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Subject	**Technical Peer Review of Environmental Statement**	**Project Name**	Altcar Moss ES Review
Attention	Andrew Mullaney (LCC)	**Project No.**	B2327FED
From	[redacted]		
Date	5 February 2020		
Copies to	Jonathan Haine (LCC)		

APPLICATION: LCC/2019/0037

PROPOSAL: CONSTRUCTION OF A TEMPORARY WELLSITE AND ASSOCIATED ACCESS TRACK, DRILL, HYDRAULICALLY STIMULATE AND TEST TWO PETROLEUM EXPLORATION BOREHOLES INCLUDING DRILLING RIG (MAXIMUM HEIGHT 60m) AND ASSOCIATED PLANT AND EQUIPMENT, FOLLOWED BY WELLSITE RESTORATION

TECHNICAL PEER REVIEW OF ENVIRONMENTAL STATEMENT CHAPTER 9 (AIR QUALITY), 17 (SEISMICITY, APPENDIX G (NOISE ASSESSMENT) AND APPENDIX I (WATER RESOURCES AND FLOOD RISK)

Lancashire County Council (LCC) is in receipt of a planning application for the construction of a temporary wellsite and associated access track, drill, hydraulically stimulate and test two petroleum exploration boreholes including drill rig (maximum height 60m) and associated plant and equipment, followed by wellsite restoration (planning application reference LCC/2019/0037). The facility is located at Sutton's Lane, Great Altcar, approximately 2km to the east of the town of Formby. The site is referred to by the applicant (Aurora Energy Resources Ltd) as the Altcar Moss Wellsite.

To support it in its determination of the planning application, the following potential impacts areas have been reviewed:

- seismic;
- air quality;
- groundwater; and
- noise.

This technical note sets out a summary of the reviews undertaken of the Environmental Statement (ES) and other related documents supporting the planning application for the Altcar Moss Wellsite. The above categories are set out below, together with the specific advice requested by LCC for ease of reference. Additional information for each category is located in appendices at the back of this review.

1. Seismic

Whether the assessment of seismic impacts has been carried out correctly and would enable the planning authority to be able to conclude that the proposed development would not be likely to give rise to significant adverse impacts, particularly in light of the Written Ministerial Statement from the government (4 November) and the recent reports from the Oil and Gas Authority?

As set out in their Scoping Opinion dated 27th March 2018 (see Appendix A of the ES), LCC require Aurora to include the following in their planning application in relation to "Seismic Impacts / Geological issues" (cf. ES Table 17.1). Note that relevant subsections of the ES are included in brackets below.

- include an assessment of the probability and likely significance of any seismic events that might be triggered by hydraulic fracturing operations on this site (Section 17.4.3, Section 17.7).
- include sufficient local and regional geological information to enable the subsurface geology including structure in the area to be explored to be adequately characterised (Section 3.2, Section 5.2.2, Section 17.4.1 and Section 17.6.1).
- include the relevant information that was gathered from the 3D seismic survey that has previously been undertaken over this area (Section 3, Section 17.6.1). This information should:
  - include details of geological structures including faulting which may have implications for the drilling operations and induced seismicity from fracking operations (Section 3, Section 17.6.1).
  - should seek to characterise the existing stresses on such faults and the risks that may result through the undertaking of hydraulic fracturing operations in proximity to such fault planes (Section 17.6.2).
- should contain information on existing natural seismicity in the area having regard to historical information and monitoring carried out pre development (Section 17.6.3).
- should include a description of the measures that will be employed to monitor seismic impacts during the fracturing operations and how such monitoring will be used to control fracturing operations in a manner to reduce seismic impacts to acceptable levels including details of the methodology of monitoring. Details of how the proposed traffic light system would operate should be provided (Section 17.8).
- should examine the risks to the integrity of the boreholes and associated casings / environmental protection measures from any seismicity that may be triggered by hydraulic fracturing operations (Section 4.2, Section 17.7 and Section 20.6).
- Although not directly related to seismicity the response also requested the ES should address the risk of subsidence: Although the risk of subsidence from fracturing and gas extraction operations is acknowledged to be low, it is considered that the ES should demonstrate how and why the risk is concluded to be low (Section 17.7).

1.1 Consistency of Inputs and Outputs

The application discusses most of the topics that we would expect to see in the planning application. However, the level of detail we would expect to see has not been realised. The topics covered are

generally considered at a superficial level and with little or no specific information regarding quantities or details of proposed further work leading to the potential for misunderstanding later when LCC's expectation of future works are not met. In addition, Aurora draw conclusions in the report that are not justified based on the level of reporting presented in the application. The report is largely qualitative rather than quantitative.

It should be noted that, in the areas of geology and induced seismicity, the Aurora planning application is based in large part on the previously successful planning application submitted by Cuadrilla Resources Limited in support of drilling operations at Preston New Road (Cuadrilla, 2014). This application t ook into consideration findings from investigations following seismic events induced by hydraulic fracturing at the Preese Hall site in 2011, details of which had been reported in a series of publications, notably Green et al. (2012), de Pater & Baisch (20 12) and The Royal Society and the Royal Academy of Engineering (2012). However, since 2014, additional data have become available from series of induced seismic events at Cuadrilla's Preston New Road (PNR) site in the final quarter of 2018 and in August 2019 which call in to question some of the assumptions and assessments made in the original Cuadrilla application. Owing to its strong reliance on the justification presented by the Cuadrilla (2014) application, we strongly recommend that Aurora review and update their own application to take into account any relevant data from the 2018 and 2019 induced seismic events.

Of particular relevance are the work and findings of the four studies commissioned by the Oil and Gas Authority (OGA) in February 2019 to un derstand the induced seismicity observed at PNR in 2018, as summarised in the OGA (2019a) Interim report of the scientific analysis of data gathered from Cuadrilla's operations at Preston New Road. The individual studies looked at rupture mechanisms (Ou te Limits, 2019); ground -motion prediction and damage estimation (Edwards et al., 2019); maximum magnitude prediction (Nanometrics, 2019) and earthquake forecasting (BGS, 2019), all based on detailed review and analysis of new data gathered from PNR. Additi onally, OGA (2019b) undertook a review of recent experience from other jurisdictions to better understand the correlation between seismicity and geological setting and to compare different approaches to induced seismicity mitigation.

A significant dataset from the 2018 operations (referred to as the PNR1Z dataset) was made available to the public on 27 June 2019, approximately 6 months after the PNR hydraulic fracturing, as required under the OGA's licensing regulations. The data, which included micro se ismic event data, pumping data, a summary of produced water, screen shots of the hydraulic fracturing operations, a seismic event video and the final hydraulic fracturing report, are available on the OGA website [https://www.ogauthority.co.uk/onshore/onsho re-reports-and-data/preston -new-road-pnr-1z-hydraulic-fracturing -operations-data/]. We note that Aurora would not have had access to this full dataset prior to submission of their ES, also in June 2019. They did, however, have access to some publicly ava ilable data form the 2018 PNR operations as they make reference to this on page 313 of their ES. It is not clear how much information was available at that stage and from which sources.

It is expected that data from the 2019 PNR operations (referred to PNR2) will soon be released by OGA under the licensing terms and therefore be available to inform the current application. Indeed, OGA 2019a specifically recommend that the new models developed using the PNR1Z dataset should be checked using the independent PNR2 dataset.

We have identified some potential omissions in the scope of their assessment owing to the limited scope of the stakeholder consultation process. The contents of the ES were based almost entirely on the requirements as set out in LCC's Scoping Opinion Letter of March 2018. We believe Aurora should have formally engaged with other stakeholders, such as those listed below who Cuadrilla consulted to support its 2014 submission for the Preston New Road site:

i. the local Borough Council (in Cuadrilla's case, Fylde; in Aurora's case, West Lancashire Borough Council),
ii. the Department for Energy and Climate Change (DECC) (now the Department for Business, Energy and Industrial Strategy, although relevant responsibilities having been devolved to the Oil and Gas Authority)
iii. Highways Agency (now Highways England)
iv. Health and Safety Executive
v. Natural England
vi. National Grid
vii. General Public
viii. CPRE Lancashire (Countryside Charity)
ix. Environment Agency

Consultees highlighted in bold above all provided specific comments in relation to induced seismicity which informed Cuadrilla's subsequent ES. We believe all of the listed stakeholders should be consulted by Aurora.

1.2 Technical Coverage of Assessment

In Table A1 in Appendix A, we list each of the review requirements relating to geology and seismicity from LCC's Scoping Opinion and make an assessment of whether Aurora has undertaken the work and whether the work has been carried out to a sufficient level of detail to meet LCC's needs.

2. Air Quality

Whether the assessment of air emissions (flare, generators, vehicles, etc) has been carried out correctly and would enable the planning authority to be able to conclude that the proposed development would not be likely to give rise to significant adverse air quality impacts?

2.1 Assumptions

- It is assumed that the results analysis of the dispersion model output files has been undertaken accurately by the applicant (in the absence of reviewing these specific files and results analysis data).
- Certain aspects of the air quality assessment, which do not have a direct impact on human health or are outside the remit of air quality assessment, were not reviewed for this technical peer review (i.e. photochemical ozone creation potential, global warming potential and radon emissions).

The text below provides a summary of the technical peer review of the air quality assessment as reported in Chapter 9 and Appendix B of the ES. Further details of the review are provided in Appendix B to this technical note.

2.2 Consistency of Inputs and Outputs

The main assessment method for the air quality assessment of pollutant emissions from the various combustion emissions associated with constructing and operating the site was based on dispersion modelling. This required the following inputs:

- Emission rates of pollutants and other emission characteristics such as exhaust gas temperature, flow rates and efflux velocity.
- Physical emission source parameters such as exhaust / stack height and diameter and details of the buildings and structures on the site which may influence dispersion.
- Other model input parameters that the model uses in the dispersion calculations such as meteorological data, terrain data, roughness of the surrounding terrain.
- Selection of the locations (known as 'receptors') where the model calculates the predicted concentration of the pollutant following emission and dispersion in the atmosphere.
- The existing background concentrations of all the pollutants to which the modelled pollutant concentrations at the receptor locations were added to determine the total concentrations for comparison to the relevant air quality standards or criteria.
- The relevant air quality standards or criteria.

The input data were reviewed to check for consistency with the sources quoted and accepted good practice in line with the relevant technical guidance and also to confirm any calculations undertaken to produce the parameters (e.g. converting the emission standards to actual emission rates of pollutants etc).

All elements of the model input data were confirmed to be appropriate, with the exception of the following:

- Potential discrepancies in the receptor locations used to represent some of the ecological sites (Ribble and Alt Estuaries SPA, Sefton Coast SAC and Liverpool Bay SPA);

- Some differences in the background concentrations or existing deposition rates at the ecological sites compared to the online source quoted and the applicant's stated approach of using the maximum at any location within each site;
- Some discrepancies in the selected minimum critical loads at the ecological receptors compared to the information held on the online source quoted by the applicant and the stated approach of using the minimum critical load for any of the habitats within each site.

To confirm, no apparent issues were identified for the input data relating to the assessment of pollutant emissions at human receptor locations.

Other air quality impacts or emission sources were assessed using qualitative / risk-based approaches. The input data for the assessment of dust emissions and road traffic emissions appeared to be consistent and appropriate, with no apparent discrepancies. No quantitative data were provided for the consideration of fugitive emissions and odours, so these were not able to be reviewed.

2.3 Technical Coverage of Assessment

2.3.1 Quantitative Dispersion Modelling

The ADMS model was used to undertake the dispersion modelling, which is considered to be appropriate for the modelling of emissions from the types of sources associated with the proposed development. The coverage of the air quality assessment is considered to be in line with expected good practice and included assessing the emissions of pollutants from a range of potential pollutant emission sources at the Altcar Moss Wellsite using a quantitative dispersion modelling technique, as listed below:

- emissions from stationary diesel engines, generators and other combustion plant providing power or steam for site operations;
- exhaust emissions from the operation of non-road mobile machinery (NRMM) brought to site for construction and site restoration activities;
- exhaust emissions from heavy duty vehicles (HDV) for transport operations within the site; and
- releases of pollutants from the flaring of natural gas produced during flow testing.

The applicant considered an appropriate range of pollutants within the assessment that are associated with the above emission sources (e.g. oxides of nitrogen (NOx, consisting of nitrogen monoxide (NO) and nitrogen dioxide (NO_2)); sulphur dioxide (SO_2); carbon monoxide (CO); particulate matter ($PM_{2.5}$ and PM_{10}) and volatile organic compounds (VOCs)

The modelling appears to have been undertaken in a robust manner, with a sufficient study area adopted for the modelling. A number of sensitivity analyses to investigate the appropriateness of many of the model input parameters were undertaken as well as adoption of worst-case assumptions for several aspects of the assessment. These are discussed in more detail in Annex X of this technical note.

The main area where the technical coverage was found to be inadequate was the assessment at ecological receptors, particularly for the European designated sites highlighted in the previous section. Only one receptor was used to represent each ecological site even though these cover a large area from north to south along the coast. The receptor location used for the assessment at each ecological site appears not to represent the closest point to the Altcar Moss Wellsite as reported by the applicant, and

the model predictions may not represent the highest impact. As these are European designated sites, this also has potential implications for the Habitats Regulations Assessment.

Another element which is potentially inadequate was the consideration of cumulative / in-combination effects at the European designated sites, where further justification is required with regard to the contributions from other current or planned developments. The assessment considered cumulative impacts from developments within 10km of the Altcar Moss Wellsite and concluded that there may be other, potentially large emitters, further than this which could contribute to nitrogen or acid deposition at the European designated sites. The relevant Environment Agency (EA) guidance requires that the in-combination contributions, and not just the proposed development contributions, are compared to the criterion for identifying potential significant effects (i.e. where the in-combination process contributions exceed 1% of the critical load). This is consistent with the Natural England consultation response dated 30 August 2019, which requested additional information on the in-combination assessment with regard to the air quality impacts at the European designated sites as part of the Habitats Regulations Assessment. We are not aware if the applicant has provided a response to this request or conducted further consultation with Natural England to resolve this issue.

2.3.2 Qualitative Risk Assessments

Other aspects of the proposed development were assessed qualitatively or were screened out following consideration against relevant criteria or thresholds by the applicant:

- dust emissions from activities during construction of the site and access track;
- emissions from road traffic on the local road network; and
- fugitive releases of natural gas, principally methane and odours.

The assessment of dust during construction (phase 1) and site restoration (phase 8) activities was carried out in line with the risk assessment methodology in relevant guidance from the Institute of Air Quality Management (IAQM) to an appropriate level of detail.

