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Appendix C

Overview report
HIA work concerning planning applications for temporary shale gas exploration

Health Impact Assessment support, shale gas exploration

Lancashire County Council

2nd September 2014

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Abbreviations and acronyms

ALARP ..... As Low As Reasonably Practicable
AQMA ..... Air Quality Management Area
BAT ..... Best Available Technology
BGS ..... British Geological Survey
CBM ..... coal bed methane
CCGs ..... Clinical Commissioning Groups
CPRD ..... Clinical Practice Research Datalink
CO_2 ..... Carbon Dioxide
COMAH ..... Control of Major Accident Hazards
COMEAP ..... Committee on the Medical Effects of Air Pollutants
DCLG ..... Department of Communities and Local Government
DECC ..... Department of Energy and Climate Change
DEFRA ..... Department of Environment, Food and Rural Affairs
DETR ..... Department of Environment, Transport and the Regions
DH ..... Department of Health
DPH ..... Director of Public Health
DsPH ..... Directors of Public Health
EA ..... Environment Agency
EIA ..... Environmental Impact Assessment
EMMP ..... Environmental Management and Monitoring Plan
ERA ..... Environmental Risk Assessment
ES ..... Environmental Statement
EWT ..... Extended Well Testing
GHG ..... Greenhouse GAs
GNP ..... Gross National Product
HIA ..... Health Impact Assessment
HGV ..... Heavy Goods Vehicle
HPA ..... Health Protection Agency (part of Public Health England from 1st April 2013)
HSE ..... Health and Safety Executive
HSfE ..... Health Survey for England
HSSE ..... Health Safety, Security and Environment
HVHF ..... high-volume hydraulic fracturing
IAIA ..... International Association for Impact Assessment
IAOGP ..... International Association of Oil and Gas Producers
IPIECA ..... International Petroleum Industry Environmental Conservation Association
ICRP ..... International Commission on Radiological Protection
ITT ..... Invitation to Tender
LCC ..... Lancashire County Council
LEP ..... Local Enterprise Partnership
LFL ..... Lower Flammable Limit
LLWR ..... Low level Waste Repository
MPA ..... Minerals Planning Authority
MSDS ..... Material Safety Data Sheet
NICE ..... National Institute of Health and Care Excellence

NORM ..... Naturally Occurring Radioactive Materials
NOx ..... Oxides of Nitrogen (NO & NO_2)
OUGO ..... Office of Unconventional Gas and Oil
PAH ..... Poly Aromatic Hydrocarbons
PEDL ..... Petroleum and Exploratory Development Licence
PHE ..... Public Health England
PM ..... Particulate Matter (e.g. PM_{10} & $PM_{2.5}$)
QRA ..... Quantitative Risk Assessment
RAFF ..... Residents Against Fylde Fracking
SEPA ..... Scottish Environmental Protection Agency
REVIHAAP ..... Review of Evidence on Health Aspects of Air Pollution
UKOOG ..... United Kingdom Onshore Operators Group
UU ..... United Utilities Plc
VOC ..... volatile organic compounds
WHO ..... World Health Organization

1 Executive summary

1.1 Introduction

1.1.1 In 2014, the Cabinet of Lancashire County Council (LCC) committed to conducting an initial Health Impact Assessment (HIA) of shale gas extraction in Lancashire. This HIA was to focus on the two proposed exploration sites (Preston New Road and Roseacre Wood). LCC would decide whether further HIA work was required once the initial study was complete. The Director of Public Health (DPH) set up a Health Advisory Group to assist in this endeavour.

1.1.2 Ben Cave Associates Ltd (BCA) has completed this work. We submit this report to the DPH.

1.1.3 In this report we make preliminary recommendations about steps the DPH may wish to take concerning the exploration for shale gas at Preston New Road and Roseacre Wood. We suggest that it will be important to establish mechanisms to ensure the views of those communities affected by the proposals are actively sought, considered and taken into account. The purpose of this is to develop and maintain trust between these communities and the relevant statutory and regulatory agencies.

1.1.4 We establish a framework that can be used for any future HIA work concerning the exploration of shale gas at these two sites. We suggest that LCC develop a baseline of existing health, and environmental conditions, in the local area and systems for monitoring change and actual effects from shale gas exploration (and any subsequent activities).

1.1.5 We do not make definitive statements on the potential effects on health arising from the current applications. Onshore shale gas activity in the UK is currently in the exploration stage and there is no experience of production operations in UK conditions as yet, although there is a history of production of oil and gas from 'conventional' onshore fields. The published literature comes mainly from the USA. Uncertainties remain, for example the range of potential health effects and the timescale over which monitoring should take place. These, and other issues, could be investigated through a systematic review of literature concerning shale gas exploration and extraction. Future steps would include ensuring that findings from studies elsewhere are generalisable and applicable to the context of exploration for, and extraction of, shale gas in Lancashire.

1.1.6 We also provide a set of clarifications that the DPH may wish to explore with the Applicant: these are listed below.

Approach

1.1.7 HIA is *… a combination of procedures, methods and tools that systematically judges the potential, and sometimes unintended, effects of a policy, plan, programme or project on both the health of a population and the distribution of those effects within the population. HIA identifies appropriate actions to manage those effects.*

1.1.8 We define health broadly as being a *state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity*. Public health is also concerned with ensuring that differences in health between population groups are minimised. These are known as inequalities in health.

1.1.9 The HIA work has included liaison with LCC and with the Health Advisory Group; a preliminary literature, policy and baseline search; reviews of submitted planning applications and permitting information; community engagement workshops; and preparation of reports.

1.1.10 The main written outputs of the HIA work are:

- Review of Preston New Road Environmental Statement;
- Review of Roseacre Wood Environmental Statement and IPPC Application; and
- Community Engagement Report.

1.2 Recommendations

Community input

1.2.1 The over-riding responses about the two proposed exploration sites voiced by members of the local communities who attended the workshops were those of fear, anxiety and stress, which are affecting their mental wellbeing, with some people experiencing sleep disturbance and depression.

1.2.2 Residents who attended the workshops felt that they did not have a voice, and that their concerns were not being addressed. These responses were associated with a lack of trust and/or confidence in the statutory and regulatory authorities responsible for either the regulation of shale gas exploration and extraction or the protection of residents' health and wellbeing. Again, these issues were affecting residents' mental wellbeing.

1.2.3 Furthermore, the residents in attendance were concerned about the approach of the Applicant, including taking note of inconsistencies in the information the Applicant had provided at various points during the planning application process, which led to further anxiety and stress. Residents also raised questions about practices in the shale gas exploration and extraction industry in general, which were a source of worry for them.

1.2.4 In the absence of information from other sources and/or the provision of information that appeared to be inconsistent, many of the residents who attended the workshops had found information on the effects of shale gas extraction and exploration from the published literature and the internet. This information mainly covered experience in the United States of America, Canada and Australia, with relatively little being found that related to the situation in the United Kingdom. Residents felt strongly that this information should be considered during the planning process. We recommend that a review is conducted of shale gas exploration and health. We describe this below.

1.2.5 Residents felt that, if planning permission was granted for the two proposals, they would be placed at a disadvantage, while receiving no benefits whatsoever. Residents thought the Government would be the main beneficiary, with the possibility of only some benefit accruing to the wider region as a whole.

1.2.6 Anxiety over emergency scenarios featured. Although emergency planning is a requirement for this type of development, this process has not been 'visible' to residents. It is unclear if the Applicant has yet undertaken modelling to identify the zone of risk in the event of worst-case loss of gas containment. In the absence of this information neither residents, nor this HIA work can rule out serious health impacts. Anxiety fuelled by uncertainty over this issue could potentially have wider health impacts than the risks themselves.

1.2.7 To develop and maintain trust between the communities affected by the proposals and the relevant statutory and regulatory agencies, it will be important to establish mechanisms to ensure the views of communities are actively sought, considered and taken into account.

Further HIA

1.2.8 The need for further HIA work for the exploration phase of shale gas extraction may be limited if the clarifications raised in the reviews of the Environmental Statements, and the recommendations for establishing a baseline and subsequent monitoring, are addressed to the satisfaction of the DPH.

1.2.9 If further HIA work is conducted (for the exploration or production phases) we suggest that consideration is given to inviting community representation onto the Health Advisory Group. The terms of reference for the Health Advisory Group name the regulators as stakeholders. We suggest that consideration is given to inviting the regulators to join the Health Advisory Group as members. Further HIA work could usefully engage industry in the process.

1.2.10 HIA should be considered from the outset of any applications for the production phase of shale gas extraction.

Systematic review

1.2.11 A systematic literature review is conducted by an independent organization such as Cochrane. This should be in conjunction with environmental specialists as well as social scientists, such that all the health impacts and wider determinants of health are included. Governance of this review is important for the acceptability of the findings. We suggest that appropriate timescales for monitoring health effects from shale gas exploration and extraction should be identified in a literature review.

Policy

1.2.12 This is a new extraction process for UK regulators. The ES and commentators place great weight on regulation. The regulators and PHE report that an appropriate regulatory framework is in place. Effective testing of the health protection arrangements is advisable.

1.2.13 This could include the use and robustness of monitoring systems to confirm that operations below ground do not pose a risk to health protection: eg fault, aquifer or gas migration impacts, both during drilling and hydraulic fracturing and longer term.

1.2.14 This could also include the reporting, the interpretation of results, and the subsequent review of any actions which may be required. Change may be to activities at the site, or development of local or national policy or regulation.

Population baseline and monitoring

1.2.15 The current applications are in rural wards. The population of these wards have a higher proportion of older people than the Lancashire and England averages. As might be expected there are a range of pre-existing mental and physical health conditions.

1.2.16 LCC should ensure that a baseline of actual health conditions is developed for the local area to enable the health effects of exploration for shale gas to be identified. This would be of use if shale gas were to be produced at these sites. This would require the use of existing datasets and survey work to establish the local conditions. This will link in with the monitoring of actual affects if the extraction and exploration of shale gas proceeds. We consider short- and longer-term approaches for such a study.

