Notification of Seismic Surveys – INEOS Upstream Ltd

Derbyshire County Council

May 2017

Turley

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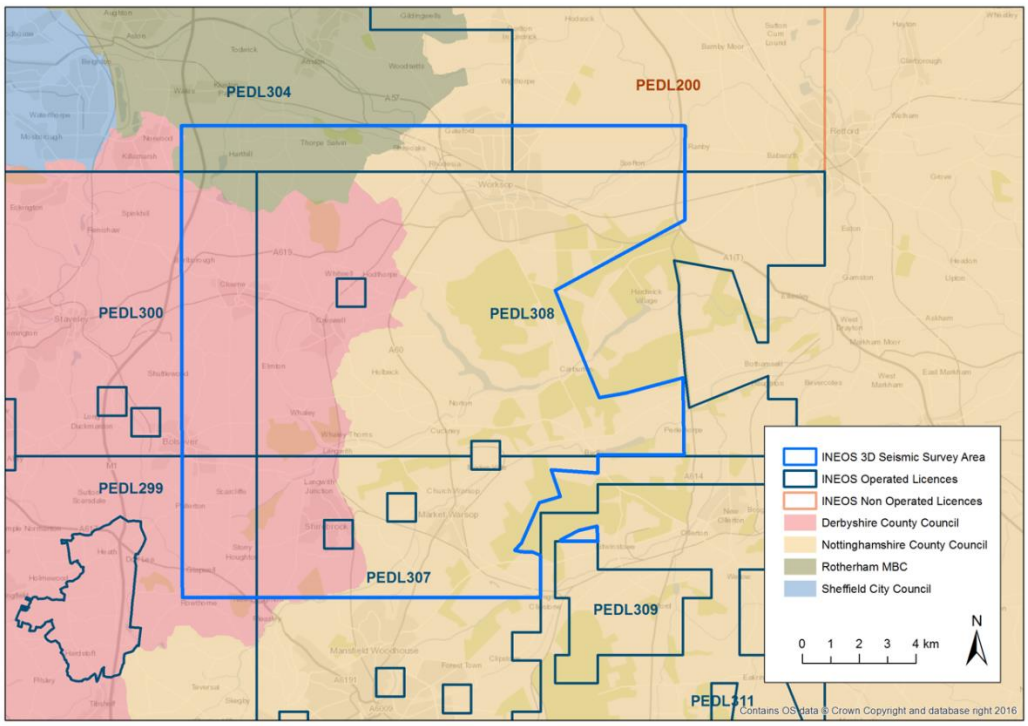
1. Introduction

1.1 Summary

1.1 This report is submitted to Derbyshire County Council to outline INEOS Upstream Ltd.'s (hereafter INEOS) proposed geophysical (seismic) survey operations in the area shown in Map 1. In total the survey area covers 250.7 km^2 (approximately 25,000 ha). Derbyshire County Council is the Mineral Planning Authority (MPA) for 90.8 km^2 of the whole survey area.

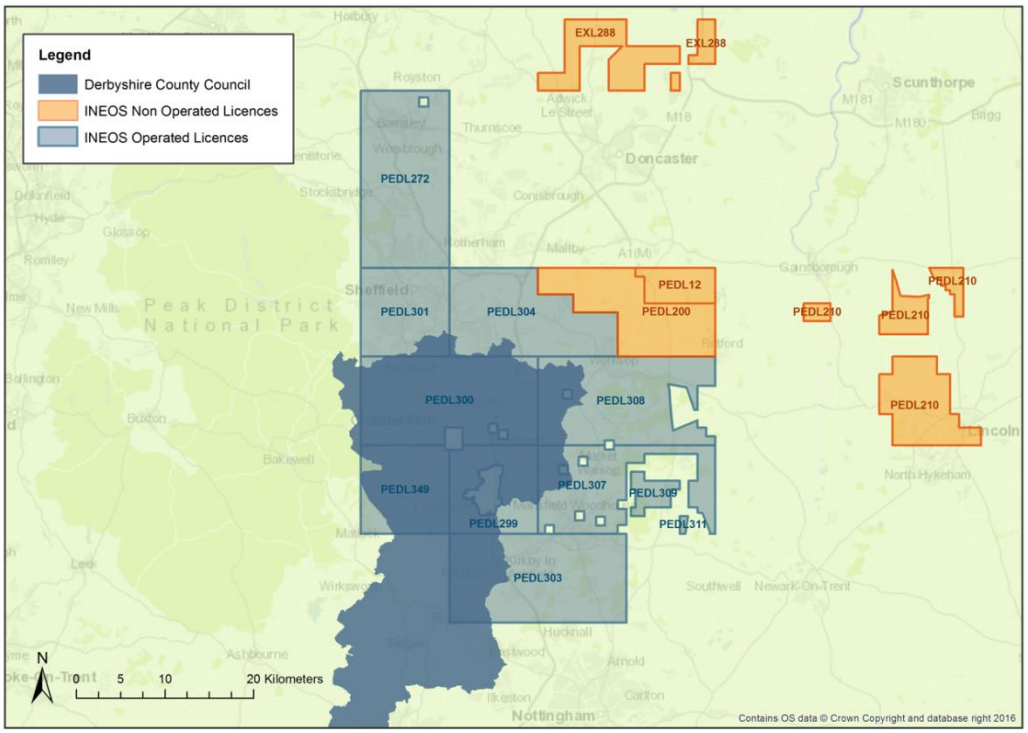
1.2 This report should be read with the accompanying document "INEOS Shale Seismic Surveying Methodology: East Midlands Seismic Survey 2017" – hereafter termed the Method Statement, which outlines the survey methods to be used and embedded environmental operative measures in place. Environmental operative measures for site specific environmental considerations are outlined in Section 4.6 and Appendices 1-3 of this report. The 3D seismic survey that INEOS proposed is described in Section 4.2 of this report.

Map 1: Boundary and Location of Seismic Survey Area



1.3 The proposed survey area is located within INEOS's Petroleum Exploration and Development Licence areas (PEDLs) 299, 300, 304, 307, 308 and 309 which were awarded to INEOS in July 2016. It extends into PEDL 200 which INEOS has a Licence interest in, but is operated by another company. The survey area also extends into PEDL 130 with the agreement of the operator Egdon Resources Ltd. INEOS's PEDL areas in the East Midlands are shown in Map 2.

Map 2: INEOS PEDL areas in East Midlands, with Derbyshire County Council area overlaid



1.4 The award of the PEDLs gives INEOS the right to search for and develop "petroleum" (including gas) within the PEDL, subject to obtaining the relevant consents.

1.5 Seismic survey is permitted development under Class J and K of Schedule 2 Part 17 of The Town and Country Planning (General Permitted Development) (England) Order 2015 as amended (GPDO 2015), meaning planning consent is not required, subject to certain restrictions. The proposed survey will take place under Class K as justified in Chapter 2 of this report.

1.6 This report and the Method Statement serve as notification to the MPA under Section 17, Class K, 1(c) of this Order. INEOS intends to carry out the development as described in this report and accompanying Method Statement. This report describes the environment and considerations within the relevant MPA, though having regard for the fact that the entire survey area covers several MPAs, each of which will be notified separately for operations in their areas.

1.7 Certain aspects of the survey design phase (for example, site condition records and "pegging out" of the survey area) do not form part of the works for which notification is made, as they do not comprise development in the terms of the Town and Country Planning Act 1990. However, they are described herein as they will take place just in advance of the seismic surveys. "Pegging out" is important to the design of the survey in relation to environmental operations.

1.8 It is important to note that the exact locations of survey points, the split between source types (vibroseis vehicles and shotholes, as described in Section 4.2) and the routes to be followed by vehicles are dependent on landowner requirements and project and site

specific restrictions that can only be determined during the pre-survey "pegging" walkover. Therefore, they are not described herein. However, this report and the accompanying documents describes the methods and restrictions on the location of the survey points followed (i.e. where points will not be placed) to ensure the requirements of the GPDO can be met.

1.9 It is anticipated to start the surveys on 5 June 2017. They will last no longer than six months from the start date in total.

1.10 Formal written notification will also be made to neighbouring Councils at Nottinghamshire County Council and Rotherham Metropolitan Borough Council with respect to the areas of the survey falling within their administrative boundaries. Correspondence regarding methods and any necessary licensing and permitting has also been ongoing or will be undertaken with regulators as outlined in Section 3.1 of the accompanying Method Statement, including Natural England, the Environment Agency and Historic England, HSE and landowners including RSPB and the Forestry Commission.

1.2 Background

1.11 As one of the UK's largest manufacturing businesses, INEOS has a need for gas both as a feedstock for its chemical manufacturing processes, and as a source of energy to run its facilities. However, the supply of gas from the North Sea is rapidly declining, and energy prices are becoming increasingly uncompetitive compared to the rest of the world, putting INEOS' UK-based facilities at a competitive disadvantage. Therefore, as a company, INEOS is committed to establishing an indigenous source of gas from shale rock in the UK to supply feedstock and gas for energy. The company is well placed to develop this resource, having land, pipelines and storage in some of the key prospective shale gas areas, a record of manufacturing excellence, a strong safety focus and good relationships with the communities in which it operates.

1.12 The proposed seismic surveys are a first step in understanding the potential shale gas resource in the East Midlands basin. The survey is part of a work programme commitment made to Government as a condition of the PEDL award to INEOS.

1.13 INEOS will use the results of the surveys to inform and improve their existing geological model of the region. This model will form part of a detailed site selection process to identify potential surface sites for further exploration for shale gas. Any such sites would be subject to consent under the Town and Country Planning and Environmental Permitting regimes.

1.3 Safety and Environmental Protection

1.14 INEOS has a strong commitment to Health, Safety and the Environment, this being reflected in the Company's Corporate Health Safety, and Environmental Policies. Field operations during the seismic surveys will be carried out to industry accepted standards in accordance with the Company Safety Manual and guidelines laid down in the IAGC Land and Marine Geophysical Operations Safety and Environmental Manuals. In addition, the Company complies with all enactments, regulations, codes of practice and working rules relating to safety, health and welfare. A full operational risk assessment

will be undertaken before deployment that will continue to be reviewed and revised where necessary throughout the project.

1.15 A full Project Specific Safety Plan and Emergency Response plan will be developed ahead of any field operations.

1.16 INEOS will take all necessary precautions to prevent damage and/or pollution to the environment. Emphasis will be placed on ensuring the survey does not compromise the landowners' and occupiers' management requirements and practices applicable to the Basic Payment Scheme and Entry Level and Higher Level Stewardship Scheme.

1.4 Structure of Report

1.17 Chapter 2 of this report explains the context of the surveys within the GPDO. It outlines the relevant restrictions and requirements and justifies how the proposed survey meets these.

1.18 Chapter 3 describes the environment within the survey area, and identifies particularly sensitive areas and possible receptors (expanded in Appendix 1).

1.19 Chapter 4 briefly summarises the methodology INEOS will use to collect geophysical data. This is outlined in more detail in the accompanying Method Statement. Section 4.5 outlines general environmental considerations that have been taken into account in the design of the survey and methodologies used, that minimise the environmental impact. In addition, Section 4.6 clarifies how the site-specific sensitivities outlined in Chapter 3 have been addressed in the survey methodology to minimise effects arising on these receptors. Appendix 2 provides a more detailed summary of a key means of environmental protection – Peak Particle Velocity (PPV) Monitoring (or vibration monitoring) which will be used at the outset of the survey to define (calibrate) appropriate stand-off distances from sensitive receptors to ensure safe vibration levels, and during the survey to check these safe vibration levels are achieved.

1.20 Appendix 3 presents a preliminary Environmental Method Statement, summarizing the general and site-specific protection methods outlined in Chapter 4. This is a live document which will change and evolve as surveys progress and further information is gathered from landowners and stakeholders, to supplement the defined parameters.

1.21 Chapter 5 provides a summary of the findings of the report and outlines INEOS's next steps to undertake the survey.

1.22 The report is supported by the following maps, and figures:

- Map 1 Boundary and Location of Seismic Survey Area
- Map 2 INEOS PEDL Areas
- Map 3 Environmental Designations and Identified Sensitivities
  - 3a - Special Areas of Conservation (SACs), Sites of Special Scientific Interest (SSSIs) and Sherwood National Nature Reserve

- 3b – Scheduled Monuments, Listed Buildings and Registered Parks & Gardens
- 3c- Local Nature Reserves and areas of Ancient Woodland
- 3d – Important Bird Areas
- 3e – Urban Areas
- 3f – Groundwater Protection Areas
- 3g– Aerodromes

- Figure A Theoretical Geological Mapping during a Seismic Survey
- Appendix 1 - List of Designations and Sensitivities
- Appendix 2 - Seismic Source Safe Operating Distances and PPV Monitoring
- Appendix 3 - Preliminary Environmental Method Statement

2. Justification for Permitted Development

2.1 Surveys as Development

2.1 Development is defined in the Town and Country Planning Act 1990 ("the 1990 Act") as "the carrying out of building, engineering, mining or other operations in, on, over or under land, or the making of any material change in the use of any buildings or other land".

2.2 It is considered that intrusive works such as drilling shotholes for seismic charges is an "engineering operation". Therefore, for the purposes of this notification it is considered that these aspects of the proposed seismic survey comprise "development".

2.2 Seismic Surveys as Permitted Development

2.3 Seismic surveys for mineral exploration are considered in The Town and Country Planning (General Permitted Development) (England) Order 2015 (GPDO 2015) at Schedule 2 Part 17.

2.4 This refers to various Classes of mining and mineral exploration that are permitted development. National Planning Policy Framework defines "minerals of local and national importance" as being "minerals which are necessary to meet society's needs, including …oil and gas (including hydrocarbons)". Therefore, gas including shale gas is considered to be a mineral, and will be covered by policies relating to mining and mineral exploration.

2.5 Class J and Class K refer to the use of land for mineral exploration including seismic survey – Class J for temporary use (up to 28 days) and Class K for up to six months unless otherwise agreed with the Mineral Planning Authority (MPA). A summary is as follows:

- Class J: temporary use of land for mineral exploration – Permits <28-day seismic survey; forbids boreholes for petroleum development. Restrictions on location of operation, height of equipment and size of explosive charge (1 kg), hours of work, excavation size and number, tree felling and soil management. Requires restoration within 28 days of cessation of operation.

- Class K: use of land for mineral exploration - Permits up to six-month seismic survey; forbids boreholes for petroleum development. Requirement to notify MPA in advance of operations. Restriction on size of explosive charge (2 kg), height of equipment (maximum of 15 m), excavation size, tree felling and soil management. Requires restoration within 28 days of cessation of operation.

2.6 The permitted development rights were amended in 2016 following consultation, in the Town and Country Planning (General Permitted Development) (England) Amendment Order 2016 (2016 Amendment). This 2016 Amendment added rights for drilling boreholes for petroleum exploration (not relevant for the proposed seismic surveys) and also made minor amendments to protected areas and height limits of equipment permitted (to the 15 m maximum in the above summary).

2.7 It is noted that there are certain aspects of a particular development which could render it not permitted development, as outlined in Article 3 of the GPDO 2015 (as amended). These include creation of roadways or tracks, laying of pipelines, or development which is EIA development. However, these are not relevant to the proposed operations.

2.3 Relevant Class for Proposed Seismic Survey

2.8 As indicated above, the relevant Class depends on the timescale and nature of the survey.

Timescale – <28 days or <6months

2.9 The seismic survey will last for no longer than six months, and therefore the survey will be undertaken under Class K. This class requires prior notification of the MPA.

Nature of Survey

2.10 Seismic survey provides a picture of the underlying geology in the region, to build up a classification of the UK's geological structure. The British Geological Survey (BGS) is currently undertaking a programme of 3D seismic survey across the UK to assist its geological research. The nature of INEOS's proposed seismic survey will be similar to the proposed BGS work. INEOS will share data collected with the BGS, after a period of confidentiality.

2.11 Class K of the GPDO 2015 prohibits mineral exploration which would involve "boreholes for petroleum exploration". Mineral exploration is defined in the GPDO 2015 as "ascertaining the presence, extent or quality of any deposit of a mineral with a view to exploiting that mineral".

2.12 It is therefore considered that shotholes drilled for seismic survey are not "boreholes for petroleum exploration" as they are not drilled to test the presence, extent or quality of the petroleum (in this case petroleum within the shale). Instead, they are to develop a picture of the underlying strata. INEOS will then analyse the geological picture to assess the prospectivity of the area for shale gas.

Conditions of Class K

2.13 Class K permits seismic works for up to six months (unless agreed otherwise with the MPA).

2.14 The following conditions outlined in Table 2.1 will also have to apply to undertake work under Class K of permitted development. If these cannot be complied with, a planning application may be required.

Table 2.1: Conditions And Requirements To Proceed Under Class K

Condition	Justification
The MPA must be notified in advance of operations (specifying the nature and location of the development), and development shall not proceed before the relevant period of notification has elapsed (28 days or earlier if	This report initiates the "relevant period of notification". Operations will not commence until this period has expired. On expiration of this period, INEOS intends to commence work in

the MPA indicate they will not issue a direction under Article 5).	June 2017. The six-month window of operations is assumed to commence from **5 June 2017** subject to agreement in writing by the MPA.
No explosive charge of more than 2kg could be used.	INEOS will use charges of no more than 2kg.
No excavation could exceed 10m in depth or 12 square m in surface area.	No excavations will be required.
No structure assembled or provided could exceed 15 m in height.	All equipment will be less than 15 m as the drilling equipment proposed will be tractor mounted and only required to drill to 8-10 m depth. The maximum height of the mast of a drill unit at full extent will be 3.8 m, though it will be <3 m in transport.
Development must be carried out in accordance with the details in the notification unless the MPA has agreed otherwise in writing.	The proposed methodology is outlined in Chapter 4 of this report, and the accompanying Method Statement and Environmental Method Statement (preliminary EMS in Appendix 3). Development will be carried out in accordance with these details.
No trees on the land could be removed, felled, lopped or topped, or any damage caused, unless the mineral planning authority has agreed in writing.	No work to trees will be carried out without previously having gained agreement of the MPA. Root protection zones will be protected by ensuring sources remained an appropriate distance following a survey of the tree in the field.
Restoration (including removal of structures, waste, sealing boreholes, levelling of the topsoil and any necessary seeding and replanting) should be completed within 28 days of cessation of operations unless agreed otherwise by the MPA in writing.	Shotholes will be sealed and backfilled immediately on completion of operations, followed by restoration. Therefore, this condition can be met.
Development must cease no later than six months after the elapse of the relevant period unless the MPA has otherwise agreed in writing.	The full survey can be undertaken across the entire survey area within six months. Therefore, all work within Derbyshire County Council could be undertaken within six months.

2.15 In addition, the MPA, upon notification, could issue an “Article 5” direction, to require a planning application to be made, based on the defined reasons outlined below. An Article 5 direction to restrict the rights otherwise permitted under Class K can only be made by an MPA under certain conditions.

2.16 These include:

- The land on which the development is to be carried out is within a National Park, area of outstanding natural beauty, site of archaeological interest (unless certain exemptions apply), site of special scientific interest or the Broads

  – The proposed survey will not include any of these areas as addressed in Chapter 3 and 4. SSSIs located in the survey boundary area will not form part of the survey (no works within their boundaries).

- The development by itself or in conjunction with other notifiable permitted development which is already being carried out in the area would cause serious detriment to the amenity of the area

  – The methodologies outlined in the accompanying Method Statement (as summarized in Chapter 4) and Appendix 3 will ensure no serious detriment to the amenity of the area will occur. As INEOS is the PEDL licence holder, no other companies will undertake seismic surveys for the purpose of onshore hydrocarbon exploration in the same area, so no cumulative impacts will be relevant.

- The development by itself or in conjunction with other notifiable permitted development which is already being carried out in the area would adversely affect the setting of a Grade I listed building

  – Grade 1 listed buildings within the survey area are located as shown in Map 3b in Chapter 3. Within Derbyshire, these are the Church of St Lawrence in Whitwell, Balborough Hall north of Barlborough and the Church of All Saints in Steetley Holme, northeast of Whitwell. The proposed good practice measures to minimise landscape and cultural heritage impacts, including the use of small scale, mobile, temporary plant, will ensure there is no permanent adverse impact to the setting of the listed buildings. As INEOS is the PEDL licence holder, no other companies will undertake seismic surveys for the purpose of onshore hydrocarbon exploration in the same area, so no cumulative impacts will be relevant.

- The development would constitute a serious nuisance to the inhabitants of a nearby residential building, hospital or school

  – Good practice measures to protect residential amenity are outlined in Chapter 4 and the accompanying Method Statement. These include timing surveys to minimise impact, surveying during daytime only, ensuring limits on vibration at the nearest properties, provision of information to residents and traffic management schemes will prevent serious nuisance to these receptors. Residential/ occupied buildings (including hospitals and schools) will have safe stand-off distances applied during the survey. The temporary nature of the survey in any particular area will ensure no particular receptor is exposed to serious or long-term nuisance from the survey.

- The development would endanger aircraft using a nearby aerodrome
  - There are no aerodromes in the survey area in Derbyshire. The nearest is located to the west of Worksop (Netherthorpe airfield). Within 3 km of this (including some land within Derbyshire County Council area), all equipment will be less than 3 m in height (with the tractor-mounted drill intermittently extended to 3.8 m). The operator of the aerodrome will be consulted regarding timing of the surveys. There will therefore be no risk to aircraft. If seismic survey work was undertaken under Class J of the GPDO 2015, operations within 3 km of an aerodrome could proceed without notification as long as equipment was less than 3 m in height.

2.17 It is therefore concluded that there will be minimal impact on the surrounding environment and therefore no justification for the removal of permitted development rights for the surveys under Article 5.

3. Environment of the Survey Area

3.1 General Description of the Entire Survey Area

3.1 The survey area is located in the East Midlands, covering parts of Nottinghamshire and Derbyshire County Councils and Rotherham Metropolitan Borough Council. In total, the survey area covers 250.7 km2. Main settlements include Worksop in the north and Market Warsop and Shirebrook in the south. Sheffield is located to the north west of the survey area, though the survey will not extend into the boundary of Sheffield City Council.