The expected road traffic movements throughout the proposed development were compared to thresholds for identifying when a more detailed assessment of road traffic emissions would be required. These were set out in guidance produced by the Highways Agency and also more relevant guidance specific to air quality assessments for the development control process produced by Environmental Protection UK (EPUK) and the IAQM. This showed that the road traffic movements would be below the thresholds that would indicate the potential for a non-negligible air quality impact and, therefore, screened out the need to proceed to a more detailed assessment.

The coverage of the assessment with regard to fugitive emissions, including odours, was limited to a statement that that pipework would be pressure tested and unlikely to deteriorate over the relatively short period of operation of up to 150 days. No further consideration was provided in the air quality assessment. There were no details provided of the potential fugitive emission or odour sources or specific controls in place to prevent or reduce emissions in Chapter 9 (Air Quality). Some reference was made to potential sources (waste and well fluid storage) and the use of enclosed tanks and skips in Chapter 8 (Interactive Impacts) (the interactive impacts between waste and air quality in Table 8.1). Table 8.1 also stated that tank breather lines would be monitored, and continuous odour monitoring would be undertaken at the wellsite. However, this was not taken forward to the assessment or proposed mitigation in Chapter 9 (Air Quality).

A study undertaken by the Department for Environment, Food and Rural Affairs (Defra) highlights th at fugitive emissions of methane and non-methane volatile organic compounds (NMVOCs) are one of the main contributing sources of total VOC emissions from drilling and hydraulic fracturing activities and associated extraction. On this basis, the assessment or proposals to control and monitor for fugitive emissions is considered to be inadequate in its coverage.

2.4 Appropriateness of Conclusions

Based on the apparent robustness of the modelling with regard to potential impacts of pollutant emissions from the on-site sources at human receptors, the conclusion that there would be no significant effects is considered to be appropriate. Although the predicted concentrations were relatively high within the site or close to the site boundary, they decrease rapidly with distance from the site. There is no relevant human exposure close to the site and the reported concentrations at any of the nearest human receptor locations such as residential properties or footpaths were appropriately reported as negligible. The conclusion with regard to cumulative effects at human receptors is also considered to be appropriate.

With regard to the impact on ecological receptors (particularly the European designated sites) from on-site emission sources, a number of potential discrepancies have been identified which decreases the robustness of the conclusion made by the applicant that effects would be not significant. Given the conservative approach adopted by the applicant in undertaking the dispersion modelling, it is possible that these discrepancies would not materially affect the outcome of the assessment. However, there is not sufficient information within the application documents to confirm this and our opinion does not constitute an assessment in this regard. Therefore, without further justification, the conclusion of no significant effect is not considered to be appropriate at this stage for the ecological receptors. As noted above, further information is required in order to confirm that the in-combination process contributions would still be below the relevant criterion for identifying a potentially significant effect. As the site would need an Environmental Permit to operate from the EA, the issues relating to the potential impacts at ecological receptors could potentially be resolved at the Environmental Permit application stage. The conclusion with regard to cumulative effects at ecological receptors is also considered not to be fully robust and further information has been requested by Natural England on this matter, with regard to the Habitats Regulations Assessment.

Given the relatively small-scale of the development in terms of construction activities and isolated location away from sensitive receptors, the applicant appropriately concluded that, with the implementation of appropriate dust controls through a Construction Environmental Management Plan (CEMP), the residual effects would be not significant.

Based on the anticipated vehicle movements during each of the phases of the proposed development, the applicant appropriately concluded that these would lead to negligible impacts on air quality and would be a not significant effect.

For fugitive emissions of pollutants such as methane, VOCs and odours, the applicant concluded that these would be negligible. As discussed above, this conclusion is not considered to be appropriate without further details and justification. However, as the site would need to apply for a permit to operate, it is likely that this would be an aspect which would be controlled through the Environmental Permitting process by the EA. For example, the Cuadrilla Preston Road Site operated to an Environmental Management and Monitoring Plan which was requested by the EA as a pre-commencement condition to the Environmental Permit. The site is regularly audited by the EA to check compliance with the plan. Therefore, appropriate consultation with the EA during the Environmental Permit application process

could achieve a similar approach for the Altcar Moss Wellsite. Furthermore, and if appropriate, a suitable condition could be applied to the planning permission which requests details of the design features and operating techniques which are proposed to control fugitive emissions from all the potential sources on the site. This could give LCC sufficient confidence that fugitive emissions are capable of being managed appropriately and to prevent any potential significant air quality effects with regard to human health or amenity.

In summary, the assessment of air emissions has been carried out using appropriate methodologies and would enable the planning authority to conclude that the proposed development would not be likely to give rise to significant adverse air quality impacts at human receptors. Some further consideration on the control of fugitive emissions has been recommended.

With regard to ecological receptors, particularly European designated sites, it is recommended that further justification is required before the planning authority would be able to conclude that the proposed development would not be likely to give rise to significant adverse air quality impacts.

3. Groundwater

Whether the assessment of groundwater impacts has been carried out correctly and would enable the planning authority to be able to conclude that the proposed development would not be likely to give rise to significant adverse groundwater impacts?

3.1 Consistency of Inputs/Outputs

In general, the consistency of inputs and outputs presented in the ES is poor. Several key pieces of design information are missing from the proposed development, including; the intended direction of drilling for the horizonal well, the source of water to be used for the hydraulic fracturing stimulation, a draft hydraulic fracturing plan, chemicals intended to be used as additives in fractu ring fluids etc. All this information should be included within the ES, as stipulated by both the EA and LCC in their scoping response issued prior to ES submission. Without this information, it's unclear as to how the outcome of the technical assessment c an conclude that there would be no significant adverse impacts to groundwater receptors as a result of the proposed development, when the proposed development itself has not been assessed in its totality.

There are also several fundamental baseline data and information gaps that have led to the site not being sufficiently characterised, and the lack of in -situ data is not compensated by a conservative approach nor additional mitigation measures. For e.g. the hydraulic properties of aquifers have been determined through a desk-based literature search and not from data obtained through a site-specific Ground Investigation (GI), and the site has not been characterised at all in relation to the proposed horizontal well. Whilst a GI was undertaken at the site, this comprised only one borehole in superficial deposits. No site-specific groundwater quality or flow data was obtained, and groundwater level data was restricted to the superficial deposits with only a 2-week monitoring period. It is noted that other sources of information were used to complement the GI, but given their distance from the proposed works, for e.g. the EA groundwater monitoring boreholes and the resistivity tomography survey, this is not considered sufficient to characterise the site, and in particular, the site in relation to the proposed horizonal well.

In addition, the conceptual hydrogeological model presented in the ES is not considered to be a full or robust Conceptual Site Model (CSM). We would expect to see a detailed geological cross section, with topography considered, and a schematic showing identified Source-Pathway-Receptor (S-P-R) linkages.

3.2 Technical Coverage of Assessment

Fundamentally, the risk assessment undertaken is not, in our professional opinion, considered to be appropri ate for the type of development proposed. This is based on the fact that the process of hydraulic fracturing is new to the UK and its particular geology, there is mixed evidence from case examples in the USA, and several independent reports have been produ ced which document the severity of potential impacts caused by hydraulic fracturing to groundwater and its associated receptors. In our professional judgement, the assessment should rest on a robust CSM (the provided Conceptual model is not considered to be complete) and a semi-quantitative assessment.

Whilst it's acknowledged that there is currently no shale-specific legislation at the overarching EU or UK level, there is a wide range of broader oil and gas, environmental, health and safety, planning and other regulatory controls that apply to UK shale gas operations, as well as several technical papers, industry standards, and guidance documents. None (or only a small proportion) of these documents have been used to inform the assessment.

There is no information provided in the ES linking the scoping report and objectives and concerns or requirements raised by the consultees at scoping stage and how those have been considered. There is no mention of any consultations that have taken place with respect t o hydrogeology and groundwater protection, and no landowner consultation has been carried out with regards to potential Private Water Supplies (PWS)-- a key groundwater receptor. Also, review of the scoping responses from the EA and LCC indicate that a number of points raised at scoping stage have not been addressed in the ES.

Definitions provided for sensitivity criteria, and criteria for determining the magnitude of impact are not consistent between the ES and its technical appendices. They are overall insufficient in that they do not have a groundwater focus or do not cover all groundwater aspects and associated receptors, such as licenced and unlicensed groundwater abstractions, Groundwater Dependent Terrestrial Ecosystems (GWDTEs), aquifer designations etc. There is also no mention of Water Framework Directive (WFD) compliance. Given the inadequacies identified with the sensitivity / magnitude of impact criteria, the methodology for determining the significance of effect cannot yet be reviewed or appra ised. Hence residual effects contained within the ES cannot yet be reviewed. There is also no evidence provided to justify important statements made in relation to scoping out cumulative effects and interactive effects between environmental disciplines.

Several concerns are also noted in relation to the mitigation measures proposed for the development, in particular the lack of a dewatering strategy, construction phase method statements, a monitoring strategy and any mitigation measures for the horizonal d rilling. In light of the comments made above, there may also be additional mitigation measures needed for phases of the development which have not been considered and mitigations should be reviewed once the assessment is completed to an appropriate standard. Furthermore, it should be noted that Environment Permitting does not constitute an embedded mitigation measure in itself, and that the ES requires the applicant to identify, assess and mitigate potential impacts irrespective of the Environment Permittin g process.

3.3 Appropriateness of Conclusions

Given the concerns raised, it is not considered possible to rule out the possibility of potentially significant adverse impacts occurring to groundwater receptors without further substantiating the assessment and providing additional details and / or additional mitigation measures.

A more details review of the documentation provided can be found in Appendix C.

4. Noise and Vibration

Whether the assessment of noise has been carried out correctly and would enable the planning authority to be able to conclude that the proposed development would not be likely to give rise to significant adverse noise impacts, particularly night time noise?

The review below is of the Noise Impact Assessment Report, Rev 3 19.06.2019 undertaken by RPS group on behalf of Aurora Energy Resources.

4.1 Assumptions

The exact drilling rig which will be used is not yet confirmed, therefore there cannot be complete certainty regarding the noise that may potentially be generated during drilling operations and the impact it may have on surrounding properties. The example drilling rigs used in the assessment seem to be appropriate but what is the possibility of an alternative drilling rig to those which are assessed? Has any advice been taken from a drilling engineer or the client regarding the typical selections? Or have these been selected based on RPS's experience alone?

Assumptions for 'on-times' in paragraph 6.1 are high/maximum, although can be considered to be conservative / worst-case. Are there are any data from other wellsite's that can provide any detail to these assumptions?

4.2 Consistency of Inputs and Outputs

Origin of the source level data outlined in section 6 is well described and presents some good empirical data for the assessment, but for the Boldon Rig 92. It would be useful to know the origin of this data and if it is as robust as data for the other rigs. The data for the other two rigs is from detailed on-site measurements.

As described in paragraph 6.12, it is not clear whether a specific method (e.g. BS or ISO) was used in the determination of the sound power levels, or if this was a bespoke method based on limitations of the measurement situation.

It is not clear why the noise data detailed in Table 6.4 for the HH 220 Rig trailer, is only stated for 250Hz octave band? It is an unusual octave band to use for a broad band approximation.

In paragraph 7.3 there is a typo: '...the lower the BS 4142 criteria...' this should read BS 5228.

It is stated in paragraph 7.9 that standard mitigation will reduce noise levels to be below the WHO criteria for the onset of sleep disturbance. The World Health Organisation (WHO) Night Noise Guidelines (NNG) criteria for self-reported sleep disturbance is 42 dB $L_{outside}$ but the evidence to arrive at this threshold is gathered from transport-related sources, i.e. Road, Rail and Aircraft which is not the character of noise under assessment in this case. Included within the WHO NNG is evidence where above the level of 35 dB $L_{outside}$ may cause complaints, which should be taken into consideration when determining an appropriate noise limit. It is also unclear if the Standard Mitigation which is mentioned has been included in the assessment and the exact form it may take.

The daytime and evening noise limits reported in Table 7.7 differ from those in Table 7.5.

4.3 Technical Coverage of the Assessment

The technical guidance described in section 4 seems to be appropriate and describes all the appropriate guidance and methodology relevant to noise impact assessments conducted in the UK.

The baseline noise survey has been completed considering appropriate techniques and guidance. The time periods are adequate to determine the baseline environment, the two main locations were visited twice, and the locations for the measurements seem appropriate.

Some of the baseline noise measurement survey locations are close to the main road and would possibly be influenced by road traffic noise to a greater extent than at the receptor locations. It is understood that baseline values needed to be adjusted in some situations to account for this. Some commentary or description on how that was determined would be useful to confirm a consistent approach has been used.

The noise model prediction method seems inconsistent for the Construction and Restoration assessment. An assessment of construction noise following BS 5228 and applying its limits, should normally use the propagation methods described within the standard (i.e. hard / soft ground attenuation) rather than using ISO 9613 method. Has the construction noise model prediction method adopted BS 5228 for source noise level derivation and ISO 9613 for propagation? If so, why?

The predicted noise generated by Phase 1 Wellsite and Access Track Construction and Phase 8 Wellsite restoration have been compared to the noise limits suggested in BS 5228. Would a more consistent approach using the temporary noise limit of 70dB L_{Aeq} for 8 weeks per year from the PPG-M be more suitable?

Why has Old Moss Lane been omitted from the assessment? It would appear to have the lowest daytime and night-time L_{A90} background noise level and may prove to be a more stringent assessment location than some of those included.

There is no description of BPM being applied or considered.

4.4 Appropriateness of the Conclusions

Generally, noise level prediction results (7.18 – 7.23) have not been placed into context with regards to the requirements of the NPSE / NPPF. No mention of the concepts of LOAEL or SOAEL or if the predictions at assessment locations meet or exceed these aims. It would appear that a perceptible noise increase, is predicted at night at all but one assessment location, but no adverse impacts are anticipated as a result.

As a consequence, the conclusion of 'No impact on health' is determined considering absolute noise levels only and no consideration has been given to the effects of a change in noise level generated by the proposed drilling operations.

PPG-M requires night noise limits to be set at a level '*to reduce to a minimum any adverse impacts, without imposing reasonable burdens on the mineral operator. In any event the noise limit should not exceed 42dB $L_{Aeq,1h}$ at a noise sensitive property.* This approach to reduce adverse impacts to a minimum does not seem to have been used, as the maximum noise limit at night has been implemented for all locations, regardless of the existing ambient noise levels. In the daytime, the maximum noise limit of 55dB has not automatically been adopted and has been related to the existing ambient noise conditions.

This approach used to determine noise limits means that the daytime limits are +10dB above the L_{A90} background sound level for the daytime, but for the night-time in some cases is +17dB above the L_{A90} background sound level; implying a more stringent approach to noise limits in the daytime than for the night-time. Paragraph 6.3 states that 'it is the night-time situation rather than the daytime which will be more critical.' The noise limits applied do not support this aim.