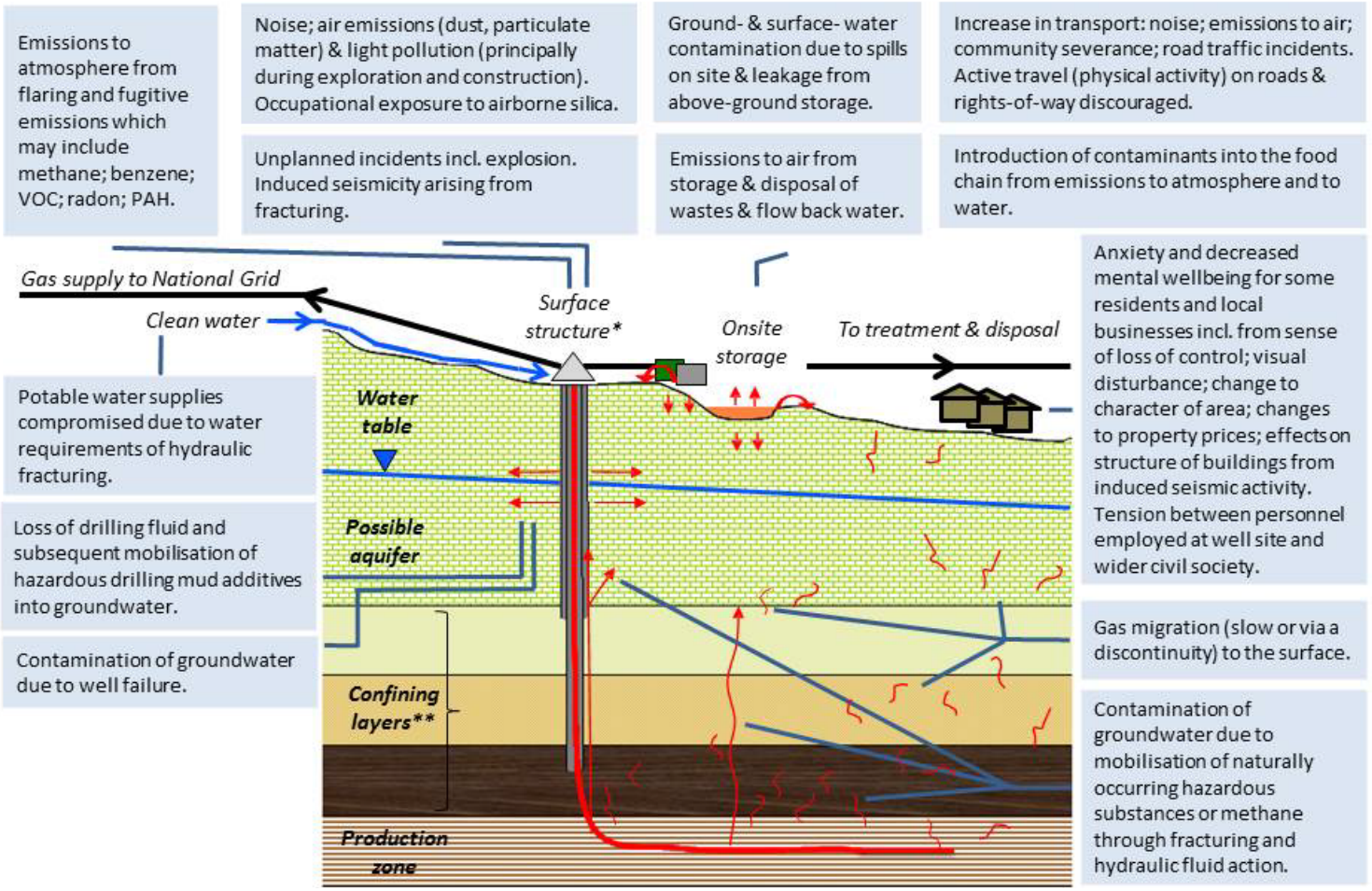
1.2.17 The governance of the study design, data collection, analysis and reporting will be of critical importance. The protocol for the study should ensure that community groups are included in identifying the geographical areas where data is collected, identifying the questions that are posed, the analysis and the reporting of results. This can include capacity building for local groups.

1.3 Localised health hazards

1.3.1 Figure ES-1 summarises the main health hazards that might be expected for a development of this type based on information collected in the course of this study.

1.3.2 Table ES-1 puts these generalised hazards into the context of the current applications. We discuss the limitations of focussing on hazards in the main body of this report (Section 4.2).

Figure ES-1: Localised health hazards arising from shale gas exploration and extraction



This diagram is a general depiction of pathways representing hazards to health. The risks these pose to health are not known and the potential for exposure to these hazards might be amenable to mitigation.
The diagram is not to scale. The position of residences or places of work relative to the well & other infrastructure is indicative.
* The operations conducted at the site and the surface structure will change between phases.
** The confining layers may not be impermeable. Fractures may extend upwards and slippage may occur across fault lines.

Adapted from Environment Agency

Table ES-1: Summary of findings

Hazard	Mitigation proposed for PNR/RW	Residual concern/clarification requested
Emissions to atmosphere from flaring and fugitive emissions which may include methane; benzene; VOC; radon; PAH.	Flare stacks designed for dispersion. Input gas and emissions to be monitored. Fugitive emissions minimised by flaring (reducing climate change impact).	Levels of radon and fine particulate matter expected to be very low, but could present a small hazard as there are no lower thresholds for harm.
Noise; air emissions (dust, particulate matter) & light pollution (principally during exploration and construction). Occupational exposure to airborne silica.	Standard plant and vehicle noise, dust and light disturbance mitigation. Hydraulic fracturing pumps limited to daytime use. Occupational H&S equipment.	Noise from drilling (24/7) and hydraulic fracturing pumps (daytime) may cause disturbance at closest residential receptors. Night light disturbance may occur at closest residential receptors. Clarification that BAT will be used to minimise all emissions.
Unplanned incidents incl. explosion. Induced seismicity arising from fracturing	Selection of drilling site away from regional faults to minimise risk of induced seismic events. Use of multiple steel casing and cement layers and shut off valves to reduce risk of major loss of gas containment.	There is a lack of data on the risks associated with a major loss of gas containment, e.g. through loss of surface infrastructure once gas flow established. A quantitative risk assessment showing zones of risk is needed to establish the health impacts.
Ground- & surface-water contamination due to spills on site & leakage from above-ground storage.	Bunding and protective impermeable layers for the entire surface site. Secondary containment volume in excess of stored liquids. Control of precipitation run-off.	Clarify if the site will be a hazardous waste management site. If so, clarify if the hazardous materials could cause problems in surface water.
Emissions to air from storage & disposal of wastes & flow back water.	Closed loop steel tanks for flowback fluid.	Clarification that all untreated drilling and fracking fluid wastes are fully contained on and off site to prevent emissions to air.
Increase in transport: noise; emissions to air; community severance; road traffic incidents. Active travel (physical activity) on roads & rights-of-way discouraged.	Standard traffic routing and scheduling to avoid congestion and delays.	Clarification on suitability of RW narrow local roads for large HGVs. Safety of alternative RW access route over MoD site needs to be established.
Introduction of contaminants into the food chain from emissions to atmosphere and to water.	Spill management and site restoration plans for contamination of surrounding agricultural land.	Identified in community engagement workshop – this could be investigated in a literature review.

Hazard	Mitigation proposed for PNR/RW	Residual concern/clarification requested
Anxiety and decreased mental wellbeing for some residents and local businesses incl. from sense of loss of control; visual disturbance; change to character of area; changes to property prices; effects on structure of buildings from induced seismic activity. Tension between personnel employed at well site and wider civil society.	Community consultation and information sharing. Minimisation of visual impacts where possible with screening.	Ongoing community anxiety apparent. Cumulative impacts of multiple types of disturbance and nuisance on closest residential receptors.
Gas migration (slow or via a discontinuity) to the surface.	Use of micro-seismic monitoring to reduce likelihood of fractures propagation to faults. Geological analysis to evidence presence of naturally impermeable layers.	Clarification of micro-seismic monitoring array accuracy. Concerns that long-term slow migration may occur if fracturing releases gas from its current layer.
Contamination of groundwater due to mobilisation of naturally occurring hazardous substances or methane through fracturing and hydraulic fluid action.	Use of non-hazardous additives to fracking fluid. Containment and treatment of hazardous substances mobilised into fracking fluid that are brought to the surface (including NORM). Also see gas migration mitigation.	Clarification of whether non-hazardous fracking fluid additives may become hazardous due to reaction with naturally occurring substances. Clarification of monitoring required to confirm hypothesised permeability of geological layers and faults to act as natural barriers. Concerns that there may be long-term slow migration into groundwater of contaminated fracking fluids that cannot be recovered. Concern that there may be a lack of capacity at treatment plants for recovered contaminated fracking fluid.
Loss of drilling fluid and subsequent mobilisation of hazardous drilling mud additives into groundwater.	Use of non-hazardous drilling muds for shallow and sensitive rock formations (aquifers). Monitoring of drilling mud pressure around known faults and alternative route taken if appropriate.	Concern that mud with hazardous additives may be used during drilling through faults, potentially contaminating surrounding ground water.
Contamination of groundwater due to well failure. [In the US inadequate cementing or casing allowed gas migration to groundwater.]	Use of multiple steel casing and cement layers to reduce risk of well failure. Selection of drilling site away from regional faults to minimise risk of seismic events damaging the well.	Concern that a well could be damaged by a seismic event, particularly where it crosses faults e.g. Mid-Elswick Graben Faults.
Potable water supplies compromised due to water requirements of hydraulic fracturing.	Confirmation from water provider (UU) that water requirements of project will not affect other users.	Clarification of whether this includes during periods of water shortage. Concerns that for RW the projects high water demand scenarios exceed available water capacity.

1.4 Clarifications sought on Environmental Statements

The following sections set out the clarifications that we suggest the DPH raises with regard to the Preston New Road and Roseacre Wood Environmental Statements. Additional queries arising from consideration of the IPPC application for Roseacre Wood can be found in section 4.3 of the review of Roseacre Wood Environmental Statement and IPPC Application.

Pertinent to both applications

***General**: We suggest that the Director of Public Health for LCC:*

1.4.1 Seeks clarification that the monitoring framework requirements set through the planning and permitting processes will address not only the short-to-medium term impacts of disturbance and pollutants arising from the site to the local population, but also the potential for long-term (and potentially more widespread) legacy impacts on groundwater and ground gas. Such monitoring should be tied to an action plan with defined roles and responsibilities for notifying and responding to exceedances for the full period of the monitoring. We suggest that the Director of Public Health for LCC should remain engaged with the process and information that emerges on monitoring from the planning and permitting processes.

1.4.2 Requests that regulators collectively produce a document that summarises each application's adherence to the DECC Regulatory road map guidance, including the planning and permitting conditions and monitoring requirements that have been imposed at each step for the protection of public health.

1.4.3 Confirms when and what further information will be available for each site regarding quantitative risk assessment (including unplanned events and reference to ½LFL[1]).

1.4.4 Seeks further detail for each site on the influence on people's understanding of safety associated with property values, amenity value of outdoor space and levels of physical activity.

1.4.5 Confirms for each site how the Applicant will ensure and demonstrate that all pollution will be as low as reasonably practical using BAT. This applies to air quality (including PM_{10} and $PM_{2.5}$), noise, vibration, light and any other release from the activities on site or associated with the site.

1.4.6 Request clarification for each site on the cumulative impacts inter (between) rather than intra (within) topics presented in the ES. For example: the cumulative radiological impact to the closest residential receptors from radiological emissions (notably radon) associated with flaring, water (NORM) and any solid waste stored onsite; or the cumulative impact of all sources of potential disturbance and nuisance to the closest residential receptors (including noise, dust, light, traffic etc).

***Air quality:** We suggest that the Director of Public Health for LCC:*

1.4.7 Seeks clarification for each site as to whether there will be periods of higher exposure to radon (e.g. during the 120 day flare period assumed by the radon modelling) than is suggested by the ES reporting the exposure levels as an annual effective dose. Notably whether peak levels will exceed 400 Bq/m^3 in any 24 hour period at any receptor (on or off site). [This clarification is unlikely to change the overall conclusion in terms of public health, but would assist in resolving this as an issue for the HIA.]

[1] Being outside the area where gas has dispersed from the source to a concentration of half its lower flammable limit (½LFL) is a recognised threshold of reasonable safety.

1.4.8 Request clarification for each site of whether one or two flares have been included for the radon modelling. It would be useful for actual receptors and weather data to be used in the radon modelling. [This clarification is unlikely to change the overall conclusion in terms of public health, but would assist in resolving this as an issue for the HIA.]

1.4.9 Request additional modelling for each site of the likely radon exposure levels during unplanned events (*e.g.* loss of gas containment at ground level) for occupational and residential receptor doses. For each radon modelling result (including those requested above), data in unit of µSv/year and Bq/m^3 would be useful. [This clarification is unlikely to change the overall conclusion in terms of public health, but would assist in resolving this as an issue for the HIA.]

1.4.10 Request information for each site on what alternatives have been considered for the capture and the use of methane during the 90 day initial flow testing stage and clarify how the decision to flare has been reached.

Noise: *We suggest that the Director of Public Health for LCC:*

1.4.11 Requests additional mitigation be incorporated into both Projects to ensure that at all receptors noise levels attributable to the Projects (notably well pad construction, drilling and hydraulic fracturing) neither exceed the WHO general health based threshold of 50/55 dB $L_{Aeq, 16hr}$; nor the WHO night noise threshold of 40 dB $L_{night, outside}$. This recommendation is aligned with the HIA objective of minimising health impacts, rather than meeting statutory or regulatory limits.