3.2 The survey area includes a large proportion of INEOS PEDLs 307 and 308 and parts of PEDL 200 and 130 (operated by separate companies), 299, 300, 304 and 309 as shown in Map 1 in Chapter 1.

3.3 There is a diverse network of roads in and around the survey area including the M1, A57, A60, A61, A619 and A617, and many local roads. The railway network runs through the area, with lines from the north west to east, through Worksop, from north to south through Creswell, Langwith and Shirebrook, and from Langwith Junction to the east, via Market Warsop.

3.4 The area is characterized by a relatively urban/ suburban character. The key settlements to the north and west and to the south are joined by smaller settlements in between. There is evidence of urban and industrial character throughout the survey area, through several marches of pylons and the extensive road and rail network. There are also many areas of more rural character, including woodland (especially in the east, which is dominated by the woodland estates of Clumber Park and Sherwood Forest National Nature Reserve – though these are excluded from the survey) and agriculture. However, these areas are well connected to the surrounding towns, and there are several holiday villages and camp sites in the country parks in the east and south east. These rural, wooded areas are largely in PEDL 308 and in the north of 307, though the partial PEDLs covered by the survey also have rural characters which are generally agricultural.

3.5 The landscape is generally flat, especially in the east, with gently rolling hills to the west. In the rural areas, agricultural fields are generally bordered by mature hedges and trees, and there are some blocks of largely deciduous woodland. Watercourses in the area include the Chesterfield Canal and River Ryton in the north, River Meden, River Maun and River Poulter in the south and center, and the River Rother runs in the west. There are several large ponds and wetland areas, especially within woodlands and associated with old quarry works.

3.6 Photographs overleaf give an indication of the nature of the rural parts of the area. The photos were taken in PEDLs 307 and 308.

PEDL 308

PEDL 307

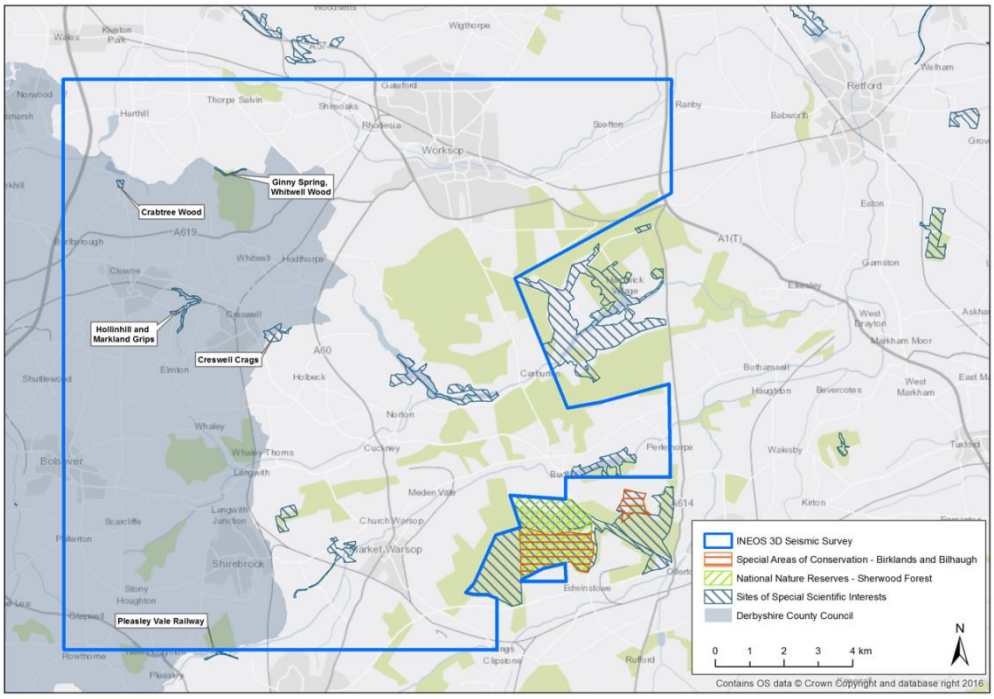
3.2 Designations and Sensitivities within Derbyshire County Council

3.7 A list of designations is provided in Appendix 1. An indication of how these sensitivities will be addressed within the survey is held in Section 4.6 and in Appendix 3.

Natural Heritage Designations

3.8 Map 3a shows the location of natural heritage designations in Derbyshire.

Map 3a: Special Areas of Conservation (SACs), Sites of Special Scientific Interest (SSSIs) and Sherwood National Nature Reserve (Derbyshire)



3.9 There are no international (Natura 2000) sites in the survey area within the MPA.

3.10 SSSIs within the survey area (though with no survey works within their boundaries) include:

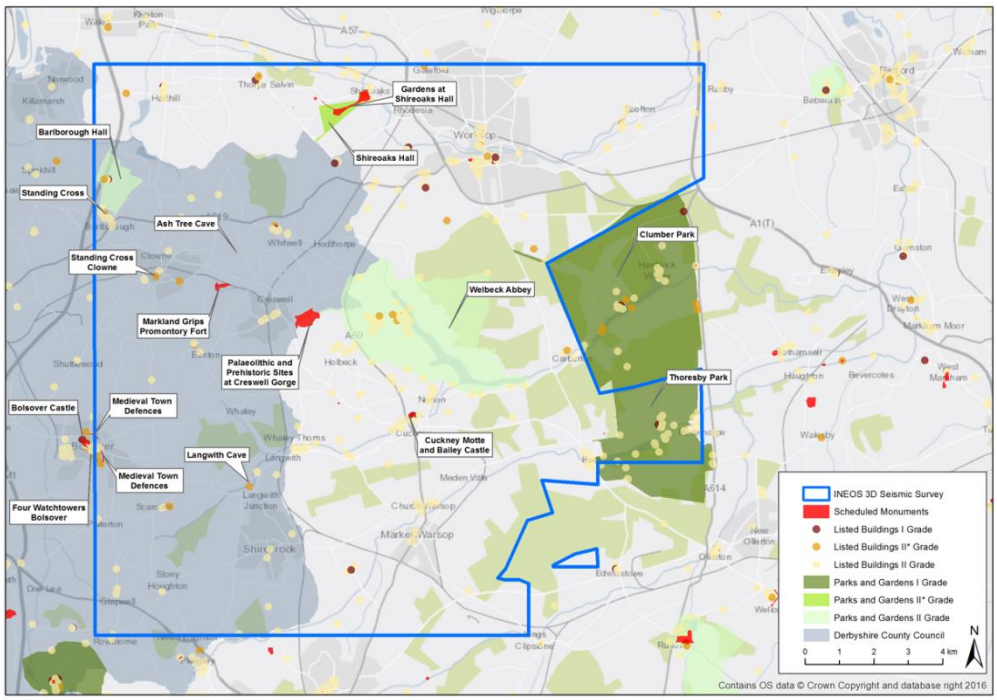
- Cresswell Crags (a geological SSSI)
- Ginny Spring, Whitwell Wood
- Hollinhill and Markland Grips
- Crabtree Wood

3.11 Pleasley Valley Railway SSSI is located just outside the survey area on the boundary of Nottinghamshire and Derbyshire authorities.

Cultural Heritage Designations

3.12 Map 3b shows the location of cultural heritage designations in Derbyshire.

Map 3b: Scheduled Monuments, Listed Buildings and Registered Parks & Gardens (Derbyshire)



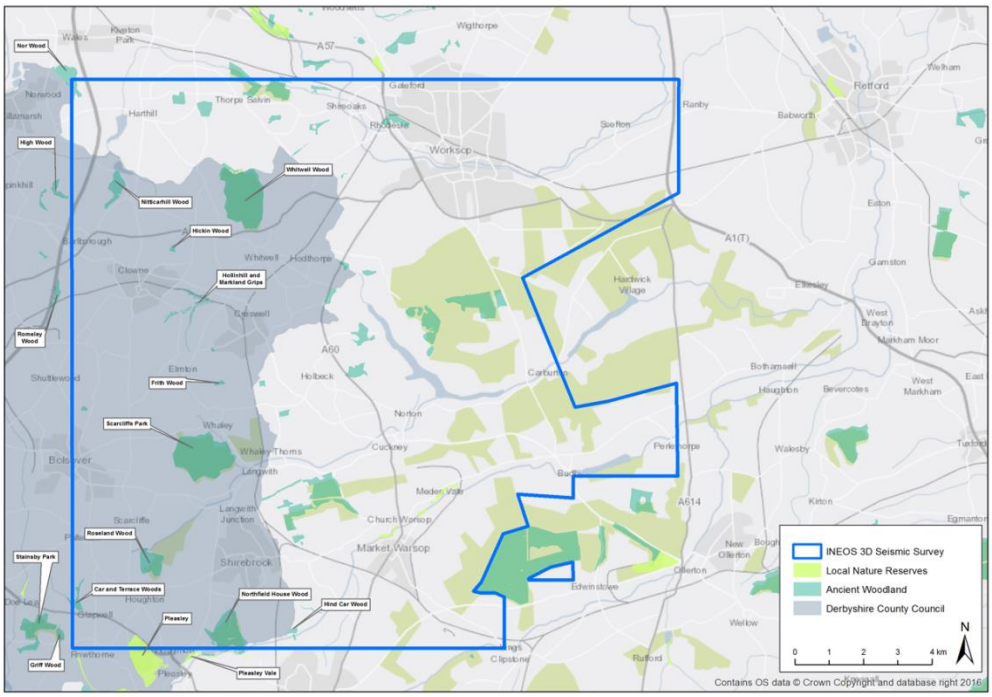
3.13 There are eight scheduled monuments within the survey area in Derbyshire, including palaeolithic monuments at Cresswell Gorge, Langwith Cave and Ash Tree Cave; medieval monuments around Bolsover, a promontory fort at Markland Grips and town crosses (as listed in Appendix 2). There are also two registered parks and gardens; Barlborough Hall and Welbeck Abbey (mostly in Nottinghamshire) – both Grade 2.

3.14 There are three Grade 1 listed buildings in the survey area in Derbyshire (two churches, and Barlborough Hall) 13 Grade 2* and 67 Grade 2, as listed in Appendix 1, with clusters around the settlements of Whitwell, Clowne, Creswell and Bolsover.

Non-Designated Natural Heritage Sites

3.15 Map 3c shows the location of Local Nature Reserves (LNRs) and ancient woodland in Derbyshire. There are 18 areas of ancient woodland within or partly within in the survey area including Whitwell Wood, Northfield House Wood, Scarcliff Park and Hollinhill and Markland Grips. Pleasley LNR is also located within the survey area.

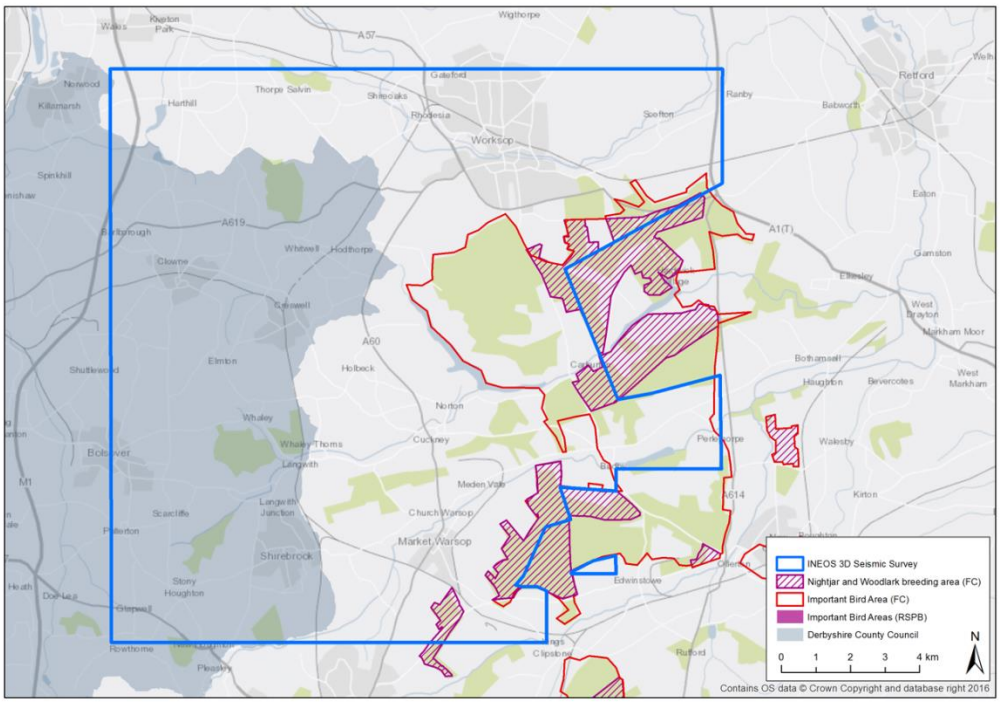
Map 3c: Local Nature Reserves and areas of Ancient Woodland (Derbyshire)



3.16 The East Midlands is an important area for birds, and in particular Woodlark and Nightjar – two species listed on Annex 1 of the European Birds Directive, as well as receiving protection through the Wildlife and Countryside Act 1981 (as amended). The Birds Directive requires member countries to identify and notify sites as Special Protection Areas (SPAs) sufficient to address the conservation of the species within its natural range. The Sherwood Forest, in which this species breeds, has been suggested to be proposed as an SPA, but there are no current proposals for this to be progressed, and no consultation on a 'proposed SPA (pSPA)' status for the site has been initiated by Natural England to date.

3.17 The boundary of this "might be" SPA is shown on Map 3d. It is not located in Derbyshire. However, protection of these two species will be an important consideration (as well as other breeding bird species) even outside the identified area.

Map 3d: Important Bird Areas (Derbyshire)



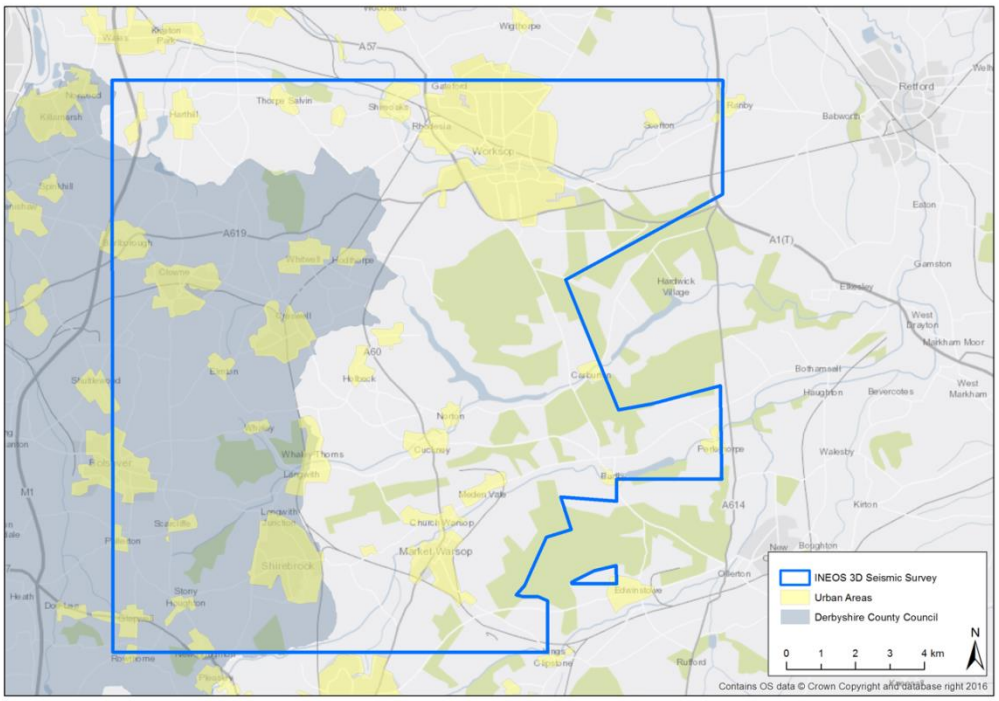
Urban Areas

3.18 Map 3e shows the location of urban areas and settlements in Derbyshire. Those in the survey area include Barlborough, Clowne and Whitwell in the north, Creswell, Elmton and Bolsover centrally and Shirebrook, Stony Houghton and Glapwell in the south.

3.19 There are numerous residences within these towns and villages, though between them there are more isolated farms.

3.20 The survey area is covered partly by the green belts in the North East Derbyshire Local Plan Review.

Map 3e: Urban areas (Derbyshire)



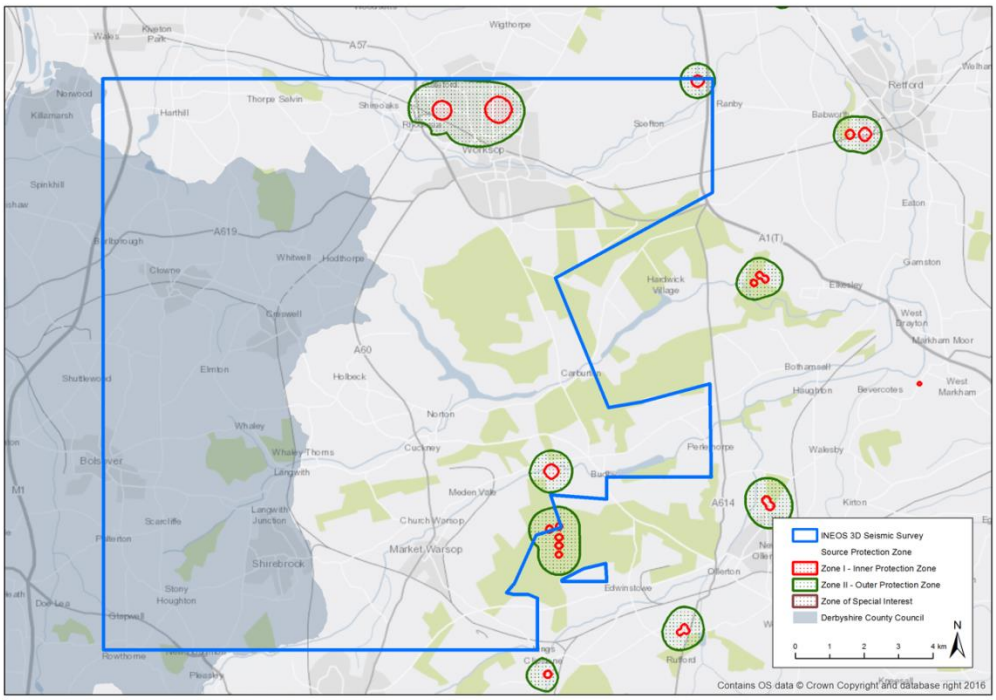
Groundwater Protection Areas, Water Receptors and Flood Risk

3.21 Map 3f shows the location of groundwater source protection zones. There are none located in Derbyshire in the vicinity of the survey.

3.22 Watercourses within the survey area in Derbyshire include the River Poulter and its tributaries including Poulter Well. The River Rother is the main watercourse to the west of the survey area, west of Bolsover. Waterbodies include ponds around Pleasley in the south, ings associated with the River Poulter at Langwith and reservoirs around Creswell, Clowne and Barlborough.

3.23 Although the banks of some of rivers and ponds are subject to flooding, there are no extensive areas of flood risk. Flood plains of the River Rother are located where it joins with the Chesterfield Canal, north of Staveley around Eckington and Mosborough outside the survey area.

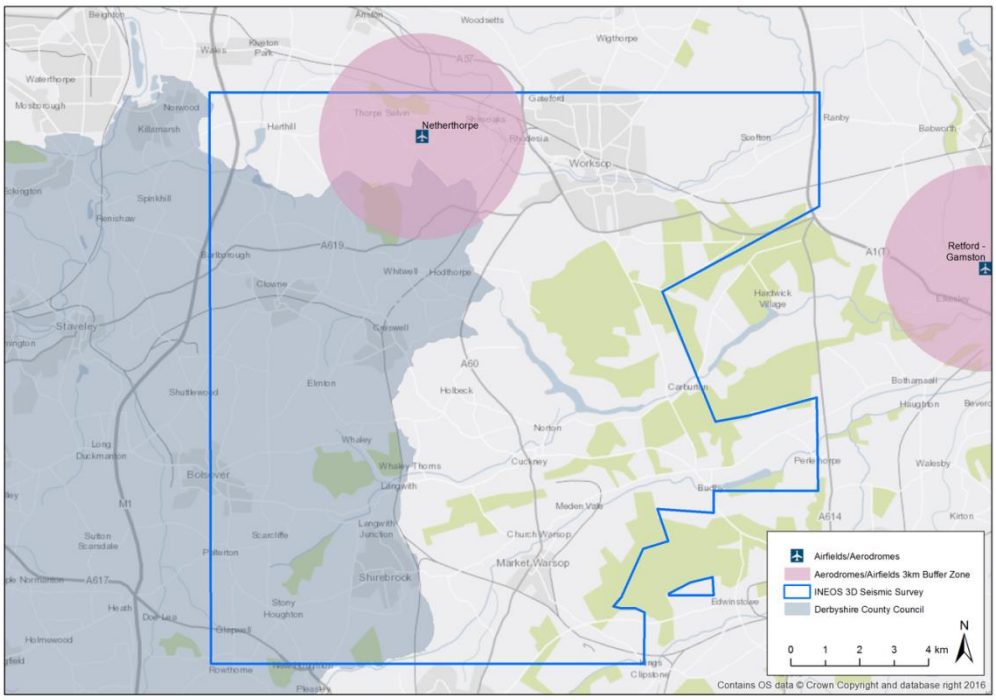
Map 3f: Groundwater Protection Areas (Derbyshire)



Aerodromes

3.24 Map 3g shows the location of aerodromes within the survey area, with a 3 km buffer. Netherthorpe aerodrome is located within Rotherham but close to Derbyshire, and the 3 km buffer extends to Derbyshire.