Using 42dB L_{Aeq} for the night-time has meant a noise limit 6 – 11dB above the existing ambient L_{Aeq} noise levels in circumstances where the ambient noise level is predicted to increase by up to 5dB. A noise increase of 5dB at a receptor is commonly considered of Moderate impact if assessing under the EIA regs and would require mitigation, yet the assessment approach implemented concludes that 'there will be no adverse impact on health'.

The guidance in PPG-M requires night noise limits to be set at a level '*to reduce to a minimum any adverse impacts, without imposing reasonable burdens on the mineral operator*'. It goes on to state '*Care should be taken, however, to avoid any of these suggested values being implemented as fixed thresholds as specific circumstances may justify some small variation being allowed.*'

The above is justification for lowering the 42dB L_{Aeq} limit. The assessment demonstrates that a noise level of up to 38dB L_{Aeq} can be achieved at the nearest receptor without any specialist mitigation measures, therefore is it reasonable to suggest that this could be considered as the night-time noise limit, which minimises adverse impacts yet does not impose an unreasonable burden upon the operator.

There is no comment regarding the tonal content of the noise generated by the drilling operations. The guidance given in the PPG-M states that where the noise from the drilling operations has peak or impulsive noise, it may also so require separate limits that are independent of background noise (e.g. L_{max} in specific octave or third octave frequency bands – and that should not be allowed to occur regularly at night.)

The application of the 42dB L_{Aeq} night-time noise limit should be considered regarding the experiences of the Preston New Road wellsite. In this instance a night-time noise limit of 42dB L_{Aeq} at the nearest receptors was used as a planning condition, which may present a historical precedent, but in applying this limit at night there were numerous complaints received regarding noise from drilling operations.

4.5 Summary

Overall the noise impact assessment has used appropriate guidance and methodology to determine the likely noise levels which may be experienced at nearby receptors due to the proposed drilling operations. The methodology used to predict the likely noise arising from proposed drilling operations has been undertaken to satisfactory level.

The assessment has applied the 42dB L_{Aeq} maximum night-time noise limit suggested by the PPG-M guidance, though this permits a noise threshold of up to 17dB above the night-time background L_{A90} sound level. The daytime noise limits have used the limit of 10dB above the background L_{A90} sound level, thereby implying an increased tolerance to noise increases at night than in the day. This appears contrary to the statement in paragraph 6.3 as the night-time situation will largely determine if adverse impacts are predicted to arise. The noise limits applied do not support this aim.

The guidance on noise limits in the PPG-M requires night noise limits to be set at a level '*to reduce to a minimum any adverse impacts, without imposing reasonable burdens on the mineral operator*'. It goes

on to state '*Care should be taken, however, to avoid any of these suggested values being implemented as fixed thresholds as specific circumstances may justify some small variation being allowed.* '

Using the 42dB for the night-time has meant a noise limit 6 – 11dB above the existing ambient (L_{Aeq}) noise levels, which are from 31dB L_{Aeq} to 36dB L_{Aeq}. Therefore, it is recommended that some consideration of the specific circumstances of the existing noise environment should be taken into account when determining an appropriate noise limit.

The WHO NNG suggests a level of 40dB $L_{night,outside}$ '*to protect the public, including the most vulnerable groups such as children, the chronically ill and the elderly, from the adverse health effects of night noise*', although it should be noted that this was derived from evidence gathered from transport-related sources. The WHO NNG also suggests an estimated threshold of 35dB $L_{night,outside}$ where complaints may arise.

Given that the assessment demonstrates that a noise level of up to 38dB L_{Aeq} can be achieved at the nearest receptor without any specialist mitigation measures, is it reasonable to suggest that this could be adopted as the night-time noise limit, which minimises adverse impacts yet does not impose an unreasonable burden upon the operator. There is no evidence to suggest that a night-time noise limit above the WHO NNG level of 40dB $L_{night,outside}$ is appropriate when the existing ambient noise levels are predicted to increase by 2–5dB and it has also been demonstrated that noise levels below this threshold can be achieved without specialist mitigation measures.

The outcomes of applying the maximum night-time noise limit should be viewed regarding the experiences of the Preston New Road wellsite, where the 42dB L_{Aeq} night-time limit was applied; numerous complaints were received due to noise from drilling operations at night.

It is not considered that the planning authority is able to conclude that the proposed development would not be likely to give rise to significance noise impacts. The exact equipment to be used is still unconfirmed therefore there cannot yet be certainty of the noise level that may be achievable, whilst not imposing unreasonable burden on the operator. Furthermore, the adopted maximum night-time noise limit of 42dB L_{Aeq} has not taken into account specific circumstances of the area and the assessment demonstrates that a noise level, with assumed drilling equipment and typical mitigation measures, can achieve 38dB L_{Aeq}. Therefore, theredoes not appear to be a reason why the night-time noise limit should exceed 38dB L_{Aeq} or the 40dB $L_{night,outside}$ suggested by the WHO Night Noise Guidelines.

Appendix A – Seismicity

Table A1: Review of LCC Scoping Requirements against Environmental Statement

LCCReview Requirements	Have Aurora carried out the Work?	Is the Work carried out to a Sufficient Level of Detail?
Include an assessment of the probability and likely significance of any seismic events that might be triggered by hydraulic fracturing operations on this site (Section 17.4.3, Section 17.7).	No. "The assessment of the likely effects of induced seismicity in this application are based on previous modelling work conducted for a similar project some 25 km to the north (Cuadrilla, 2014)" p306 "The predicted ground motion (PPV mm/s) results (95th percentile) from the Preston New Road Study are given in Table 17.4 for varying horizontal distances from the epicentre." p312 Aurora quote a subset of the ground-motion estimates reported by Cuadrilla (2014) and do not include peak particle velocities for the 3.1ML event which they highlight in Table 17.5 as being "an impact significant scenario".	No bespoke site-specific work has been carried out for the Altcar Moss site. Maximum credible induced seismic event of c. 3.0 ML is based on Green et al. (2012) from assessment of historical coal mining induced seismicity in rocks of similar strength to those at Preese Hall. This is consistent with estimates of c. 3.1ML by de Pater & Baisch (2011) based on geomechanical modelling of fluid injection in the Bowland shale. The recent work by OGA (2019a) concludes that, for future operations, the current methods for predicting maximum magnitude need further testing and cannot be viewed as reliable for PNR. Predicting maximum magnitude for a new site such as Altcar Moss, even for broadly similar geological conditions, would need additional work on top of that required for PNR. The ground-motion estimates made by Arup for Cuadrilla (2014) were based on a bespoke site-specific deterministic seismic hazard assessment (DSHA) using worst credible event scenarios and a selection of published empirical ground motion prediction equations. Results were presented in terms of peak ground velocity (PGV) for a range of confidence levels. (PGV is equivalent to peak particle velocity, PPV).

		Aurora should carry out a bespoke site-specific seismic hazard assessment using insights from the OGA (2019a) studies of the PNR1Z dataset and any further insights from the PNR2 dataset once it becomes available. The OGA (2019a) work, specifically Edwards et al. (2019) includes new recommendations regarding ground-motion estimation but also includes the results of loss estimation modelling. A similar exercise is recommended for the region in the vicinity of the proposed Altcar Moss site. It is noted that any assessment of spatial distribution of ground-motion as a result of an induced seismic event would need suitable characterisation of the shallow geology at receptor sites as the stiffness of the ground can have a significant effect on ground-motion amplitude.
Include sufficient local and regional geological information to enable the subsurface geology including structure in the area to be explored to be adequately characterised (Section 3.2, Section 5.2.2, Section 17.4.1 and Section 17.6.1).	Yes. Aurora list a number of resources employed (Section 17.4.1), including: • Geological maps and memoirs, • Results of historical drilling activity in the area, including 70 predominantly oil and gas wells within 1.5km of the application site, of which 2 penetrated the Bowland-Hodder Units, • Bespoke 3D geophysics (and historical 2D geophysics reprocessed by the Applicant),	No. The general ground model is reasonable, but any future revision of Aurora's application should include more of the detail of how the ground model was derived and justification for their assessment and conclusions presented, including comprehensive referencing of sources consulted. An independent review of aspects of the geophysical investigations (acquisition, processing, interpretation and presentation) should be carried out to confirm the conclusions presented in the report– see below.

	• Published papers and reports.	
Include the relevant information that was gathered from the 3D seismic survey that has previously been undertaken over this area (Section 3, Section 17.6.1). Include details of geological structures including faulting which may have implications for the drilling operations and induced seismicity from fracking operations (Section 17.6.1).	Yes. Aurora include some outline conclusions from their interpretation of the 3D seismic survey: "Carboniferous faults predominantly trend NE-SW …. In the 3D geophysical survey area, the most important local Carboniferous-age fault trends ENE-WSW." p306 "there is little or no linkage between these N-S-orientated faults in the shallow section and the deeper Carboniferous-age faults with a different orientation. The later N-S faults appear for the most part to die out within the Permian Manchester Marls section where more ductile, anhydrite-bearing, rocks have been recorded." p306 The results of these predominantly shallow wells and the more recent results of a resistivity tomography survey, conducted by the Applicant in 2010, show that the Hillhouse fault is not present in this area with the mapped orientation. It is likely that, if present, the fault has more of a N-S orientation in this area similar to the orientation of the Ince Blundell fault to the west, the northerly extension of which forms the bounding fault of the Formby shallow oilfield.	No. Any future revision of Aurora's application should include more of the detail of how the geophysics was acquired, processed, interpreted and presented and justification for the conclusions presented, such as regarding the unconnected nature of geological structures. Aurora do not provide sufficient information about the nature (specification) of the seismic survey (collection) that was carried out. We do not know the specification of the processing and interpretation of the seismic data (to provide information). We have not seen the results of the 3D geophysics survey other than a single unspecified cross-section. What is the location, orientation and scale in metres (not 2-way travel time) of the geological cross section (Figure 17.1) presented on Page 307. Also, the faults are unlabelled and the proposed location of the vertical and horizontal wells are not marked on the section. It would be good to see the justification of the statement regarding the orientation of the Hillhouse fault. We expect to see plans of the top and bottom of the Bowland shale with location of the proposed vertical borehole and lateral wells and anticipated extent of induced fractures and interpreted faults labelled.

		An independent revie w of aspects of the geophysical investigations (acquisition, processing, interpretation and presentation) should be carried out to confirm the conclusions presented in the report.
Should seek to characterise the existing stresses on such faults and the risks that may result through the undertaking of hydraulic fracturing operations in proximity to such fault planes (Section 17.6.2).	Yes. Compilations of stress data from the World Stress Map (2008) and Baptie (2010).	No. Any future revision of Aurora's application should include more of the detail of the location and orientation of the faults, how the in situ stresses on the faults were characterised, the location, and nature of proposed hydraulic fracturing, the proposed pressures to be used, quantities of fluids proposed etc., detailed descriptions of proximity of any faults and justification of fracturing nearby. The conclusions drawn are not justified based on the minimum qualitative level of assessment presented.
Should contain information on existing natural seismicity in the area having regard to historical information and monitoring carried out pre development (Section 17.6.3).	Yes. Maps of seismicity within 100 km and 25 km radii of Altcar Moss are included, usi ng data from the BGS instrumental catalogue. Reference is made to a planned baseline monitoring scheme although no details are provided.	No. More detail is needed to describe patterns of seismicity at different scales around the site, including any possibl e associations between seismicity and geology. Details should be provided of significant historical events which were felt in the vicinity of the application site in order to better understand the context of any induced seismicity, either historical or future. Details should include source mechanism, focal depth, epicentral distance from site and intensity distribution. Details of the specification, design and implementation of the seismic baseline monitoring array described on p.311 should

		be provided. A ny future revision of the application should include results from the monitoring. The inclusion of magnitude detection threshold maps for the site vicinity would be useful to highlight the benefit of the baseline monitoring array compared to the current BG S seismic network.
Should include a description of the measures that will be employed to monitor seismic impacts during the fracturing operations and how such monitoring will be used to control fracturing operations in a manner to reduce seismic impacts to acceptable levels including details of the methodology of monitoring. Details of how the proposed traffic light system would operate should be provided (Section 17.8).	Yes. A list of generic embedded mitigation measures is provided, including those whic h can be employed prior to hydraulic fracture stimulation (such as interpretation of geological and geophysical data, baseline monitoring and fracture modelling) as well as during operations such as implementation of the Hydraulic Fracture Plan (HFP), real time monitoring during mini -fracs and main hydraulic stimulation and for location, orientation and extent of the induced fractures. The Applicant provides summaries of the OGA's requirements for the HFP and the current UK Traffic Light System of trigger and action levels.	No. Any future revision of Aurora's application should include more of the detail of the location, depth and nature of the monitoring equipment, information about sensitivity, frequency of readings, accuracy and precision of readings etc. and justification for the conclusions presented. Is the monitoring of mini -fracs and main hydraulic stimulation in real time? If so, what is the delay? What is the size and distribution of the seismic network? How is the data assessed and the stop/go dec ision made? How is the decision relayed to the drilling crew? How long between the decision to stop has been made and the pressure is reducing at the stimulation front? How will the location, orientation and extent of the induced fractures be measured and monitored? Is the monitoring of growth in real time? If so, what is the delay? What is the size and distribution of the seismic network? How is the data assessed and the stop/go decision made? How is the decision relayed to the drilling crew? How long between the decision to stop has been made and the pressure is reducing at the stimulation front?

		What is the nature and extent of the downhole microseismic array? We require information about sensitivity of equipment, frequency of readings, accuracy and precision of readings etc. How results will be communicated with the Aurora team. The assumption that the Traffic Light System is an effective way of managing risk from induced seismicity is no longer valid after the August 2019 bank holiday induced seismic event at Preston New Road. “By setting the threshold level at the current level of 0.5ML it is expected, even given the observed potential for an increase in event magnitude once pumping has stopped (the so-called trailing effect or post-injection magnitude increase), that the maximum observed event will have a magnitude of no more than 1.5ML as opposed to a maximum ~3.0ML without mitigation.” p312 How does the Applicant intend to apply relevant findings from the recent studies reported in OGA (2019a)?
Should examine the risks to the integrity of the boreholes and associated casings / environmental protection measures from any seismicity that may be triggered by hydraulic fracturing operations (Section 4.2, Section 17.7 and Section 20.6).	Yes. The Applicant states that, “There are considered to be no borehole integrity issues associated with the low levels of induced seismicity associated with normal hydraulic fracture stimulation operations for which the boreholes have been designed.” p316	No. Needs more detail. Any future revision of Aurora’s application should include more of the detail to justify the conclusions presented. We recommend making reference to the recent work presented by Edwards et al. (2019) on well integrity when subject to ground shaking or fault rupture associated with induced seismicity.
Although not directly related to seismicity the response also requested the ES should	Yes.	No.

address the risk of subsidence: Although the risk of subsidence from fracturing and gas extraction operations is acknowledged to be low, it is considered that the ES should demonstrate how and why the risk is concluded to be low (Section 17.7).	The Applicant states that, “In shale reservoirs their low porosity and low Biot’s parameter means that compaction effects are negligible and hence subsidence and subsidence-related induced seismicity will not occur.” p312	Needs more detail. Any future revision of Aurora’s application should include more of the detail of the calculations justifying the conclusions presented.