1.4.12 We suggest that for each site the Director of Public Health for LCC requests regulatory authorities control the working hours and days for Project activities, particularly hydraulic fracturing. Consideration could be given to only operating the fracturing pumps during weekday daytime and ceasing activity during weekends and bank-holidays.

1.4.13 For noise impacts attributable to each Project which are justified on the basis of being of a similar decibel level to background noise, requests further reporting of the frequency spectrum and time-structure of such noise to evidence that it will not be clearly audible against background levels.

Hydrogeology & ground gas: *We suggest that the Director of Public Health for LCC:*

1.4.14 Requests updates from the Environment Agency for each site to be assured that:

- baseline data on methane in water is understood for the proposed operational area;
- emerging knowledge on fracture proliferation continues to inform monitoring requirements;
- the DPH is informed of any breach of regulation which may occur in the future should this application be granted; and
- monitoring regimes take account of long-term migrations and the potential deterioration of the well over time.

1.4.15 Seeks clarification for each site of how, and for how long, the Applicant will monitor the project's effect on the permeability and mobility of surrounding geological strata and natural fractures to ground water. Confirming the hypothesis, advanced in the ES, that the Woodsfold fault creates a barrier to water movement between the ground water contamination of the application and the public water supply is particularly important. Sufficient information should be provided to satisfy the Director of Public Health for LCC that public water supply will not be contaminated directly or indirectly as a result of the Project, including long-term impacts.

1.4.16 Requests further information for each site on how the application will affect long-term low level gas permeation to the surface including permeation to the surface which may be

distant to the proposed site. Estimates of potential surface concentrations and areas of effect would be helpful.

1.4.17 Seeks confirmation of what remediation action will be taken if a significant pathway, along a fault or other discontinuity, is established for gas to the surface.

1.4.18 Requests that for each site regulators require an appropriate long-term monitoring plan post decommissioning / abandonment to ensure that the Project does not cause adverse legacy issues for air, ground or water contamination. Responsibility for monitoring should be clearly defined and set through condition, legal agreement and / or bond. The Director of Public Health for LCC should remain engaged with the monitoring information that emerges from the planning and permitting processes.

Climate change: *We suggest that the Director of Public Health for LCC:*

1.4.19 Seeks further specific clarification for each site on long-term post abandonment impacts to climate change both: as well integrity degrades, potentially creating a pathway for natural gas (notably methane) to the surface; and long-term slow permeation of un-extracted natural gas to the surface as a result of hydraulic fracturing mobilising such gases from their current geological layer. Climate change is an increasingly important determinant of health.

Waste: We suggest that the Director of Public Health for LCC*:*

1.4.20 Confirms with the Environment Agency that each Project's impact on the capacity of regional waste sites to treatment/disposal of medical waste is being considered as part of the permitting process.

1.4.21 Seeks clarification for each site regarding the presence, treatment and disposal or use of liquid hydrocarbons including arrangements for storage and disposal of any NORM which may be contaminated with liquid hydrocarbons, to prevent release of VOCs to atmosphere.

1.4.22 Seeks clarification for each site on how much equipment, which has been radioactively contaminated with NORM, will need to be disposed of and what implication this has for waste management capacity.

1.4.23 Seeks clarification for each site on how suspension brine will be disposed of, as the ES does not describe this waste management pathway.

Induced seismicity: *We suggest that the Director of Public Health for LCC:*

1.4.24 Considers research (eg Verdon), who, having looked at drilling, fracking and deep injection (for analogous processes), concludes that deep injections have a direct action on fault lines; and requests clarification of how this analysis relates to conclusions of each ES concerning impacts on induced seismology associated with hydraulic fracturing.

1.4.25 Requests clarification for each site that the Applicant has considered the implications of induced seismic activity on salt/brine mining activity in the area.

1.4.26 Seeks supporting evidence on the degree of accuracy to which the microseismic arrays measure the extent of hydraulic fractures. Including clarification of the relationship between fracture growth and the measurement of induced seismicity as a surrogate for this growth.

Visual impacts: *We suggest that the Director of Public Health for LCC:*

1.4.27 Seeks clarification for each site on whether the flares will be associated with condensation plumes due to convection effect in the atmosphere under certain weather conditions. Any plume could increase visual disturbance and introduce an industrial element into the rural landscape.

***Transport:** We suggest that the Director of Public Health for LCC:*

1.4.28 Seeks clarification for each site on the locations and routes for hazardous and radioactive waste treatment. It is noted that hazardous loads are a familiar feature of the UK road network. Once the locations of relevant treatment facilities have been identified, the Director of Public Health for LCC could comment on the need for routing away from population centres and accident hotspots.

1.4.29 Confirms that the traffic impacts (including air quality) of both proposals have considered seasonal road congestion, for example during the summer months standing traffic can become a feature of roads leading into Blackpool.

***Water resources:** We suggest that the Director of Public Health for LCC:*

1.4.30 Confirms with the Environment Agency that each Project's impact on public water capacity in the event of hot weather, drought or other unusually high periods of increased demand is being considered as part of the permitting process.

Clarifications specific to Preston New Road

***General:** We suggest that the Director of Public Health for LCC:*

1.4.31 Seeks clarification of what effect (for example: direct, indirect, cumulative, differential, synergistic) the Project will have on proposed development within Fylde, including the proposed mental health unit at Whyndyke Farm.

Clarifications specific to Roseacre Wood

***General:** We suggest that the Director of Public Health for LCC:*

1.4.32 We suggest that the Director of Public Health for LCC should seek reassurance that any use of or changes to the MoD Inskip site is not associated with a public or occupational increased risks from electrocution or EMF exposure.

***Hydrogeology & ground gas:** We suggest that the Director of Public Health for LCC:*

1.4.33 Seeks clarification as to whether non-hazardous drilling mud will be used when drilling through faults, particularly the Mid-Elswick Graben Faults. Alternatives to drilling through this fault could be set out.

***Transport:** We suggest that the Director of Public Health for LCC:*

1.4.34 Seeks clarification from both LCC and the Highways Agency that the proposed traffic flow (including consideration of vehicles sizes, percentage increases in movements and road suitability for large vehicles) will not lead to increased accidents along the proposed routes, nor a compromise to the use of these routes for cycling or walking.

***Water resources:** We suggest that the Director of Public Health for LCC:*

1.4.35 Seeks clarification on the implication of United Utilities' disclosure that the network does not support the Project's highest flow rate scenario for the Roseacre Wood site.

2 Introduction

2.1.1 The Government has issued Petroleum Exploratory Development Licences (PEDLs) for the exploration of onshore shale gas in Lancashire. Lancashire County Council has received applications for exploration and monitoring works at a site known as Preston New Road (1;2) and at a site known as Roseacre Wood (3;4).

2.1.2 In 2014, the Cabinet of Lancashire County Council (LCC) committed to undertaking a Health Impact Assessment (HIA) of shale gas extraction in Lancashire, initially of the two proposed sites followed by the wider industry (5;6).

2.1.3 Ben Cave Associates Ltd (BCA) is providing HIA support to LCC.

2.1.4 In this overview report we summarise the findings of the study. This includes:

- a description of the method and approach for this current study (see Section 3 on page 12);
- a summary of the processes involved in shale gas exploration and extraction (see Section 4 on page 18);
- a preliminary search of literature on shale gas extraction and health (see Section 5 on page 25);
- the policy context in which this application is taking place and the roles and responsibilities of a Director of Public Health (DPH) (see Section 6 on page 38); and
- a community profile (see Section 7 on page 48);
- summary of two community engagement workshops (see Section 8 on page 55);
- a review of the Environmental Statement (ES) for Preston New Road (see Section 9 on page 61);
- a review of the ES and other documentation for Roseacre Wood (see Section 10 on page 66); and
- a list of information sources (see Section 11 on page 71) – when cited in the body of the report these are numbered and shown in brackets.

2.1.5 Detailed information about the components of the study are presented in documents which accompany, and need to be read in conjunction with, this report:

- Review of Preston New Road Environmental Statement (7);
- Review of Roseacre Wood Environmental Statement (8);
- Community Engagement Report (9); and
- Annexe to Overview Report (10).

3 Method statement

3.1 Introduction

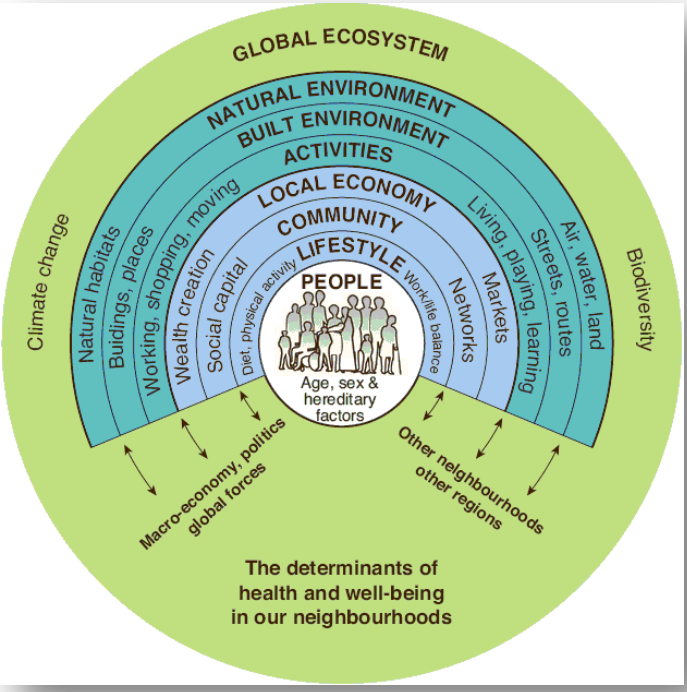
3.1.1 This section describes how this study has been conducted. Further information about each component of this study can be found in subsequent sections and in the accompanying reports.

3.2 Health and HIA

Health and wellbeing

3.2.1 The WHO define health as a 'state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity' (11). Public health is also concerned with ensuring that differences in health between population groups are minimised. These are known as inequalities in health.

Figure 3-1: Determinants of health and wellbeing in our neighbourhoods



Source: Barton and Grant (12), based on Whitehead and Dahlgren (13)

3.2.2 Many factors in the social, economic and physical environment can influence the health of communities and the health of individuals within communities. These factors can have positive, negative or neutral effects. Figure 3-1 summarises some of the main determinants of health and their spheres of influence, starting with those at an individual level and moving through to those at a societal level. Some factors that influence health are outside

an individual's control, such as age, but individuals have more control over other factors such as lifestyle factors including physical activity and smoking.

Health Impact Assessment

3.2.3 The International Association for Impact Assessment (IAIA), in conjunction with the World Health Organization, define HIA as:

… a combination of procedures, methods and tools that systematically judges the potential, and sometimes unintended, effects of a policy, plan, programme or project on both the health of a population and the distribution of those effects within the population. HIA identifies appropriate actions to manage those effects (14).

3.2.4 HIA aims to ensure that health gain is derived from proposals that are not directly related to health eg roads, housing, waste, education. HIA also aims to maximise health gain from proposals directly related to health eg health services.

3.2.5 HIA helps to identify the potential health effects of a proposal. Then it identifies ways to enhance any benefits and avoid or minimise any harms. Thus, HIA gives decision-makers information not only about potential effects on health but also how to manage these effects.

3.2.6 Decision-makers, therefore, have the opportunity to amend a proposal accordingly, such that the proposal will be more likely to promote health and less likely to cause ill health in the community.

3.2.7 In this way, HIA can contribute to reducing the demand on resources that is made by poor health and well-being and other types of inequality.

3.2.8 In 2005 the International Petroleum Industry Environmental Conservation Association (IPIECA) and the International Association of Oil and Gas Producers (IAOGP) produced a guide to HIA for the oil and gas industry (15). The focus of this guidance is on infrastructure projects in resource poor countries. It is not normally used for projects in the UK but the approach adopted in this current HIA study is broadly consistent with the IPIECA/IAOGP guidance.