Map 3g: Aerodromes (Derbyshire)



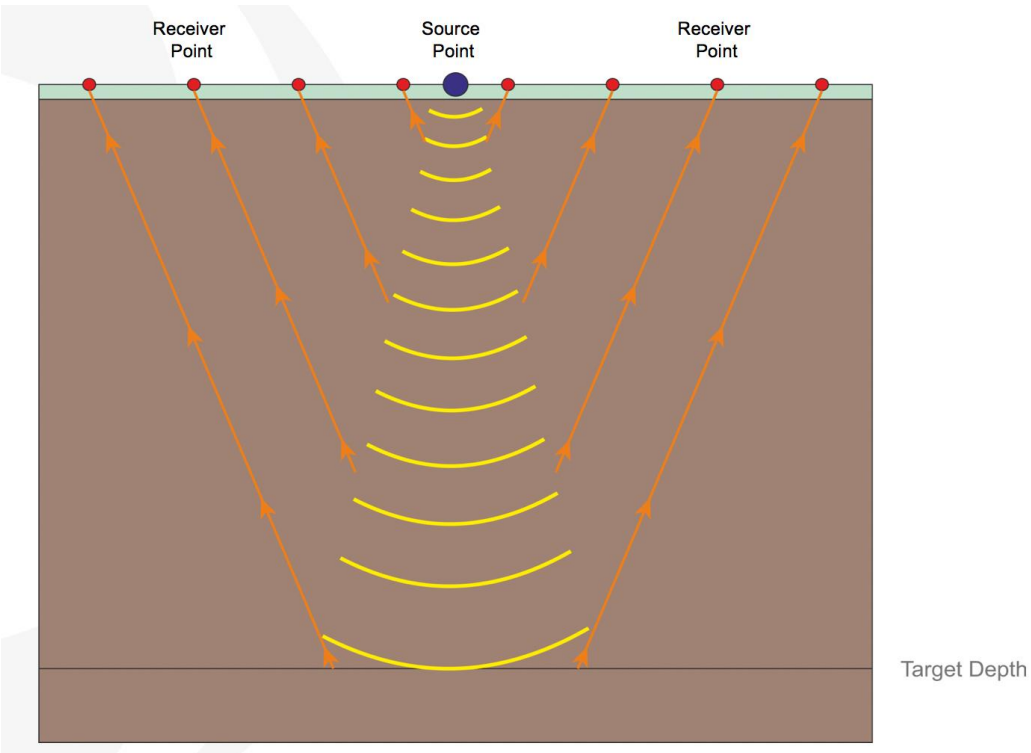
4. Survey Methodology

4.1 General Survey Description and Theory

4.1 Seismic surveys can be undertaken in several ways and use well-established techniques for mapping subsurface strata, used to identify hydrocarbon reserves in the UK onshore area. Such techniques are commonly employed throughout the United Kingdom by exploration companies as part of accumulation of knowledge and understanding of the subsurface environment. Power, utility and engineering concerns involved in the design and construction of power stations, underground gas storage facilities or similar type projects also routinely use seismic surveying techniques.

4.2 Seismic survey is a technique to map subsurface geology using seismic (sound) waves. The method requires a controlled seismic source, positioned on or near surface to generate a high frequency seismic reflection signal which passes through the various subsurface rock strata. Where changes in rock type and density are encountered by the signal, part of this signal is refracted and reflected to surface where a "receiver" (a series of connected microphones (geophones) or individual stand-alone recording nodes) receives its return as shown in Figure A.

Figure A: Theoretical Geological Mapping during a Seismic Survey



4.3 By recording this 'two way' time, the depth, extent and characteristics of rock strata can thus be determined and imaged. The resulting picture can be used to identify various strata, geological faults and indicate the location of mineral deposits, including hydrocarbons such as oil and gas.

4.2 INEOS Survey Proposals and Methodology

4.4 INEOS proposes a “3D” surveying techniques within its PEDLs across the East Midlands. This differs from 2D survey data which is acquired on a line by line basis producing a series of individual ‘depth and length’ profiles. For 3D acquisition, data will be acquired from a grid or ‘patch’ of survey lines covering a specific area of land. This will provide a multi directional image beneath the surface. The acquisition programme will comprise a series of individual survey lines, with positional and spacing parameters of the line programme being dependent on the required subsurface target depth and degree of resolution that is required.

4.5 The methodology for the proposed seismic survey is described in detail in Chapter 3 of the accompanying Method Statement. This outlines the stages that are followed as a seismic survey is planned, permitted and executed. It outlines how seismic operations will be managed in and around specific areas of the survey and the potential infrastructure and industries encountered. Photographs of equipment are also provided.

4.6 In summary the following methodology will be used (Stage 1 and 2 have already been undertaken):

- Stage 1: Consultation with Landowners and Occupiers, acquisition of relevant permits and notifications, following consultations with relevant bodies
  - A licence agreement will be put in place to permit works on private land, and relevant agreement with landowners and occupiers made. The MPA will be notified under the GPDO 2015, the Environment Agency will be notified under Section 199 of the Water Resources Act 1991, the Oil and Gas Authority will be notified under Petroleum Operations Notice (PON) 14b and relevant permits under the Explosives Act 2014 will be acquired.
- Stage 2: Topographical Surveying & ‘Pegging’ of Source and Receiver Positions
  - A pre-entry survey of land condition will be made, and any in-field obstacles, utilities or other constraints noted. An Environmental Clerk of Works (EnCoW) will walk with the survey team (or access land via an All Terrain Vehicle- ATV) to assess any local environmental restrictions. Metal flagged pegs will be placed in potential locations for sources and receivers considering landowner requirements, and locating positions following road and field boundaries where possible. Relevant safe distances from buildings and utilities and stand-off distances from environmental restrictions and heritage sites will be followed (Appendix 1 in Method Statement and Appendix 2 of this report). An assessment will also be made as to the type of seismic source that will be used at each location. This will be dependent on terrain, access to the area, environmental restrictions, subsurface constraints and geophysical objectives. Landowners will have an agreed period to review and comment on the marked location.
  - In general, sources and receivers will be located at 50 m intervals, though this can be varied if ground sensitivities require a reduced density.

- Stage 3: Field Operations

  – Maps will be developed with the source or receiver locations, access points and the routes to be taken within the individual properties. Utility services and constraint locations will be marked up to ensure that no encroachment occurred. Each landowner/ occupier will be allocated an Agricultural Liaison Officer (ALO) with whom they could liaise with for the duration of the surveys.

  – *Receiver Deployment* - Four field operatives will access the site by foot or ATV to lay the receivers (geophone, battery and data recorder) in the location of the pegs. Geophones, batteries and data nodes will be anchored in the ground with a short (approx. 7 cm) spike, pushed in by foot. Six to twelve geophones will be grouped around a data recording node. Receivers are shown in Figures 2-6 of the Method Statement. Receivers will be deployed over a wide area to record each individual source point, and will record continuously during operations. The receiver deployment process will result in negligible disturbance or damage to the ground surface. Receivers will be left in place for approx. seven to ten weeks at a time, (with redeployment possible at the same location), with batteries being changed periodically (generally every two to three weeks).

  – *Seismic Source Generation* - Two possible source types will be used as outlined in Section 3.3.2 of the Method Statement. These are “vibroseis” trucks, or small charges deployed down shallow shotholes. The decision on source type is generally made during the surveying stage (Stage 2 above).

  – Vibroseis trucks will travel along the survey route in a pod of two or three trucks, linked telemetrically to ensure the seismic source (a 12-30 second “sweep”) took place in unison. There will be no requirement to remove vegetation for the sweeps.

  – Shotholes (<10 cm diameter) will be created by a small drill or auger mounted on a tractor or quad bike. The shotholes will typically be 8-10 m in depth. No drilling muds or fluids, other than clean water, will be used. Any spoil will be either used for backfilling, removed from the site or dispersed in the field. The shotholes will be loaded with a charge of <2 kg of a non-toxic explosive (the size used will depend on the depth of the shothole, the near surface geology and the lay of the land). Should holes be pre-augered a number of days prior to the loading of the charge, then to ensure the hole remains open plastic piping will be used to temporarily case each hole, which will be removed once the charge was inserted. Once the charge was inserted, the shothole will be backfilled with soil, gravel or bentonite (inert clay which expands when in contact with water), with the appropriate wiring (located at least 0.5 m below ground level) left available for later use. On detonation, a muffled thud can be heard.

  – In general, vibroseis vehicles will be used in preference to shotholes, due to the speed at which the survey can be carried out. However, shotholes will be used if specifically requested by the landowner, if vibroseis vehicles

could not access the source location due to constraints such as field entrances or overhanging trees, if the ground were not hard enough to support vibroseis vehicles, or if stand-off distances could not be achieved.

– *Data Acquisition* - A recording and communication truck will travel with the survey team. The team within the recording truck will ensure that for each source fired there are sufficient receivers deployed on the ground to initiate the source. This team also coordinates which locations the vibroseis trucks should move to next or the order of the shotholes, and coordinates the timing between all equipment. The team will also Quality Control data harvested from the recording units to ensure it is of sufficient quality to meet the geophysical objectives. Communication between the different teams will generally be by handheld radio.

– *Retrieval of equipment* - Once data acquisition was complete across a given area the receivers will be collected by hand or by personnel on ATV, along with the batteries, data nodes and the flagged peg. Wires will be removed from each hole and additional backfilling of source locations undertaken if required using pea gravel. All equipment will be audited on deployment and retrieval to identify any lost or stolen equipment.

– *Restoration* - All land will be reinstated to a condition as near as reasonably practicable to that existing prior to entry and as evidenced in the pre-entry record of condition. All apparatus below the ground surface will be removed and any shotholes sealed below plough depth with a small concrete plug. Any residual backfilling will be undertaken, and the land will be reseeded where necessary. All used materials will be removed on an ongoing basis during the survey. Vibroseis sources will require minimal restoration, but pre-survey route audits will establish if any restoration is required.

4.7 Further details on the surveying methodology are provided in the Method Statement.

4.8 Operations will take place between 7am to 7pm conducted on a seven day a week basis, unless specifically agreed to extend with the landowner. No seismic activity will be conducted between dusk and daybreak. Temporary welfare vans will be placed in appropriate locations with landowner agreement.

4.9 In addition to the seismic survey crew the following contractors will be engaged by INEOS to accompany the crew:

- Land team (ALOs) to ensure landowner agreements and restrictions are complied with.

- Environmental Clerk of Works/ EnCoW (ecologically trained) to ensure environmental restrictions are complied with, in particular with regard to identifying nests or resting places or birds or protected mammals and also enforcing stand-offs from trees, heritage features, watercourses and other identified environmental features.

- Vibration consultant to undertake Peak Particle Velocity (PPV) monitoring as outlined in Section 4.4 and Appendix 2.

- Explosives contractors holding relevant licences to transport and handle explosives, to undertake setting and detonation of shothole charges, and removal and disposal of any subsequent wastes.

- Security team with experience and accreditation to guard and protect the high value technical equipment and shotholes used during a seismic survey throughout the prospect area, and respond to any incidents or protester demonstrations in liaison with the local police force. An Incident Response number will be supplied to landowners and their agents prior to the commencement of operations, and a response plan will be developed.

4.10 INEOS and its contractors are companies with extensive experience of undertaking operations across the UK. The companies are committed to ensuring high standards of health, safety and environmental protection, and operate in accordance with strict management practices and procedures. INEOS and its contractors have in place all necessary insurance, including adequate third party cover and environmental liability insurance.

4.11 INEOS will hold local, advertised events to inform the public about what they can expect to see, when operations will commence and how long they will last. Landowners will be notified of the dates of these events.

4.3 Protection of Agricultural Land, Infrastructure and Utilities

4.12 Section 4 of the accompanying Method Statement outlines how works in agricultural land will be undertaken to minimise disruption to agricultural works. This includes placing receiver and source locations within tramlines or grass field margins, and ensuring agricultural vehicles could pass over receivers, cables and marker pegs. Special measures will be taken when surveying in fields with livestock, including bio-security measures. Care will be taken to preserve land drains, and if damage occurs, replacement drains will be installed during restoration.

4.13 In amenity land, or land such as golf courses, receivers will be marked out with canes and high visibility tape to help prevent trips on cables and equipment. All field operations staff will wear appropriate PPE including hard hats and fluorescent jackets on site.

4.14 Where operations take place on highway land (grass verges) INEOS will work with the local highways authorities to comply with legislation to undertake seismic activities along highways. This is outlined in Section 5 of the accompanying Method Statement. INEOS will develop a Traffic Management Plan (TMP) for approval with the highways authorities prior to commencement of activities along a highway. This will include accepted routing of vehicles, any restrictions on timing and means of traffic control during surveys (e.g. arrows, stop/go board). This will minimise disruption to other road users and ensure safe working.

4.15 Protection of utilities (Section 6 of the accompanying Method Statement) will involve ensuring utilities service providers are aware of the survey, and designing the survey to

ensure all restrictions and conditions are applied. Industry approved stand-off distances to general utilities are illustrated in Appendix 1 of the Method Statement.

4.4 Vibration Monitoring

4.16 Seismic energy sources are designed to direct the sound energy downwards but due to the varying near surface geology some of this energy is directed sideways, this degrades rapidly with distance and the distance varies with different unconsolidated surface geology.

4.17 When undertaking both seismic charge and vibroseis operations within close proximity to buildings, utility services etc., peak particle velocity (PPV) monitoring will be conducted to strict British Standard safety tolerances. This will identify the transient ground vibration levels experienced at or near the surface.

4.18 Appendix 2 outlines the theory behind the establishment of stand-off distances, based on thresholds at which cosmetic damage could feasibly occur to fragile buildings (15mm/s Peak Particle Velocity) and levels at which vibration is perceptible to humans (approximately 1 mm/s) and when it could potentially be annoying/ disturbing (approximately 5 mm/s). These human “disturbance” levels could also be influenced by the perception of potential damage, even though this is highly unlikely at such levels. For example, vibration caused by a person walking in a room can exceed 5mm/s at the wall of the room, and slamming a front door to a house can result in vibrations of 5mm/s at the far side of the house (and over 25 mm/s at the wall adjacent to the door). Jumping in a room can result in measurements of over 15 mm/s at the wall of the room.

4.19 The avoidance of disturbance to residential and environmental receptors for the purposes of INEOS’s proposed survey will use a threshold of 15 mm/s and 5 mm/s respectively at the outset. Stand-off distances to achieve this will be determined through initial tests at the outset of the field surveying process, using an area of land with no sensitive receptors in the vicinity. A series of vibroseis sweeps and shotholes will be made approaching a PPV meter, using different numbers of vehicles, different intensities of the vibration peak force (generally 15% to 90%) and different charge sizes (not exceeding 2 kg) for shotholes. The PPV arising from these tests will be used to establish distances where “safe” vibration levels could be achieved. These will be tested throughout the survey, as vibration propagation can vary in different geologies and substrate types.

4.20 Field experience suggests that distances will not exceed the conservative distances outlined in the stand-off tables in Appendix 1 in the Method Statement, though there may be local variations. PPV monitoring will be undertaken at sensitive receptors throughout the survey to ensure appropriate vibration levels are maintained.

4.21 It is acknowledged that some receptors may be disturbed by features of the survey separate from the vibration impact. For example, breeding birds may be disturbed by the close passage of people or vehicles to their nest, regardless of any vibration. Therefore, where the exact location of sensitive receptors is unknown or where a detailed survey could cause more disturbance than would result from the survey proceeding cautiously, the conservative stand-off will be maintained from possible receptors (for example, habitat that could be suitable for sensitive species). During the

survey, the EnCoW will observe for signs of any disturbance caused by the approaching survey outside this conservative stand-off. Should disturbance be observed the survey would move from the area, and any further survey work on return to the area would use a lower “maximum” PPV level in the vicinity of that particular receptor (by increasing the stand-off or decreasing the source intensity).

4.5 General Environmental Considerations

4.22 As outlined in Appendix 1 of the accompanying Method Statement, general procedures will be followed over the entire survey area to ensure environmental protection, similar to measures used to protect agricultural, amenity and highway land. Specific procedures and restrictions within the Derbyshire survey area to protect receptors are outlined in Section 4.6. The general and site-specific considerations are combined in Appendix 3: Preliminary Environmental Method Statement.

4.23 These measures will be put in place to minimise impacts from:

- Noise and vibration
  - These would be the most obvious impacts arising from the surveys and could arise from the seismic sources (seismic sweeps or use of charges) and also vehicles transporting the survey team and equipment, as well as creation of the shotholes or other survey preparation. Receptors could include people in nearby residences or non-residential buildings or ecological receptors (birds, bats etc.). Vibration could also affect utilities such as buried pipelines or cause cosmetic building damage without appropriate controls. Stand-offs from these receptors (either directly, or by routeing survey vehicles away from sensitive receptors), and controlling the size of the seismic source, accompanied by vibration monitoring will be the main mitigation as addressed in Appendix 2 and Section 4.4. Timing of surveys is also important in reducing noise-related disturbance.
- Traffic
  - The impact would primarily be due to the slow moving vibroseis trucks on the public highway. Staff and delivery vehicles will also be required, but these will be small in number in the context of background traffic numbers (each survey team will travel in one or two vehicles). Issues associated with road condition of the public highway will be addressed through access agreements reached with the relevant Highway Authority. Air quality issues associated with the traffic will be minimal compared to background levels. Dust generation will be minimized through good practice on roads and in fields during vehicle use and drilling, including damping down fields in very dusty conditions.
- Visual Effect of Surveys
  - Very temporary small-scale landscape impact could occur as a result of equipment forming a new feature within the landscape. This will be of a similar nature to that caused by agricultural vehicles; however, it could

temporarily affect views from certain receptors including settings of cultural heritage features. The key mitigation to prevent these impacts will be the temporary nature of the survey in a particular area (less than six months over the entire survey area, and likely no more than two to three months in any one area, if there is a gap between drilling, loading and setting off shotholes, followed by restoration) and the height of the equipment used (the tractor-mounted drilling unit will be approximately 3.8 m fully extended and less than 3 m in transit, and less than the height of surrounding trees and structures). There will be no requirement for lopping of trees for the survey without prior agreement from the MPA. Surveys will not take place at night, minimizing the requirement for temporary lighting.

- Crossing of land and drilling into soil
  - The vibroseis trucks and tractor-mounted drill unit to create shotholes will be able to traverse bare ground in a similar way to agricultural vehicles, and will use existing field entrances where possible. No new tracks will be required. Where soil is at risk of compression (for example, in areas of high water table, or where there could be unrecorded cultural heritage interest in non-agricultural land), existing tracks will be used, or tractor-mounted drills used rather than vibroseis trucks. Only water will be used to drill into the soil and non-toxic charges will be used. Shotholes will be sealed and backfilled after use. There will be no significant emissions from the use of charges due to careful control of their size, composition and use.

4.24 A Project Specific Safety Plan will be developed ahead of any field operations and measures outlined herein (general and specific) will form part of this.

General Survey Restrictions and Stand-offs

4.25 No **sources or receivers** will be placed in any of the following designated areas:

- Sites of Special Scientific Interest (SSSIs)
- Scheduled Monuments
- Areas of standing water or watercourses

4.26 Designations including Birklands and Bilhaugh SAC and Sherwood Forest NNR are excluded from the survey area.

4.27 No survey vehicles will pass through these areas, unless on the public highway.

4.28 In addition, no **sources or receivers** will be placed in private gardens. No receivers or shotholes will be located within the road carriageway, and they will be placed in such a way as not to obstruct footpaths, bridleways or private entrances.

4.29 When seismic **sources** are generated, stand-offs as below will be retained from the following receptors. As indicated in Appendix 2, these generic figures have been used to guide survey design, but will be finalised following agreement with landowners and relevant regulatory bodies, and clarified in the field following PPV testing. The key aim

of stand-offs is to prevent potential damage or disturbance to the receptor by reducing PPV experienced by the receptor. These incorporate industry-approved PPV levels to ensure no damage to property, disturbance to receptors or harm to environmental sensitivities. However, in the field this distance could be decreased, or may need to be increased:

- Occupied buildings, hospitals or schools – 50 m, unless otherwise agreed by the landowners and safe distances for PPV can be achieved (see Appendix 2)

- Listed Buildings – 50 m from the listing (curtilage of the building), unless otherwise agreed with Historic England and the landowner and safe distances for PPV can be achieved (see Appendix 2)

- Scheduled Monuments – 50 m from the designation boundary unless otherwise agreed with Historic England and the landowner (dependent on safe levels of PPV being achieved)

- Trees –Root Protection Zone, which will be determined in the field by the EnCoW (likely similar to the crown spread)

- Veteran trees (over 400 years old, as advised by landowner or EnCoW) - Root Protection Zone is considered as the area around the tree whose radius is 15 times the diameter of the tree at breast height or 5 m beyond the crown, whichever is the greater

- Watercourses, including field drains and standing water bodies – 8 m

- Private Water Supplies – i.e. springs or watercourses used for water supply (identified by landowner or manager) – 50 m (to be refined by the site specific PPV monitoring)

- Known badger setts (identified by landowner, site manager or pre-operational survey by EnCoW) – a stand-off to ensure <5 mm/s PPV. A conservative 50 m stand-off will be maintained during pegging, to be refined by the site specific PPV monitoring

- Known holts, nests, corridors for otter, water vole, bats or other protected mammals (identified by landowner, site manager or pre-operational survey by EnCoW) – a stand-off to ensure <5 mm/s PPV. A conservative 50 m stand-off will be maintained during pegging, to be refined by the site specific PPV monitoring

- Known nests of wild birds (identified by landowner, site manager or pre-operational survey by EnCoW) – if surveys were undertaken within the breeding bird season, a stand-off to ensure <5 mm/s PPV at nests will be used. A conservative 50 m stand-off will be maintained during pegging, to be refined by the site specific PPV monitoring

- Habitat that could be suitable for protected species, including breeding birds during the breeding bird season - If the EnCoW considers there to be potential for

a particular habitat to support protected species, a conservative 50 m stand-off will be maintained during pegging.

4.30 In addition to SSSIs and scheduled monuments, **receivers** will not be placed in the grounds (curtilage) of listed buildings (unless agreed with the landowner and Historic England) on banks of watercourses or standing waterbodies, or in other locations as agreed with the landowner and relevant bodies (to avoid disturbance to environmental features or protected species).

4.31 A key protection measure built into the survey is the potential to microsite sources and receivers in the field to avoid site-specific receptors such as nests, mammal burrows or runs, trees, hedges or small watercourses. This can only be determined on pegging the survey.