A1 References

Aurora Resources Ltd. (2019). Environmental Statement: Altcar Moss Wellsite, Document No: AER-PA-AM-ES-01 Revision: 0, June 2019.

British Geological Survey. (2019). "Statistical Modelling of the Preston New Road Seismicity: Towards Probabilistic Forecasting Tools," Earth Hazards Programme Commissioned Report CR/19/068, Keyworth, Nottingham, [https://www.ogauthority.co.uk/media/6147/bgs-innovations-in-forecasting.pdf]

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Edwards, B., Crowley, H., Pinho, R. & Bommer, J. (2019). "Final Report on: WP-2 Impacts of Seismicity: Transmission to People, Property and Well Integrity: A Technical Report Commissioned by the Oil and Gas Authority", Rev 4, 29/10/2019 [https://www.ogauthority.co.uk/media/6127/final-reports-wp2-2.pdf].

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OGA (2019a) Interim report of the scientific analysis of data gathered from Cuadrilla's operations at Preston New Road, [https://www.ogauthority.co.uk/media/6149/summary-of-pnr1z-interim-reports.pdf]

OGA (2019b). Experience of induced seismicity in other geological settings and jurisdictions, [https://www.ogauthority.co.uk/media/6148/oga-global-seismicity-experience.pdf]

Outer Limits (2019). "Geomechanical Interpretation of Microseismicity at the Preston New Road PNR-1z Well, Lancashire, England," Report Internal ID OLG.OGA-PNR2, August 2019. [https://www.ogauthority.co.uk/media/6145/nanometrics-real-time-forecasting.pdf].

The Royal Society and the Royal Academy of Engineering (2012). "Shale gas extraction in the UK: a review of hydraulic fracturing"

Appendix B – Air Quality

This appendix provides an assessment of the technical robustness of the air quality assessment presented in Chapter 9 of the Environmental Statement (ES), Appendix B of the ES and associated relevant figures. It also considers whether the applicant has correctly assessed the potential impacts of emissions to air from the key pollutant emission sources. It should be noted that no modelling files or calculations were made available as part of this review.

B1. Method

B1.1 Overall Approach

The overall approach to assess the potential impacts of air emissions was in line with expected good practice and what is required for Environmental Impact Assessment. The assessment of pollutant emissions to air considered the following:

- emissions from stationary diesel engines and generators providing power for site operations;
- exhaust emissions from the operation of non-road mobile machinery (NRMM) brought to site for construction and site restoration activities;
- exhaust emissions from heavy duty vehicles (HDV) for transport operations within the site; and
- releases of pollutants from the flaring of natural gas produced during flow testing.

The applicant considered an appropriate range of pollutants within the assessment that are associated with the above emission sources, namely:

- Oxides of nitrogen (NOx, consisting of nitrogen monoxide (NO) and nitrogen dioxide (NO_2));
- Sulphur dioxide (SO_2);
- Carbon monoxide (CO);
- Particulate matter (considered as both $PM_{2.5}$ and PM_{10}); and
- Volatile organic compounds (VOCs – assessed as benzene).

B1.2 Dispersion Model

The main assessment method for the air quality assessment approach outlined above was based on dispersion modelling. The significance of the change in pollutant concentrations determined by the dispersion model is then determined based on comparison to relevant air quality standards (with the existing concentrations taken into account), other relevant criteria set out in appropriate guidance, and also using professional judgement.

The dispersion modelling of the process emissions from the Altcar Moss Wellsite was undertaken using the ADMS 5 atmospheric dispersion model developed in the UK by Cambridge Environmental Research Consultants (CERC) in collaboration with the Met Office, National Power and University of Surrey. The latest version of the model (version 5.2) was used for the assessment. The ADMS dispersion model software is widely used in the UK to model pollutant emissions from combustion activities and sources such as those proposed and accepted by regulatory authorities including the EA and local authorities for permitting and planning purposes. Further information on the model is available at http://www.cerc.co.uk/environmental-software/ADMS-model.html. The model selected to undertake

the dispersion modelling assessment is considered to be appropriate and fit for purpose. A sensitivity analysis using an alternative dispersion model was also undertaken by the applicant to confirm the appropriateness of the model selection.

B1.3 Other Emissions

Other aspects were also considered by the applicant, as outlined below:

- dust emissions from activities during construction of the site and the associated access track;
- emissions from road traffic on the local road network; and
- fugitive releases of natural gas, principally methane and odours.

The assessment of these is not considered in detail in this review as these are expected to be a relatively lower risk than the sources identified previously, principally due to the remote location of the site with regard to nearby sensitive receptors such as residential properties. The assessment of dust during construction was carried out in line with the risk assessment methodology in relevant guidance from the Institute of Air Quality Management (IAQM) (IAQM, 2016). This appropriately concludes that dust risks are low or negligible and effects would be not significant. Mitigation is proposed by the applicant to control dust emissions and these should be implemented via a construction environmental management plan (CEMP) secured via a planning condition which requires approval of the CEMP before construction can commence.

An analysis of the heavy duty vehicle (HDV) movements over the eight phases of the project is provided in section 9.8 of chapter 9. This indicates that the highest annual average daily traffic flow (AADT) of HDVs would be well below the two sets of relevant criteria adopted by the applicant to identify where further assessment is required (i.e. the criteria in the Design Manual for Roads and Bridges (DMRB) guidance (HA207/07) (Highways Agency, 2007) and those in the Environmental Protection UK (EPUK) / IAQM guidance (EPUK / IAQM, 2017). This also applies to all light duty vehicle flows (reported by the applicant to be no more than 100 per day) which are well below the relevant criteria adopted by the applicant. On this basis, the assessment appropriately screens out road traffic emissions on the local road network as

Although fugitive releases, including odours, were considered briefly in section 9.1 of chapter 9, it was concluded that these would be unlikely to be significant and not considered further within the assessment. The ES states the following:

"Fugitive releases of natural gas, principally methane, are considered unlikely to be significant. Leakages from associated transport pipework on the application site are likely to be minimal as the necessary surface pipework during the flow testing phases will be temporary construction which will be pressure tested prior to use. Deterioration of the integrity of the pipework over the relatively short period of operation (maximum 150 days) is consider unlikely to be significant and as such fugitive releases and any associated odour are not considered within the assessment."

However, whilst it is acknowledged that the majority of emissions of NOx and particulate matter (plus CO and SO_2) would arise from onsite machinery and equipment, the emissions of methane and non-methane volatile organic compounds (NMVOCs) could predominantly arise from fugitive sources (e.g. fugitive emissions from drilling, during the extraction process, storage of wastes or condensates/liquids within tanks such as drilling fluids, rock cuttings, flowback fluid etc, venting and capped wells) (Defra, 2018).

No commitment to undertake odour or VOC / NMVOC monitoring is included within chapter 9. However, Table 8.1 of chapter 8 (Interactive Impacts) includes proposals to undertake continual odour monitoring at the wellsite as part of the consideration of wastes.

It is understood that the applicant would need to apply for an Environmental Permit under the Environmental Permitting (England and Wales) Regulations 2016. Therefore, given the potential for fugitive emissions and effects on the environment, it is assumed that this would be relevant to the Environment Agency's (EA) determination of the Environmental Permit application and subject to review. On this basis, it is assumed that an appropriate Environmental Management and Monitoring Plan (or equivalent plan or plans) would be requested by the EA as part of the Environmental Permit process (i.e. as part of a pre-commencement condition) and the applicant would be audited during operation of the site to ensure compliance with the approved plan(s). This was the case for the Cuadrilla Preston New Road shale gas site in Lancashire which was required to undertake fugitive emissions and ambient monitoring to determine the potential changes in local concentrations of key substances (methane, VOCs (benzene, ethylene, toluene, xylene), hydrogen sulphide, NO_2 etc), including on-site monitoring of methane to detect potential leaks.

It is recommended that LCC provide relevant consultation comments to the EA requesting that an appropriate Environmental Management and Monitoring Plan (or equivalent plan) be produced to control, monitor and manage fugitive emissions from the site operation and regulated via the Environmental Permit. If this is implemented, no significant effects with regard to fugitive emissions would be expected. This could be supplemented by setting a condition on the planning permission requesting a report detailing the design measures and operating techniques which are proposed to control fugitive emissions from all potential sources on the site.

B2. Baseline Conditions

A review of the existing air quality in the study area was undertaken and reported in section 9.7 of chapter 9. The review has considered the Local Air Quality Management (LAQM) work undertaken by nearby local authorities including Sefton Council, West Lancashire Borough Council and Liverpool City Council. The review accurately identifies the nearest Air Quality Management Areas (AQMAs), the nearest of which is in Crosby, approximately 8km to the south of the site. Section 9.7 confirms that there are no appropriate measurements of air quality within the vicinity of the site at Great Altcar or would be representative of the relatively low concentrations of pollutants associated with the semi-rural location of the site. In the absence of any measurements, the modelled background map concentrations provided by Defra on a 1km x 1km basis across the UK were used. The maximum concentration within the modelled domain (i.e. the nine 1km x 1km grid squares lying within or bisected by the 1km radius from the Altcar Moss Wellsite) was used as the baseline concentration. This was based on 2016 data which is considered to be suitably conservative as using a more recent dataset would result in lower concentrations. A cross-check was performed on the background concentrations and these were found to be consistent (Defra, 2020).

The background concentrations for the nature conservation sites (ecological receptors such as Site of Special Scientific Interest (SSSI), Special Protection Area (SPA) or Special Area of Conservation (SAC) designations) were reported in section 9.7 to have been obtained from the APIS website. Some potential discrepancies were identified in relation to the background concentrations and nitrogen / acid deposition rates at the ecological receptors reported in Table 9.15. In some cases, the differences in either background concentrations or existing deposition rates were quite large. This has potential implications for the impact assessment. Discrepancies were also identified in the selected critical loads which could also the impact assessment (see below). Seeking further clarification from the applicant on

these discrepancies is recommended. Further details of the discrepancies and the potential effect on the impact assessment is discussed in the Results and Analysis section below.

No specific monitoring was undertaken by the applicant to support the planning application. However, this is not always a requirement to support planning applications due to the time it takes to obtain robust data (usually a minimum of six months, ideally longer) and that other data sources are usually available. Although specific monitoring of the key pollutants likely to raise the most concerns (i.e. NO_2, PM_{10}/$PM_{2.5}$) would have helped to reduce any uncertainty associated with using the Defra modelled background map data, there are some mitigating factors which potentially reduce the risk that the baseline concentrations could be underestimated as follows.

- For the Defra modelled data, using the maximum value obtained for the nine 1km x 1km grid squares resulted in the concentrations for the edge of Formby and the A565 Formby Bypass being used for the assessment. These are likely to be higher than those in the vicinity of the proposed development where the highest concentrations from the modelled emission sources would be predicted.
- The approach used data for 2016 and assumed no improvement in background concentrations for future years. This is a conservative approach as concentrations of most pollutants have historically shown a decreasing trend. For example, the NO_2 concentration was based on the 2016 Defra modelled concentration. The concentration in 2020 or later would be expected to be much lower than the 2016 value due to the expected improvement, primarily in road traffic emissions.
- If it views the absence of specific monitoring in setting the baseline air quality conditions, during the determination of the Environmental Permit application, the EA could request that air quality monitoring is required to confirm the baseline conditions.

The annual mean background concentrations were doubled to determine the 1-hour mean background concentration, which follows the appropriate EA guidance for Environmental Permitting. However, for 8-hour and 24-hour mean modelled concentrations, the applicant used factors which are supposed to be used for converting modelled process emissions to relevant averaging periods, which led to factors of less than two being used to determine the background concentrations for these averaging periods. The EA guidance states *"When you calculate background concentration, you can assume that the short-term background concentration of a substance is twice its long-term concentration"* so it is not clear why the applicant did not adopt this approach for 8-hour and 24-hour mean predictions. The potential effect of this on the impact assessment is discussed in the Results and Analysis section below.

B3. Input Data (ADMS 5 Modelling of Emissions to Air)

A review of the key model inputs was undertaken to identify any potential limitations in the assessment.

B3.1 Emissions

The applicant has modelled the emissions to air from the following source types:

- stationary diesel engines and generators;
- NRMM;
- HDVs; and
- flaring of natural gas.

Spot checks on the input data to determine the emission rates of the various pollutants were undertaken. Based on experience of undertaking similar assessments and reviewing the references stated in Appendix B online, these were found to be acceptable and, in some cases, appropriately conservative by calculating emissions based on using older plant or equipment with higher pollutant emissions than new plant. Other emissions parameters such as exhaust diameter, exhaust gas temperature and velocities were also found to be appropriate for the source types being modelled.

The modelling was based on emissions continuously at the limits or levels selected for each source and assumed each relevant plant item was operating at maximum load (i.e. 100% load) during operation.

B3.2 Model Scenarios

The modelling was based on each of the eight work phases being carried out consecutively and information is provided in Appendix B on the emission sources and number operating during each phase. The model was run to cover all eight phases occurring over two calendar years and the applicant reported that the model was run for a number of assumed project start dates, with the maximum impact for each location and pollutant used from the multiple start dates as a worst case approach.

B3.3 Design Data (buildings, layout, stacks)

The design and layout of the facility have been considered within the air quality dispersion model. Based on the information provided in Appendix B, the relevant building and structures appear to have been correctly represented and located in the model. The buildings and structures were simplified for representation in the model and sensitivity analyses were undertaken to investigate the appropriateness of this and selection of the main building within the model. Removing all buildings from the model was also tested. The analyses showed that the proposed approach of including buildings and the main building selection was suitable.

B3.4 Model Grid Domain, Grid Spacing and Specified Receptors

A model grid of 1km x 1km was used to model emissions from the main stacks, this was centred on the proposed development site. The grid had 10,201 (101 x 101) nodes resulting in a grid spacing of 10m. A larger 4km x 4km grid was also used to assist with providing contour plots of the pollutant dispersion shown in Annex A of Appendix B.

A number of specific receptors (40 No.) were also used for the assessment at human receptors. These represent nearby locations where the highest concentrations would be expected for a range of wind directions at particularly sensitive receptors (e.g. residential properties, farms). Receptors (113 No.) were also specified along the Cheshire Lines multi-use route. Receptors (61 No.) were also placed around the site boundary to enable the maximum concentrations at the site boundary to be determined, which in most cases also represented the maximum off-site concentration. The number and location of human and site boundary receptors used for the assessment are considered to be appropriate for the assessment of pollutant emissions to air from the Altcar Moss Wellsite.