3.2.9 The stages of the HIA are described variously in guidance documents. The stages for the complete process can be characterised as follows (16):

- **Screening**: do we undertake an HIA?
- **Scoping**: what are the parameters for the HIA study? What are the governance and management arrangements?
- **Appraisal**: what are the potential impacts on health? How can we address those impacts?
- **Reporting**: including a Public Health Management Plan of recommendations to control and manage the health impacts
- **Supporting decision-makers**: how do we present the results so that they are both useful and usable by relevant decision-makers?
- **Monitoring and evaluation**: this can be Process Evaluation, Effectiveness Evaluation or [Health] Outcome Evaluation.

Health and Environmental Impact Assessment

3.2.10 Recent Environmental Impact Assessment (EIA) Directive changes (to be transposed into national legislation by spring 2017) require that 'human health' is included in the scoping of all EIAs (17). The changes require that EIAs will identify, describe and assess in an appropriate manner, in the light of each individual case, the direct and indirect significant effects of a project on population and human health. The current EIAs are not required to

meet this standard, but this is the direction in which impact assessment expectations are moving.

3.3 Aims and objectives

3.3.1 On 8th May 2014 the DPH submitted a report to LCC Cabinet (5) in which it was proposed that LCC undertake an initial HIA of the two proposed sites (Roseacre Wood and Preston New Road) when the expected planning applications had been submitted (5). It was recommended that the further need to complete a wider HIA of shale gas industry would be determined by the pace of industry development and the recommendations from the initial HIA (5).

3.3.2 The proposed objectives of the HIA were described as being to (5):

- establish and quantify the potential health impacts of shale gas extraction in Lancashire;
- identify the potential distribution of health impacts across different groups in the population; and
- make recommendations for action to mitigate negative and maximise positive impacts of the shale gas industry on the health and wellbeing of Lancashire residents.

3.3.3 The scope was identified as including direct impacts on the health and wellbeing of the population such as contamination of land, water and air, and indirect impacts on health such as social, economic, community factors, and climate change (5).

3.3.4 The Invitation to Tender (ITT) listed the project outputs and outcomes as:

- a report on the methodology to undertake the Rapid HIA for the exploratory stage of the shale gas industry and to quantify the potential health impacts and the potential distribution of health impacts across different groups of the population for Roseacre Wood and Preston New Road;
- Rapid HIA awareness sessions;
- the delivery of a community engagement workshop; and
- the production of a community engagement workshop report

3.4 Governance

3.4.1 The Director of Public Health established a Health Advisory Group. The membership of this group consists of officers from Lancashire County Council, Fylde Borough Council and Public Health England. Relevant stakeholders including the industry and regulators, interest groups, academics and scientists and local communities including elected Members are consulted, where appropriate (5).

3.5 Approach

3.5.1 Ben Cave Associates Ltd (BCA) responded to the ITT and was appointed on 28th May 2014. It was agreed that the focus of BCA's work would be on establishing the framework (or scope) for a rapid HIA for the exploratory stage of the shale gas industry. On 9th June it was agreed that the Environmental Statement (ES) for the exploration works (18) should be reviewed as part of the HIA work. A review of the Roseacre Wood ES (19) was requested on 1st August 2014.

3.6 Study components

3.6.1 This current report does not make definitive statements on the potential effects on health arising from the applications at Preston New Road and at Roseacre Wood. It has identified issues that the DPH may wish to clarify.

3.6.2 This report recommends some actions that can be implemented to address concerns and which can be conducted as part of further impact assessment; as part of ongoing dialogue between LCC and the Applicant; or as ongoing monitoring.

3.6.3 The report aims to be clear about uncertainty. This is an important part of risk communication (see, for example, source 20).

3.6.4 The findings of the study are summarised in this document. Detailed information about the components of the study are presented in documents which accompany, and need to be read in conjunction with, this report:

- Review of Preston New Road Environmental Statement (7);
- Review of Roseacre Wood Environmental Statement and IPPC Application (8);
- Community Engagement Report (9); and
- Annexe to Overview Report (10).

3.6.5 The HIA work has included:

- liaison with LCC and with the Health Advisory Group;
- reviews of information submitted in support of the applications;
- community engagement workshops;
- additional meetings; and
- preparation of reports.

Liaison with LCC and with the Health Advisory Group

3.6.6 BCA have met with LCC three times and held telephone conferences as and when required.

3.6.7 The Health Advisory Group has met three times. BCA attended the second and third meetings.

Reviews of information submitted in support of the applications

3.6.8 Desk-based reviews have been conducted on each ES. These are the final reports of the Environmental Impact Assessment (EIA). HIA is usually iterative and conducted during, and in tandem with, the design process. This allows for the modification of the Project design or for additional modelling or other investigation. This enables potential health effects to be identified and addressed prior to a design being finalised and a final impact assessment report being issued.

3.6.9 In this case the reviews of the ES conducted as part of the HIA process flag up potential issues requiring further investigation. Emerging findings from the reviews were discussed briefly at the site visit but there has been no substantive dialogue with the Applicant regarding these reviews (see source 10 for notes of this site visit).

3.6.10 As a consequence the reviews conducted for this HIA work leave some issues unresolved. Some of the requests for clarification raised by the reviews relate to the permitting, regulatory and monitoring frameworks that are being developed in parallel. Where possible we have taken account of this information. We acknowledge that the timescale for the review and the amount of information provided has been challenging.

3.6.11 Some clarifications are therefore likely to be resolved through the permitting, regulatory and monitoring frameworks. We suggest that LCC will want to discuss these with the Applicant. We summarise the process for each ES review below.

Preston New Road

3.6.12 The review focuses on the ES. The process of this review is described below:

- a desk-based review was conducted;
- a draft report was sent to the DPH;

- questions arising from the review were sent to the Health Advisory Group and the regulators;
- the report was updated in light of responses received;
- the draft report was sent to LCC, the Health Advisory Group and the regulators;
- the report was updated in light of responses received and issued (see source 7).

Roseacre Wood

3.6.13 The review focuses on the ES. It also includes questions arising from a review of the permitting application. The process of this review is described below:

- a desk-based review of the ES was conducted; and
- a desk-based review of the permit application was conducted and questions identified for the DPH; and
- a report was issued to LCC (see source 8).

Community engagement workshops

3.6.1 It was agreed that two community workshops would be held to seek local views on shale gas extraction and health. The process of setting up, running and reporting on the workshops is given below. A summary of the findings from the workshops is provided in Section 8 below (see page 55). The process and the findings are described in full in the *Community Engagement Report* (9).

Process

3.6.2 LCC sent out the invitations, and organised the publicity and the venue. LCC liaised with the Parish Council relevant to each site, and the parish councillors gave advice about who should attend. The invitations were sent to communities in the immediate vicinities of the two sites. The workshops were open to anyone who was able to attend thus some people from other communities attended. No-one was turned away. The participants were self-selected.

3.6.3 BCA prepared the materials and facilitated the workshops.

3.6.4 BCA prepared a draft report. This was sent to LCC, the Health Advisory Group and the regulators. The report was updated in line with comments received and issued to LCC (see source 9).

Additional meetings

3.6.5 Two members of the HIA team went on a site visit with Residents Against Fylde Fracking (RAFF). This was in response to an offer made at the first community engagement workshop. Notes of the visit are provided in the annexe to this report (see source 10).

3.6.6 The Applicant offered to provide information to the HIA process. Two members of the HIA team met with the Applicant and were given a tour of the sites. Notes of the visit are provided in the annexe to this report (see source 10).

3.6.7 The HIA team also facilitated two briefing sessions for elected members and council officers. These sessions covered HIA in general and did not consider any current applications. The information provided at this briefing session is available in the annexe to this report (see source 10).

Preparation of reports

3.6.8 In this overview report we provide an outline of requirements for further appraisal. This includes consideration of:

- a preliminary search of literature on shale gas extraction and health (see Section 5 on page 25);

- the policy context in which this application is taking place and the roles and responsibilities of a DPH (see Section 6 on page 38); and
- parameters and data sources for community profile (see Section 7 on page 48).

3.6.9 BCA discussed the requirement for an initial HIA (5) with LCC. The 'initial HIA' was interpreted as being the same as a 'rapid HIA'. The Wales Health Impact Assessment Unit define a *Rapid HIA* as an exercise that (21):

… can take days or weeks and usually includes the establishment of a small steering group and often uses the approach of a participatory stakeholder workshop – it typically involves a brief investigation of health impacts, including a short literature review of quantitative and qualitative evidence and the gathering of knowledge and further evidence from a number of local stakeholders.

3.6.10 The current study may thus be termed a 'rapid HIA'.

- the study has taken 12 weeks;
- the Health Advisory Group have functioned as a Steering Group;
- the community engagement workshops were participatory and sought knowledge from local stakeholders; and
- the literature search considers qualitative and quantitative research.

3.6.11 In discussion with LCC it was noted that although a 'rapid HIA' does not complete the appraisal stage it involves screening and scoping and the drafting of preliminary recommendations. It is to this end that LCC agreed that BCA's work would make preliminary recommendations and it would establish a framework (or scope) for an HIA on the potential health effects from exploration of shale gas.

3.7 Recommendations

3.7.1 The need for further HIA work may be limited if the clarifications raised in the reviews of the Environmental Statements, and the recommendations for establishing a baseline and subsequent monitoring, are addressed to the satisfaction of the DPH.

3.7.2 If further HIA work is conducted (for the exploration or production phases) we suggest that consideration is given to inviting community representation onto the Health Advisory Group. The terms of reference for the Health Advisory Group name the regulators as stakeholders. We suggest that consideration is given to inviting the regulators to join the Health Advisory Group as members. Further HIA work could usefully engage industry in the process.

3.7.3 HIA should be considered from the outset of any applications for the production phase of shale gas extraction.

4 Shale gas exploration and extraction

4.1 Introduction

4.1.1 LCC state that onshore shale gas activity in the UK is currently in the exploration stage. Companies are drilling test wells. There is no experience of production operations in UK conditions as yet, although there is a long history of production of oil and gas from 'conventional' onshore fields (22). In this section we provide summaries of the processes involved in the exploration for, and extraction, of shale gas. This includes:

- the Royal Society and Royal Academy of Engineering's description of the process of hydraulic fracturing (see Figure 4-1) and of the stages of shale gas production (see Figure 4-2); and
- LCC's description of the nature of operations for exploratory well sites (see Figure 4-3).

4.1.2 Specific descriptions of the current applications are provided in each ES (18;19).

4.1.3 We also provide a scaled diagram showing the distance from surface to a gas shale (see Figure 4-4) and a pathway diagram showing localised health hazards arising from shale gas exploration and extraction (see Figure 4-5). We conclude this section with Table 4-1 which relates the pathways identified in Figure 4-5 to a high-level overview of the findings from this HIA work.

Figure 4-1: Description of the process of hydraulic fracturing

Shale is a common type of sedimentary rock formed from deposits of mud, silt, clay and organic matter. Shale gas mainly consists of methane, although other gases may also be present, trapped in shale with very low permeability. Shale gas does not readily flow into a well ('produce'). Additional stimulation by hydraulic fracturing (often termed 'fracking') is required to increase permeability.

Once a well has been drilled and cased ('completed'), explosive charges fired by an electric current perforate holes along selected intervals of the well within the shale formation from which shale gas is produced ('production zone').

Pumps are used to inject fracturing fluids, consisting of water, sand ('proppant') and chemicals, under high pressure into the well. The injection pressure generates stresses in the shale that exceed its strength, opening up existing fractures or creating new ones.

The fractures extend a few hundred metres into the rock and the newly created fractures are propped open by the sand. Additional fluids are pumped into the well to maintain the pressure in the well so that fracture development can continue and proppant can be carried deeper into the formation.