General Measures Protecting Ecological Interests

4.32 The EnCoW will work with the survey team during the pegging stage, to identify receptors requiring stand-offs, and during and after the survey, to observe any disturbance. If required, they will instruct for surveys to be halted or lower charges to be used if necessary.

4.33 A key potential for ecological impact could arise from noise and vibration disturbance to mammals, birds or reptiles in the vicinity of the survey, caused by use of charges or seismic sweeps. In addition, increased activity and traffic in the area could create disturbance. Vibration arising from source generation will be controlled through establishing conservative stand-offs (thus also limiting disturbance from presence of survey vehicles and personnel) and limiting the size of the source vibration to limit vibration at identified receptors to “safe” levels. Stand-offs will also apply to placement of receivers if this could disturb protected species or breeding birds. PPV monitoring as outlined in Section 4.4 and Appendix 2 will be undertaken where appropriate. Such controls will also avoid the potential for physical vibration damage of fragile receptors should levels not be controlled.

4.34 In addition, measures to minimise noise and vibration, including limiting surveys to daylight hours will be used.

4.35 If an area has particular potential for breeding birds, the surveys will take place outside of the bird breeding season where possible (i.e. generally September-January inclusive, the breeding season being February-August). If this is not possible the EnCoW will identify nesting potential and require appropriate stand-offs for sources and receivers. Sensitive areas will be observed before, during and after the survey for bird disturbance.

4.36 Where nearby habitat is potentially suitable for other protected species (for example bats, badgers, water vole, or otters) stand-offs will be maintained. For example, no shotholes will be drilled within 8 m of watercourses, and receivers will not be sited in or on the banks of watercourses. This will avoid impact to populations of otters and water voles, as well as protecting the integrity of the watercourse for any fish, invertebrates or other riparian animals using the watercourse.

4.37 There is anticipated to be minimal direct damage to habitats as a result of the surveys. Shotholes will cover a minimal area with limited vegetation clearance or disturbance

necessary. Where required for agricultural purposes (for example, if receivers required to be buried to allow grazing of livestock) this will only take place in mid-field with the agreement of the landowner, and not in field margins (unless specifically requested by the landowner and agreed with the MPA).

4.38 Where possible, existing field entrances will be used for access, to avoid removal of sections of hedges. Any trimming of hedges (if required) will be carried out outside of the breeding bird season or following a breeding bird survey (undertaken by the EnCoW).

4.39 No trees will be felled, lopped or topped as part of the survey unless agreed with the MPA, landowners and other relevant bodies. No activities liable to damage trees will be undertaken, due to the protection measures in place. Stand-offs from trees at least equal to the crown spread (or greater for veteran trees as outlined above) will be employed when pegging for source points; this will avoid Root Protection Zones, and also minimise disturbance to any unidentified roosts within the tree.

4.40 The overall surface impact of the proposed surveys on rural environments will be similar to agricultural work, so no specific surveys are proposed. Any disturbance will be localized and temporary, and will not permanently affect the relevant populations.

General Vehicle Use

4.41 A site-specific Transport Management Plan will be followed including accepted routeing of vehicles and means of traffic control during surveys (e.g. stop/go board). This will minimise disruption to other road users and ensure safe working. It will also ensure that routes of vehicles will not pass through especially sensitive areas where possible, and will avoid unsuitable sections of road; for example, sections of road with a weight limit which vehicles will exceed (particularly applicable for vibroseis vehicles).

4.42 Any safety measures and temporary road signage will comply with Chapter 8 of the Department of Transport's Traffic Signs Manual, 2009. Instructions of Police and Highways Authority will be followed in relation to management of slow moving vehicles.

4.43 Pre-and post-survey assessments of the routes to be followed will be undertaken and any damage made good.

4.44 Traffic speeds will be kept low to avoid noise and vibration effects at homes and non-residential receptors. Staff will travel to the survey area by minibus (or similar) to the survey, to minimise staff travel movements.

4.45 Timing of surveys will address the potential to avoid residential areas in peak times (for example, to avoid peak periods of traffic including school drop off and pick up times, or timings to protect hospitals). Any route or time restrictions will be strictly followed.

4.46 All field personnel drivers will be ADR certified[1].

4.47 Vehicles have the potential to create pollution through fuel drips or leaks. To avoid this, all vehicles will be regularly serviced and maintained to prevent accidental pollution.

[1] Certification in accordance with European Agreement concerning the International Carriage of Dangerous Goods by Road

Hoses and valves on vehicles will be checked for wear daily and immediately replaced where required. Where possible, vehicles will be fully fuelled prior to field entry, and any necessary refuelling of vehicles will be undertaken within designated safe areas – for example in farm courtyards or hardsurfaced areas by prior agreement with the landowner, and not on fields or open land. The company refuelling procedure will be followed, which requires compliance with UK oil and fuel storage guidance [2]. Biodegradable hydraulic oil and lubricants will be used in the vehicles where possible.

4.48 All vehicles will be supplied with the appropriate commercial spill kit. Spill kits will also be available from the mechanic and security vehicles. In the unlikely event of a fuel or oil spillage, the relevant landowner and the Environment Agency Incident Response Hotline will be informed.

4.49 Operations in dry, windy conditions will be monitored to ensure dust is not created. Damping down equipment will be used where appropriate to avoid dust blow. Wheels will be cleaned on leaving fields where necessary, and road sweeping undertaken to avoid dust and dirt being tracked onto the roadway.

4.50 When requiring to travel off-road, only vehicles with appropriate tyres will be used to avoid damaging soils. Track mats may be used in appropriate conditions to further protect the soil.

Other Environmental Protection

4.51 No shotholes will be drilled in Groundwater Protection Zone 1.

4.52 All equipment will be less than 15 m tall (to comply with GPDO requirements), with further restrictions in the vicinity of aerodromes. In practice, the majority of equipment will be less than 3 m in height, with tractor-mounted drills less than 3.8 m when the mast is fully extended (and less than 3 m for the majority of the time).

4.53 Any lighting needed for low-light daytime conditions will be low intensity, temporary and angled to the ground.

4.54 Only charges non-toxic to the soil will be used. Management of setting off charges will ensure there were no undetonated charges left in the ground. Guidance produced by the HSE and CBI (Guidance for the Safe Management of the Disposal of Explosives) will be followed.

4.55 There will be some waste arising from the surveys from packaging, residual material from charges such as the cap wire, and staff general waste. This will be removed from the site and licensed carriers and disposal sites will be used if needed. The Waste Management Plan within the Project Specific Safety Plan will be followed in relation to waste reduction and recycling where appropriate.

[2] https://www.gov.uk/guidance/storing-oil-at-a-home-or-business

4.6 Specific Environmental Protection Measures and Consultation Undertaken

Natural Heritage Designations

4.56 Natural England has been consulted in relation to their regulatory role under the Wildlife and Countryside Act 1981 (as amended) in terms of protected species and habitat protection, and their role as contracting agent for agri-environment schemes.

4.57 Discussion has been held in relation to protected species and wildlife protection; in particular the Sherwood Forest NNR, Birklands and Bilhaugh SAC and nearby SSSIs, and also SSSIs elsewhere in the survey area.

4.58 In addition, Natural England, RSPB and Nottinghamshire County Council (the current managers of the SAC) attended a meeting and walkover of the NNR and SAC in March 2017 where particular sensitivities were discussed and the potential for survey works to proceed were addressed. Key sensitivities in the SAC were veteran trees and nesting birds. Key sensitivities in Budby Forest South RSPB Reserve (part of Birklands and Bilhaugh SSSI) to the north of the SAC (a heathland) were breeding birds – especially woodlark and nightjar and tree pipit, and invertebrate assemblages (hymenoptera (bees and wasps) along bare tracks and paths) and the dingy skipper butterfly.

4.59 At this meeting, certain concerns and points of agreement were reached. These included:

- Vibration to veteran trees resulting in damage to dead/ dying or unstable trees - Even dead trees were important ecosystems within the SAC. Use of appropriate stand-offs with charges would minimise surface-level vibrations which may impact on veteran trees. Requirement to provide indication of how far impact would spread from shothole or vibroseis. Veteran trees would have a stand-off of a radius 15 times the diameter of the ancient/veteran tree at breast height, or 5 m beyond the crown, whichever is the greater.

- Ground compaction along access routes resulting in damage to tree roots – Shothole source laying with tractors/ ATVs would be less damaging than vibroseis trucks as ground compaction will be minimal. Where possible, established tracks should be used.

- Removal of tree branches overhanging access tracks – this will not be permitted under the GPDO restrictions without MPA agreement, as well as agreement from the other regulators and landowners. Low hanging branches were present along many tracks; especially in the SAC. Tractor access would therefore be more feasible than vibroseis access.

- The potential to drive vibroseis vehicles into the NNR - It was agreed that physical access would be difficult from all but a couple of entrances to the NNR (e.g. from the Forestry Commission land to the east and south of the SAC, and from the road to the northeast), and the nature of tracks within the NNR could also prove difficult to accommodate such vehicles without surface damage due to ground conditions. Damage to cattle grids was also considered a problem with vibroseis

vehicles. Main tracks in Budby forest were around the edge and only perimeter "surfaced" tracks likely to be suitable for vibroseis.

- Disturbance to public access in the NNR - Use of minor tracks could be less disturbing to public access than the main bridleways.

- Tractor/ ATV access for shothole drilling would be possible – certain areas were highlighted with open spaces and younger trees (diameter <1 m) which could host source points. Generally Natural England considers trees less than 1 m in diameter will be more robust to the activities associated with seismic surveys although their root protection zones should be avoided if possible. Risk of unexploded ordnance in Budby forest was raised.

- Potential for shotholes to damage bedrock - This would be especially important around SSSIs that were fed by groundwater.

- Disturbance and nest damage/ destruction of breeding bird species – Avoid use of vibroseis vehicles in the location of known nests. Use of shotholes and location of receivers should be limited to locations just off the existing tracks. Works should be undertaken outside the breeding bird season (February to end August). Failing this, a pre-works check by an ecologist should be undertaken prior to establishing shotholes and laying receivers to avoid disturbing nesting birds and damaging or destroying nests.

- Damage to habitats supporting invertebrates in SSSI - Avoid use of vibroseis vehicles on bare and sandy ground. Access across the middle of Budby forest should be avoided, even on foot, to avoid damage to assemblages in sandy ground.

- Communication - Requirement to ensure ongoing communication with parties to address public questions and concerns.

4.60 Following from the meeting, INEOS made a commercial decision to exclude all such designated areas from the survey. The Sherwood Forest NNR, Birklands and Bilhaugh SAC, Birklands and Bilhaugh SSSI and Birklands West and Ollerton Corner SSSI (all located in Nottinghamshire) were entirely removed from the survey area, as they were on the periphery of the proposed area. Natural England therefore has no role under Section 28E (1)(a) Wildlife and Countryside Act 1981 (as amended and inserted by section 75 and Schedule 9 of the Countryside and Rights of Way Act 2000) in relation to carrying out works within a SSSI.

4.61 Regardless, liaison with these parties is continuing, to ensure protection of designated features when surveys occur outside the boundary of the designation. In particular, information on the vibration produced by the seismic source at different distances will be provided, to assist in establishing stand-offs from SSSIs and ground nesting birds.

4.62 The preliminary Environmental Method Statement in Appendix 3 outlines how these matters will be addressed in carrying out the survey. The key protection to SSSIs in Derbyshire is the avoidance of any survey works within them. There are no SACs, SPAs (or might-be-SPAs) or National Nature Reserves in the survey area in Derbyshire.

Cultural Heritage Designations

4.63 Historic England has been consulted with in relation to their regulatory role in protecting scheduled monuments, listed buildings and registered parks and gardens. This liaison is continuing, and information on vibration produced by the seismic source at different distances will be provided. This will assist with development of appropriate stand-off distances for the sites mentioned below, and the impacts on veteran trees and parkland trees in parks and gardens.

4.64 It is noted that vibration sources such as quarry blasting already take place in close proximity to culturally important features with no noted adverse effects, such as at Creswell Crags, directly south of a limestone quarry.

4.65 Particular concern has been expressed relating to vulnerable sites and structures including but not limited to:

- Thoresby Park – coal fissures – a registered park and garden with a cluster of listed buildings in Nottinghamshire, in the east of the survey area
- Shireoaks Hall - unstable structure – a scheduled monument in a registered park and garden in the north of the survey area in Nottinghamshire (and partly in Rotherham)
- Welbeck Abbey - tunnel systems – these are located within a registered park and garden in the survey area, spanning Nottinghamshire and Derbyshire
- Creswell Crags – this Palaeolithic scheduled monument is located within the survey area spanning Nottinghamshire/ Derbyshire
- Ash Tree Cave – a scheduled monument in Derbyshire. The cave has produced material from the Palaeolithic, Mesolithic, Neolithic, Bronze Age, Iron Age and Roman periods
- King John's Palace Old Clipstone – ruin & addition remains in surrounding field – the field and site is located approximately 300 m outside the survey area, to the south
- Rufford Abbey - ruin – located approximately 3 km southeast of the survey area, in Rufford, Nottinghamshire
- St Edmund's Church Holm Pierpoint - coal subsidence – although in Nottinghamshire, this is located approximately 25 km south of the survey area, to the east of Nottingham
- Annesley Hall and church – ruins – approximately 10km south of the survey area, south of Mansfield in Nottinghamshire

4.66 Of these, Ash Tree Cave and part of Creswell Crags and Wellbeck Abbey are located in Derbyshire.

4.67 The key protection to scheduled monuments in Derbyshire will be avoiding any survey works within them. In addition, a 50 m stand-off will be maintained from any source

points. Receivers will not be placed in the scheduled monument, but could be placed within the 50 m stand-off as long as they were laid by hand. At land to the south of Creswell Crags scheduled monument (in Nottinghamshire and Derbyshire), there is the potential for caves and fissures to extend as far as the southern end of the magnesian limestone ridge immediately to the south of the protected area. Therefore no sources will be placed in this area.

4.68 As indicated in Appendix 2 and Section 4.4, vibration monitoring will be carried out to ensure safe levels of vibration at sensitive receptors could be achieved (through maintaining a stand-off distance from the seismic source, or reducing the size of the source). Levels proposed at the designations will be less than 5 mm/s, which will be equivalent to vibration caused by walking in a room.

4.69 Similarly, unless specifically agreed with Historic England and the landowner no sources will be placed within 50 m of the curtilage of a listed building. Receivers will not be placed in the grounds of the listed building (unless agreed), but could be placed within the 50 m stand-off as long as they were laid by hand.

4.70 Within registered park and gardens (such as Barlborough Hall and Wellbeck Abbey) surveys will only take place along existing tracks and roads, and care will be taken to protect trees and other vegetation.

4.71 Although there is a possibility of unrecorded archaeological remains to be disturbed as a result of the survey, due to shotholes, or compression of soil by the use of vibroseis vehicles, the extent of impacts will be minimal. Shotholes will be formed by tractor mounted drills or augers, and will be a maximum of 10 cm diameter. Soil compression by vibroseis vehicles will be prevented by using existing tracks where possible, and only travelling on bare soil in agricultural areas where the top soil layer has been previously disturbed by agricultural activities. Impacts from vibroseis trucks will be similar to impacts from agricultural vehicles.

4.72 The preliminary Environmental Method Statement in Appendix 3 outlines how these matters will be addressed in carrying out the survey.

Non-Designated Natural Heritage Sites

4.73 Survey works in ancient woodland, Local Nature Reserves and Local Wildlife Sites will be carried out with regards to the environmental sensitivities of the areas, and landowner requirements.

4.74 The key protections will be ensuring that surveys are only carried out on existing tracks, clearings and paths, and that vegetation was not disturbed. If there were no appropriate tracks through the required section of the site the route will either be diverted, or the area will be excluded from the survey. Appropriate stand-offs from trees will be maintained where possible, as advised by the landowner and EnCoW although in a woodland with young trees that will not be adversely affected by vibration there is likely to be minimal impact.

4.75 Although the use of vibroseis vehicles is generally less intrusive, and quicker than shotholes, and does not require repeated visiting of the site by the survey team, it may be that the nature of the sites, especially woodland, is better suited to tractor-mounted

drills and shotholes. This was observed at the site visit undertaken in Sherwood Forest. Therefore, the source type in non-designated sites will be determined during the pegging out process, in agreement with the landowner and other stakeholders as appropriate.

4.76 Breeding birds, especially ground-nesting species including nightjar, woodlark and tree pipit are also important in the area. Woodlark is listed on Schedule 1 of the Wildlife and Countryside Act 1981 (as amended) and so receives enhanced protection from disturbance whilst nesting, attempting to nest or being on or near a nest with dependent young. It is also listed on Annex 1 of the European Birds Directive. Nightjar is listed on Annex 1 the Birds Directive, and receives general protection under the Wildlife and Countryside Act 1981 (as amended) against harm whilst nesting or attempting to nest, and nest damage/ destruction afforded to all species of nesting bird under this Act. Tree pipit also receives this general protection.

4.77 In areas where there could be ground nesting birds – such as open heath, grass or heather tussocks, recently cleared/ felled woodland and new planted woodland, particular note will be taken of this potential where surveys take place during the breeding season. The EnCoW will monitor any potentially sensitive bird breeding areas or areas where nests could be present before, during and after the survey to ensure no disturbance of breeding birds during the survey if it occurred within the breeding season. No areas in Rotherham/ Derbyshire are noted within the Sherwood “might-be” SPA.

4.78 The preliminary Environmental Method Statement in Appendix 3 outlines how sensitivities will be addressed in carrying out the survey.

Urban Areas

4.79 It is intended to exclude the majority of urban areas (as identified in Map 3e) from the survey. There will be no sources or receivers placed there, though survey vehicles may pass along roads to access other areas of the survey.

4.80 In areas where surveys are proposed, to ensure good coverage across the region, the following safeguards will be followed:

- The stand-off distances outlined in Appendix 1 of the accompanying Method Statement will be followed, unless superseded by site-specific PPV monitoring as described in Section 4.4. This allows for a varying proximity of sources to buildings and other infrastructure, depending on the intensity of the source. When shotholes are used, the distance from certain buildings, such as occupied dwellings remains constant (50 m), regardless of the size of the charge. From other receptors (for example, agricultural buildings and utilities), a closer proximity is permissible. If vibroseis vehicles are used, sources may be closer to residences if fewer vehicles are used, or if the intensity is decreased.

- No sources or receivers will be placed in private gardens. Only the public highway, including grass verges will be used.

- Where there are other designations or sensitive areas within the urban areas, protections afforded to these designations will be maintained.

4.81 Information on monitoring the vibration caused by these different sources is provided in Section 4.4 and Appendix 2.

Groundwater Protection Areas, Watercourses and flood risk areas

4.82 There are no groundwater protection zones in Derbyshire within the survey area.

4.83 Stand-offs from watercourses and waterbodies will be maintained (vibroseis sweeps and shotholes will be placed no closer than 8 m from streams to protect ecological interests), and no receivers will be placed in watercourses or on the banks. Vehicles will be regularly serviced and maintained to prevent accidental pollution.

4.84 In areas with a high water table or high levels of standing water in the wider area it may be appropriate to temporarily case the shotholes; this will be determined in the field, with the potential identified during the preliminary topographic survey.

4.85 The surveys will avoid flood plains where there were areas of standing water covering the proposed location of receivers or sources. If heavy rain were forecast, the survey would be halted in areas of flood risk, and equipment moved away. Flooding would lessen the effectiveness of the surveys, risk collapse of the shothole (during drilling) and would risk damage to or loss of the receivers. However, the nature of the surveys will mean that there will be no additional flood risk to surrounding areas as no hardstanding will be created, and once the shotholes are backfilled there will be no residual impact of flood on the area.

4.86 Non-toxic drilling fluids and charges will be used in all shotholes.

Aerodromes

4.87 Operations within 3 km of Netherthorpe aerodrome will limit the height of equipment.

4.88 The vibroseis vehicles are no higher than 3 m tall. The tractor mounted drill is less than 3 m in height. When the short mast is fully extended while drilling, the tractor mounted drill rigs will be no higher than 3.8 m tall – less than the height of a double decker bus. The receiver masts of recording vehicles (wire cables like a car antennae) could be a greater height, but these could be positioned outside the 3 km buffer.

4.89 Guidance on crane use in the vicinity of aerodromes[3] indicates that such tall, temporary construction equipment should be notified to the operator if it exceeds 10 m or the height of surrounding structures or trees, within 6 km of the airfield. The proposed drill rigs will not approach 10 m in height and will be below the height of surrounding structures and trees.

4.90 The owners and operators of the aerodrome will be consulted regarding the timing of surveys in the area.

4.91 Therefore there will be no danger to aircraft using the aerodrome.

[3] Civil Aviation Publication 738 (Safeguarding of Aerodromes) and British Standard Institute Code of Practice for the safe use of cranes (BS 7121, Part 1)

5. Summary and Requirements for Proposed Seismic Survey

5.1 In summary, it is considered that the proposed seismic survey is capable of being undertaken within the provisions of Class K of Schedule 2, Part 17 of GPDO 2015.

5.2 This class permits seismic survey work for up to six months. There is a requirement to notify the MPA in advance of operations and adhere to the specified restrictions on the size of charge permitted, height of equipment, excavation size, tree felling, soil management, and restoration.

5.3 This report forms the notification to the MPA under Class K of GPDO 2015 (as amended).

5.4 The seismic survey will follow good practice, with methods in place to prevent damage to the environment and amenity of local residents, as described in Chapter 4. INEOS has taken in account the local environment in designing the survey, and particular sensitivities have been taken into account during the design. In particular, sites of special scientific interest, and scheduled monuments will be excluded from the survey, and stand-offs from other designations and sensitivities will be maintained. Therefore the survey complies with the restrictions outlined in Class K. INEOS and its contractors are aware of these restrictions and will comply with them. The potential to comply with the restrictions is outlined in this report.

5.5 INEOS proposes to commence operations on 5 June 2017.

5.6 We request agreement in writing that this methodology is acceptable and that the proposed development is permitted under GPDO 2015 (as amended).