A number of receptors were also specified to represent the nearby ecological receptors. For those sensitive to air pollution (i.e. all those considered except the nearby Downholland Moss SSSI designated for geological reasons), the applicant has used one receptor location which it reports to be the closest location to the Altcar Moss Wellsite. However, this does not appear to be accurate. For example, the receptor location used for the Sefton Coast SAC (E 330861 N 412933) is a location to the north of Ainsdale (reported as 5.7km to the north of the site). There would appear to be a closer location to the west, where the Sefton Coast SAC extends southwards around Formby. Our review indicates that the

closest location of the Sefton Coast SAC is less than 4km to the west north west of the site (the Shadow Habitats Regulations Assessment Screening Report in Appendix D3 of the ES states the SAC is 3.7km southwest, west and northwest). There are similar concerns for the receptor locations chosen for the other two ecological receptors (Ribble and Alt Estuaries SPA and Liverpool Bay SPA). Therefore, there is uncertainty in the model predictions at these European designated sites, which is a key concern. The implications of these potential discrepancies are discussed in the Results and Analysis section below.

B3.5 Meteorological Data

The modelling used five years of weather data (2013 to 2017) recorded at the Crosby meteorological station which is approximately 7km to the south of the proposed development site. Other sites were investigated by the applicant, however, these were further away (nearest was Blackpool 29km to the north) and subsequently discounted. The meteorological data appears to have been appropriately selected. The assessment was based on the maximum predictions obtained for any of the five years of data.

B3.6 Terrain, Surface Roughness, and other Relevant Parameters

The local terrain was investigated by the applicant who concluded that the terrain is relatively flat across the study area with only a slight gradient from west to east, below that usually considered to be required to include terrain effects within modelling. In any case, the applicant undertook a sensitivity analysis of the use of terrain which showed predominantly that higher concentrations were predicted without terrain effects included in the model. The main assessment results were based on the conservative approach of not including terrain.

The surface roughness value of 0.3m used by the applicant is considered to be appropriate for the study area and this was also tested by the applicant using sensitivity analyses for a range of surface roughness values. Although slightly higher concentrations were predicted for a lower surface roughness of 0.1m, the difference wasn't significant and would not be representative of the land use / surface roughness which is a mix of agricultural fields, some wooded areas and a larger urban and business area to the west (i.e. the eastern edge of Formby).

The Monin-Obukhov length (a measure of how the atmospheric stability is affected by the presence of urban expanses) was set at a value (10m) representing a small town which is likely to be the upper end of the applicable value at the site location which is predominantly rural. The applicant undertook a sensitivity analysis of the use of higher (less representative of a rural location) and lower values (more representative of a rural location). For the lower values of 5m and 1m, the differences in the predicted concentrations were minimal and would not affect the outcome of the assessment.

Other parameters such as the surface albedo and Priestley Taylor parameter were considered to be appropriately represented in the model, and were also tested using sensitivity analyses by the applicant.

B3.7 Alternative Dispersion Model

The applicant carried out a sensitivity analysis for use of an alternative dispersion model (AERMOD). This showed that the predicted concentrations were predominantly lower in the nearer study area at the site boundary and human receptor locations but slightly higher at long distances representative of the ecological receptors. The applicant concluded that *"it is not considered that the differences exhibited due to model selection will have any substantial impact on the conclusions of this assessment."* It is not possible to determine which model is more suitable or accurate than the other, however, using ADMS is

an accepted approach and suitable in this instance to form the basis o f the model predictions and subsequent assessment.

B4. Sensitivity Analyses and Assumptions

As noted above, several sensitivity analyses were conducted to check the robustness of certain model inputs/parameters as follows:

- buildings;
- terrain;
- surface roughness;
- Monin-Obukhov length; and
- Priestley Taylor parameter.

As is common practice for dispersion modelling assessments, a number of conservative assumptions or approaches were used and reported by the applicant to attempt to ensure that the model predictions were overestimates rather than underestimates of what would occur in practice. These are summarised below.

- The modelling was based on the combustion sources operating at full load and emissions continuously at the emission standards or levels adopted for the study. Periods of lower load or downtime would be expected for many of the combustion sources.
- The emissions of total particulates were assumed to consist entirely of PM_{10} or $PM_{2.5}$.
- The emissions of volatile organic compounds (VOCs) were assumed to consist entirely of benzene, which has the most stringent air quality standard. This would not occur in practice and VOCs would consist of other organic compounds with much higher air quality standards or guidelines.
- The conversion of the emitted NOx to NO_2 at receptor locations was assumed to be the worst-case based on EA guidance (70% conversion for annual mean and 35% conversion for 1-hour means). Over the relatively short distances to the point of maximum location and key receptors, the conversion is likely to be considerably less than these values, particularly for the annual mean conversion. This was investigated and confirmed by the applicant in Annex C of Appendix B of the ES. Thus, the predicted NO_2 concentrations are likely to be conservative in this regard.
- The results were based on the maximum predicted concentrations obtained from any of the five years of meteorological data that was used in the model. Predicted concentrations during a typical year would be lower.
- As discussed previously, the selection of the background concentrations was largely based on using Defra modelled data from a previous year (i.e. data representing 2016) and assumed no reduction in concentrations for future years. Some reduction would be expected in a four or five year period (or more) between 2016 and the commencement of the proposed development.

B5. Assessment Criteria

The appropriate air quality standards and guidelines (and relevant pollutant averaging periods and percentiles) were adopted for the assessment. Where more stringent standards or non-statutory guidelines were available, these were used, presenting an appropriately conservative approach.

The process of categorising / describing the impacts and determination of significance of the emissions to air was based on two differing approaches which covers the requirements from both the planning and Environmental Permitting perspectives and also for human and ecological receptors:

- the EPUK/IAQM guidance (Land-Use Planning & Development Control: Planning for Air Quality) (EPUK/IAQM, 2017); and
- EA guidance (Air emissions risk assessment for your environmental permit) (Environment Agency, 2016).

Although section 9.6 of chapter 9 indicates that impact significance would ultimately be translated into the common significance criteria set out in Chapter 6 of the ES, no evidence of this was found within chapter 9. Any references to the significance of effect in the text were to categorise the effect as significant or not significant based on consideration of the magnitude of change, assessment criteria and compliance with air quality standards (which is broadly in line with the relevant guidance for air quality assessment). However, in table 9.33 of chapter 9, there is some inconsistency as it refers to significance of each aspects of the air quality impacts in various ways including "Negligible", "Low" and "Minor", none of which are consistent with the scale of significance set out in chapter 6 (or as stated in Table 9.10. In any case, this has no direct bearing on the outcome of the assessment as it would not alter the reported overall significance of 'not significant'. The appropriateness of the conclusion of not significant is considered in the Results and Analysis section below.

The overall approach for describing the impacts and determining significance is considered to be appropriate.

B6. Results and Analysis

B6.1 Human Receptors

The results of the air quality dispersion modelling indicate that predicted concentrations are relatively high within the site or close to the site boundary, where there is no relevant public exposure. It is observed (in figures A.1 and A.2 in Annex A of Appendix B of the ES) that the predicted concentrations decrease rapidly with distance from the site and the reported concentrations at any of the human receptor locations such as residential properties or footpaths are described as negligible in accordance with the impact descriptors in the EPUK/IAQM guidance. On that basis, the assessment presented in section 9.8.2 of Chapter 9 concludes that the impact of emissions to air on human health would be not significant. This appears to be a suitable conclusion based on the lack of relevant exposure locations close to the site and apparent robustness of the air quality modelling undertaken to underpin the assessment at human receptors as discussed above.

B6.2 Ecological Receptors

As noted previously, there are some potential omissions or limitations in the assessment of air quality impacts at ecological receptors (Sefton Coast SAC, Ribble and Alt Estuaries SPA and Liverpool Bay SPA) which could reduce the confidence in the assessment outcome. The applicant reported in Chapter 9 of

the ES that the background levels for the ecological receptors were obtained from the APIS website (CEH, 2020) and that the maximum value across the full extent of each ecological site was used for the assessment. Chapter 9 also states that the critical loads were the minimum specified for the most sensitive habitat within each ecological site. The background concentration and depos ition data presented in Chapter 9 (Table 9.15) and critical loads (Table 9.20) were cross -checked with the data available on the APIS website via the Site Relevant Critical Loads tool and this showed the following:

- Some discrepancies in either background concentrations or existing deposition rates compared to the information on APIS; and
- Some discrepancies in the selected minimum critical loads compared to the information on APIS.

It should be noted that the dataset used to determine the background pollutant concentration and deposition rates at the ecological sites was updated on the APIS website in June 2019 to use the three-year average data for 2015 - 2017. The assessment undertaken by the applicant pre-dates this and likely to differ from the current dataset (i.e. either based on the 2013 – 2015 or 2014 – 2016 three-year average data). Where any small discrepancies are likely to be due to the cross-check using the updated dataset, these have been ignored. For larger discrepancies which are unlikely to be due to the use of the newer dataset, these are discussed in more detail in Table B1.

As also noted previously in the review of the receptor locations, there appears to be some inaccuracy in the single receptor location selected by the applicant to represent the nearest point of the ecological site to the Altcar Moss Wellsite. Other points within the three European designated ecological sites appear to be closer to the Altcar Moss Wellsite than used for the assessment. Therefore, without further information being provided by the applicant, there is a high level of uncertainty relating to the maximum predicted process contributions outputted from the modelling and used as the basis of the assessment.

On the above basis, given the number of apparent discrepancies and the potential for the assessment to not consider the worst-case receptor locations, the assessment of impacts at ecological receptors is considered to be inadequate. Given the generally conservative approach adopted by the applicant in undertaking the air quality dispersion modelling, it is considered unlikely that these limitations would materially affect the outcome of the assessment. Should these issues be addressed by the applicant, it is possible that the outcome would be consistent with that presented in Chapter 9 (i.e. not significant). However, there is not sufficient information within the application documents to confirm this and our opinion does not constitute any form of assessment.

Table B2: Issues Identified at Ecological Receptors

Ecological Receptor	Issue	Comment
Ribble and Alt Estuaries SPA [1]	The maximum background SO_2 concentration on APIS is 2.9 µg/m^3, compared to a value of 0.97 µg/m^3 used in the assessment.	Given the very low process contributions for annual mean SO_2, this is unlikely to alter the outcome of the assessment (however, there remains uncertainty in the receptor location representing the location of maximum impact).
	The maximum nitrogen deposition on APIS is 27.3 kgN/ha/year, compared to a value of 12.74 kgN/ha/year used in the assessment.	The value for deposition onto a water based feature appears to have been used rather than the existing deposition onto a land-based vegetation feature. However, as both values are above the critical load this is unlikely to alter the outcome of the assessment, when considered in isolation.
	The maximum acid deposition on APIS is 1.95 keq/ha/year and 0.44 keq/ha/year (nitrogen and sulphur derived acid, respectively), compared to values of 0.91 keq/ha/year and 0.35 keq/ha/year used in the assessment.	The value for deposition onto a water based feature appears to have been used rather than onto a land-based vegetation feature. However, as both sets of values are above the critical load this is unlikely to alter the outcome of the assessment, when considered in isolation.
	The lowest critical load on APIS is 3 - 10 kgN/ha/year, compared to a value of 5 - 10 kgN/ha/year used in the assessment.	The lower value of 3 - 10 is specified for a water-based critical load class "Permanent oligotrophic waters: Softwater lakes". Based on the apparent difference in deposition velocities for water-based and land-based short vegetation, it is likely that the process contribution as a percentage of the lower critical load of 3 would be similar or lower than used for the assessment as shown in Table 9.22 of Chapter 9 (i.e. 0.9% of the critical load or less). However, please note the other issue regarding uncertainty in the receptor location representing the location of maximum impact.

[1] Site Relevant Critical Loads feature on the APIS website, accessed Jan 2019, available at http://www.apis.ac.uk/srcl/select-a-feature?site=UK9005103&SiteType=SPA&submit=Next.

Ecological Receptor	Issue	Comment
Sefton Coast SAC [2]	The maximum SO_2 concentration on APIS is 2.9 µg/m^3, compared to a value of 1.05 µg/m^3 used in the assessment.	Given the very low process contributions for annual mean SO_2, this is unlikely to alter the outcome of the assessment (however, there remains uncertainty in the receptor location representing the location of maximum impact).
Liverpool Bay SPA [3]	The maximum background NOx concentration on APIS is 46.5 µg/m^3, compared to a value of 25.8 µg/m^3 used in the assessment.	Although there are large discrepancies, it is likely that there is no sensitive vegetation within the areas of the SPA closest to the wellsite (i.e. within 10km). At this area, the SPA appears to be below the low and high mean water lines and therefore likely to be continuously or predominantly inundated by seawater or representative of the sea itself. The applicant has not provided any discussion or details on this so remains an area of uncertainty.
	The maximum SO_2 concentration on APIS is 6.1 µg/m^3, compared to a value of 1.1 µg/m^3 used in the assessment.	
	APIS provides critical loads for nitrogen and acid deposition for Liverpool Bay SPA. The assessment has stated that the habitat is not sensitive to nitrogen or acid deposition.	The approach adopted by the applicant for Liverpool Bay SPA is not consistent with the overall approach of using the minimum specified critical load for the most sensitive habitat within the ecological site. However, those areas of the SPA closest to the wellsite (i.e. within 10km) appear to be below the low and high mean water lines and therefore likely to be continuously or predominantly inundated by seawater or representative of the sea itself. The applicant has not provided any discussion or details on why the approach has differed for the Liverpool Bay SPA or that it has considered local sensitivities in contradiction to the overall worst-case approach adopted for the other ecological sites.

[2] Site Relevant Critical Loads feature on the APIS website, accessed Jan 2019, available at http://www.apis.ac.uk/srcl/select-a-feature?site=UK0013076&SiteType=SAC&submit=Next.

[3] Site Relevant Critical Loads feature on the APIS website, accessed Jan 2019, available at http://www.apis.ac.uk/srcl/select-a-feature?site=UK9020294&SiteType=SPA&submit=Next.

B6.3 Cumulative Assessment

The cumulative assessment considered planned and current developments within a 10km search area around the Altcar Moss Wellsite. This concluded that there were no current or planned developments which are likely to have any significant impact on the existing background concentrations of the pollutants of interest in the area of influence around the Altcar Moss wellsite. This would indicate that there would not be any significant cumulative effect with regard to human receptors.