A well may be too long to maintain sufficient pressure to stimulate fractures across its entire length. Plugs may be inserted to divide the well into smaller sections ('stages'). Stages are fractured sequentially, beginning with the stage furthest away and moving towards the start of the well. After fracturing, the plugs are drilled through and the well is depressurised. This creates a pressure gradient so that gas flows out of the shale into the well. Fracturing fluid flows back to the surface ('flowback water') but it now also contains saline water with dissolved minerals from the shale formation ('formation water').

Fracturing fluid and formation water returns to the surface over the lifetime of the well as it continues to produce shale gas ('produced water'). Although definitions vary, flowback water and produced water collectively constitute 'wastewaters'.

From Royal Society and Royal Academy of Engineering (23)

Figure 4-2: Stages of shale gas production

Shale gas extraction consists of three stages.

Exploration. A small number of vertical wells (perhaps only two or three) are drilled and fractured to determine if shale gas is present and can be extracted. This exploration stage may include an appraisal phase where more wells (perhaps 10 to 15) are drilled and fractured to characterise the shale; examine how fractures will tend to propagate; and establish if the shale could produce gas economically. Further wells may be drilled (perhaps reaching a total of 30) to ascertain the long-term economic viability of the shale.

Production. The production stage involves the commercial production of shale gas. Shales with commercial reserves of gas will typically be greater than a hundred metres thick and will persist laterally over hundreds of square kilometres. These shales will normally have shallow dips, meaning they are almost horizontal. Vertical drilling would tend to pass straight through them and access only a small volume of the shale. Horizontal wells are likely to be drilled and fractured. Once a shale formation is reached by vertical drilling, the drill bit can be deviated to run horizontally or at any angle.

Abandonment. Like any other well, a shale gas well is abandoned once it reaches the end of its producing life when extraction is no longer economic. Sections of the well are filled with cement to prevent gas flowing into water-bearing zones or up to the surface. A cap is welded into place and then buried.

From Royal Society and Royal Academy of Engineering (23)

Figure 4-3: The nature of operations for exploratory well sites

Site development works and drilling activities are common for exploratory well sites and involve four phases:

The construction of the drilling platform: stripping of top soils, some sub soil levelling and storing, the laying of an impervious and stabilising membrane followed by the construction of a sealed stoned working platform. The removed topsoil and subsoil is stored as bunds along the sides of each of the sites and which assist in providing temporary screening of plant and equipment during the drilling operations. The site preparation works take up to six weeks.

The drilling operations: a borehole is drilled to the depth of the target rock formation. Of the permissions granted in Lancashire the variation in depth of the shale is between 2,470 metres (8,100 ft.) and 3,505 metres (11,500 ft.) below ordnance datum. The drilling operations are undertaken 24 hours per day, 7 days per week over a period of five to six weeks or more. The drilling rig is up to 36m high. The borehole is lined with steel tubing ("casing") to prevent the escape of drilling or fracking fluids and to control the flow of hydrocarbons if encountered.

Testing for the presence of hydrocarbons: This is undertaken on completion of drilling operations and during normal daytime hours. To allow the gas to flow, the shale is fractured (see Figure 4-1) which allows gas to flow from the fractured rock up the borehole to the surface where it is sampled, tested and managed by either flaring off or closing the borehole.

If no gas is detected or not detected in commercially exploitable quantities the borehole will be plugged and the site restored over a period of up to six weeks.

If successful, the borehole will be temporarily sealed with a control valve and the rig and other temporary buildings removed. The land would not be restored immediately as further testing or production facilities may be required. However, further planning permission would be required for the retention of the platform and for any further testing or subsequent production facilities.

From Lancashire County Council (22)

4.2 Pathways by which health might be affected

4.2.1 Figure 4-5 shows pathways by which health may be affected during the exploration for and extraction of shale gas. Figure 4-5 does not cover abandonment. It does not show the seismic array.

4.2.2 Figure 4-5 shows hazards to health. There are some important points to note as introduction to this summary of hazards to health. Figure 4-5 covers a single well-site and does not depict hazards that might arise from multiple well-sites. Figure 4-5 seeks to summarise the different strands of information have been collected in the course of this study eg literature search (Section 5) ; community engagement events (Section 8); reviews of Applicant's information (Section 9 and Section 10) etc. Detailed points raised in the community engagement, such as the potential effect on property prices and subsequent effect on life choices, are not covered in this diagram.

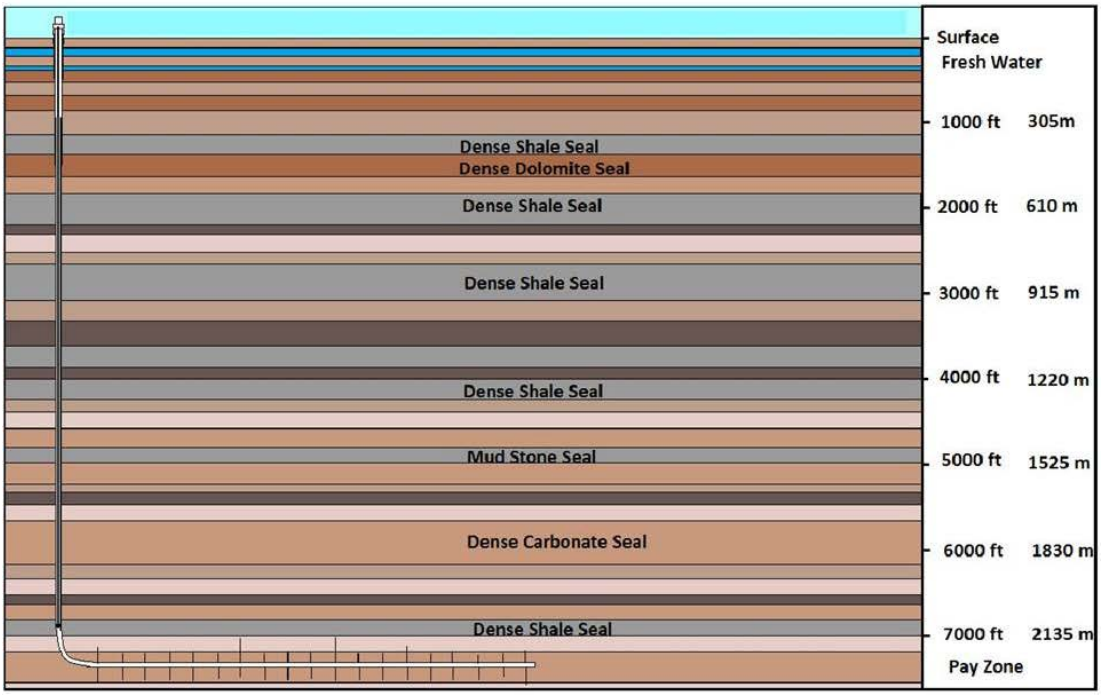
4.2.3 The focus on hazards to health mean that:

- the risks these hazards pose to health is not identified;
- the potential for exposure to some of these hazards (ie the risk) might be amenable to mitigation;
- exposure is not considered in Figure 4-5 so it does not show potential effects on health inequalities; and
- Figure 4-5 does not depict any potential beneficial effects of exploration for, and extraction of, shale gas eg contribution to national energy security or the provision of employment (this could be expected to be directly beneficial to employees and their dependents and it to provide indirect benefits to the local economy).

4.2.4 Each of the hazards in Figure 4-5 is a localised hazard. This means that hazards posed to health from changes to climate are not depicted.

4.2.5 The timescale and geographic range over which health outcomes might be expected to manifest themselves is not depicted in the diagram. For example: the contamination of groundwater due to mobilisation of naturally occurring hazardous substances or methane through fracturing and hydraulic fluid action is a hazard. Direct effects (health outcomes as yet unknown) and indirect effects (eg contaminants entering food chain) arising from any contamination of the groundwater would become apparent over a longer and unknown timescale.

Figure 4-4: Scaled distance from surface to a gas shale at approx. 2,200 m

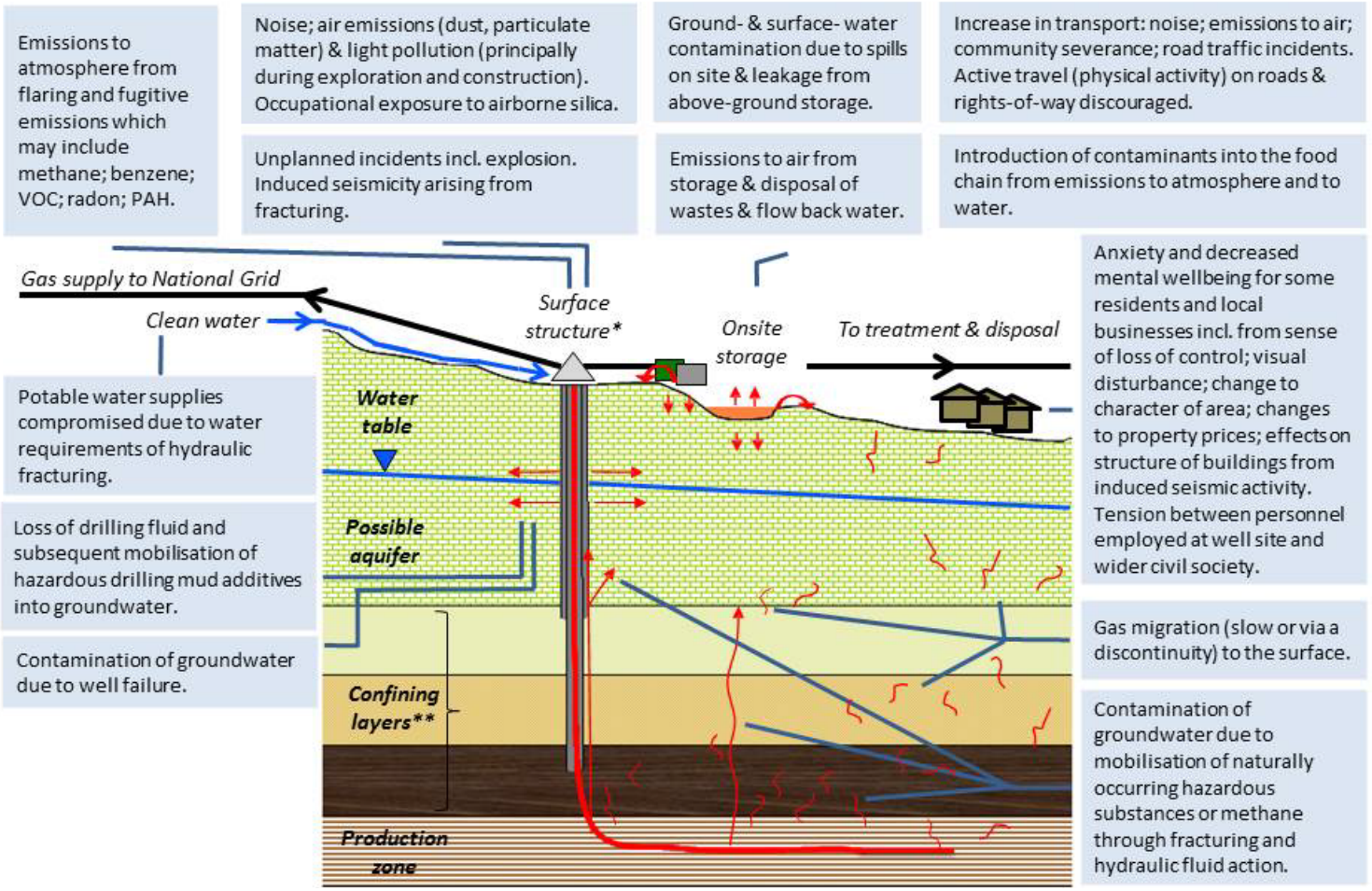


From King (24)

4.2.6 Figure 4-5 is not to scale. King (24, p4) notes the importance of scale drawings to illustrate the distance from surface water and near-surface fresh water supplies to show the physical distance between the surface and the production zone. Figure 4-4 is from King and makes the point that the majority of fresh water supplies are within 300 metres of the surface.