Appendix 1: List of Designations and Sensitivities

Derbyshire County Council

	Number	Details	Name	Grid reference
Special Area of Conservation	None			
National Nature Reserve	None			
Sites of Special Scientific Interest	5	19.5 ha	Creswell Crags – Geological SSSI	SK 535 742
		5 ha in total	Pleasley Vale Railway	SK 519 649
		4.2 ha	Ginny Spring, Whitwell Wood	SK 519 789
		19.9 ha	Hollinhill and Markland Grips	SK 511 751
		3.5 ha	Crabtree Wood	SK 490 785
Scheduled Monuments	8[4]	23.3 ha	Palaeolithic and later prehistoric sites at Creswell Gorge including Pinhole Cave, Mother Grundy's Parlour and Robin Hood's Cave	(located in Nottinghamshire) SK 53544 74219 Outside but adjacent to survey area
		23.3ha	Palaeolithic and later prehistoric sites at Creswell Gorge, including Boat House Cave and Church Hole Cave	SK 53544 74219
		0.03 ha	Four watchtowers SW of town	SK 47340 70252
		1.3 ha	Medieval town defences, 183m south east of church of St Mary and St Lawrence, and 335m north east of Bolsover Castle	SK 47588 70305

[4] Cresswell Gorge refers to the same site covering 2 MPA areas

	Number	Details	Name	Grid reference
		4.7 ha	Markland Grips promontory fort	SK 50908 75043
		0.003ha	Standing cross	SK 47615 77275
		0.007ha	Standing cross, Clowne	SK 49150 75434
		0.1ha	Langwith Cave	SK 51799 69497
		0.03ha	Ash Tree Cave	SK 51485 76144
Registered Parks and Gardens	2	Grade 2 132 ha	BARLBOROUGH HALL	SK 48078 78122
		Grade 2 1270 ha	WELBECK ABBEY	SK 56610 74062
Listed Buildings (Listing, Name, NGR)	3	Grade 1	Church Of St Lawrence	SK 52624 76830
			Balborough Hall	SK 47770 78257
			Church Of All Saints	SK 54357 78727
	13	Grade 2*	Village Cross	SK 47616 77277
			Church Of St John The Baptist	SK 49828 75294
			Church Of St Mary And St Lawrence	SK 47442 70306
			Whitwell Hall	SK 52609 76914
			Clowne Cross	SK 49148 75437
			Conduit House	SK 47559 69987
			Church Of St Peter	SK 50265 73452
			Church Of St James	SK 47696 77188
			Barlborough Old Hall	SK 47645 77296
			Church Of The Holy Cross	SK 51878 69331
			Gazebo At Barlborough Hall	SK 47652 78265
			Conduit House To Rear Of Number 85	SK 47456 70116
			Church Of St Leonard	SK 49543 68750
	67	Grade 2	Park Street Farmhouse	SK 47628 77342

Number	Details	Name	Grid reference
		Coach House To North West Of Barlborough House	SK 47647 77155
		Manor Farmhouse And Attached Barn	SK 49520 76184
		106, High Street	SK 48815 75369
		Southgate Stables, Including Wall To South Enclosing Stable Yard	SK 49896 77166
		Creswell Junior School	SK 52340 74218
		Gatepiers To East Of Barlborough Hall	SK 47805 78250
		Shirebrook Lower School	SK 53112 67951
		Lilac Farmhouse	SK 47437 68347
		Lodge At Entrance To Pleasley Vale	SK 51581 65044
		Hall Farmhouse	SK 49336 66278
		Barn At Steetley Farm	SK 54420 78770
		44, High Street	SK 52716 76805
		North Walls Farmhouse	SK 50177 77713
		Elmton Park Farmhouse	SK 49030 72426
		Glapwell Lane House	SK 48005 66934
		Gatepiers At Entrance To Glapwell Hall	SK 47990 66208
		Lodge At West Entrance To Pleasley Vale	SK 51556 65034
		Palterton Hall	SK 47462 68391
		Hall Farmhouse	SK 49397 68738
		Rose Cottage	SK 52096 69752
		Stuffynwood Farmhouse	SK 52420 65834
		The Birks Farmhouse	SK 54759 76861
		The Old Rectory	SK 52540 76818
		Village Pump	SK 52978 76654
		Pigeon House At Steetley Farm	SK 54396 78762

Number	Details	Name	Grid reference
		28, Market Place	SK 47395 70472
		32 And 36, Town End	SK 47513 70455
		War Memorial	SK 49243 75609
		Barn To The South East Of Number 106	SK 48830 75339
		Southgate House	SK 49805 77108
		Former Creswell Church Of England Secondary School	SK 52630 74351
		Barn To South Of Grange Farmhouse	SK 50279 73485
		1-3, Church Street	SK 47638 77270
		The Pole Almshouses	SK 47772 77169
		7 And 9, Church Street	SK 47793 77157
		Stone Croft	SK 47808 77130
		Barlborough House	SK 47676 77150
		Wall, Railings And Gatepiers To North Of Barlborough House	SK 47667 77165
		Stone Gateway And Attached Wall At Entrance To Memorial Gardens	SK 47563 77285
		Lodge To Barlborough Hall	SK 47608 77413
		Pear Tree Farmhouse	SK 47905 65034
		Railway Goods Shed Immediately To East Of Langwith Maltings	SK 52664 69674
		Crenellated Stone Memorials	SK 47872 76893
		Stone Memorials	SK 47879 76909
		Church Of St Mary Magdalen	SK 52572 74295
		11 And 13, Church Street	SK 47800 77148
		The Old Rectory	SK 47727 77142

	Number	Details	Name	Grid reference
			Clowne Fields Farmhouse	SK 47860 77054
			Stable Block At Barlborough Hall	SK 47725 78247
			Elmtree Farmhouse	SK 50438 73230
			The Bothy At Glapwell Nurseries	SK 48028 66359
			Former Infants School And Attached House	SK 53285 71080
			Church Of The Holy Trinity	SK 52475 67509
			The Old George Inn	SK 52720 76780
			Steetley Farmhouse	SK 54426 78811
			Cart Hovel At Steetley Farm	SK 54450 78775
			Gipsyhill Farmhouse	SK 50974 77814
			The Old Manor House	SK 52672 76757
			The Old Hall	SK 52085 69771
			Grange Farmhouse	SK 50255 73495
			Barlborough Infants School	SK 47561 77351
			2, Church Street	SK 47622 77236
			Shirebrook Model Village Primary School (Eastern Blocks)	SK 52379 67259
			Shirebrook Model Village Primary School (Eastern Blocks)	SK 52409 67262
			War Memorial	SK 52980 76688
			2-4, Church Street	SK 47402 70405
			Manor Farmhouse	SK 49319 68712
			War Memorial	SK 52224 74138
			Creswell Church Of England Infants School	SK 52688 74380
Ancient	18 [5]	1.4 ha	Unnamed Ancient &	

[5] Units of the same named wood are counted as a single wood

	Number	Details	Name	Grid reference
Woodland			Semi-Natural Woodland	
		1.1 ha	Unnamed Ancient & Semi-Natural Woodland	
		1.8 ha	Unnamed Ancient & Semi-Natural Woodland	
		1.0 ha	Unnamed Ancient & Semi-Natural Woodland	
		0.5 ha	Unnamed Ancient Replanted Woodland	
		11.5 ha	CAR AND TERRACE WOODS Ancient & Semi-Natural Woodland	
		3.1 ha	FRITH WOOD Ancient Replanted Woodland	
		2.8 ha	HICKIN WOOD Ancient & Semi-Natural Woodland	
		ha	HIND CAR WOOD/ HIND CAR Ancient & Semi-Natural Woodland	
		1.4 ha	HOLLINHILL AND MARKLAND GRIPS Ancient & Semi-Natural Woodland	
		ha	HOLLINHILL AND MARKLAND GRIPS Ancient & Semi-Natural Woodland	
		0.7 ha	HOLLINHILL AND MARKLAND GRIPS Ancient & Semi-Natural Woodland	
		5.4 ha	HOLLINHILL AND MARKLAND GRIPS Ancient & Semi-Natural Woodland	
		2.0 ha	HOLLINHILL AND MARKLAND GRIPS Ancient & Semi-Natural Woodland	

Number	Details	Name	Grid reference
	1.2 ha	HOLLINHILL AND MARKLAND GRIPS Ancient Replanted Woodland	
	7.5 ha	KILN WOOD Ancient & Semi-Natural Woodland	
	27.7 ha	NITTICARHILL WOOD Ancient & Semi-Natural Woodland	
	32.3 ha	NOR WOOD Ancient & Semi-Natural Woodland	
	3.3 ha	NORTHFIELD HOUSE WOOD Ancient & Semi-Natural Woodland	
	8.3 ha	NORTHFIELD HOUSE WOOD Ancient & Semi-Natural Woodland	
	ha	NORTHFIELD HOUSE WOOD Ancient Replanted Woodland	
	66.4 ha	NORTHFIELD HOUSE WOOD Ancient Replanted Woodland	
	40.6 ha	ROSELAND WOOD Ancient Replanted Woodland	
	9.0 ha	SCARCLIFFE PARK Ancient & Semi-Natural Woodland	
	164.3 ha	SCARCLIFFE PARK Ancient Replanted Woodland	
	2.3 ha	WALLINGBROOK WOOD Ancient & Semi-Natural Woodland	
	1.8 ha	WALLINGBROOK WOOD Ancient & Semi-Natural Woodland	
	0.8 ha	WHITWELL WOOD Ancient & Semi-Natural	

	Number	Details	Name	Grid reference
			Woodland	
		0.9 ha	WHITWELL WOOD Ancient & Semi-Natural Woodland	
		0.6 ha	WHITWELL WOOD Ancient & Semi-Natural Woodland	
		1.3 ha	WHITWELL WOOD Ancient & Semi-Natural Woodland	
		0.9 ha	WHITWELL WOOD Ancient & Semi-Natural Woodland	
		1.3 ha	WHITWELL WOOD Ancient & Semi-Natural Woodland	
		7.6 ha	WHITWELL WOOD Ancient & Semi-Natural Woodland	
		160.4 ha	WHITWELL WOOD Ancient Replanted Woodland	
Local Nature Reserves	1	82.4 ha in total, 15.5ha in survey area	Pleasley	SK 494 646
Important Bird Area/ Might be SPA	None			

Appendix 2: Seismic Source Safe Operating Distances and PPV Monitoring

INEOS Upstream Services

Seismic Source Safe Operating Distances

PPV Monitoring

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1 Executive Summary

This document has been generated to provide information regarding the basic technical aspects of PPV (Peak Particle Velocity) real time monitoring for vibration levels generated by seismic sources at identified sensitive receptors in the INEOS East Midlands license. It describes the proposed methodology for recording data to assure compliance to agree stand-off distances.

It takes from the project method statement tables of recommended minimum safe offset distances for both explosive and vibratory source, from various environmental, social and industry infrastructure elements that are collectively referred to as sensitive receptors (SR). These tables are generated from significant experience of land seismic exploration and are cognisant of industry standards and norms. However, they are only recommended safe distances on the understanding that they are set to help **achieve very low levels of vibrations at the SR's**. Comparisons of these levels with other more frequently experienced causes of ground vibration (such as walking or jumping near the SR) are provided in Figure 5. The maximum threshold levels of PPV are set in line with globally recognised standards for safe practice within the vicinity of people and property. There are no published guidelines for vibration levels for animals in their natural habitat but consideration must be given at testing and in consultation with ecologists to what stand-off distances would be appropriate so as not to disturb nesting and the general wellbeing of the fauna in the area.

The stand-off distances included in the East Midlands Method Statement and repeated in the embedded tables of this information document were generated based on international norms and experience gained on previous UK seismic surveys. It is important to understand that stand-off distances are designed as a safety guideline only and are not fixed, due to the fact that the response of the earth to propagated sound waves can vary in localised surface geology. There are two key elements to safe stand-off guidelines, one is a minimum prescribed distance or buffer to the sensitive receptor (set to ensure very low PPV values) and the other is the maximum acceptable threshold level of vibration (PPV) measured at the sensitive receptor. This PPV threshold is normally taken from the most applicable standard that applies in the country of operation. The internationally recognised measurement of vibration in regard to potential damage of property or disturbance of human beings is PPV (Peak Particle Velocity), which is discussed in more detail in this document. The standards that are used in conjunction with the distance tables for this survey are BS 7385 (Evaluation and Measurement for Vibration in Buildings) and BS 5228 (Code of Practice for Noise and Vibration control).

The stand-off distances will be calibrated before commencing and monitored throughout the survey. The calibration will be in the form of tests at a location that has no sensitive receptors and allows for PPV levels to be recorded for all offsets from the PPV measuring apparatus. This data is then compared with the proposed stand-off distances and may lead to a revision of tables should it be felt that they need to be increased.

2 Objectives of the Measuring Process

The objective of a well-managed vibration measurement and monitoring program is to create a methodology that is agreed between stakeholders to allow seismic recording in the East Midlands license, using a mixture of impulsive and vibratory source to be carried out in a compliant and industry best practice manner, whilst satisfying legal, social and moral responsibilities. The underlying objectives are:

1. Generated and in line with British Standards guidelines regarding vibration measurement and monitoring
2. Consideration to Social Responsibility and acceptance by affected stakeholders of efforts to protect dwellings, structures, amenities and natural resources.
3. Consideration toward environmental protection of natural resources, zero permanent impact operations.
4. Protection of National and Local Government infrastructure
5. Protection of Industry infrastructure
6. Offering evidential support to all parties in the unlikely event of litigious claims for damages
7. Upholding reputation of the INEOS group.

3 What is PPV (Peak Particle Velocity)?

Particle Velocity is where the particles of a medium are displaced from their random motion in the presence of a Sound Wave. In simple terms the sound wave excites the particles of the ground (soil) as the compression wave passes through. The particles oscillate, hence the vibration. The speed or velocity of a particle during this displacement is called the particle velocity and has a unit which is measured in meters per second (m/s). It must be kept in mind that the displacement of the particles in the medium (earth) produced by the small explosive charges and vibrator machines used in seismic surveys is minute (in the region of mm/s rather than m/s) and the energy levels low, and quickly dispersed.

Peak Particle Velocity (PPV) is the greatest instantaneous particle velocity during a given time interval. However, as motion occurs along three “axes” (vectors - see Figure 2) a more realistic measure of motion and its potential effects addresses this three-axis movement. If measurements are made in three-axis then the resultant value is the Peak Vector Sum (PVS) This is the square root of the summed squares of the maximum velocities, regardless of when in the time history those occur. It is this measure which is calculated during seismic survey measurement, and what is intended when reference to PPV is made in this report.

This single figure provides a conservative assessment of vibration/ movement experienced by a receptor. For most events, the PVS occurs at about the same time as the maximum velocity value of one of the three directional components. However, as one peak component normally does not occur at a time when there is no motion in the other two directions, the PVS reflects the addition of two other ground motions at the same time and therefore is slightly greater. Using the PVS to determine the safety distances is therefore a more conservative approach, and reflects that structures do not just respond in one of the three component directions of motion.

4 PPV Equipment

The equipment proposed for the East Midlands project is a Blastmate III, which is recognised by the industry for Seismic applications and is reliable when coming to data collection. The Seismic crew is proposing two units for this program

Figure 1: Blastmate III

The PPV unit has four sensors: three geophones aligned in longitudinal (X), transverse (Y) and vertical (Z) directions that measured particle motion, and a microphone that can measure air disturbance (sound). The three component geophone should be firmly coupled and level to the ground and the arrow on the top of the case normally aligned to the line of source points to be recorded.

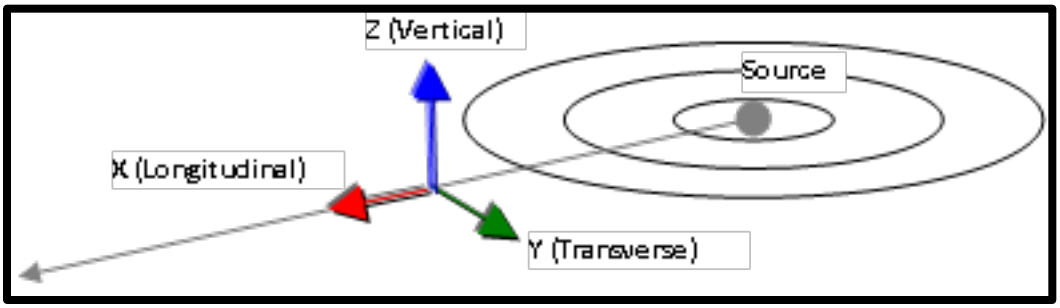


Figure 2: PPV Sensor Component Direction Definition

A geophone sensor is a coil of wire suspended over a permanent magnet. The coil is free to move in a field of magnetic flux lines. By Lenz's law, induced voltage is proportional to the speed at which the flux lines are traversed. In seismic applications, the magnet is moved by the sound energy, because it is coupled to the particles of the surrounding terrain. The coil because of its inertia does not move and the resulting magnet versus coil motion induces a voltage, which is proportional to particle velocity. Voltages produced by the vibrating PPV sensors are proportional to particle velocities in the longitudinal, transverse and vertical directions. Dynamic calibration ensures the verification and calibration of the system's geophones each time they are used and precludes using the unit with damaged or inaccurate geophones. A satisfactory calibration was indicated by 'Passed' in the Event Report for each recorded PPV measurement. A trigger can be initiated manually or triggered automatically by the system. If it is triggered automatically by the system, the trigger is generated when a signal is strong enough to cause the geophone output to exceed a pre-determined value. If the system were started manually, the PPV operator would start the system immediately before the shot is fired.

5 PPV Vibration Thresholds

The intensity of vibration at the point of interest will normally be a function of many variables including:

1. Energy of explosive shot or amplitude of the cycle of the vibration
2. Distance between source and receiver;
3. Ground conditions at the site, e.g. soft or hard driving and location of water table;
4. Soil–structure interaction, i.e. nature of connection between soil and structure being monitored;
5. Construction of structure and location of measuring points.

The PPV (PVS) is the simplest indicator of both perceptibility and the risk of damage to structures.

British Standard Guidance on Vibration

The vibration assessment criteria used here is based on guidance contained in BS 6472:1992, BS 7385: 1993 and BS 5228:1992. This guidance includes information on building damage, noting that buildings are reasonably resilient to ground-borne vibration and vibration-induced damage is rare[1]. However, it can arise in different ways; directly, due to high dynamic stresses due to accelerated ageing or indirectly, for example by stresses caused by soil compaction. Therefore, universal criteria to adequately and simply indicate damage risk cannot be established.

There are currently two British Standards that offer advice on acceptable levels of vibrations in structures. British Standard BS 7385: Part 2: 1993[2] gives guidance on the levels of vibration above which the building structures could be damaged as a result of direct vibration effects. BS 5228: Part 4: 1992[3] also provides guidance on acceptable vibration levels in structures.

Vibration levels at which cosmetic damage could occur (formation of hairline cracks usually in wall and/or ceiling lining materials) are outlined in Figure 3 overleaf.

Lower frequencies (for example, those created by earthquakes) have higher potential to cause damage as they normally have higher displacement of particles. Frequency generated by vibroseis vehicles covers the full range of frequencies in a <30 second “sweep” (INEOS will use 6 Hz to 125 Hz over 12 seconds), and therefore no particular frequency dominates over a period of time. Charges would generate a spectrum of frequencies depending on how far the impulsive source has travelled in the earth.

Since case-history data, taken alone, has so far not provided an adequate basis for identifying thresholds for vibration-induced damage, data using controlled vibration sources within buildings has been established to enable definition of vibration thresholds judged to give a minimal risk of vibration-induced damage.

[1] http://www.clacksweb.org.uk/document/3243.pdf

[2] ‘Evaluation and measurement for vibration in buildings Part 2. Guide to damage levels from ground borne vibration’

[3] ‘Code of practice for noise and vibration control applicable to piling operations’.

Table B.2 **Transient vibration guide values for cosmetic damage**

Line (see Figure B.1)	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	50 mm/s at 4 Hz and above
2	Unreinforced or light framed structures Residential or light commercial buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Figure B.1 **Transient vibration guide values for cosmetic damage**

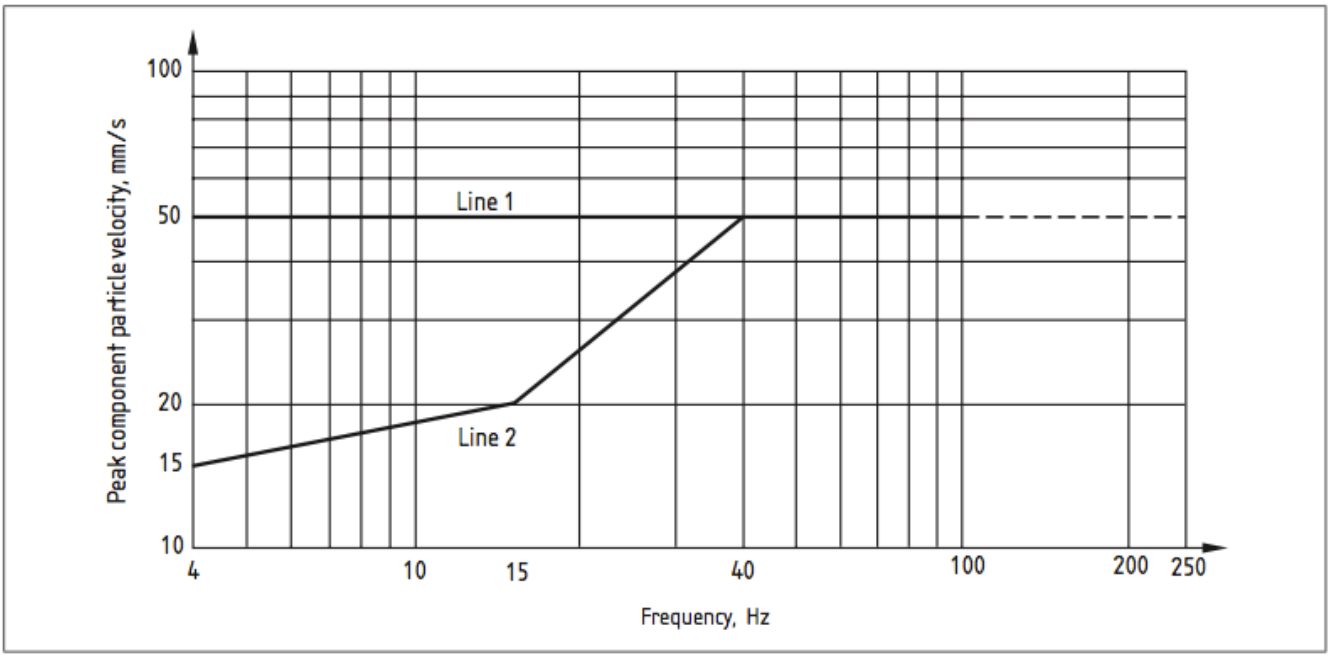


Figure 3: Guideline Values for Vibration Velocity on Structures – BS 7385

The standards recommend that setting stand-off distances that will keep vibration levels below 15 mm/s will offer a high probability of safety to structures within the area of operations. It is normal to lower this significantly for listed building and ancient monuments and historically the industry will use a limit of 5mm/s as a starting threshold and test this at commencement of the program to validate that the stand-off distances are sufficient to support this value. It is likely that this can be increased to 15 mm/s for most non-designated structures without any risk of damage.