However, particularly for European designated sites (i.e. the SPAs and SAC), the criteria for determining the need to undertake a more detail assessment and which could potentially indicate a significant effect, is whether the process contribution is greater than 1% of the critical load. According to the EA guidance (Environment Agency, 2016), this needs to be considered, firstly, in isolation, and, secondly, in-combination with other plans/projects. Although the applicant has stated that there are no current or planned projects within 10km of the Altcar Moss Wellsite, it is possible that a development outside of this search radius could contribute to nitrogen and acid deposition at the European designated sites considered in the assessment, resulting in an in-combination contribution which would exceed the 1% threshold. This issue was identified by Natural England, who, in its consultation response dated 30 August 2019, requested additional information on the in-combination assessment with regard to the air quality impacts at the European designated sites as part of the Habitats Regulations Assessment. We are not aware if the applicant has provided a response to this request or conducted further consultation with Natural England to resolve this.

B7. References

Centre for Ecology and Hydrology (2020). Air Pollution Information System [online] Available at: http://www.apis.ac.uk [Accessed January 2020].

Department for Environment, Food and Rural Affairs (Defra) (2018). Air Quality Expert Group, *Potential Air Quality Impacts of Shale Gas Extraction in the UK* [online] Available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1807251315_AQEG_Shale_Gas_Extraction_Advice_Note_vfinal_for_publishing.pdf [Accessed January 2020].

Department for Environment, Food and Rural Affairs (Defra) (2020). UK-AIR: Air Information Resource. Modelled Background Pollution data [Online]. [Accessed: January 2020]. Available from: https://uk-air.defra.gov.uk/data/pcm-data

Environment Agency (2016). *Air emissions risk assessment for your environmental permit.* [online] Available at: https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit [Accessed 12 August 2019].

Environmental Protection UK (EPUK) and Institute for Air Quality Management (IAQM) (2017). *Land-Use Planning and Development Control: Planning for Air Quality*. Version 1.2.

Highways Agency (2007). *Design Manual for Roads and Bridges, Volume 11 Environmental Assessment, Section 3 Environmental Assessment Techniques, Part 1 HA 207/07 Air Quality*

Institute of Air Quality Management (IAQM) (2016). Guidance on the assessment of dust from demolition and construction. Version 1.1.

Appendix C - Groundwater

Table C1: Assessment of Documentation

Criterion	RAG	Comment	Example / Location of Issue	Further Work Recommended
1. Development Description and EIA Process				
Does the ES provide a description of the development comprising information on the site, design and size of the development during construction and operation relevant to the technical topic being assessed? Is the information enough to inform the assessment	R	Whilst an outline description of the development is provided, several key pieces of information are missing. This includes information that the EA and LCC requested to be contained within the ES as part of their scoping response. Missing information includes, but is not limited to: • Intended direction of drilling for the proposed horizonal well. This is fundamental for potential significant impacts that could arise, for e.g. as a result of intersecting faults. • Source of water to be used for the hydraulic fracture stimulation. This is important because there could be a significant impact on water resources depending on the water source, and the location and timing of demand could be critical. • Specific well design information, for e.g. depths and lateral extents of solid vs. perforated well casing. • Methodology for installing sections of perforated casing, i.e. insertion of pre-perforated casing/ lining or in-situ perforation. • A draft configuration for the hydraulic fracture stimulation. This is particularly important given that the process of hydraulic fracturing is new to the UK and its particular geology, there is mixed evidence from case examples in the USA, and several independent reports have been produced which document the severity of potential impacts to groundwater and its associated receptors, including Cuadrilla's operations at the Preston New Road site. It is not therefore considered sufficient to leave submission of this information to the environmental permitting process as the potential environmental impacts should be assessed (at least in draft) during production of the ES. • Chemicals intended to be used in the drilling method and, in particular, chemicals intended to be used as additives in fracturing fluids. It's not sufficient to state that all hydraulic fracturing fluid additives will be non-hazardous to groundwater, as the introduction of non-hazardous substances into the groundwater environment can still be a breach of environmental regulations. As a minimum, an initial list of chemicals should therefore be provided in the ES and used to inform the HRA carried out in Appendix I3. This list would then need to be discussed from a regulatory and WFD compliance perspective. If the list of chemicals were to be refined, this could be carried out at a later stage and as part of a subsequent detailed review.	Chapter 4 of the ES and Section 3 of Appendix I3 provide descriptions of the proposed development and its individual phases, from construction, operation and through to decommissioning.	Provide further details to address the points listed and use this information to inform the hydrogeological risk assessment carried out in Section 8 of Appendix I3.

Criterion	RAG	Comment	Example / Location of Issue	Further Work Recommended
		However, this action would then need to be included as part of the mitigation measures outlined i n Chapter 20. • Likely chemicals or other contaminants (such as radioactivity) to be present in the production water and flowback fluid. • Draft Construction Method Statements should be submitted as part of the ES. They could subsequently be refined and submitted to the EA for approval, but if this were to be the case, then these later submissions should be included as part of the mitigation measures outlined in Chapter 20.		
Does the ES outline any difficulties encountered by the developer in compiling the information presented in the ES for the technical topic being assessed e.g. gaps in baseline data, design information or assessment methods and assumptions?	R	Neither Appendix I3, nor Chapter 20 of the ES has a section on limitations or assumptions. There are also no clear references to, or discussions of data gaps and uncertainty. Appendix I3 does occasionally state that additional information would be submitted to the Oil and Gas Authority and Environment Agency for approval before any hydraulic fracture stimulation operations commence. However, there is no acknowledgement of what potential impact not having this information available at the time of writing the ES could have on the assessment undertaken. Fundamental design information such as the proposed direction of horizonal drilling, a draft hydraulic fracture plan, draft construction method statements and an initial list of all chemicals to be used should be included within the ES and used to inform the HRA. Similarly, whilst there are occasional references to a lack of available baseline data, or its limited extent or quality, the potential impact of this on the CSM presented, and whether it significantly affects the assessment is not considered. For e.g. the two potential unrecorded PWS are assumed to be associated with properties, but there could also be PWS associated with agricultural usage not captured by a review of Ordnance Survey maps. Land owner consultation should have been undertaken to identify the locations and usage of potential PWS within a pre-determined search radius.	Section 20.4 of the ES has the following under a sub-heading entitled “Limitations and Assumptions”: “ *The assessment is based on the development description provided in Chapter 4 of this ES. Baseline conditions a the application site have been assessed using information from third party data sources, as described in the Assessment Methodology above.* Section 3.4.4 of Appendix I3 mentions that a final hydraulic fracture plan, and full details of all chemicals would be provided at a later date as part of the environmental permitting process. Sections 6.2 and 6.4 of Appendix I3 state that in some instances there are no nearby EA g roundwater level and/or quality monitoring locations targeting certain geological formations of relevance to the site. Section 5.2 of the ES notes that few historic oil and gas wells in the vicinity of the site penetrate the target horizons for hydraulic fracturing. Section 7.3 of Appendix I3 acknowledges that PWS records held by the local authority may be incomplete. Section 7.9 of Appendix I3 comments on the uncertainty around the exact location of a historic pollution incident.	Ensure that all data gaps, limitations and assumptions are clearly listed and discussed in Chapter 20 and Appendix I3. Clarify any uncertainties arising from these data gaps/limitations/assumptions that could affect the CSM presented. Review the assessme nt of effects, mitigation, and residual effects sections in Chapter 20 and Appendix I3 and ensure that there are no amendments needed.
2. EIA Context				
2.1 Scoping				
Has the ES clearly stated what environmental issues will be addressed regarding the technical topic being assessed and how this decision was reached? Are they relevant?	R	The ES does state that a scoping request was submitted to LCC and that 12 topics were identified for possible inclusion within the ES. Section 6.3 of the ES explicitly states, “*In order to determine whether potential impacts are significant, and therefore need to be included within the environmental statement each impact was considered by the Assessment Team in terms of direct and indirect effects, secondary,*	Section 6.3 of the ES summarises the scoping process carried out by the applicant. Section 20.3 of the ES provides a scoping response from the EA. Appendix A of the ES comprises the full scoping opinion issued by LCC to the applicant.	Within Chapter 20, the scoping report needs to be referred to, with clarity provided over the potentially significant impacts identified during the scoping stage in relation to hydrogeology and groundwater protection, consultee responses on these individual

Criterion	RAG	Comment	Example / Location of Issue	Further Work Recommended
		cumulative, short, medium and long -term, permanent or temporary, positive and negative effects of the development. In accordance with the EIA Regulations 2017, the content of the Environmental Statement has been agreed with LCC. However, Chapter 20 of the ES does not include any information relating to: • The scoping assessment undertaken. • Any significant impacts identified during the scoping stage. • Whether there was any consultation carried out on specific issues in relation to hydrogeology and groundwater protection. • How the issues considered in this chapter were derived. • How the methodology for assessing potentially significant impacts was derived. In addition, there are several fundamental aspects of the proposed development which have not been assessed, including for e.g. the impacts of the various phases of the development on groundwater flows, the source of the water to be used for the hydraulic fracture stimulation, potential impacts associated with the horizontal drilling etc. Furthermore, without highlighting any potentially significant impacts and consultee responses at the scoping stage, it's uncertain as to whether the EA, Natural England etc. did have any specific concerns at the scoping stage that have/haven't been addressed within the ES.		impacts, and the methodology used to determine how the issues to be considered were derived.
Does the ES identify the environmental issues associated with the technical topic being assessed, raised during the scoping / consultation process, that will not be assessed and explain why they are not being considered further?	R	As noted above, no information is provided in Chapter 20 as to the scoping assessment undertaken, whether consultee's specific concerns have been considered, or how the issues considered in this chapter were derived. Section 20.3 of the ES has mis-quoted the scoping response provided by the EA and has omitted several key points and considerations raised by the EA which relate to specific concern areas that the EA stipulate should be assessed within the ES. These omissions include: • "*The ES should contain the details for the construction of the boreholes…*" • "*The physical and chemical characteristics of the drilling fluids used for different stages of the boreholes should be explained in the ES.*" • "*The ES should explain the methods to be used to store, treat and dispose of all water that is captured within the site compound. The EA have also noted that this area could be subject to rising groundwater issues during periods of heavy rainfall whic h could*	The Executive Summary presented in Chapter 20 of the ES states that the assessment takes into accounts comments made by the EA in the Scoping Opinion issued by LCC. Section 20.3 of the ES summarises the scoping response provided by the EA. Section 1.2 of Appendix I3 states that the report considers the comments provided in the Scoping Opinion Report provided by LCC. Section 6.4.2 of Appendix I3 references the Scoping Opinion in relation to comments provided by the EA on groundwater quality. Appendix A of the ES comprises the full scoping opinion issued by LCC to the applicant.	Chapter 20 needs to refer to information contained within the scoping document, list more clearly the individual responses from consultees around specific concern areas for hydrogeology and groundwater protection. Where the chapter does not follow the advice contained within the Scoping Opinion, it should justify why certain issues are not being considered further, and detail consultation on these matters with the relevant stakeholders.

Criterion	RAG	Comment	Example / Location of Issue	Further Work Recommended
		exert an upward pressure on any lateral storage ditches thereby reducing the volume of storage." • "*The EA note that shallow groundwater may potentially be perched over the site. Consideration should be given to groundwater control during constructio n of the conductor casing to prevent escape and possible contamination of surface waters.*" • "*An assessment should be made of the volume of water that will be intercepted during a maximum rainfall event to ensure that on site storage is sufficient. Consideration should be given to on site treatment to allow intercepted water to be discharged to a surface water course thereby avoiding the additional traffic that would be generated from an offsite treatment option.*" • "*The ES should explain the implications of pr oposed fracking operations in terms of water resources. This should include the volumes and sources of water to be used and any additives that are to be used to facilitate hydraulic fracturing. The methods to be used for the storage (and if proposed, on site treatment) of any flow back waters should also be explained including for the treatment of any naturally occurring radioactive materials that may be present within the flow back water.*" There is no mention within Chapter 20 of the scoping response provided by other key consultees that relate to hydrogeology and groundwater protection, for e.g. Natural England's response in relation to habitats and detailed surveys / assessment. There is also no mention of LCC's Scoping Opinion in relation to the design elements required to be assessed within the ES. The absence of this latter piece of information is also discussed in Section 1 of this appendix.		
2.2 Alternatives and Consultation				
Are any alternatives pertinent to the topic being assessed set out in the ES such as alternative methods / structures that would have different effects – or different control measures? If lesser effects would be envisaged from these alternatives is their non-use justified?	G	The ES does provide information relating to the site selection process, which included constraints mapping of numerous geological, social and environmental factors to inform screening of alternative sites. The main limiting factor in the site selection process was the extent of a 3D geophysical survey carried out in 2016. There is no information given about the size of this survey area in relation to the overall extent of the Bowland Basin shale plays, or why this survey area was initially selected in the first instance. This does not however mean that the site screening process is considered to be inadequate. In addition, the applicant does not always consider potential alternatives for development design, construction methods / techniques proposed, or alternative materials and / or equipment to be used, for e.g. drilling methods, pollution controls etc. This does not however mean that the methods/ materials/ equipment proposed are considered to be	Section 5.2 of the ES provides information relating to the site selection process which concludes that the application site is the most suitable location from which to drill the two exploratory boreholes, as it (a) meets the surface selection criteria and (b) seeks to minimise adverse impact on both environmental and social interests. Section 4.1 states that a geotechnical evaluation of the soils underlying the site was undertaken to inform the site design and construction method for the proposed wellsite. Section 4.4 mentions that a workover rig could be deployed if a coil tubing unit is not sufficient for all downhole mechanical operations.	Although it is considered that this is largely adequately covered, the chapter could be improved by setting out more clearly the justification for the construction methods / techniques / materials / equipment etc. to be used in the context of acceptable alternatives and their potential environmental impact in relation to hydrogeology and groundwater protection.