4.2.7 Figure 4-5 is a general depiction of pathways representing hazards to health. The relation of the current applications to these pathways is summarised in Table 4-1 on page 23.

Figure 4-5: Localised health hazards arising from shale gas exploration and extraction



This diagram is a general depiction of pathways representing hazards to health. The risks these pose to health are not known and the potential for exposure to these hazards might be amenable to mitigation.
The diagram is not to scale. The position of residences or places of work relative to the well & other infrastructure is indicative.
* The operations conducted at the site and the surface structure will change between phases.
** The confining layers may not be impermeable. Fractures may extend upwards and slippage may occur across fault lines.

Adapted from Environment Agency (25)

Table 4-1: Summary of findings

Hazard	Mitigation proposed for PNR/RW	Residual concern/clarification requested
Emissions to atmosphere from flaring and fugitive emissions which may include methane; benzene; VOC; radon; PAH.	Flare stacks designed for dispersion. Input gas and emissions to be monitored. Fugitive emissions minimised by flaring (reducing climate change impact).	Levels of radon and fine particulate matter expected to be very low, but could present a small hazard as there are no lower thresholds for harm.
Noise; air emissions (dust, particulate matter) & light pollution (principally during exploration and construction). Occupational exposure to airborne silica.	Standard plant and vehicle noise, dust and light disturbance mitigation. Hydraulic fracturing pumps limited to daytime use. Occupational H&S equipment.	Noise from drilling (24/7) and hydraulic fracturing pumps (daytime) may cause disturbance at closest residential receptors. Night light disturbance may occur at closest residential receptors. Clarification that BAT will be used to minimise all emissions.
Unplanned incidents incl. explosion. Induced seismicity arising from fracturing	Selection of drilling site away from regional faults to minimise risk of induced seismic events. Use of multiple steel casing and cement layers and shut off valves to reduce risk of major loss of gas containment.	There is a lack of data on the risks associated with a major loss of gas containment, e.g. through loss of surface infrastructure once gas flow established. A quantitative risk assessment showing zones of risk is needed to establish the health impacts.
Ground- & surface-water contamination due to spills on site & leakage from above-ground storage.	Bunding and protective impermeable layers for the entire surface site. Secondary containment volume in excess of stored liquids. Control of precipitation run-off.	Clarify if the site will be a hazardous waste management site. If so, clarify if the hazardous materials could cause problems in surface water.
Emissions to air from storage & disposal of wastes & flow back water.	Closed loop steel tanks for flowback fluid.	Clarification that all untreated drilling and fracking fluid wastes are fully contained on and off site to prevent emissions to air.
Increase in transport: noise; emissions to air; community severance; road traffic incidents. Active travel (physical activity) on roads & rights-of-way discouraged.	Standard traffic routing and scheduling to avoid congestion and delays.	Clarification on suitability of RW narrow local roads for large HGVs. Safety of alternative RW access route over MoD site needs to be established.
Introduction of contaminants into the food chain from emissions to atmosphere and to water.	Spill management and site restoration plans for contamination of surrounding agricultural land.	Identified in community engagement workshop – this could be investigated in a literature review.

Hazard	Mitigation proposed for PNR/RW	Residual concern/clarification requested
Anxiety and decreased mental wellbeing for some residents and local businesses incl. from sense of loss of control; visual disturbance; change to character of area; changes to property prices; effects on structure of buildings from induced seismic activity. Tension between personnel employed at well site and wider civil society.	Community consultation and information sharing. Minimisation of visual impacts where possible with screening.	Ongoing community anxiety apparent. Cumulative impacts of multiple types of disturbance and nuisance on closest residential receptors.
Gas migration (slow or via a discontinuity) to the surface.	Use of micro-seismic monitoring to reduce likelihood of fractures propagation to faults. Geological analysis to evidence presence of naturally impermeable layers.	Clarification of micro-seismic monitoring array accuracy. Concerns that long-term slow migration may occur if fracturing releases gas from its current layer.
Contamination of groundwater due to mobilisation of naturally occurring hazardous substances or methane through fracturing and hydraulic fluid action.	Use of non-hazardous additives to fracking fluid. Containment and treatment of hazardous substances mobilised into fracking fluid that are brought to the surface (including NORM). Also see gas migration mitigation.	Clarification of whether non-hazardous fracking fluid additives may become hazardous due to reaction with naturally occurring substances. Clarification of monitoring required to confirm hypothesised permeability of geological layers and faults to act as natural barriers. Concerns that there may be long-term slow migration into groundwater of contaminated fracking fluids that cannot be recovered. Concern that there may be a lack of capacity at treatment plants for recovered contaminated fracking fluid.
Loss of drilling fluid and subsequent mobilisation of hazardous drilling mud additives into groundwater.	Use of non-hazardous drilling muds for shallow and sensitive rock formations (aquifers). Monitoring of drilling mud pressure around known faults and alternative route taken if appropriate.	Concern that mud with hazardous additives may be used during drilling through faults, potentially contaminating surrounding ground water.
Contamination of groundwater due to well failure. [In the US inadequate cementing or casing allowed gas migration to groundwater.]	Use of multiple steel casing and cement layers to reduce risk of well failure. Selection of drilling site away from regional faults to minimise risk of seismic events damaging the well.	Concern that a well could be damaged by a seismic event, particularly where it crosses faults e.g. Mid-Elswick Graben Faults.
Potable water supplies compromised due to water requirements of hydraulic fracturing.	Confirmation from water provider (UU) that water requirements of project will not affect other users.	Clarification of whether this includes during periods of water shortage. Concerns that for RW the projects high water demand scenarios exceed available water capacity.

5 Literature search

5.1.1 In this section we present findings from a preliminary and non-systematic search of the literature on health and the exploration for, and extraction of, shale gas.

5.1.2 We consider the requirements for a comprehensive and systematic literature review to examine the potential health effects associated with all stages of the extraction of shale gas.

5.2 Findings from the preliminary search

5.2.1 Table 5-2 on page 26 shows documents identified as part of this search. This is a non-systematic and opportunistic search and it will not necessarily have identified all sources. The search was based upon:

- references identified by PHE in course of preparing review (26);
- PubMed search for terms 'shale' & 'unconventional' and 'health'
- google search;
- documents provided by participants at engagement workshop; and
- documents identified in the course of reviewing the information provided by the Applicant in support of the applications.

5.2.2 Table 5-3 on page 30 shows documents considering shale gas extraction that have been prepared by professional associations. This includes a US review given to the HIA team by the Applicant during the site visit.

5.2.3 Table 5-1 shows that the number of publications on health and the exploration and extraction of unconventional gas has increased in the last few years.

Table 5-1: Distribution, by country and year of publication, of studies in preliminary literature search

	Total	2014	2013	2012	2011	2010	2009	2008	2007
USA	55	22	20	7	3	1	-	1	1
Australia	3	3	-	-	-	-	-	-	-
England	5	5	-	-	-	-	-	-	-
Canada	1	-	-	1	-	-	-	-	-
Europe	3	-	-	2	1	-	-	-	-
Total	*67*	*29*	*21*	*10*	*4*	*1*	*0*	*1*	*1*

5.2.4 We have not examined each of the studies in Table 5-2 so we do not comment on their quality. The types of publications include:

- peer-reviewed academic literature: research and reviews; and
- grey literature: including websites.[2]

[2] Grey literature includes: government reports, committee reports, academic papers, theses, bibliographies, conference papers and abstracts, discussion papers, newsletters, PowerPoint presentations, conference proceedings, programme evaluation reports, standards/best practice documents, technical specifications and standards, and working papers (27).

Table 5-2: Documents examining shale gas extraction and health

Study	Year	Type	Geographic region	Unique identifier
Adgate JL et al. *Potential public health hazards, exposures and health effects from unconventional natural gas development.*	2014	Review	USA	(28)
Bamberger M, Oswald RE. *Unconventional oil and gas extraction and animal health.*	2014	Review	USA	(29)
Brown D et al. *Understanding exposure from natural gas drilling puts current air standards to the test*	2014	Review	USA	(30)
Bunch AG et al. *Evaluation of impact of shale gas operations in the Barnett Shale region on volatile organic compounds in air and potential human health risks.*	2014	Review	USA	(31)
Carey MG et al. *Harms unknown: health uncertainties cast doubt on the role of unconventional gas in Australia's energy future*.	2014	Letter to editors	Australia	(32)
Centner TJ et al. *Unfinished business in the regulation of shale gas production in the United States*.	2014	Review	USA	(33)
Concerned Health Professionals of NY. *Compendium of scientific, medical and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction).*	2014	Review	USA	(34)
Coram A, et al. *Harms unknown: health uncertainties cast doubt on the role of unconventional gas in Australia's energy future*.	2014	Review	Australia	(35)
de Melo-Martin I, et al *The role of ethics in shale gas policies.*	2014	Discussion	USA	(36)
Field RA et al *Air quality concerns of unconventional oil and natural gas production.*	2014	Review	USA	(37)
Goldstein BD et al. *The role of toxicological science in meeting the challenges and opportunities of hydraulic fracturing*.	2014	Review	USA	(38)
Goldstein BD. *The importance of public health agency independence: Marcellus shale gas drilling in Pennsylvania*	2014	Case study	USA	(39)
Harrison J *Public Health England's reply to editorial on its draft report on shale gas extraction*	2014	Letter to editors	England	(40)
Hill M. *Shale gas regulation in the UK and health implications of fracking.*	2014	Letter to editors	England	(41)
Kondash AJ et al. *Radium and barium removal through blending hydraulic fracturing fluids with acid mine drainage*.	2014	Research	USA	(42)
Kovats S et al. *The health implications of fracking.*	2014	Review	England	(43)
Kravchenko J et al. *A review of the health impacts of barium from natural and anthropogenic exposure.*	2014	Review	USA	(44)

Study	Year	Type	Geographic region	Unique identifier
Law A et al. *Public Health England's draft report on shale gas extraction.*	2014	Letter to editors	England	(45)
McCarron GP, King D. *Unconventional natural gas development: economic salvation or looming public health disaster?*	2014	Commentary	Australia	(46)
McKenzie L.M. et al, *Birth outcomes and maternal residential proximity to natural gas development in rural Colorado.*	2014	Research	USA	(47)
Moore CW et al. *Air Impacts of Increased Natural Gas Acquisition, Processing, and Use: A Critical Review*.	2014	Review	USA	(48)
Penning TM et al. *Environmental Health Research Recommendations from the Inter-Environmental Health Sciences Core Center Working Group on Unconventional Natural Gas Drilling Operations*.	2014	Review	USA	(49)
Pennsylvania Alliance for Clean Water and Air. *List of the harmed.*	2014	Website	USA	(50)
Public Health England. *Review of the potential public health impacts of exposures to chemical and radioactive pollutants as a result of shale gas extraction*	2014	Review	England	(26)
Rich A, Grover JP, Sattler ML. *An exploratory study of air emissions associated with shale gas development and production in the Barnett Shale*.	2014	Research	USA	(51)
Saberi P et al. *Field survey of health perception and complaints of Pennsylvania residents in the Marcellus Shale region*	2014	Research	USA	(52)
Shonkoff SB, Hays J, Finkel ML. *Environmental Public Health Dimensions of Shale and Tight Gas Development.*	2014	Review	USA	(53)
Small MJ et al *Risks and Risk Governance in Unconventional Shale Gas Development*	2014	Review	USA	(54)
Vengosh A et al. *A critical review of the risks to water resources from unconventional shale gas development and hydraulic fracturing in the United States.*	2014	Review	USA	(55)
Ziemkiewicz,P *Practical measures for reducing the risk of environmental contamination in shale energy production*	2014	Review	USA	(56)
Bamberger M, Oswald RE. *Science and politics of shale gas extraction*	2013	Commentary	USA	(57)
Coussens, C, Rose M. *Health impact assessment of shale gas extraction: workshop summary.*	2013	Workshop summary	USA	(58)
Down A et al. *Shale gas extraction in North Carolina: research recommendations and public health implications.*	2013	Editorial	USA	(59)
Ferrar KJ et al. *Assessment and longitudinal analysis of health impacts and stressors perceived to result from unconventional shale gas development in the Marcellus Shale region.*	2013	Review	USA	(60)