Human Perception of Vibration

There is a difference between the sensitivity of people in feeling vibration and the onset of levels of vibration, which can damage structures. Levels of vibration at which adverse comment from people is likely, are below levels of vibration, which damage buildings. However, human perception is greater at higher frequencies although, as shown in Figure 3, lower frequencies are most damaging to structures as they propagate further through the earth and cause greater particle vibration. Earth (and water) attenuates higher frequency to a greater extent.

The chart shown in Figure 4 below indicates levels at which humans can perceive vibration (approximately 1 mm/s) and at what elevated levels it becomes unpleasant and even intolerable. Again experience shows that setting the threshold level at 5 mm/s, which is perceptible but not deemed to be unpleasant will not cause any significant disturbances to humans. However, this needs to be continuously monitored and any concerns from stakeholders investigated.

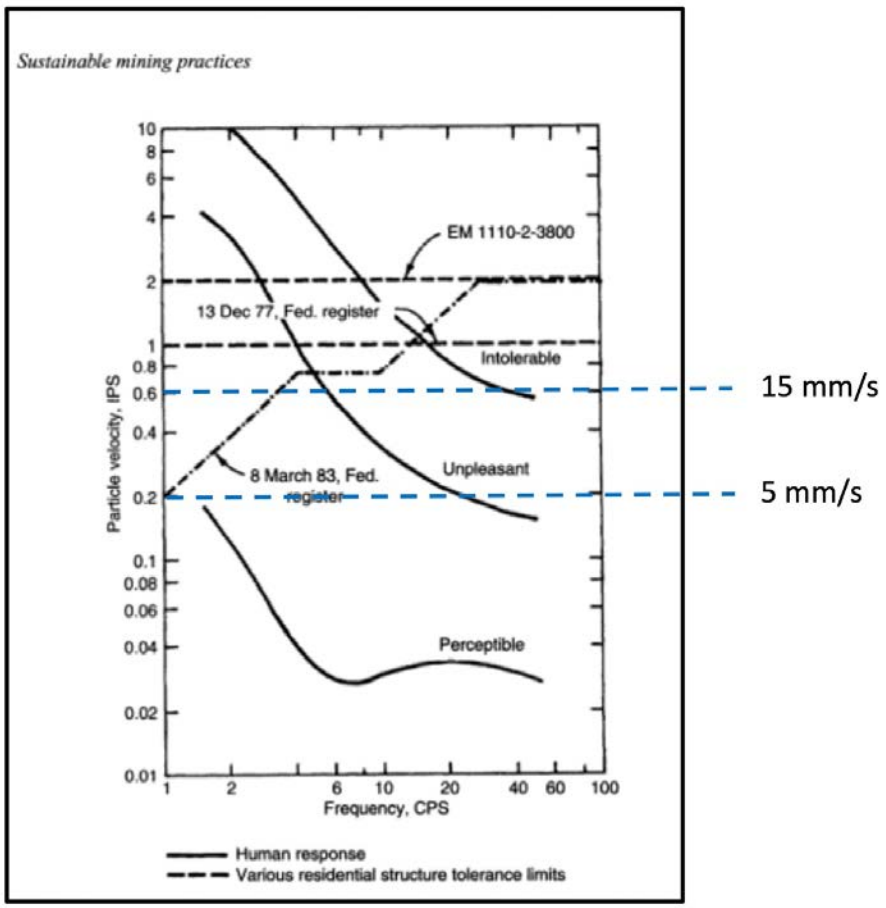


Figure 4: Human Response to Vibration

y axis is labelled as "inch per second" (IPS) with points marked to correspond to proposed PPV of 5 mm/s – maximum PPV for sensitive receptors, and 15 mm/s - maximum PPV for standard residential receptors. x axis refers to "cycles per second" (Hz).

Figure 5 shows an example taken from a study carried out in the United States, which shows typical vibration levels for everyday activities, including something as simple as walking. The PPV levels are in inches per second but the diagram has two blue lines indicating the corresponding levels of 5 mm/s and 15 mm/s as proposed for this survey in conjunction with stand-off. It is interesting to note that jumping can produce levels in excess of 15 mm/s (a threshold for normal buildings in this survey) and is indicative of how much safety margin is being proposed for acceptable vibration levels. Slamming doors and nailing pictures to walls can produce even higher levels of vibration in a dwelling than will be generated by the source energy INEOS would use at distance.

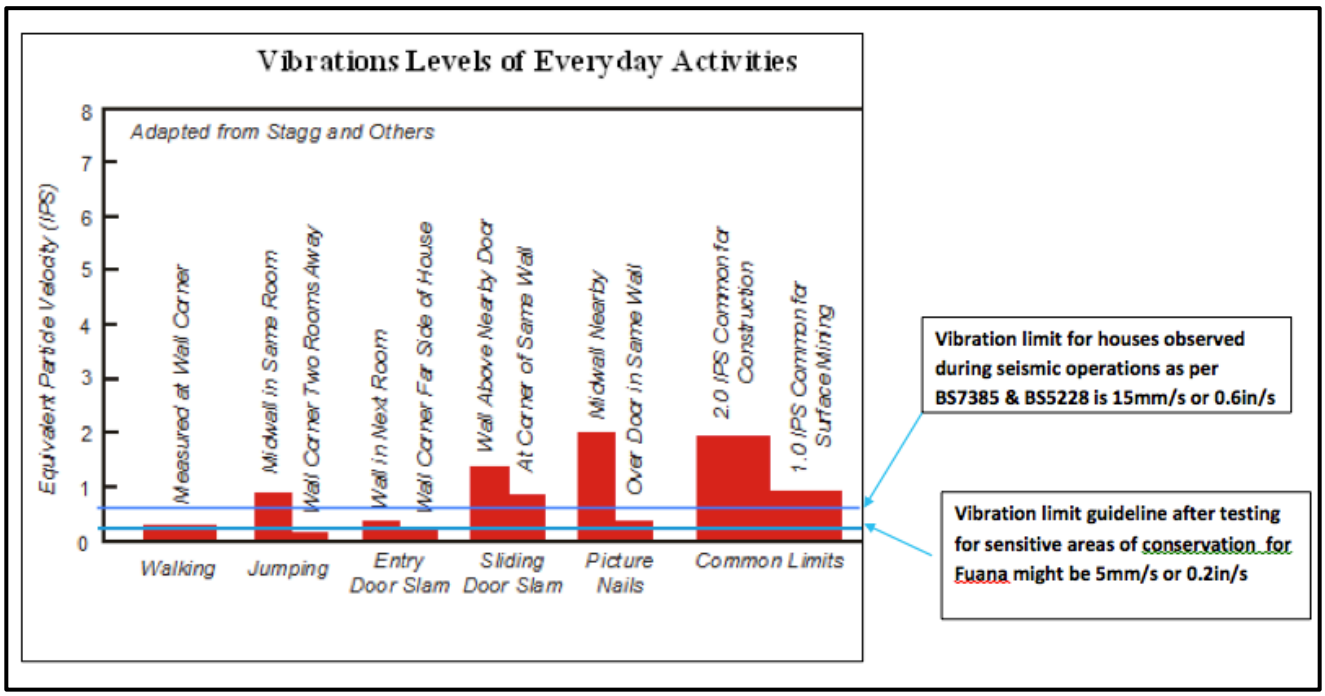


Figure 5: Vibration Levels of Everyday Activities

Non-human perception of vibration

There has been very little research on non-human response to vibration caused in seismic surveys, including the threshold of perception or disturbance by vibration of species likely to be encountered on surveys in the East Midlands. It is acknowledged that non-human receptors such as ground-nesting birds may have a low tolerance to vibration as their predator response may rely partly on vibration sensing. However, as shown in Figure 5, it is likely that the presence of people or vehicles in the vicinity would generate similar vibration to the survey itself, so the imposition of very low vibration limits would not actually offer any additional protection.

In practice, therefore, the maintenance of standoff distances from identified ecological receptors would be the most efficient mitigation. This would be enforced by an environmental clerk of works who would observe for disturbance in potential sensitive habitat over the course of the survey. Observed disturbance would cause the survey to be halted and moved from the area (since continued disturbance could trigger a nest to be abandoned, for example) and once resumed, a greater standoff maintained.

6 Developing Site Attenuation Equations

The two most influential factors on vibration amplitude that need to be considered are the configuration of the source point and the distance to the receptor. In general, it is intuitively obvious that the following are true (as long as all other factors remain constant)

1. PPV amplitude increases as the charge/ vibration size increases
2. PPV amplitude decreases as the distance increases
3. PPV (for shot holes) amplitude decreases as the hole depth increases though local geological conditions, confinement and relations hole quality make this less certain than 1. or 2.

A regression analysis is carried out from monitoring data (as demonstrated in Section 7 using data from non-UK tests) to assess how rapidly the vibration intensity declines from the source. This is termed "seismic attenuation". It is a combination of "geometric spreading" (an assumption that a spherical wave traveling through a medium continually spreads out so that the energy per unit area of the wave front decreases), combined with "material damping" or seismic attenuation (loss of energy caused by friction, heat exchange, or deformation). Most vibration analyses use "square root scaled distance" which is the distance between the source point and the monitoring point divided by the square root of the maximum explosive charge weight (or source size).

A least squares regression analysis[4] is used to fit data from PPV testing. The gradient of the slope is a measure of the amplitude attenuation decay and is dependent on the bulk rock properties in the subsurface. It may vary with location within a general geological regime, and rock properties within a general location may vary according to the angle at which vibration passes through them. For instance, river valleys, upland outcrops and agricultural land should be expected to produce different coefficients.

The relationship between peak particle velocity and scaled distance can be obtained by determining the "best fitting" line to the plotted data. This represents the best approximation of the amplitude of the vibrations from a blast at a given scaled distance. "Outer envelopes" and "95%iles" of data can also be calculated, to ensure conservative standoffs can be maintained.

Different surface conditions would result in a wider distribution of measurements and larger standard deviation. Good practice[5] requires that the goodness of fit for this best fit line should be at least 0.70

---

[4] Scaled Distance is achieved through the following formula:

$SD = D/\sqrt{W}$

Where SD = scaled distance, m/kg$^{1/2}$
D = distance from explosive charge to monitoring point, m
W = charge size, kg

The attenuation formula will be:

$V = K\,(D_S)^{\beta}$

Where D_S is scaled Distance
K is y-intercept (D_S=1)
β is attenuation factor
The variable K and β are constants that are particular to a site.

[5] United States Office of Surface Mining Reclamation and Enforcement (OSMRE)

and the standard deviation less than 0.50 to ensure that any standoff distances calculated from it can be estimated with reasonable accuracy.

INEOS would undertake such tests at the outset of the pegging out of the survey, to provide data to calculate site specific standoffs at which the required PPV would be achieved. It is anticipated that appropriate standoffs will be similar to those identified in Table 1 and 2 in Section 8, but there may be local differences for the reasons outlined above. For the purpose of this survey the test data would be constantly upgraded with every PPV / offset distance recorded in the field.

7 Examples of PPV data

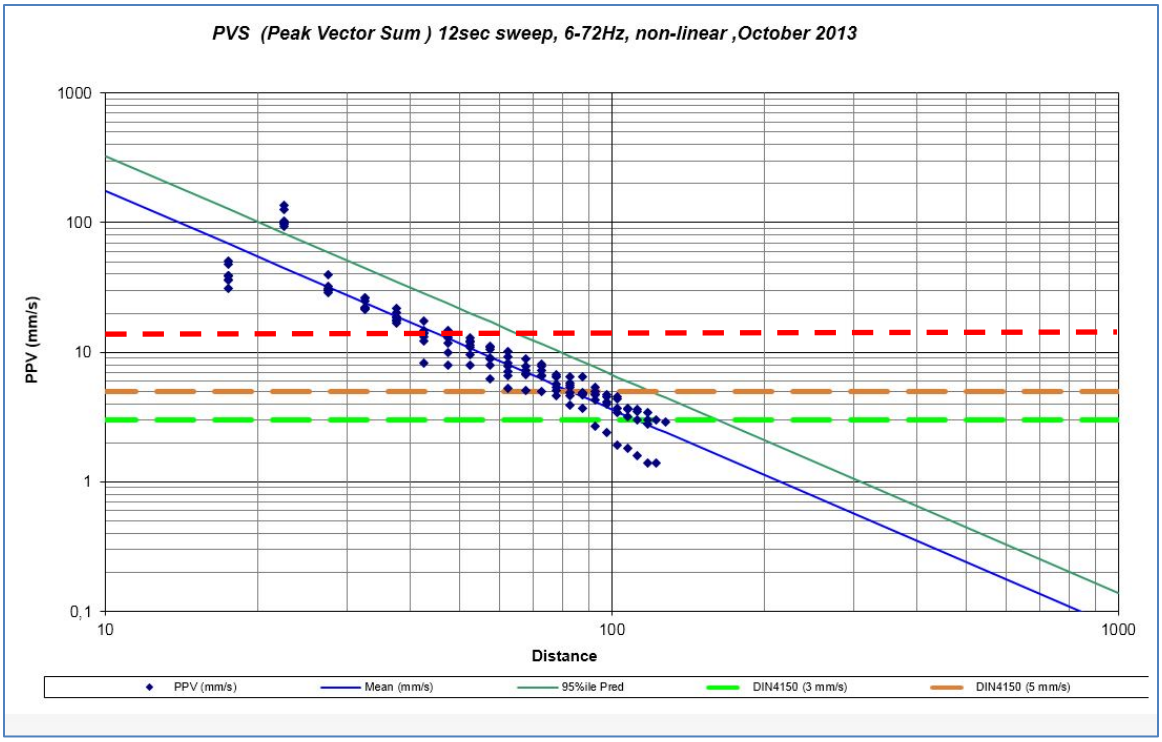
There follow some examples of data sets collected for both vibratory source (vibroseis) and explosive source (impulsive). The key to being able meet the agreed maximum vibration threshold criteria is to have the ability to adjust the energy of the sources.

These examples of monitoring data, test the vibration achieved at different distances from the receiver (in this case a PPV meter). They are carried out in areas with no sensitive receptors. It is important to record such data periodically to check what levels are reached for all distances in a particular geological environment.

As indicated in Section 6, INEOS will collect such data (using the methodology outlined in Section 8). This would provide data (similar to that presented in this section collected from seismic surveys with much larger units and charge sizes) for the three proposed vibroseis units to be used in the East Midlands, and the charge type (including size and depth) to be used. Stakeholders would be invited to attend the PPV source testing at the beginning of the project and persons will be able to see firsthand just how low the levels of vibration are for both explosive and vibratory source at the proposed stand-off distances published in the tables of the method statement.

Vibroseis

The example given in Figure 6 below is indicative of how vibrator source measurements are taken. This Figure plots data from a project outside the UK, that used four vibrator units (Model AHV IV) with a force of 61,000 lb or 373 kN. The intention for the East Midlands would be to use three vibrator units initially, each rated at 30,000 lb (130 kN peak force) if operated at 100% peak. In practice the vibrators would be operated at 90% force at their highest level (117 kN) but could be reduced as per the stand-off table for vibroseis (Table 1), showing corresponding distances for reduced force. In addition, it would be possible to reduce the number of vibrator units down to two or one depending on the required reduction.



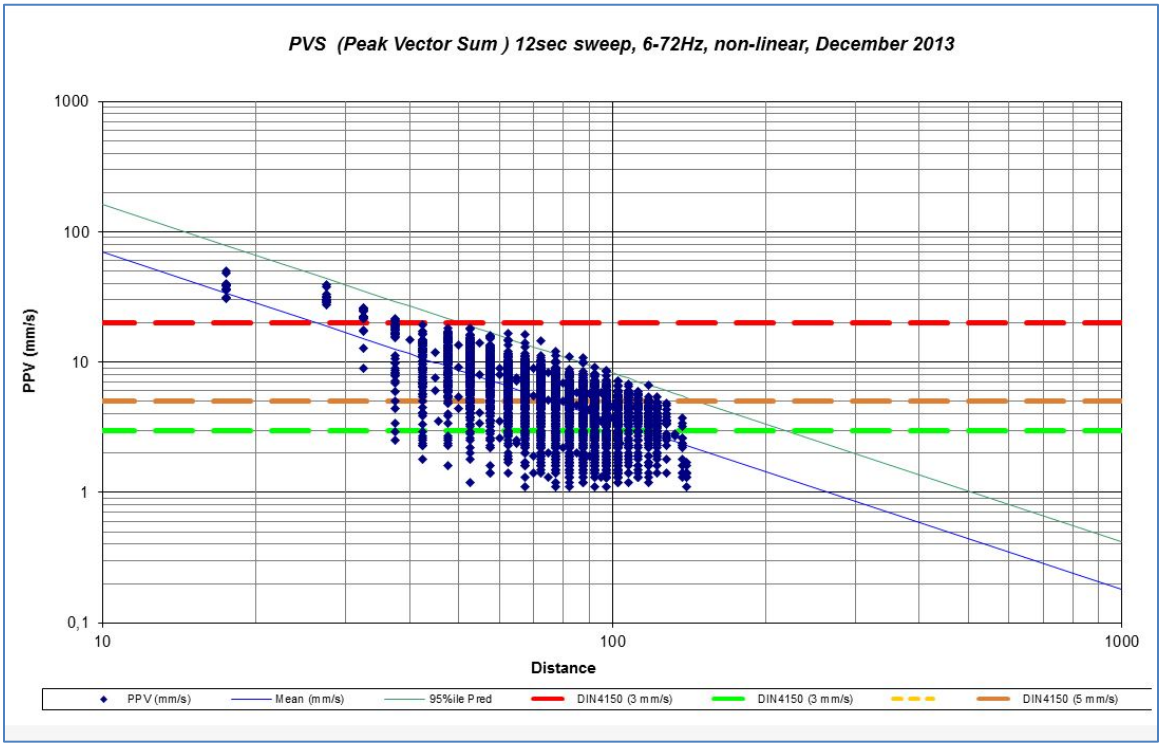


Figure 6: Examples of PPV for fleet of 4 AHV IV at 61,000 lb force

This particular example (for more units, with stronger vibration force than in the East Midlands) show higher PPV readings at distances above 50 m in stand-off, than would expect to be achieved on this project. Nevertheless, these show that 5 mm/s PPV could be achieved at approximately 80 m from the receptor (mean) and 95% of readings would be less than 5 mm/s at 110-120 m.

Figure 7 shows that reducing the number of vehicles used will substantially reduce the PPV at a given standoff distance – for example from a PPV of approximately 10 mm/s at 20m using four vehicles to approximately 6.5-7mm/s using two.

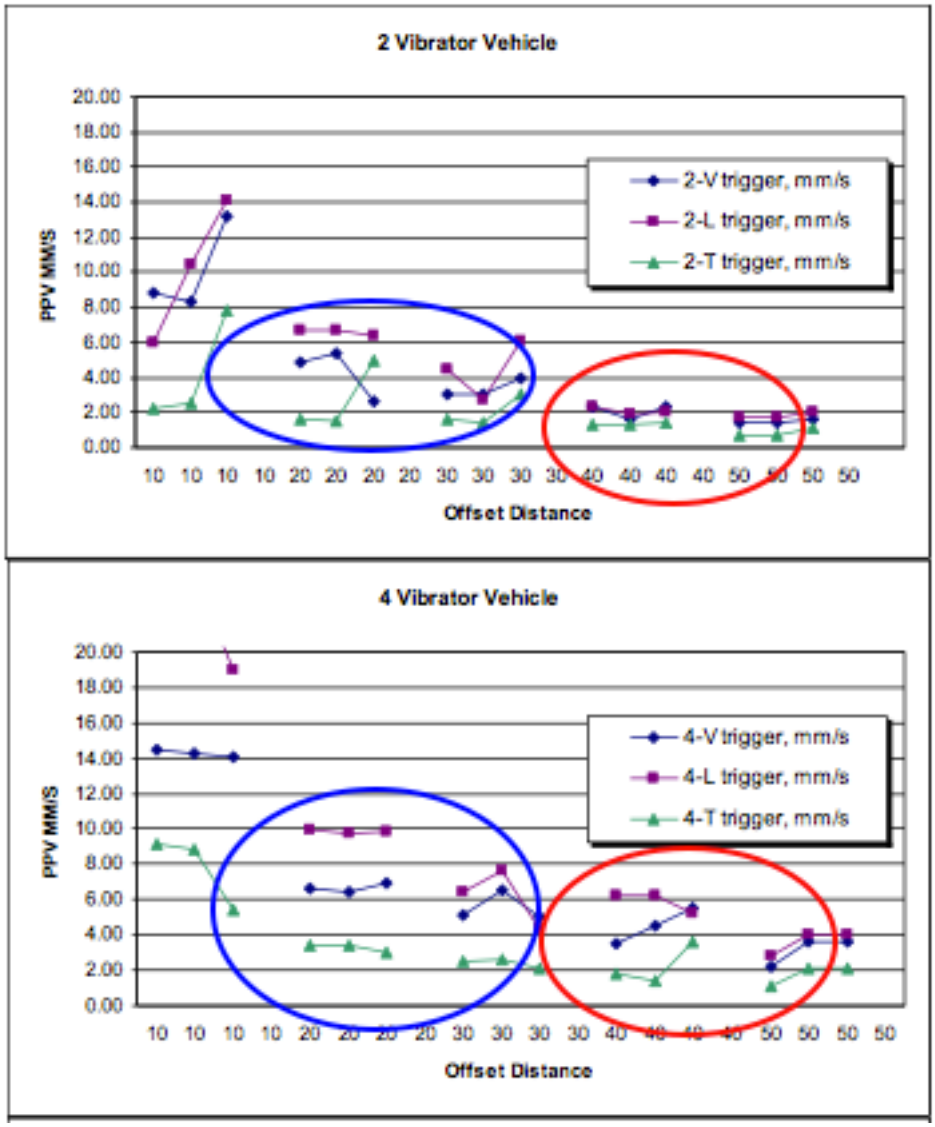


Figure 7: Shows direct correlation of reduced PPV when reducing number of units

Vibrators produce energy that propagates from contact with the surface into the sub-surface (earth) as mostly a spherical compression P wave, but some of that energy is also transmitted along the surface

of the ground in either a longitudinal direct wave or a transverse shear wave. The earth is a great attenuator of energy, especially high frequencies and the energy from a vibrator is transient and dispersive because it is a sweep of frequencies and does not dwell on a single frequency for a prolonged period. However, the earth is not uniform in its response and the attenuation (absorption and spherical divergence of energy) also differs with near surface geology and conditions (wet or dry). It is therefore critical that the crew continues to monitor response throughout the length of the project and in as many places geographically as possible.

