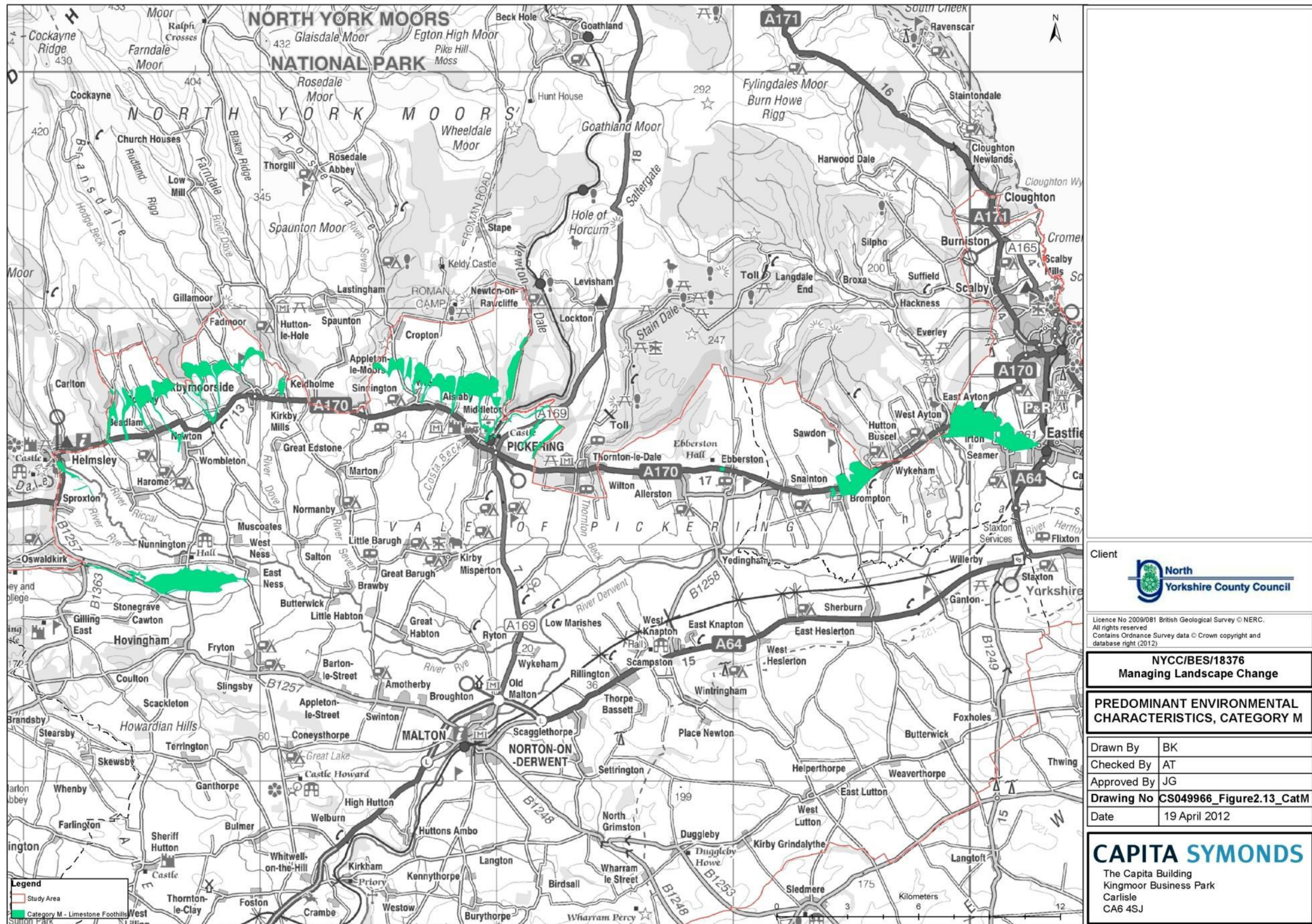
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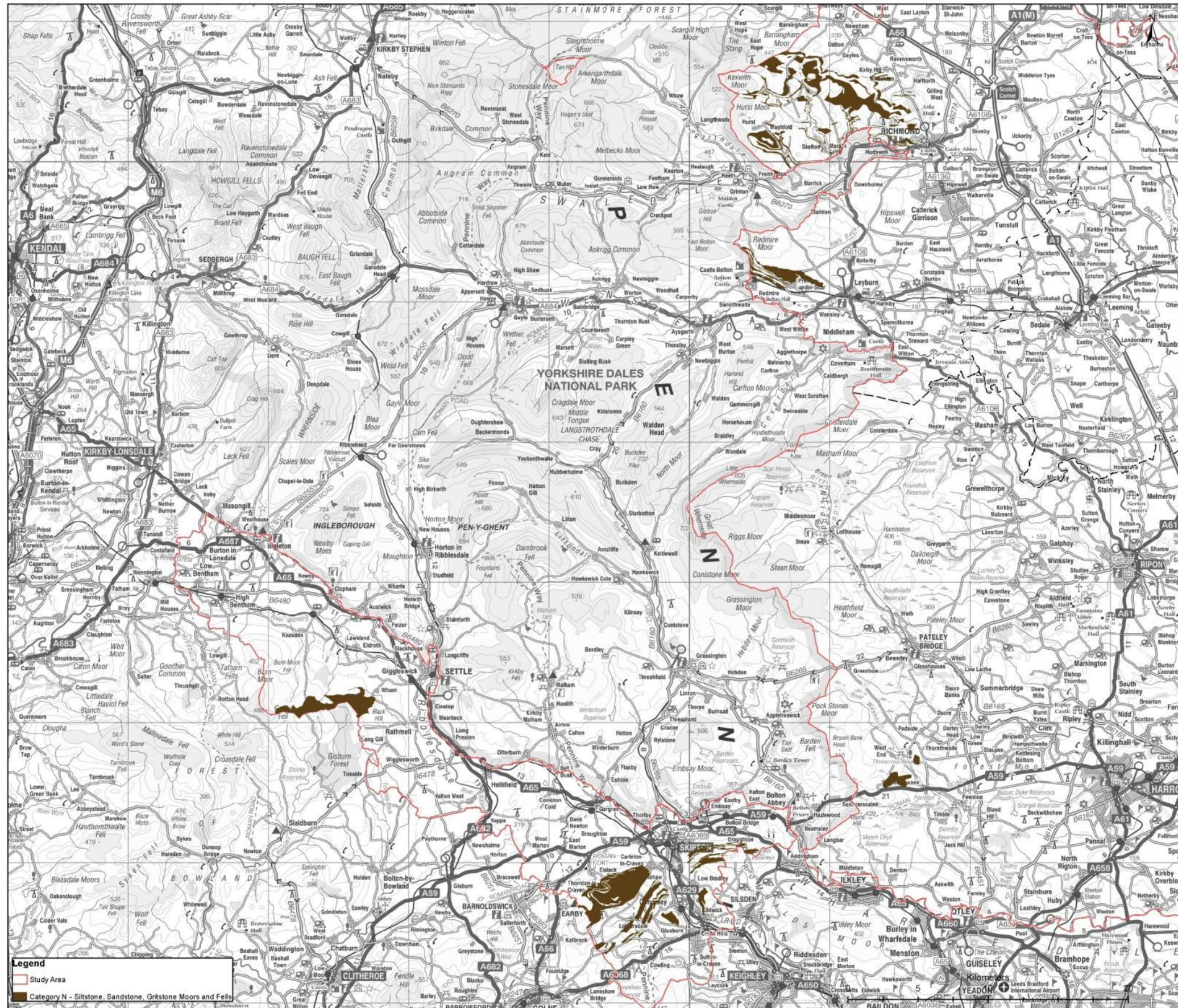
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**PREDOMINANT ENVIRONMENTAL