Study	Year	Type	Geographic region	Unique identifier
Ferrar KJ et al. *Assessment of effluent contaminants from three facilities discharging Marcellus Shale wastewater to surface waters in Pennsylvania.*	2013	Research	USA	(61)
Finkel M et al *The shale gas boom and the need for rational policy*	2013	Review	USA	(62)
Finkel ML et al. *Marcellus Shale Drilling's Impact on the Dairy Industry in Pennsylvania: A Descriptive Report.*	2013	Review	USA	(63)
Finkel ML, Hays J. *The implications of unconventional drilling for natural gas: a global public health concern.*	2013	Review	USA	(64)
Fryzek, J., S. Pastula, et al. *Childhood cancer incidence in Pennsylvania counties in relation to living in counties with hydraulic fracturing sites.*	2013	Research	USA	(65)
Korfmacher KS et al. *Public health and high volume hydraulic fracturing*.	2013	Commentary	USA	(66)
Ladd AE. *Stakeholder perceptions of socioenvironmental impacts from unconventional natural gas development and hydraulic fracturing in the Haynesville Shale*.	2013	Research	USA	(67)
McDermott-Levy,R. et al. *Fracking, the environment, and health*.	2013	Commentary	USA	(68)
Perry SL. *Using ethnography to monitor the community health implications of onshore unconventional oil and gas developments: examples from Pennsylvania's Marcellus Shale.*	2013	Research	USA	(69)
Rafferty MA, Limonik E. *Is shale gas drilling an energy solution or public health crisis?*	2013	Commentary	USA	(70)
Rich AL, Crosby EC. *Analysis of reserve pit sludge from unconventional natural gas hydraulic fracturing and drilling operations for the presence of technologically enhanced naturally occurring radioactive material (TENORM).*	2013	Research	USA	(71)
Saberi, P. *Navigating medical issues in shale territory*.	2013	Review	USA	(72)
Shaffer DL et al. *Desalination and reuse of high-salinity shale gas produced water: drivers, technologies, and future directions.*	2013	Review	USA	(73)
Smith, M. F. and D. P. Ferguson. *Fracking democracy: Issue management and locus of policy decision-making in the Marcellus Shale gas drilling debate*.	2013	Research	USA	(74)
Steinzor N, Subra W, Sumi L. *Investigating links between shale gas development and health impacts through a community survey project in Pennsylvania.*	2013	Research	USA	(75)
Tillett, T. *Summit discusses public health implications of fracking*.	2013	Commentary	USA	(76)
Chief Medical Officer of Health New Brunswick Department of Health. *Chief Medical Officer of Health's recommendations concerning shale gas development in New Brunswick.*	2012	Review	Canada	(77)
Goldstein, BD et al *Missing from the table: role of the environmental public health community in governmental advisory commissions related to Marcellus Shale drilling*	2012	Commentary	USA	(78)

Study	Year	Type	Geographic region	Unique identifier
AEA Ltd. *Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe.* Report for European Commission, DG Environment	2012	Consultancy report	Europe	(79)
Bamberger M, Oswald RE. *Impacts of gas drilling on human and animal health.*	2012	Research	USA	(80)
DG Internal Policies. *Impacts of shale gas and shale oil extraction on the environment and on human health: workshop proceedings*.	2012	Workshop summary	Europe	(81)
Lauver LS. *Environmental health advocacy: an overview of natural gas drilling in northeast Pennsylvania and implications for pediatric nursing*.	2012	Commentary	USA	(82)
McDermott-Levy R, Kaktins N. *Preserving health in the Marcellus region*.	2012	Commentary	USA	(83)
McKenzie L.M. et al, *Human health risk assessment of air emissions from development of unconventional natural gas resources*.	2012	Research	USA	(84)
Research Triangle Environmental Health Collaborative. *Shale gas extraction in North Carolina: public health implications*	2012	Review	USA	(85)
Walter GR, et al. *Effect of biogas generation on radon emissions from landfills receiving radium-bearing waste from shale gas development.*	2012	Review	USA	(86)
Finkel ML, Law A. *The rush to drill for natural gas: a public health cautionary tale.*	2011	Review	USA	(87)
Lechtenböhmer, S et al. *Impacts of shale gas and shale oil extraction on the environment and on human health.*	2011	Consultancy report	Europe	(88)
Mitchell AL, Casman EA. *Economic incentives and regulatory framework for shale gas well site reclamation in Pennsylvania.*	2011	Commentary	USA	(89)
Schmidt C.W. *Blind rush? Shale gas boom proceeds amid human health questions.*	2011	Commentary	USA	(90)
Witter, R et al. *Health Impact Assessment for Battlement Mesa, Garfield County Colorado.*	2010	Consultancy report	USA	(91)
Witter, R et al. *Potential exposure-related human health effects of oil and gas development: a literature review (2003-2008)*	2008	Review	USA	(92)
Erickson BE. *Toxin or medicine? Explanatory models of radon in Montana health mines.*	2007	Research	USA	(93)

Table 5-3: Reports from professional associations concerning shale gas extraction

Study	Year	Type	Geographic region	Unique identifier
Royal Society for the Protection of Birds. *Hydraulic fracturing for shale gas in the UK. Examining the evidence for potential environmental impacts.*	2014	Review	England	(94)
CIWEM. *Shale gas and water. An independent review of shale gas exploration and exploitation in the UK with a particular focus on the implications for the water environment.*	2014	Review	England	(95)
MIT. *The future of natural gas: an interdisciplinary MIT study*	2014	Review	USA	(96)
Environmental Data Services (ENDS). *The real environmental implications of fracking and the key sustainability challenges facing a future UK onshore shale energy industry*	2014	Review	England	(97)
British Geological Survey. *The Carboniferous Bowland Shale gas study: geology and resource estimation.*	2013	Review	England	(98)
Royal Society and Royal Academy of Engineering. *Shale gas extraction in the UK: a review of hydraulic fracturing.*	2012	Review	England	(23)
King.G.E. *Hydraulic Fracturing 101: what every representative, environmentalist, regulator, reporter, investor, university researcher, neighbor and engineer should know about estimating frac risk and improving frac performance in unconventional gas and oil wells.*	2012	Review	USA	(24)

5.2.5 The publications can be further categorised as

- reviews of evidence;
- discussion papers;
- research into specific effects;
- letters to journals;
- comments in journals;
- editorials in journals;
- reports or summaries of workshops;
- consultancy reports;
- case studies; and
- websites.

5.2.6 It is important to ensure that the results of any study are relevant to the context, setting and population in Lancashire. Findings from other studies need to be both generalisble between different populations and geographical areas and also applicable to the population adjacent to Preston New Road and Roseacre Wood.[3] Table 5-1 shows most of the studies (n=55) come from the United States and that 5 come from the UK.

5.2.7 Extrapolation of results must be pertinent: for example the implications must be considered of:

- density of residential settlement and proximity to well sites;
- changes in technology;
- regulatory context; and
- geological conditions.[4]

5.2.8 It would be advisable for specific research to take place through UK research bodies on UK conditions.

5.2.9 There is agreement that there is uncertainty associated with the health effects of unconventional gas exploration and extraction. Studies agree that management and regulatory controls are paramount.

Health and extraction of shale gas

5.2.10 Kovats et al (43) note that the scientific study of the health effects of fracking is in its infancy, but suggest that this form of extraction might increase health risks compared with conventional oil and gas wells because of the larger surface footprints of fracking sites; their close proximity to locations where people live, work, and play; and the need to transport and store large volumes of materials.

5.2.11 The literature notes that no sound epidemiological studies have been done to assess the extent of exposure-related adverse health effects among populations living in areas where natural gas extraction is ongoing. Kovats et al (41) lists the following potential health concerns:

- outdoor air pollutants (volatile organic compounds, tropospheric ozone, and diesel particulate matter);
- pollutants in both ground and surface water (benzene, hydrocarbons, endocrine-disrupting chemicals, and heavy metals);
- occupational exposure to airborne silica at the well pad;

[3] This is central to evidence-based decision-making and is described further in Gray (99).
[4] For example the Marcellus Shales that predominate in Pennsylvania are different from the Bowland Shale in Lancashire. The methane levels are higher, the methane is of a different origin and it is nearer the surface.

- known and unknown toxicological properties of fracking fluid; and
- the contribution of shale gas extraction to greenhouse-gas emissions and, thus, to climate change.

5.2.12 Whilst Kovats' list is not exhaustive it highlights a range of important health issues for HIA to consider including the timeframe of any study to monitor long-term effects. We suggest that an appropriate timescale for monitoring should be identified in a literature review.

5.2.13 Kovats et al (43) conclude that public health professionals have a role in informing decisions about fracking in the UK and in monitoring to ensure that, if it does proceed, operational best practices are implemented and enforced through regulation. See page 38 for a discussion of the regulatory context governing shale gas exploration and extraction in the UK.

Figure 5-1: A note on surveys and the *List of the Harmed*

The way in which data is collected, including the method of contacting respondents, the medium of delivering the questionnaire to respondents, and the administration of the questions can influence the quality of the data that is collected (100).

The Pennsylvania Alliance for Clean Water and Air maintain a website to which people report harms they have experienced. This is called the *List of the Harmed* (50). This records cases as reported by members of the general public In the USA.

This list is part of the available literature and it can be considered grey literature.

The health outcomes in the list could be used as indicators for a baseline but they are not part of the existing routine data collected in this country either in general or specific to the process of exploring for, and extracting, shale gas.

The Pennsylvania list brings health issues into the public domain and it establishes a publicly accessible list that might be read as a baseline. The scientific validity of this list is open to criticism given that all depositions are self-reported and are not independently verified. It is, however, undoubtedly a disturbing list of symptoms. It will do little to dispel any fears that people may feel.

The design and governance of studies to establish a baseline and ongoing monitoring for the current applications are considered on page 52.

5.2.14 PHE review the potential public health impacts of exposures to chemical and radioactive pollutants as a result of shale gas extraction (26). They find that the currently available evidence indicates that the potential risks to public health in the vicinity of shale gas extraction sites will be low if shale gas extraction is properly run and regulated. Where potential risks have been identified in the literature, the reported problems are typically a result of operational failure and a poor regulatory environment. Therefore good on-site management and appropriate regulation of all aspects from exploratory drilling, gas capture, use and storage of fracking fluid, and post-operations decommissioning are essential to minimise the risk to the environment and public health. PHE do not regard shale gas exploitation as posing a significant regulatory challenge for the protection of local people's health as a result of releases of chemical and radioactive pollutants. The PHE position is that the shale gas extraction process poses a low risk to human health if properly run and regulated.

5.2.15 PHE state that the risks from small-scale drilling for exploratory purposes (eg single wells) are clearly different from the risks from commercial-scale operations. The potential health impact from single wells is likely to be very small, but the cumulative impacts of many wells in various phases of development in relatively small areas are potentially greater and will need careful scrutiny, during the planning process (26, p.iv).

5.2.16 PHE state that the UK has the opportunity in advance of significant development of shale gas extraction activities to consider appropriate environmental and epidemiological studies to extend and strengthen the evidence base on potential health impacts from shale gas extraction emissions (26, p.iv).