An example of how terrain affects PPV readings for a uniform stand-off distance can be seen in Figure 8 below. The survey this data was collected in was undertaken outside the UK using large vibrator units. It was not carried out in the vicinity of any sensitive receptors. However, regardless it shows that the standard 15 mm/s value to protect robust structures could be achieved at all points where a 97 m standoff from the relevant receiver was maintained.

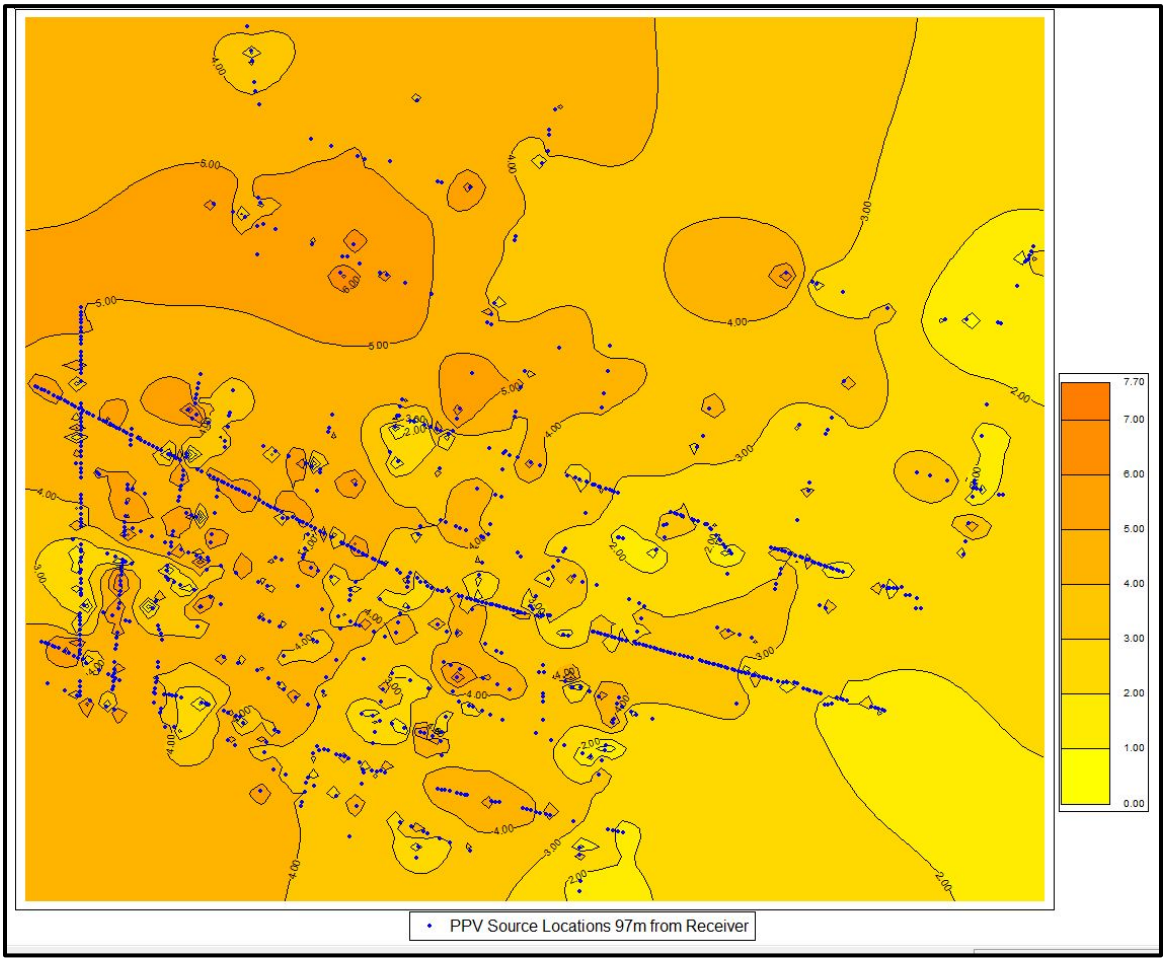


Figure 8: Gradient contour map for PPV readings over a 2D seismic project

Explosives

The example given in this section is taken from a large amount of explosive shot hole data collected over a one-year project in South America. The charge sizes are all higher than planned for East

Midlands, and the depths of the shot holes used varied (the largest shots were placed in deep shot holes (approximately 15 m) and the smaller ones in shallower holes (approximately 5 m). The survey was intended to prevent 15mm/s PPV at a 50 m standoff (as shown in the blue polygon), which was achieved.

The results are also a good indication that there would be very limited risk of PPV exceeding 15mm/s (the limit for robust structures) at above 50 m (nothing in blue polygon in graph) for the low charge sizes (<2 kg) planned for a single shot hole (likely 8-10 m depth). In addition, only a small percentage of shots (orange polygon) exceeded the more stringent threshold of 5 mm/s at 50 m, even when far higher charges than proposed in the East Midlands were used.

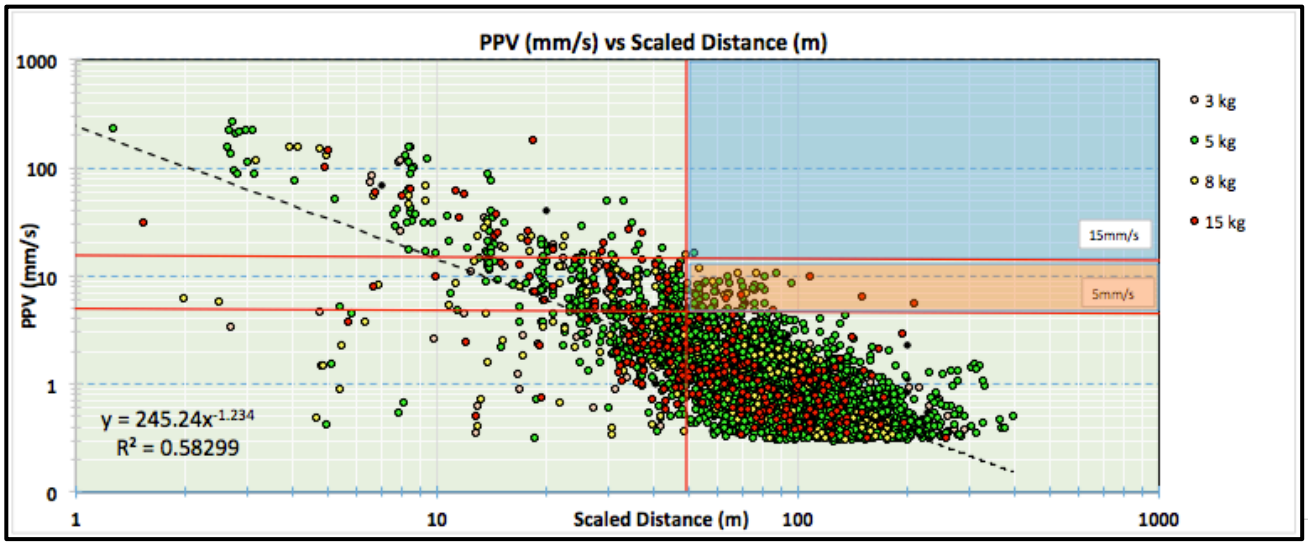


Figure 9: Example of explosive source data for various charge sizes

8 Pre-operational Testing

As indicated in Section 6, INEOS will undertake a set of parameter tests into the PPV meters (with sources gradually moving closer to, past and away from the PPV meters) to check and calibrate the stand-off distances that have been designed for this project. Stakeholders will be invited along to this event, which will involve just the vibrators to start with and followed by explosives when these have been drilled.

The PPV test locations will be chosen for ease of agreed access for the vibrators but more importantly the section of line chosen for the test needs to be free of any sensitive receptors so that the monitors can be placed on line and records taken at a series of distances on either side. The vibrator source parameters to be tested will be over a 300 m distance, and a fleet of three units will sweep every 25 m along the test line, with the PPV meter positioned at the center and will be repeated for different drive levels as per the guidelines designed in Table 1 below.

The range of offset distances will allow for verification of the minimum safe distances that will be used by the survey teams when planning the source points around sensitive receptors, in compliance with the table distances published in the Method Statement and replicated in Tables 1 and 2 below and overleaf. These distances will constantly be monitored in real time by utilising and planning the two PPV meters available along the source lines as they are recorded.

RECOMMENDED SAFE DISTANCES FOR VIBRATORY ENERGY SOURCES (m) (Thomas)

INEOS Shale

Drive level (% peak force)	**15**				**30**				**50**				**75**				**90**			
No. of vibrators	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Houses and other dwellings	5	10	20	35	10	20	35	50	15	25	40	60	25	35	50	75	45	55	70	100
Strong industrial buildings	5	5	10	20	10	10	20	30	10	20	30	40	20	30	40	50	30	40	50	60
Listed or fragile buildings	25	30	40	50	30	40	50	75	40	50	75	100	50	75	100	100	100	100	100	100
Hospitals	25	30	40	50	30	40	50	75	40	50	75	100	50	75	100	100	100	100	100	100
Petrol storage tanks	5	10	15	20	10	15	20	35	15	20	35	50	20	35	50	75	35	50	70	100
Culverts, man-holes	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
Bridges, tunnels	5	10	15	20	10	15	20	35	15	20	35	50	20	35	50	75	35	50	70	100
Electricity sub-stations	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
Electric cables	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
HP gas, oil and water pipes, parallel	4	4	4	4	5	5	5	5	7	7	7	7	10	10	10	10	20	20	20	20
HP gas, oil and water pipes, crossing	5	10	15	20	10	15	20	35	15	20	35	50	20	35	50	75	35	50	70	100
MP and LP oil, gas and water pipes parallel	1.5	1.5	1.5	1.5	2	2	2	2	3.5	3.5	3.5	3.5	5	5	5	5	10	10	10	10
MP and LP oil, gas and water pipes crossing	1.5	3	4	5	2	5	7	10	3.5	7	10	15	5	10	15	20	10	15	20	25
Radio masts	5	10	15	20	10	15	20	35	15	20	35	50	20	35	50	75	35	50	70	100
Telephone boxes	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
Fire hydrants	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
Telephone fibre-optic junctions	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
Sewage pipelines	2	2	2	5	2	5	5	7	5	5	7	10	5	7	7	10	7	10	10	10
Sewer rising main, iron or steel	4	4	4	4	5	5	5	5	7	7	7	7	10	10	10	10	20	20	20	20
Sewer rising main, plastic	2	2	2	2	3	3	3	3	5	5	5	5	7	7	7	7	10	10	10	10

Table 1: Vibroseis Stand-off Distances

Total Charge Size	0.09kg	0.18kg	0.25kg	0.5kg	1.0kg	2.0kg
Buildings						
Occupied dwelling	50m	50m	50m	50m	50m	50m
Listed building	50m	50m	50m	50m	50m	50m
Industrial building	10m	18m	25m	25m	50m	50m
Agricultural building	10m	18m	25m	25m	50m	50m
Church/ Mosque	50m	50m	50m	50m	100m	100m
Graveyard	50m	50m	50m	50m	100m	100m
Services						
HP gas pipelines	10m	18m	25m	25m	25m	50m
MP & LP gas pipelines	5m	5m	5m	10m	15m	20m
HP water pipelines	10m	18m	25m	25m	25m	50m
MP & LP water pipelines	5m	5m	5m	10m	15m	20m
Sewage pipelines	5m	5m	5m	10m	15m	20m
O/H Power pylon (main)	25m	25m	50m	50m	50m	50m
O/H Power pylon (sub)	15m	20m	25m	25m	25m	25m
O/H Electric cables	*No less than 2.5 x detonator lead length*					
U/G Electric cables	5m	5m	5m	10m	15m	20m
U/G Telecom cables	5m	5m	5m	10m	15m	20m
General Utilities						
Roads	5m	5m	5m	5m	5m	5m
Railways	10m	10m	10m	10m	10m	10m
Manholes/culverts	5m	5m	5m	5m	5m	5m
Bridges/tunnels	10m	18m	25m	25m	50m	100m
Water wells	25m	25m	50m	50m	50m	50m
Fibre-optic junctions	5m	10m	10m	10m	15m	20m
Aqueducts	10m	18m	25m	25m	25m	50m

Table 2: Explosive Stand-off Distances

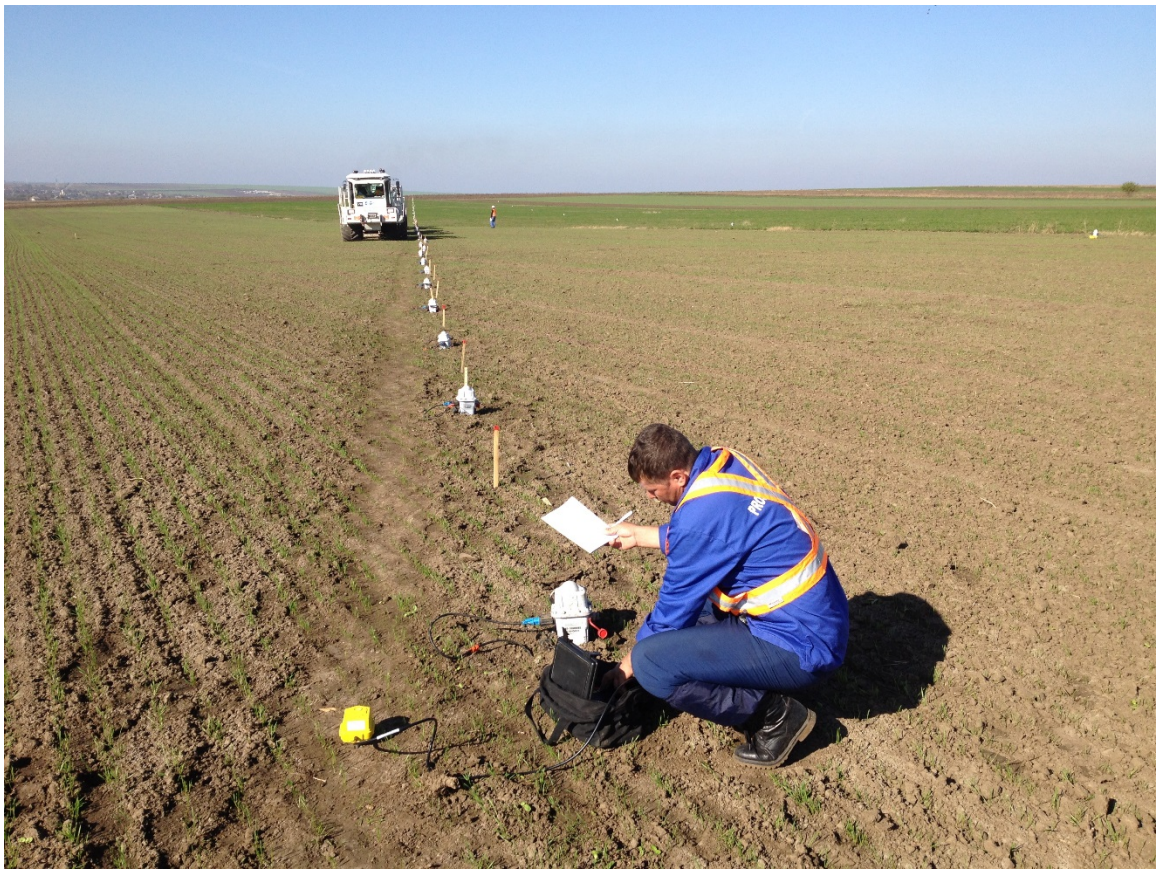


Figure 10: Typical PPV monitoring of vibrator offset

9 Field Procedures

It is expected that field procedures will evolve during the execution of the project and especially after the initial testing. This evolution will detail the number of PPV meters deployed and their preferred location with respect to a Sensitive Receptor (SR) and the selected source point (SP) to be monitored.

As a preliminary field procedure the following must be observed:

- The survey post-plot would identify all SR agreed by QC, Social and Environmental stakeholders and approved by Company Representatives. These SRs would be identified based on desktop surveys (e.g. designated sites, identified utilities, mapped watercourses etc.) and also in-field surveys carried out during the preliminary field surveying and pegging (e.g. private water supplies identified by the landowner, breeding bird nests, resting places of protected mammals, trees, including veteran trees etc.). Pegging would have regard for standoff distances identified for these receptors to ensure risks of disturbance are minimised.
- Where PPV monitoring is required for a specific SR or group of SRs the nearest 4 (as a minimum) SPs would be identified and PPV locations approved for each SR/SP pairing. These locations would be pre-surveyed and dependent on SP/SR configuration one or more PPV meters and teams may be required to be deployed.
- Where possible 2 meters would be deployed for each 4 shots as a minimum.
- Each SP/SR pair would require a PPV measurement.
- An agreed per section (to be determined) PPV plan would constitute a requirement to commence recording activities in that sector.
- Party Chief or Senior Observer would have the authority to vary PPV plan on a daily basis, subject to daily review by Company representative and in full agreement of the ALO and landholders.

In an ideal world the PPV monitor should be set as close to the SR as possible to give a true reading of the particle movement at the receptor itself. However, this would depend on the location of the SR and if the owner gives permission for the operator to be stationed that close. Also, it is important to avoid disturbance to some SRs, such as breeding birds, which could be caused by placing PPV monitors very close to their nests. In the ideal case Figures 11 and 12 overleaf show how as single and double monitoring situation might be deployed.

In left hand diagram of Figure 11, PPV monitor records would be taken at every SP between 1008 and 1016 for the single yellow sensitive receptor (house). In right hand diagram of Figure 11, as there are two sensitive receptors along the 2D seismic line and two monitors would be used both recording SPs 1008 to 1018. If the monitor cannot be stationed exactly at the SR for any reason, valid offset and PPV levels data can be collected as long at the monitor is placed between the SR and the source as per the example in Figure 12.

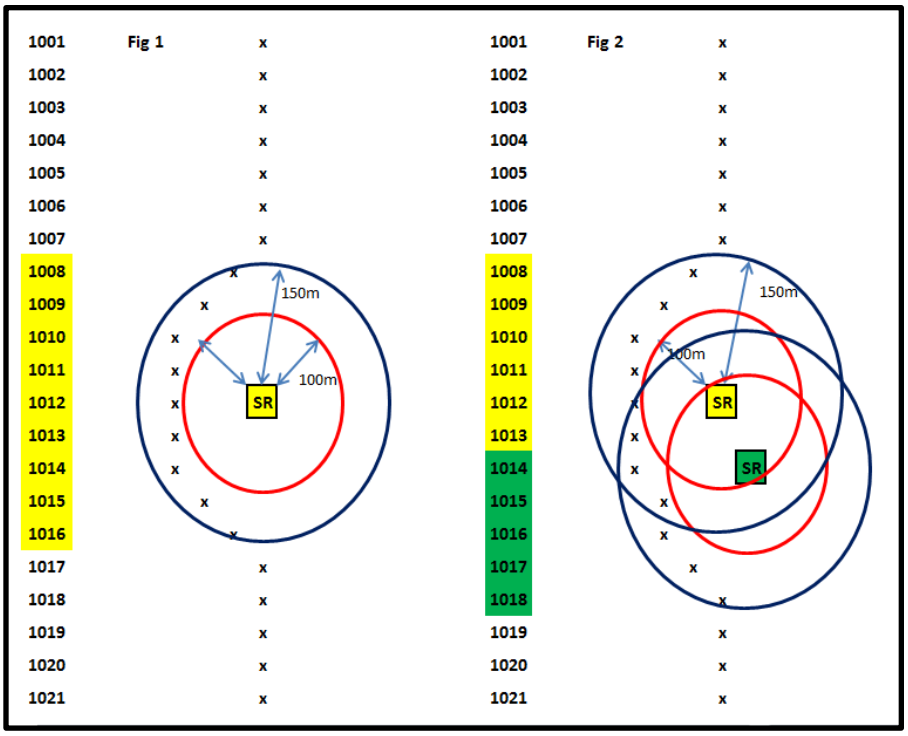


Figure 11: Example of planned source stand-off from SRs

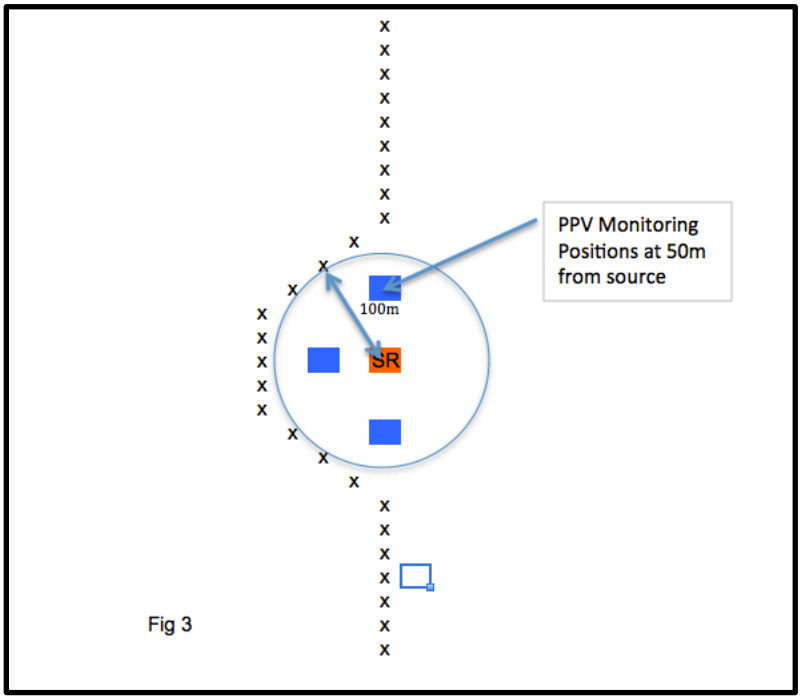


Figure 12: PPV monitoring between source and SR in the case where access to the SR is restricted

10 Summary

In conclusion this report outlines the justification for use of PPV monitoring to protect sensitive receptors, and levels where cosmetic damage to property and human perception could potentially occur. Levels of 15 mm/s for the former and 5 mm/s for human perception and sensitive receptors are considered highly conservative, and similar to vibration levels produced by “routine” occurrences such as walking or closing doors within buildings.