Criterion	RAG	Comment	Example / Location of Issue	Further Work Recommended
		unreasonable, or not as good as other alternatives from an environmental perspective.	Section 4.5 states that an assessment of the management of waste gases was carried out to inform the best available technique.	
Does the description of any consultation related to the technical topic being assessed include an indication of those contacted, including statutory and non - statutory consultees, and the public? Is this level of c onsultation appropriate in this instance?	R	Chapter 6 of the ES mentions that consultation has been carried out with key stakeholders. Chapter 20, however, makes no mention of any consultations that have taken place with respect to hydrogeology and groundwater protection. There is only one mention o f consultation (in Section 20.3), which relates to a scoping response from the EA, rather than consulting with key stakeholders over particular areas for concern for example. As mentioned above, landowner consultation should have also been carried out in relation to potential PWSs. In the absence of location / usage information, potentially significant adverse impacts cannot be ruled out for a key groundwater receptor.	Section 6.4.1 of the ES is entitled " *Consultation*" and states that the applicant has undertaken consultations with key stakeholders as part of the Planning Application preparation and EIA process. It also states that the relevant consultation responses have been summarised and details provided as to where within each topic chapter the commen ts made have been addressed for each environmental topic included within the ES. Section 20.3 of the ES is entitled "*Consultation*", which provides a scoping response from the EA to LCC in response to the EIA scoping request. Appendix A of the ES comprises the scoping opinion issued by LCC to the applicant.	Chapter 20 of the ES should include a section on consultations which have taken place with respect to ground and groundwater protection and ensure that any valid concerns are addressed in the chapter. Landowner consultation should be carried out to provide clarity over PWS locations and usage.
Does the ES provide a summary of the main issues, pertinent to the technical topic being assessed, raised by consultees?	R	As noted above, Chapter 20 does not indicate that any consultation has taken place with respect to hydrogeology and groundwater protection. The scoping opinion is provided in Appendix A of the ES which includes a response from the EA and Natural England but no other organisations. No mention of the response from Natural England is included in Chapter 20. There is also no mention of scoping responses from other key stakeholders, such as The Wildlife Trust for Lancashire, Manchester and North Merseyside, National Trust etc.		Chapter 20 needs t o include a summary of the consultee's response and their main concerns.
Does the ES set out if any of the issues pertinent to the technical topic being assessed raised by consultees were not dealt with in the ES? If so, is justification for omission set out?	R	As noted above, Chapter 20 does not indicate that any consultation has taken place with respect to hydrogeology and groundwater protection.		Chapter 20 needs to state if any issues raised by the consultees have not been considered and if so, why they weren't considered in the ES.
3. EIA Content				
3.1 Baseline				
Has all the information required to identify and assess the main effects relevant to the technical topic being assessed been collected and reviewed in sufficient detail?	R	There are several fundamental baseline data and information gaps that have led to the site not being sufficiently characterised. As a result, the "conceptual hydrogeological model" presented in Appendix I3 is not considered, in our professional opinion, to be a complete or robust CSM. For e.g. we would expect to see a relevant geological cross section with topography taken into account, and a schematic showing identified S-P-R linkages. The key baseline information considered to be missing includes:	Environmental baseline information is provided in Section 4 to Section 7 of Appendix I3 and Section 20.5 of the ES. The hydrogeological conceptual model is presented in Section 6.5 of Appendix I3. Section 6.4.3 of Appendix I3 states that there is no driving head to connect poor quality water within the Permo-Triassic sandstones at the site with fresh, recent-recharge water in the Permo-Triassic	Collect and review additional site-specific baseline data and information, including: • Characterise the site with groundwater levels, flows, quality and hydraulic property information for key aquifer units. • Assess in more details potential impacts in relation to the horizontal well, and not just the

Criterion	RAG	Comment	Example / Location of Issue	Further Work Recommended
		• Hydraulic properties of aquifers have been determined by literature search of EA and BGS publications and not from data obtained through site-specific ground investigations. No quantitative information for permeability or porosity is provided, which is of relevance for assessment of potential vertical movement of groundwater and / or contaminants between formations. There is no consideration of whether the literature values quoted in the ES and the approach taken are conservative enough to compensate for the lack on in-situ data.. • Proven site-specific groundwater level data is restricted to the superficial deposits and a 2-week monitoring period. Groundwater level data for the superficial deposits that is provided in Appendix I3 is inconsistent with that presented in the GI report, which appends Appendix I2 of the ES. There is no other data on groundwater levels for deeper formations at the site to support an assessment of vertical driving heads between strata. • No site-specific groundwater quality data is provided. It is not considered sufficient to describe soil chemistry data as a substitute for water chemistry. Groundwater quality is also likely to vary with depth through different strata. • There is uncertainty in relation to the horizontal well design and how its interaction with geology and hydrogeology varies away from the site. Whilst a summary of the regional geology is given, no information is provided on anticipated formation thickness away from the drilling site. For e.g. it is uncertain as to whether horizontal drilling in different horizons presents different risks, the direction of drilling, and the reason for drilling in that direction (as opposed to any other). Of key importance, is that no assessment has been made for the horizontal drilling in terms of whether it could cause groundwater contamination, for e.g. due to passing through faults and/or connecting different horizons. • There is no description of potential faults to be encountered in relation to the proposed horizontal well. The extent of the resistivity tomography data, which underpins the baseline understanding of local faults, is unclear. Whilst Appendix I3 comments that faults are an important consideration for the development of a hydrogeological CSM, there is no information provided relating to the current impact of local faults on existing groundwater flow regimes (rates/direction) in various formations, and particularly within the target geology. • Soil texture information contained within the GI report is described in Appendix I2 but is not included in Appendix I3. This is relevant for shallow groundwater / contaminant migration. • The identification of potential Groundwater Dependent Terrestrial Ecosystems (GWDTEs) is restricted to sites with a	sandstones beneath the superficial deposits east of the site, which are targeted by the United Utilities public water supply at Blundell House Pumping Station. However, no references or data are provided to support this conclusion. Section 5.2.4 of Appendix I3 describes two major faults that could lie close to the site, but states that one of them probably passes further to the east of the site. However, again no reference or data is given to back up this claim. This is important because this statement eludes to the fact that there could be no impacts associated with complications during drilling, tremors, or fluid leakage in this area as a result of local faults.	drilling platform, access track and vertical well, including potential faults to be encountered. Provide further details to address the remaining points listed. Where important statements are made that support the CSM, clearly indicate what data / information / references were used. For e.g. what information was used to state with such certainty that there is no driving head to connect poor quality water within the Permo-Triassic sandstones at the site, with fresh, recent-recharge water in the Permo-Triassic sandstones beneath the superficial deposits east of the site. Appendix I3 could also be improved by merging Section 7 "Environmental Setting" with sections 4 through to 6 to support the development of the CSM.

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		statutory or non-statutory ecological designation and Habitats of Priority Importance (HPI) that are shown on the Multi Agency Geographical Information Centre (MAGIC) website. Other non-statuary designated sites, or sites without an ecological designation that could support potential GWDTEs have not been considered. The Extended Phase 1 Habitat Survey report submitted as part of the planning application (Appendix D1) has not been referenced or used to identify potential GWDTEs.		
Have any baseline surveys relevant to the technical topic being assessed been undertaken appropriately to relevant, best practice and up to date guidance, in appropriate locations and looking for relevant data? If not has this been justified?	A	Data have been obtained for a high-level assessment on the site's history, geology (lithology and structural) and hydrogeology, from relevant published sources. This pre-existing data covers the wider area around the proposed site but none of this information relates to the site itself. Within Chapter 20, reference is made to a resistivity tomography survey that was carried out 1km north of the site. However, no information is provided on the maximum survey depth reached, the lateral extent of the survey, and / or key data collected of relevance to hydrogeology and groundwater protection. Unless proven otherwise, the location of this survey is not considered appropriate given its distance from the proposed well site, and any potential data gaps in this survey are not justified or referenced within the relevant chapter of the ES. One intrusive GI has been undertaken at the site. The scope of works presented in the factual report was to undertake preliminary soil sampling to establish baseline ground conditions in superficial deposits at the site and determine if the site is tidally influenced by the Irish Sea. The purpose of the GI is not mentioned in the ES and is relevant because the baseline data collected for the site is of limited use to the HRA presented in Chapter 20. It is noted that other sources of information were used to complement the GI as mentioned earlier, but given their distance, for e.g. the EA groundwater monitoring boreholes, this is not considered sufficient to characterise the site. Furthermore, the site GI comprised only one borehole, hence determination of groundwater flow rates and directions in shallow geological formations was not considered. No groundwater quality data was collected to assess baseline chemistry for the shallow aquifers present. This is important due to the potential for groundwater contamination to occur during the construction period. In addition, given that the conceptual hydrogeological model presented in the ES considers the Mercia Mudstone Group to act as a confining layer which is later used as justification for reducing the significance of potential effects on the groundwater environment, the GI could have comprised a borehole that penetrated the Mercia Mudstone Group (anticipated to be present at a depth of 18m), to determine the local hydraulic properties of this unit. This would have provided invaluable quantitative data to support the CSM and subsequent risk assessment.	Environmental baseline information is provided in Section 4 to Section 7 of Appendix I3 and Section 20.5 of the ES. Section 5.2.4 of Appendix I3 states "*A resistivity tomography survey carried out 1km north of the Site by AER [Ref. 28] imaged the subsurface across a ground through which the Hillhouse Fault should pass according to BGS mapping data [Ref. 20]. However, the survey data did not show the continuation of the Hillhouse Fault as mapped*." The intrusive ground investigation report is presented in Appendix B of Appendix I2 of the ES.	Clarification should be given over the lateral extent and depth of the resistivity tomography survey undertaken and the limitations of the survey in relation to hydrogeology and groundwater protection. A second phase of ground investigation should be undertaken at the site, with the aim of obtaining baseline groundwater flow and quality information for shallow superficial aquifers, and to drill through the base of the superficial deposits at the site to identify the local hydraulic properties of the underlying Mercia Mudstone Group, and to support the conclusions drawn in the conceptual hydrogeological site model.

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Does the ES describe the condition of those aspects of the environment that are likely to be significantly affected by the development and is the 'sensitivity' of the baseline environment clearly evaluated using an appropriate method?	A	The sensitivity criteria given in the ES differ to those given in Appendix I3, but the two need to be consistent. The sensitivity criteria outlined in Table 20.3 of the ES are insufficient and provide no definitions in relation to groundwater receptors. The sensitivity criteria given in Appendix D of Appendix I3 are better defined but they: • Do not have a groundwater focus. • Combine aquifer designations with water resources, whereas the two should be treated separately and do not use EA aquifer designations. • Omit several key groundwater receptors, including licenced and unlicensed groundwater abstractions, GWDTEs etc.	Table 20.3 in the ES defines the sensitivity of water resource receptors. Section 8.3.1 of Appendix I3 describes the sensitivity attributed to each groundwater receptor being assessed. Table 1 in Appendix D (of Appendix I3 of the ES) provides the classification system adopted for receptor sensitivity.	The sensitivity criteria given in the ES should be the same as those given in Appendix I3 and should provide clear definitions in relation to all groundwater aspects and associated receptors.
3.2 Assessment				
Does the ES contain descriptions of the likely significant effects of the proposed development on the environment for the technical topic being assessed, including as reasonably required: direct, indirect, secondary, cumulative, short, medium, long-term, permanent and temporary, positive and negative effects?	A	In general, the assessment does describe the likely significant effects in sufficient detail. However, more clarity could be given as to whether the effect is adverse, positive, direct, indirect etc. and the timescales over which the effect is anticipated to last. The significance of impacts needs to be reviewed in light of all previous comments made. Cumulative impacts are briefly considered, but Chapter 20 of the ES concludes that with respect to hydrogeology and groundwater protection there are no cumulative impacts associated with the proposed development. Whilst the ES does outline potential interactive effects between environmental disciplines, several are considered to be missing, and all potential interactive effects are ruled out based on distance, without any justification for this provided.	Section 20.6.1 of the ES describes the likely significant effects associated with the proposed development, after implementation of embedded mitigation measures. Section 20.6.2 of the ES states that there are no other committed developments located within close proximity to the application site which need to be considered in terms of cumulative effects. Section 20.6.3 of the ES considers potential interactive impacts between environmental disciplines but concludes that through mitigation and distance from sensitive receptors, the likely significance of any water resource and flood risk effects from the proposed development is considered to be low.	Provide clarity over whether the potentially significant effects listed are adverse, positive, direct, indirect etc. and the timescales over which the effect is anticipated to last. Consider further assessment of cumulative and interactive effects between environmental disciplines. Or provide sufficient evidence to justify important statements made in relation to scoping out cumulative / interactive effects.
Are the methods of assessment relevant to the technical topic being assessed appropriate, up to date and best practice? Do they meet the requirements of the relevant Regulations and any other local / technical institute guidance?	R	As previously mentioned, the "conceptual model" presented is not considered to be a complete and robust CSM. The HRA has been carried out using a Source-Pathway-Receptor (S-P-R) approach, which is considered appropriate as a principle however the level of assessment is kept high level review and lacks site characterisation and semi-quantification. In our professional judgement the level of assessment is not considered to be appropriate to assess the potential effects associated with the proposed development, on the basis that: • The process of hydraulic fracturing is new to the UK and its particular geology.	Section 20.4 of the ES and Section 8.1 of Appendix I3 describe the assessment methodology undertaken for the hydrogeological risk assessment carried out for the proposed development. Section 8.1 of Appendix I3 states " *The construction and restoration of sites and the construction, testing and decommissioning of oil and gas wells is well understood. There is good understanding of the geology, hydrology and hydrogeology. Mitigation measures are clearly defined, tested and known to work. Therefore, a semi-qualitative (Tier 1/2)*	A robust CSM based on which a semi-quantitative based assessment should be carried out. This should: • Provide detailed justification for the search area used for receptor identification. • Define the groundwater study area for both the vertical and horizonal wells. • Acknowledges all relevant legislation and regulatory / planning controls. • Use and refer to the plethora of guidance documents and studies available for hydraulic fracturing.

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		• There is mixed evidence from case examples in the USA. • Several independent reports have been produced which document the severity of potential impacts caused by hydraulic fracturing to groundwater and its associated receptors. There is no justification provided for the search radius chosen for groundwater receptor identification. There is no definition provided for the groundwater study area, in terms of lateral and vertical extents, and in particular with regards to the proposed horizontal well. It should also be noted that some potential impacts, in particular in relation to groundwater flows, are not discussed. Although there is currently no shale-specific legislation at the overarching EU or UK level, a wide range of broader oil and gas, environmental, health and safety, planning and other regulatory controls apply to UK shale gas operations, which include but are not limited to: • Infrastructure Act 2015 • Offshore Installations and Wells (Design and Construction) Regulations 1996 • Borehole Sites and Operations Regulations 1995 • The Water Environment (Controlled Activities) Regulations 2011 • Provision and Use of Work Equipment Regulations 1998 • Town and Country Planning Act 1990 • Environmental Protection Act 1990 • Environmental Permitting (England and Wales) Regulations 2010 • Coal Industry Act 1994 Most of these are not referenced in Chapter 20. In addition, whilst there are no specific regulations with respect to the undertaking of assessments for this topic area, there are several technical papers, industry standards, and guidance documents which should be reviewed and referenced for this assessment, including but not limited to: • UK Onshore Shale Gas Well Guidelines 2015 • An Environmental Risk Assessment for shale gas exploratory operations in England • EA Onshore oil and gas exploratory operations: technical guidance • BGS aquifer / shale separation study and methane baseline study	*assessment is considered to be appropriate to assess the risks associated with the Proposed Development.* Section 8.2 of Appendix I3 and Section 20.6.1 of the ES list the hazards identified and discuss the potential S-P-R linkages to groundwater receptors. Section 6.2 and Section 20.2 of the ES provide information regarding the legislative and regulatory context for the proposed development. Section 3.9 of Appendix I3 comments on the environmental permitting process. References to environmental permits are dotted throughout Chapter 20 of the ES rather than under one header.	• .