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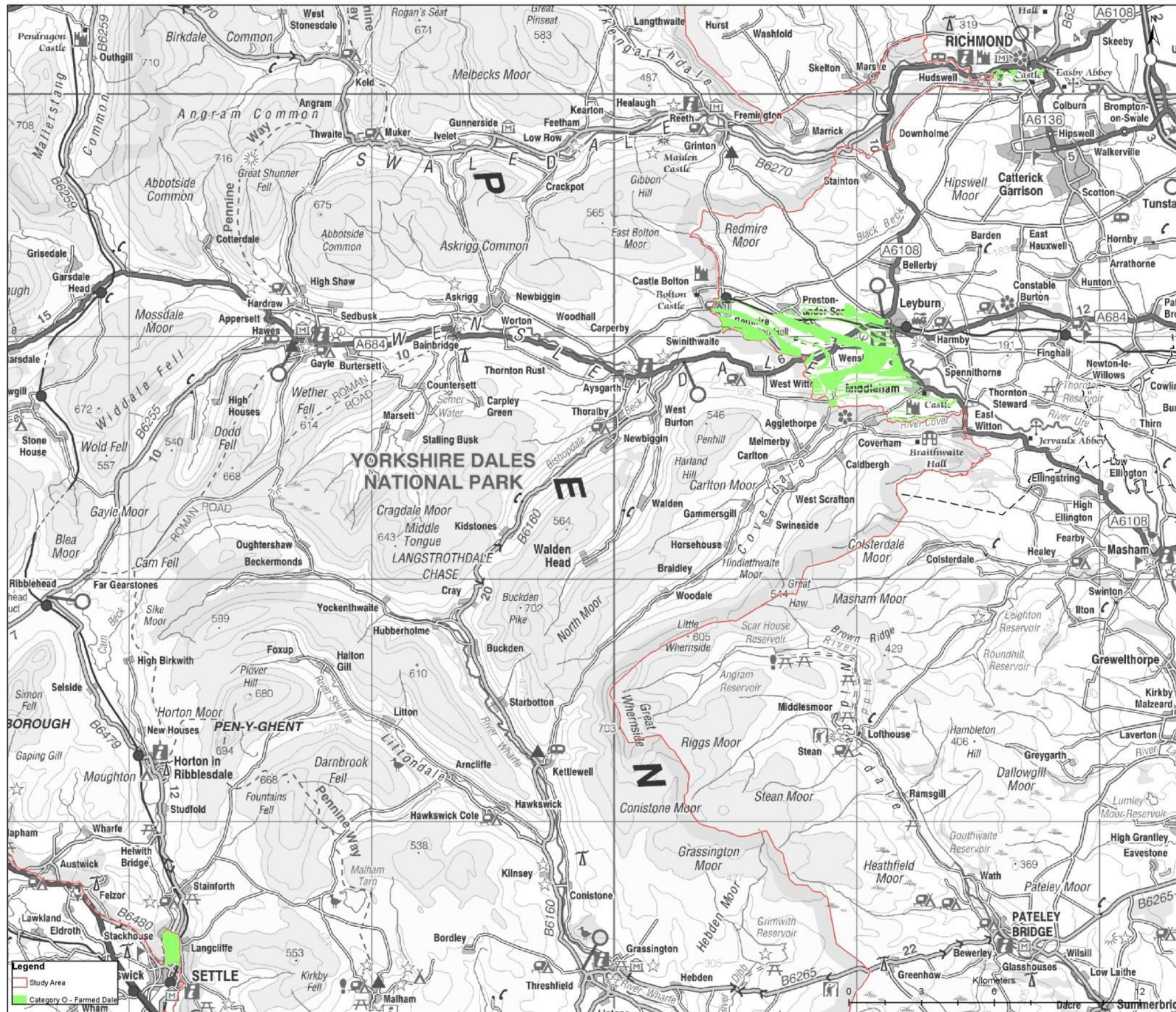
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**PREDOMINANT ENVIRONMENTAL
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PREDOMINANT ENVIRONMENTAL CHARACTERISTICS, CATEGORY O

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 Carlisle
 CA6 4SJ

Capita Symonds
The Capita Building
Kingmoor Business Park
Carlisle
CA4 6SJ

Tel: 01228 673000
Fax: 01228 673111