The methodology by which vibration at these levels can be achieved is described. INEOS proposes a test at the outset of the survey pegging (at which point standoffs from known receptors would require to be applied) to establish site-specific attenuation curves. These will ensure conservative standoffs can be maintained from sensitive receptors. This test would be carried out in an area with no identified sensitive receptors, and open to invited stakeholders to demonstrate the methodology and the measured vibration (using PPV monitors) occurring at different distances from the source points.

During the survey, INEOS would carry out continuous monitoring to ensure these standoffs are appropriate (as vibration attenuation varies according to geological and topological variation). In addition, ecological/ environmental observations would be made to ensure disturbance to receptors of unknown sensitivity or location is avoided.

Appendix 3: Preliminary Environmental Method Statement

This environmental method statement outlines measures to be followed by the survey crews in order to avoid potential impact to the environment, including pollution of water resources or soil, damage to protected habitats, disturbance to protected species, damage to cultural heritage designations (scheduled monuments, listed buildings and registered parks and gardens) and amenity disturbance to local residents (including noise, traffic and general disruption). It provides an additional level of protection to the methods outlined in the main body of the accompanying Method Statement; for example, agreeing access with landowners and undertaking survey work to minimise disturbance to agricultural works.

This appendix will form part of the project specific site safety document, so it repeats measures outlined in the main body of the document. It is assumed that measures to ensure the safe operations of the surveys (for example, in relation to training staff, ensuring correct safety equipment is in use, ensuring members of the public are protected) will be in place and relevant insurances relating to third party cover and environmental protection will be in place.

This environmental method statement is divided into “general” measures to be followed through the whole survey, and “specific” measures within or close to particular environmental sensitivities and designations. As different environmental designations may have similar sensitivities (for example, the potential for breeding birds) several points are therefore repeated throughout this method statement.

A list of additional consents and notifications required to be made is held in Section 3.1 of the accompanying Method Statement.

This preliminary environmental method statement is a live document and will be modified or added to as surveys progress and as stakeholders provide further advice or restrictions.

GENERAL

Survey Strategy

An Environmental Clerk of Works (EnCoW) will monitor the survey and identify where changes need to be made due to environmental considerations. If necessary, the EnCoW will have the power to stop the survey in that area.

The Agricultural Liaison Officer (ALO) will ensure agreement of all operations with the landowner. No un-agreed access to landholdings will be taken, no un-agreed operations will be undertaken, and all access points will be as agreed. The ALO will have the power to stop the survey in that area.

Survey operations will take place only between 7am and 7pm. No surveying activity will be conducted between dusk and daybreak.

Mobile security patrols will continue during the day and night-time to protect some site equipment, where necessary.

Any site-specific timing restrictions (for example, to protect the amenity of schools or hospitals during particular hours) will be strictly observed.

Temporary welfare vans will be placed in appropriate locations with landowner agreement.

Local residents will be informed of the survey through leaflet drops, providing contact details of the local field office and other telephone numbers. A notice will also be placed in the local press to notify residents of operations and provide telephone contact numbers.

No trees will be felled, lopped or topped as part of the survey unless agreed with the MPA, landowners and other relevant bodies.

Where possible, existing field entrances will be used, to avoid removal of sections of hedges. Any trimming (if required) will be carried out outside of the breeding bird season or following a breeding bird survey.

Staff will travel by minibus (or similar) to the survey, to minimise staff travel movements.

All equipment will be less than 15 m tall (to comply with GPDO requirements), unless other restrictions apply (see below in relation to aerodromes).

Any lighting needed for low-light daytime conditions will be low intensity, temporary and angled to the ground.

Waste generated during the survey will be removed from the site and licensed carriers and disposal sites will be used if needed. The Waste Management Plan will be followed in relation to waste reduction and recycling where appropriate.

General Vehicle Usage

All survey vehicles given approval to operate across agricultural farmland will be, wherever possible, fully fuelled prior to field entry. Should refuelling be required, this will be undertaken within a designated safe area (e.g. designated forecourt or similar with appropriate drip trays and spill remediation).

All hoses and valves on vehicles will be checked for wear daily and immediately replaced where required.

Any vehicle taking access to agricultural land will be supplied with the appropriate commercial spill kit. Spill kits will also be available from the mechanic and security vehicles.

Biodegradable hydraulic oil and lubricants will be used in the vehicles where possible.

Drivers operating survey vehicles will be fully trained.

Any spillage of fuel or oil will be immediately managed using supplied spill kits, and reported to the relevant landowner and to the Environment Agency Incident Response Hotline.

All vehicles will be regularly serviced and maintained to prevent accidental pollution.

A Transport Management Plan will be followed including accepted routeing of vehicles and means of traffic control during surveys (e.g. stop/go board). This will minimise disruption to other road users and ensure safe working. Any time restrictions (for example, to avoid peak periods of traffic including school drop off and pick up times) will be strictly followed.

Operations in dry, windy conditions will be monitored to ensure dust is not created. Damping down equipment will be used where appropriate to avoid dust blow.

Road sweeping and wheel cleaning will be used if conditions result in dust or mud being tracked onto the road.

Traffic speeds will be kept low to avoid noise and vibration effects at homes and non-residential receptors.

When requiring to travel off-road, only vehicles with appropriate tyres will be used to avoid damaging soils. Track mats may be used in appropriate conditions to further protect the soil.

Vehicles will be routed to avoid unsuitable section of road; for example, sections of road with a weight limit which vehicles would exceed (particularly applicable for vibroseis vehicles).

General Stand-offs Where No Survey Work will be Undertaken

There will be no surveys (sources or receivers) in SSSIs or Scheduled Monuments or areas of standing water or watercourses. There will also be no surveys in Natura 2000 sites (SAC/SPA) though there are none within the survey area in East Midlands.

Stand-offs for seismic **sources** will be retained from the following environmental receptors. The generic figures below have been used to guide survey design, but will be finalised following agreement with landowners and relevant regulatory bodies, and clarified in the field following preliminary PPV monitoring:

- Trees – dependent on the Root Protection Zone, which will be determined in the field by the EnCoW (likely similar to the crown spread) – see additional measures below

- Veteran trees (over 400 years old, as advised by landowner or EnCoW) - Root Protection Zone is considered as the area around the tree whose radius is 15 times the diameter of the tree at breast height or 5 m beyond the crown, whichever the greater. PPV not to exceed 5 mm/s– see additional measures below

- Occupied buildings, hospitals or schools – 50 m, unless otherwise agreed by the landowners and safe distances for PPV can be achieved. PPV not to exceed 15 mm/s

- Listed Buildings – 50 m from the listing (curtilage of the building), unless otherwise agreed with Historic England and the landowner and PPV not to exceed 5 mm/s

- Scheduled Monuments – 50 m from the designation boundary unless otherwise agreed with Historic England and the landowner and PPV not to exceed 5 mm/s

- Watercourses, including field drains and standing water bodies – 8 m

- Private Water Supplies – i.e. springs or watercourses used for water supply (identified by landowner or manager) – 50 m (to be refined by the site specific PPV monitoring – PPV not to exceed 5 mm/s)

- Known badger setts (identified by landowner, site manager or pre-operational survey) – a stand-off to ensure <5 mm/s PPV. A conservative 50 m stand-off will be maintained during pegging, to be refined by the site specific PPV monitoring – see additional measures below

- Known holts, nests, corridors for otter, water vole, bats or other protected mammals (identified by landowner, site manager or pre-operational survey) – a stand-off to ensure <5 mm/s PPV. A conservative 50 m stand-off will be maintained during pegging, to be refined by the site specific PPV monitoring – see additional measures below

- Known nests of wild birds - (identified by landowner, site manager or pre-operational survey) - if surveys were undertaken within the breeding bird season, a stand-off to ensure <5 mm/s PPV at nests will be used. A conservative 50 m stand-off will be maintained during pegging, to be refined by the site specific PPV monitoring – see additional measures below

- Habitat that could be suitable for protected species, including breeding birds during the breeding bird season - If the EnCoW considers there to be potential for a particular habitat to support protected species, a conservative 50m stand-off to ensure <5 mm/s PPV will be maintained during pegging, to be refined by the site specific PPV monitoring – see additional measures below

Receivers will not be placed within scheduled monuments, in the grounds of listed buildings (unless agreed with the landowner and Historic England). Where they are used within 50m of these designations they will be laid by hand rather than ATV. Receivers will also not be placed on the banks of watercourses or standing waterbodies, or in other locations as agreed with the landowner and relevant bodies (to avoid disturbance to environmental features or protected species).

Although some survey work will take place along roads and roadside grass verges in urban areas, the majority of urban areas will be excluded from the survey, and no private gardens will be used.

Laying Receivers

Disturbance of vegetation will be kept to a minimum.

Where receivers require to be buried, this will only take place in mid-field with the agreement of the landowner, and not in field margins (unless specifically requested by the landowner and agreed with the MPA).

Where otherwise appropriate, and with regard to stand-offs from identified receptors within hedges, trees, watercourses etc., receivers will be placed to avoid undue disturbance to agricultural work.

Receiver placement will not prevent access to fields, rights of way, footpaths, bridleways, private entrances or other accesses.

No receivers will be placed in the road carriageway.

Drilling of Shotholes, Laying and Setting Off Charges

Minimum size charge possible to be used: not exceeding 2kg.

In the vicinity of sensitive environmental receptors (woodland, cultural heritage designations, natural heritage designations, Local Nature Reserve etc.) the charge will be limited so as not to cause disturbance, ensuring vibration at receptors is minimised, as agreed with the relevant regulators.

In vicinity of other sensitive receptors (utilities, occupied houses, hospitals, schools, places of worship, cemeteries etc.) recommended safe distances will be adhered to for different charge sizes (as indicated in Appendix 1 of the main method statement).

Peak Particle Velocity (PPV) monitoring will be taken at nearest sensitive receptors, including environmental designations.

Where receptors have a vibration limit (e.g. residential homes and other buildings) vibration at receptors will be measured as the source gradually approaches. Where vibration levels approach the maximum permissible, the survey must stop, and start again at a safe distance, gradually approaching the receptor from the other side.

Only air or drinking-standard water will be used as drilling fluids, and charges will be non-toxic.

Hand augering will be used if vehicle access is not possible.

Shotholes may be cased with a temporary plastic casing if there will be any delay in loading in areas of high water table. This will prevent holes collapsing or filling with water in advance of charges being laid. This casing will be removed upon loading, and the shothole backfilled as normal.

Where otherwise appropriate, and with regard to stand-offs from identified receptors within hedges, trees, watercourses etc., shotholes will be placed to avoid undue disturbance to agricultural work

Shothole placement will not prevent access to fields, rights of way, footpaths, bridleways, private entrances or other accesses.

No shotholes will be placed in the road carriageway.

Shotholes with charges will be backfilled with gravel and spoil or bentonite clay prior to setting off the charge. If there will be a delay, liaison with the landowner will assess if access to the field for management will be required, and if so, the shotholes will be constructed accordingly.

Guidance produced by the HSE and CBI (Guidance for the Safe Management of the Disposal of Explosives) will be followed. Relevant requirements of the Explosives Act 2014 will be followed,

in relation to training of staff working with charges, and licensing. For example, charges will be brought to the site daily and not stored on site without appropriate permits.

Any residual material will be removed from the shothole and disposed according to the waste management plan to prevent contamination.

Use of Vibroseis Vehicles

Vehicles will stay on the surfaced roadway unless agreed with landowner that access can be taken onto fields.

Stand-offs from identified receptors will be maintained.

Measures in the Traffic Management Plan will be followed.

Instructions of Police and Highways Authority will be followed in relation to management of slow moving vehicles.

Peak Particle Velocity (PPV) monitoring will be taken at nearest sensitive receptor, including environmental designations.

In the vicinity of sensitive environmental receptors (woodland, cultural heritage designations, natural heritage designations, Local Nature Reserve etc.), the vibroseis intensity will be limited so as not to cause disturbance, ensuring vibration at receptors is minimised, as agreed with the relevant regulators. In vicinity of other sensitive receptors (utilities, occupied houses, hospitals, schools, places of worship, cemeteries etc.) recommended safe distances will be adhered to for different vibration intensities (as indicated in Appendix 1 of the main method statement).

Restoration of Survey

A pre-and post-survey of road and field condition will take place.

Any damage caused by the survey will be made good to the landowner or Highway Authority satisfaction.

Shotholes will be backfilled with gravel and spoil or bentonite. The ground surface will be made suitable for agricultural management and seeded if required.

Any field drains damaged by the survey will be restored

Restoration (including removal of structures, waste, sealing boreholes, levelling of the topsoil and seeding and replanting) will be completed within 28 days of cessation of operations unless agreed otherwise by the MPA in writing.

SPECIFIC

Additional Safeguards to Protect Trees

No sources will be placed in the root protection zones of trees unless specifically agreed by the landowner and EnCoW (and only then if no damage will be caused to the tree and not in any

designated area). The root protection zone will be determined by the EnCoW at the pegging out stage.

If a tree is not assessed as being of value to protected species and is not an ancient tree, the root protection zone is considered to be roughly equivalent to the crown spread.

If a tree is assessed as being of potential importance to protected species, a stand-off to ensure vibration is kept at or below 5 mm/s will be maintained. This will depend on PPV monitoring, but a conservative stand-off of 50 m will be used initially (at pegging). This stand-off is also likely to apply to veteran trees, unless the distance at which 5 mm/s could be achieved is less than the stand-off reached through the formal root protection zone assessment (in which case, this will take priority) – i.e. area around the tree whose radius is 15 times the diameter of the tree at breast height, or 5 m beyond the crown.

If receivers are placed within root protection zones, care will be taken to minimise the numbers of receivers used and minimise soil compaction in the area, with receivers laid by foot access. If the EnCoW notes any disturbance to species within the tree during laying receivers, no further receivers will be laid and the laying-out will move carefully from the area. When receivers are collected after the survey, care will be taken to avoid further disturbance.

The EnCoW will monitor the survey and identify where changes need to be made. If necessary, the EnCoW will have the power to stop the survey in that area.

Additional Safeguards to Protect Breeding Birds, including in identified "Might-Be SPA"

These safeguards will apply during the breeding bird season (between February and August). Breeding season dates may be amended following discussion with RSPB and Natural England (depending on the progress of breeding in the year of survey, and the species involved). However, the EnCoW will be aware of possible nests throughout the year and apply the safeguards if they consider them appropriate.

In areas where there could be nesting birds, a conservative stand-off for sources will be maintained from potentially suitable habitat or any known nests. This will be 50 m initially, to ensure vibration does not exceed 5 mm/s at any nest. There may be potential to reduce this stand-off from potential habitat after preliminary PPV testing.

Care will be taken to avoid disturbance during receiver laying in potentially suitable habitat, and if disturbance is observed, no further receivers will be laid and the laying-out will move carefully from the area. When receivers are collected after the survey, particular care will be taken to avoid further disturbance.

The EnCoW will observe any identified nests and potentially suitable habitat for any disturbance of protected species during pegging, laying receivers and the survey itself. Should disturbance be observed, the survey will move from the area and when returning will maintain a greater stand-off or (if disturbance was caused during shooting) a reduced vibration level. The EnCoW will if necessary, have the power to stop the survey in that area.

Should multiple episodes of disturbance be observed from any particular activity, this methodology will be revised to increase stand-off from protected species, or decrease the acceptable vibration level. This will be discussed with the EnCoW.

Surveys in the vicinity of breeding birds should take place on and immediately adjacent to existing tracks and roads where available, unless otherwise agreed with the landowner and other relevant stakeholders (including site managers where applicable). Receivers should be laid by hand rather than by ATV.

Whether shotholes or vibroseis sources are used will depend on the nature of the site and agreement with landowners and stakeholders.

The EnCoW will monitor the survey and identify where changes need to be made. If necessary, the EnCoW will have the power to stop the survey in that area.

Additional Safeguards for Other Protected Species

In areas where there could be other protected species, a conservative stand-off for sources will be maintained from potentially suitable habitat or any known setts, burrows or resting places. This will be 50 m initially, to ensure vibration does not exceed 5 mm/s. There may be potential to reduce this stand-off after preliminary PPV testing. Care will be taken to avoid disturbance during receiver laying in potentially suitable habitat, and if disturbance is observed, no further receivers will be laid and the laying-out will move carefully from the area. When receivers are collected after the survey, care will be taken to avoid further disturbance.

The EnCoW will observe potentially suitable habitat for any disturbance of protected species during pegging, laying receivers and the survey itself. Should disturbance be observed, the survey will move from the area and when returning will maintain a greater stand-off or (if disturbance was caused during shooting) a reduced vibration level.

The EnCoW will monitor the survey and identify where changes need to be made. If necessary, the EnCoW will have the power to stop the survey in that area.

Additional Safeguards adjacent to Birklands and Bilhaugh SAC, Sherwood Forest NNR and SSSIs

Any surveys adjacent to SSSIs, SACs or NNRs using vibroseis vehicles will be on surfaced tracks where possible.

Measures above to protect trees, breeding birds and protected species will be followed.

Additional Safeguards in Local Nature Reserves and Local Wildlife Sites

Liaison with the landowner/ management of the LNR/ LWS will identify areas of sensitivity and methods to avoid disturbance will be agreed.

Surveys will take place on and immediately adjacent to existing tracks, paths and roads unless otherwise agreed with the landowner and manager.

Whether shotholes or vibroseis sources are used will depend on the nature of the site and agreement with landowners and stakeholders (such as site managers).

Receivers require sensitive placing. If receivers require to be placed away from roads and tracks, they will be carried on foot, and use forestry rides or similar.

Measures above to protect trees, breeding birds and protected species will be followed.

Additional Safeguards in Woodland (including Ancient Woodland)

Where possible, surveys will take place on and immediately adjacent to existing tracks and roads. If receivers require to be placed away from roads and tracks, they will be carried on foot, and use forestry rides or similar.

Whether shotholes or vibroseis sources are used will depend on the nature of the site and agreement with landowners and stakeholders (such as site managers).

Measures above to protect trees, breeding birds and protected species will be followed.

Additional Safeguards adjacent to Creswell Crags Scheduled Monument and SSSI

At land to the south of Creswell Crags Scheduled Monument and SSSI no source points will be located in the area forming the southern end of the magnesian limestone ridge immediately to the south of the protected area, as caves and fissures may extend into this ground.

Additional Safeguards within 3km of an aerodrome

All equipment within 3 km of the aerodrome should be less than 3 m tall in general use; although taller temporary equipment (such as the temporarily drill mast of tractor mounted drills which could extent up to 3.8 m) could be used. Any taller equipment (e.g. recording unit mast) will be located outside the 3 km buffer.

Owners of the aerodrome will be consulted regarding the survey timing.

Additional Safeguards in Parks and Gardens

No surveys until the landowner (and Historic England for Grade 1 and 2*) has confirmed access and method statement.

Where possible, surveys will take place on and immediately adjacent to existing tracks and roads. If receivers require to be placed away from roads and tracks, their placement will use breaks in vegetation to minimise disturbance.

Whether shotholes or vibroseis sources are used will depend on the nature of the site and agreement with landowners and stakeholders (such as site managers).

If other designated features are present within the park and garden (for example, listed buildings), measures to protect them will be used – e.g. 50 m stand-off of source points from listed buildings.

Measures above to protect trees, breeding birds and protected species will be followed.

Additional Safeguards in Groundwater Protection Zone 1

Only vibroseis sources will be used.

Care will be taken to prevent vehicle use or drilling from silting watercourses during operation (the risk of this will be minimised by ensuring no source points are placed within 8 m of a watercourse or pond and no receivers will be placed on banks).

Any additional protection measures relating to surface water (field drain, river, pond) or groundwater as agreed with the Environment Agency through the Section 199 Consent process (Conservation Notice, if one is issued) will be incorporated into this Method Statement.

Additional Safeguards in Areas at Risk of Flooding

Surveys will not take place in known flood plains where heavy rain or high river levels are forecast.

Equipment will be moved from such areas should weather forecast suggest these conditions may occur.

Soil compaction will be avoided by avoiding use of vibroseis vehicles on bare soil, and by minimising tracking of vehicles on soil. Track boards will be used for vehicles if necessary.

Additional Safeguards in Urban Areas

The stand-off distances identified during preliminary PPV monitoring will be followed so vibrations at properties will not exceed upper safe limit of 5mm/s to prevent statutory nuisance.

No sources or receivers will be placed in private gardens. Only the public highway, including grass verges will be used.

Where there are other designations or sensitive areas within the urban areas, protections afforded to these designations will be maintained.

Timing restrictions for schools (for example avoiding the beginning and end of the school day) or other receptors within the TMP will be followed.

Surveys will avoid peak traffic times and periods early in the morning.

Residents to be provided with information relating to surveys, including contact numbers.

All utilities in urban areas carefully mapped in advance of survey.

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