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		• Hydraulic fracturing for shale gas in the UK: Examining the evidence for potential environmental impacts • Shale gas extraction in the UK: a review of hydraulic fracturing • Interim report of the scientific analysis of data gathered from Cuadrilla's operations at Preston New Road None of these are mentioned or referenced in Chapter 20. Chapter 20 of the ES and Appendix I3 mention consents and permitting as a general process, but there is little or no information provided around the individual environmental permits and consents that would / should be applied for by the applicant or justification as to why certain consents / permits are not required, for e.g. if there is no planned discharge of groundwater to local watercourses then a discharge permit would not be required. In addition, it's considered that the environmental impact assessment (including the hydrogeological risk assessment process) is fundamental for supporting environmental permit applications and fulfilling the requirements of the planning application. Therefore, delaying submission of key development design information and details of proposed embedded mitigation measures until the environmental permitting process, in the context of significant baseline data gaps, is not considered appropriate in this instance.		
Is the assessment input data appropriate and adequately justified?	A	For some of the information presented in the report there is no reference to key documents and it not possible to verify the accuracy of some of the statements made. This is particularly true for the geology expected to be encountered during the horizontal drilling, and any faulting associated with this geology.	Section 6.3 of Appendix I3 mentions faulting generally in the context of groundwater flows and hydrogeology, but not in relation to the target horizons expecting to be drilled or hydraulically fractured.	Provide references for all data / information sources to back up key statements. Consider faulting in all relevant geological horizons and how this may affect horizontal drilling.
Are the methods for establishing the 'magnitude' of effects on the receiving environment relevant to the technical topic being assessed clearly defined and appropriate?	A	As with the sensitivity criteria, the magnitude of impact criteria outlined in the ES do not align with that provided in Appendix I3. Within the ES, the magnitude of impact criteria are insufficient and provide no definitions in relation to groundwater receptors. The magnitude of impact criteria presented in Appendix I3 do not have a groundwater focus and do not cover all groundwater receptors. There is also no mention of WFD compliance, for e.g. a potential change to groundwater flows (quantity) and / or quality.	Table 20.4 in the ES defines the assessment criteria for determining the magnitude of impact. Table 2 in Appendix D (of Appendix I3 of the ES) provides the assessment criteria for magnitude of impact of relevance to hydrogeology and groundwater protection. Section 8.3.2 of Appendix I3 describes the magnitude of impact attributed to each groundwater receptor being assessed.	The magnitude of impact criteria given in the ES should be the same as those given in Appendix I3 and should provide clear definitions in relation to all groundwater aspects and associated receptors and potential impacts, with a discussion on WFD compliance.
Are the specific methods used to evaluate significance of the technical topic being assessed clearly justified and appropriate?	A	Given the inadequacies identified with both the sensitivity criteria and the criteria for identifying the magnitude of impact, the methodology / criteria for determining the significant of effect cannot yet be reviewed or appraised.	Table 20.5 in the ES defines the assessment criteria for determining the magnitude of impact. Table 3, Table 4 and Table 5 in Appendix D (of Appendix I3 of the ES) provides the assessment criteria for preliminary significance of effect, likelihood of occurrence and risk, respectively. Section 8.3.3, Section 8.3.5 and Section 8.4 of Appendix I3 describe the preliminary significance of effect, likelihood of occurrence and risk classification, respectively, for	Review the methodology for determining the potential significance of effects, following improvements to the sensitivity criteria and the criteria for identifying the magnitude of impact.

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			each groundwater receptor and potential impact being assessed.	
Does the impact assessment consider the different stages of development (construction, operation) and relate the effects identified to the condition of the baseline environment?	G	For the effects and mitigation measures considered, the assessment does provide an assessment for all stages of the work and does relate the potential effects to the baseline environment.	The impacts and mitigation measures of the different phases of work are provided in Section 20.6 of the ES.	
Does the ES identify the significance of residual effects relevant to the technical topic being assessed that are anticipated to remain following the successful implementation of any mitigation described in the ES?	A	The ES does describe the residual effects anticipated to remain following the implementation of embedded and additional mitigation. However, as discussed above, the criteria for determining sensitivity, magnitude of impact, and significance of effect are not considered to be sufficient. Hence residual effects contained within the ES cannot yet be reviewed.	Residual effects following additional mitigation are provided in Section 20.8 of the ES.	Update sensitivity, magnitude of impact, and significance of effect criteria in line with previous comments made. Then review the HRA and potential residual effects once all groundwater receptors are considered to an appropriate level of detail.
Is it clear that the ES has considered inter relationships in order to identify secondary, cumulative and synergistic effects relevant to the technical topic being assessed?	A	Potential cumulative impacts arising from hydrocarbon exploration at the Preston New Road wellsite are not considered based on the distance from the proposed development. However, some cumulative impacts could still arise irrespective of distance, for e.g. impacts on water resources as a result of concurrent hydraulic fracturing operations. It is not deemed sufficient to scope out the Preston New Road wellsite without an assessment of cumulative impacts being carried out in relation to the water environment, or justification provided as to why this distance would not result in any cumulative effects for hydrogeology and groundwater protection. Another factor for consideration includes the potential cumulative impacts associated with faults, which traverse long distances laterally, and groundwater / contaminant movement through geological formations. Although Section 7.3 of the ES mentions potential cumulative effects for ecology with regards to habitat loss, there is no reference to this within Chapter 20, and the potential cumulative effects of habitat loss that could be caused as a result of the proposed development, for e.g. at GWDTEs. The potential cumulative impacts listed for water environment include leaks and / or spills of chemicals / fuels, and creation of additional areas of hardstanding. Both of these could impact the shallow groundwater environment. The cumulative effect of the proposed development alongside these other committed developments is not assessed within Chapter 20 of the ES, also on the basis of distance. However, it's unclear how these effects can be scoped out without any assessment actually being undertaken. Again, there is no evidence presented to justify why this distance would lead to no cumulative effects needing to be considered. No reference is made in Chapter 20 to the cumulative effects discussed in Chapter 7. Chapter 8 states "*The interaction between topic areas has the potential to convert a non-significant effect into a significant effect.*" Whilst Chapter 8 lists potential interactive impacts between environmental disciplines, the	Chapter 7 of the ES considers cumulative impacts for the proposed development. Section 7.2 states "*With regards to other hydrocarbon exploration sites, the Preston New Road wellsite is located approximately 26km to the north of the application site and due to this distance is not considered by the Assessment Team to have any cumulative impact.*" Section 7.3 of the ES mentions two committed developments that could have potential cumulative impacts for ecology, in terms of habitat loss, and the water environment, in terms of discharges to watercourses, leaks and / or spills of chemicals / fuels, and creation of additional areas of hardstanding. Section 20.6.2 of the ES states that there are no other committed developments located within close proximity to the application site which need to be considered in terms of cumulative effects. Chapter 8 of the ES considers the potential interactive impacts between environmental disciplines. Section 20.6.3 states "*With specific regard to water resources and flood risk, any impact as a result of the proposed development could have interactive effects on ecology and public health. However, through mitigation and distance from sensitive receptors, the likely significance of any water resource and flood risk effects from all phases of the proposed development is considered by the Assessment Team to be low.*"	Provide evidence to justify important statements made in relation to scoping out cumulative effects and interactive impacts between environmental disciplines. This includes justification as to why distance is a sole reason for cumulative / interactive effects not being considered within the assessment. Ensure that all effects mentioned in Chapter 7 and Chapter 8 are evaluated within Chapter 20.

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		reason provided for these impacts to not be considered further is that the individual di scipline assessments concluded there to be no significant effects. There is no acknowledgement of how these non -significant effects could escalate if considered cumulatively between disciplines, as mentioned in the statement given previously. In addition, statements such as " *Even if unmitigated, induced seismicity from the proposed operations is considered unlikely to result in any loss of well integrity that might potentially impact on water receptors* " are considered highly misleading, and there is no evid ence to support a conclusion of this nature, which has such importance for groundwater protection. There is also no reference in Chapter 20 to the interactive impacts considered in Chapter 8 between water and seismicity, and water and waste.		
3.3 Environmental Mitigation and Management				
Does the ES describe the measures proposed to be implemented to av oid, reduce, offset or remedy significant adverse effects of the proposed development relevant to the technical topic being assessed?	R	It's noted that several key mitigation measures are proposed to protect the groundwater environment and its associated r eceptors, including for e.g. the use of a HDPE liner at the wellsite. However, some of the mitigation measures listed are not considered to provide enough detail. For e.g. " *Hydraulic fracturing will not extend beyond the formations in which the fracturing take place.*" There is no indication of how exactly this would be achieved. It's the latter detail that would be considered as embedded mitigation. Some mitigation measures, which are considered relevant to the assessment are lacking. These include, but are not limited to: • A dewatering strategy for the construction phase. The Intrusive Ground Investigation Report (supporting Appendix I2 of the ES) states "*Based upon the shallow depth of groundwater across the site, it is likely that groundwater will be encountered during foundation construction, and it is considered that sump and pump dewatering techniques will be required to form foundations, drilling cellars and perimeter ditches.*" The EA also note the need to control shallow groundwater in their scoping response. However, this is not considered within the ES. This is of particular importance for contaminant migration in shallow aquifers, disposal of dewatering water etc. • No mitigation measures are proposed for horizontal drilling aside from those already proposed for drilling the vertical well. It is not considered sufficient to rely on the same mitigation measures, given the difference in potential effects that could arise as a result of the two operations. For e.g. there is no consideration given to mitigation measures required should faults be intercepted in the horizonal drilling process. • Draft construction method statements should be provided and appended to the ES. These should be reviewed and used to inform	Table 20.8 of the ES and Table 7 of Appendix I3 provide embedded mitigation measures proposed for each phase of the development. In Table 20.8 of the ES, under Phase 3 – Horizontal Drilling, the following is stated: "*Drilling will incorporate the same mitigation measures as Phase 2.*" Section 20.7 of the ES and Section 8.4.1 of Appendix I3 describes additional mitigation measures proposed as part of the proposed development.	Provide more detail with regards to how certain mitigation measures proposed would prevent or reduce significant adverse effects. Review the mitigations required in light of comments made in this section and in previous sections.

Criterion	RAG	Comment	Example / Location of Issue	Further Work Recommended
		the HRA. Final construction method stat ements could be submitted at a later stage, in parallel with the environmental permitting process. • A detailed monitoring strategy including a traffic light system for monitoring potential adverse effects to ground or groundwater during drilling or hydraulic fracturing operations. For e.g. providing defined levels of well deterioration, and subsequent actions to be followed if those deterioration levels are reached at different phases of the development. The references made to a monitoring strategy within the ES refer only to boreholes being installed within the well platform area and ignores all other construction and operational phase activities. Aside from the mitigation measures listed above, there could be additional mitigation measures that are needed for aspects of the proposed development that have not been assessed or not been assessed in sufficient details, after addressing previous comments and once the classification for sensitivity, magnitude of impact, and significance of effect criteria are updated.		
Does the ES describe the measures proposed to be implemented to monitor significant adverse effects of the proposed development relevant to the technical topic being assessed?	R	The ES does refer to a groundwater monitoring plan, but this plan has not been submitted as part of the ES. It is therefore not possible to determine whether the monitoring proposed is sufficient to offset potential significant adverse impacts to groundwater receptors. There is also no mention of monitoring discharges from the site surface water collection system, or for e.g. nearby designated sites to ensure no adverse change to their baseline functioning. A monitoring strategy should to be developed and submitted as part of the ES. A robust and comprehensive groundwater and surface water monitoring strategy is considered to be a mitigation measure irrespective of the environmental permitting process.	Table 20.8 of the ES and Table 7 of Appendix I3 state the following will be included as embedded mitigation during Phase 1 Construction: "*Monitoring boreholes will be constructed within the unsealed part of the wellsite in accordance with Environment Agency good practice and BS EN ISO 5667*" No reference is made to monitoring other activities or locations such as the horizontal drilling and subsequent hydraulic fracturing. Section 20.8 of the ES and Section 8.4.2 of Appendix I3 states "*The effectiveness of the mitigation measures will be assessed through the implementation of a scheme of surface water and groundwater monitoring that will be agreed with the Environment Agency and confirmed as part of the environmental permitting process*." In Section 1.2 and Section 8.4.2 of Appendix I3 there are references to a groundwater monitoring plan for the proposed development, however, this document has not been submitted as part of the ES.	A monitoring strategy should be developed and submitted as part of the ES, or if sufficient, the referenced groundwater monitoring plan should be updated to include monitoring of all activities and locations, such as for the horizonal drilling, monitoring discharges from the site surface water collectio n system, monitoring of relevant nearby receptors where necessary, and submitted as part of the ES.
Is the effectiveness of the stated mitigation measures indicated, relevant to the technical topic being assessed, provided? Is the mitigation proposed appropriate to the effects envisaged? If	A	Both embedded and additional mitigation measures are provided in the ES. However, as mentioned above, not all necessary mitigation measures have been incorporated in Chapter 20. The EA in their response to the planning application make the following comment: " *The applicant has chosen not to parallel track their planning*	Table 20.8 of the ES and Table 7 of App endix I3 provide embedded mitigation measures proposed for each phase of the development.	As mentioned above, en sure that all required mitigation measures (both embedded and additional) are considered in the assessment and presented in Chapter 20 of the ES.

Criterion	RAG	Comment	Example / Location of Issue	Further Work Recommended
not, is this justified? Will the proposed mitigation work?		*and Environmental Permit applications. This means that we cannot offer any detailed advice or comments on issues we regulate through permitting that may also be considered through the planning regime*". This highlights the fact that there is an overlap between the assessment needed to support both planning and permitting. The reference mad e in the ES that Environmental Permitting is an embedded ES mitigation measures is incorrect. The ES requires to identify, assessment and mitigate potential impacts irrespective of the environment permitting process.	Section 20.7 of the ES and Section 8.4.1 of Appendix I3 describes additional mitigation measures proposed as part of the proposed development.	Environment Permitting does not constitute an embedded mitigation measure.
Is the monitoring proposed appropriate to the effects envisaged? Does the ES set out what actions will be undertaken at what trigger levels?	R	As mentioned above, there are no details provided for the groundwater monitoring proposed for the protection of ground or groundwater, and n o information relating to trigger levels or actions.		A monitoring strategy should be developed and submitted as part of the ES, which includes trigger values and actions that should be taken if these values are exceeded.