Environmental risks to health by project stage

5.2.17 In a study for the European Commission AEA conducted an assessment of the environmental and health risks associated with the use of hydraulic fracturing for hydrocarbon extraction, and in particular, shale gas extraction (79). AEA identified the main causes of risks and impacts from high-volume hydraulic fracturing as being (79):

- the use of more significant volumes of water and chemicals compared to conventional gas extraction;
- the lower yield of unconventional gas wells compared to conventional gas wells means that the impacts of HVHF processes can be greater than the impacts of conventional gas exploration and production processes per unit of gas extracted;
- the challenge of ensuring the integrity of wells and other equipment throughout the development, operational and post-abandonment lifetime of the plant (well pad) so as to avoid the risk of surface and/or groundwater contamination;
- the challenge of ensuring that spillages of chemicals and waste waters with potential environmental consequences are avoided during the development and operational lifetime of the plant (well pad);
- the challenge of ensuring a correct identification and selection of geological sites, based on a risk assessment of specific geological features and of potential uncertainties associated with the long-term presence of hydraulic fracturing fluid in the underground;
- the potential toxicity of chemical additives and the challenge to develop greener alternatives;
- the unavoidable requirement for transportation of equipment, materials and wastes to and from the site, resulting in traffic impacts that can be mitigated but not entirely avoided;
- the potential for development over a wider area than is typical of conventional gas fields; and
- the unavoidable requirement for use of plant and equipment during well construction and hydraulic fracturing, leading to emissions to air and noise impacts.

5.2.18 AEA (79) examined the main environmental risks at each stage of a project (well-pad) development, and also covered the cumulative environmental effects of multiple installations. The stages are:

- well pad site identification and preparation;
- well design, drilling, casing and cementing;
- technical hydraulic fracturing stage;
- well completion;
- well production; and
- well abandonment.

5.2.19 AEA describe the stages differently to the sources cited in Section 4: exploration encompasses the stages from *well pad site identification and preparation* to *well completion*. AEA acknowledge the limits of their risk screening exercise and acknowledge that expert judgement was used to characterise these effects (79). They note:

- the absence of systematic baseline monitoring in the US (from where most of the literature sources come);
- the lack of comprehensive and centralised data on well failure and incident rates; and

- the need for further research on a number of possible effects including long term ones.

5.2.20 The summary results are shown for individual sites in Table 5-4 on page 35 and, cumulatively across multiple sites, in Table 5-5 on page 36. [5]

5.2.21 AEA focus on environmental risks to health: these issues are considered with regard to exploration in our review of the Preston New Road ES (7) and of the information on the Roseacre Wood ES and permitting application (8). The AEA report does not consider potential effects on regional and local economies, on communities, including property prices and on public understanding of risk.

5.2.22 The risks for individual sites considered over the whole process are generally considered to be moderate or high. Seismicity is considered to pose a low risk and visual impact is ranked as low to moderate.

5.2.23 The risks for multiple sites considered over the whole process are considered to be high. Seismicity is considered to pose a low risk and visual impact is ranked as moderate.

5.2.24 This risk identification process also points to areas of uncertainty. AEA deem some risks as 'not classifiable' due to there being insufficient information available to assess the significance of the particular impact. These apply to the risks of an individual site and of multiple sites and are as follows:

- risk to biodiversity at *site identification and preparation* and at *well abandonment and post-abandonment*; and
- risk to biodiversity, land take and groundwater contamination at *well abandonment and post-abandonment*.

[5] The methodology by which AEA assign risk categories to each stage and to the process as a whole is summarised in the annexe to this report (see source 10).

Table 5-4: Summary of preliminary risk assessment for individual site

	Site identification and preparation	Well design drilling, casing, cementing	Fracturing	Well completion	Production	Well abandonment and post-abandonment	Overall rating across all phases
Groundwater contamination	N/A	Low	Moderate-High	High	Moderate-High	N/C	High
Surface water contamination	Low	Moderate	Moderate-High	High	Low	N/A	High
Water resources	N/A	N/A	Moderate	N/A	Moderate	N/A	Moderate
Release to air	Low	Moderate	Moderate	Moderate	Moderate	Low	Moderate
Land take	Moderate	N/A	N/A	N/A	Moderate	N/C	Moderate
Risk to biodiversity	N/C	Low	Low	Low	Moderate	N/C	Moderate
Noise impacts	Low	Moderate	Moderate	N/C	Low	N/A	Moderate –High
Visual impact	Low	Low	Low	N/A	Low	Low-moderate	Low - Moderate
Seismicity	N/A	N/A	Low	Low	N/A	N/A	Low
Traffic	Low	Low	Moderate	Low	Low	N/A	Moderate

N/A: Not applicable - impact not relevant to this stage of development
N/C: Not classifiable - insufficient information available for the significance of this impact to be assessed

From AEA (79)

Table 5-5: Summary of preliminary risk assessment cumulatively across multiple sites

	Site identification and preparation	Well design drilling, casing, cementing	Fracturing	Well completion	Production	Well abandonment and post-abandonment	Overall rating across all phases
Groundwater contamination	N/A	Low	Moderate-High	High	High	N/C	High
Surface water contamination	Moderate	Moderate	Moderate- High	High	Moderate	N/A	High
Water resources	N/A	N/A	High	N/A	High	N/A	High
Release to air	Low	High	High	High	High	Moderate	High
Land take	Very high	N/A	N/A	N/A	High	N/C	High
Risk to biodiversity	N/C	Low	Moderate	Moderate	High	N/C	High
Noise impacts	Low	High	Moderate	N/C	Low	N/A	High
Visual impact	Moderate	Moderate	Moderate	N/A	Low	Low-moderate	Moderate
Seismicity	N/A	N/A	Low	Low	N/A	N/A	Low
Traffic	High	High	High	Moderate	Low	N/A	High

N/A: Not applicable - impact not relevant to this stage of development
N/C: Not classifiable - insufficient information available for the significance of this impact to be assessed

From AEA (79)

5.3 Recommendation

5.3.1 That a systematic literature review is conducted by an independent organization such as Cochrane – in conjunction with environmental specialists as well as social scientists, such that all the health impacts and wider determinants of health are included - governance of this review is important for the acceptability of the findings. Information resources to search are suggested in Figure 5-2.

5.3.2 We suggest that appropriate timescales for monitoring health effects from shale gas exploration and extraction should be identified in a literature review.

Figure 5-2: Suggested information resources to search

Due to the nature of the topic, much of the information may be found in the grey literature - industry and government monographs, regulatory documents, professional association reports, conference abstracts. Relevant websites should be searched. A search engine such as Google can be used for specific terms.

Ecology Abstracts	This database combines information on scientific research and government policies on the environment.
Embase	A major biomedical and pharmaceutical database.
Envirolink	Freely available: a non-profit organization which has been providing access to thousands of online environmental resources http://www.envirolink.org/.
Environmental impact statements	EIS extracts the key issues from complex government-released environmental impact statements, converting massive documents into concise, readable abstracts.
Environmental science & pollution management	Comprehensive coverage of the environmental sciences.
HMIC	Health Management Information Consortium (HMIC) database brings together the bibliographic database of two UK health and social care management organizations: the Department of Health's Library and Information Services (DH-Data) and King's Fund Information and Library Service.
HTA database	The focus of the HTA database is on completed and ongoing health technology assessments from around the world. The HTA database is a valuable source for identifying grey literature as much of the information it contains is generally only available directly from individual funding agencies.
Index to Thesis	A comprehensive listing of theses with abstracts accepted for higher degrees by universities in Great Britain and Ireland.
Medline	United States National Library of Medicine's (NLM) premier bibliographic database.
TRID	TRID provides access to more than one million records of transportation research worldwide http://trid.trb.org/.
Urbadoc	A major international resource bringing together over 700,000 references to documents relating to urban and regional policy and planning from key European database producers.

6 Policy context

6.1 Introduction

6.1.1 In this section we provide descriptions of the processes by which shale gas exploration and extraction are licensed and regulated. We conclude with some observations on the duties of a Director of Public Health (see page 42).

6.1.2 LCC, the LCC Public Health Department, the Health and Safety Executive (HSE), Public Health England (PHE), the Environment Agency and other regulators have complementary roles with regard to health protection and health improvement. We identify the broader public health agenda affected by exploratory drilling and the rest of the process. We include a high-level summary of governance arrangements for health protection when we consider the procedural aspects for LCC.

6.1.3 The current regulatory regime is complex. Marshall (101) sees this as an evolving process for a new technology and suggests that the first applications are expected to be subject to challenge. Some commentators argue that shale gas regulation in the UK does not represent best practice (41;102). In a letter to the Lancet Hill (41) states the need for specific regulations coupled with strict enforcement through an independent, competent body but finds that no such body exists and no such efficient regulations are forthcoming.

6.1.4 We note the weight that is likely to be attached to regulatory regimes to mitigate and prevent effects, including health effects, post application.

6.2 Regulatory framework

6.2.1 Lancashire County Council provide an overview of onshore oil and gas operations in Lancashire (22). The following bullet points are adapted from DECC (103;104) and SEPA (105).[6]

- DECC administers a licensing system under the Petroleum Act 1998 (112), which authorises each particular drilling and development activity. A petroleum exploration and development licence (PEDL) grants exclusivity to operators in the licence area to explore for and produce petroleum, but does not confer any exemption from other legal/regulatory requirements.
- DECC issues Petroleum Licences, gives consent to drill under the Licence once other permissions and approvals are in place, and has responsibility for assessing risk of any monitoring any seismic activity, as well as granting consent to flaring or venting.
- The local authority deals with applications for planning permission and other regulatory controls such as Environmental Impact Assessments, Local Air Quality Management and Management of Extractive Waste Regulations.
- Minerals Planning Authorities – grant permission for the location of any wells and wellpads, and impose conditions to ensure that the impact on the use of the land is acceptable.
- Environment Agency – protects water resources (including groundwater aquifers), ensures appropriate treatment and disposal of mining waste, emissions to air, and suitable treatment and manage any naturally occurring radioactive materials.
- An environmental permit will be required from the Environment Agency for any borehole drilling as well as hydraulic fracturing activities in addition to permits to store

[6] See DECC, HSE and Environment Agency for additional sources of information (106-111).

radioactive waste, as well as dispose of it. Gas produced in the exploration phase will be flared: flaring also needs a permit.

- The Health and Safety Executive regulates the safety aspects of all phases of extraction, which contribute to mitigating the environmental risk. In particular they are responsible for ensuring the appropriate design and construction of well casings for any unconventional gas borehole. They scrutinise the well design for safety. The HSE monitors progress on the well. The HSE is also notified of any unplanned events. If it is deemed necessary, inspections may be undertaken by HSE to inspect specific well operations on-site.
- The Coal Authority regulates access to the nation's coal in addition to ensuring that planning applications do not jeopardise existing adits, abandoned mines, and other associated mining infrastructure
- Natural England – responsible for issuing European Protected Species Licences.
- The British Geological Survey – require notification by licensees of their intention to undertake drilling and, upon completion of drilling, must also receive drilling records and cores.
- Hazardous Substances Authorities - responsible for providing hazardous substances consents.

6.2.2 Figure 6-1, Figure 6-2 and Figure 6-3 also illustrate the regulatory process. It is notable that health stakeholders are not explicitly listed as statutory consultees. Health is a statutory consultee for the Environment Agency's IPPC.

Figure 6-1: Regulatory process regarding exploration and development activity associated with the development of new energy resources

DECC works closely with regulatory partners to make sure any exploration and development activity associated with the development of new energy resources is safe and sustainable, but we continue to improve it.

The process of obtaining consent to drill a well is the same whether the well targets conventional or unconventional gas. Operators bid for exclusive rights to an area in competitive license rounds. The operator then needs the landowner's and planning permission, which may require an environmental impact assessment.

They also need environmental permits (from either the Environment Agency, Natural Resources Wales, or the Scottish Environment Protection Agency). The Environment Agency ensures that any shale gas operations are conducted in a way that protects people and the environment. The Environment Agency's environmental permitting regulations cover:

- protecting water resources, including groundwater (aquifers) as well as assessing and approving the use of chemicals which form part of the hydraulic fracturing fluid;
- appropriate treatment and disposal of mining waste produced during the borehole drilling and hydraulic fracturing process;
- suitable treatment and management of any naturally occurring radioactive materials (NORM); and
- disposal of waste gases through flaring.

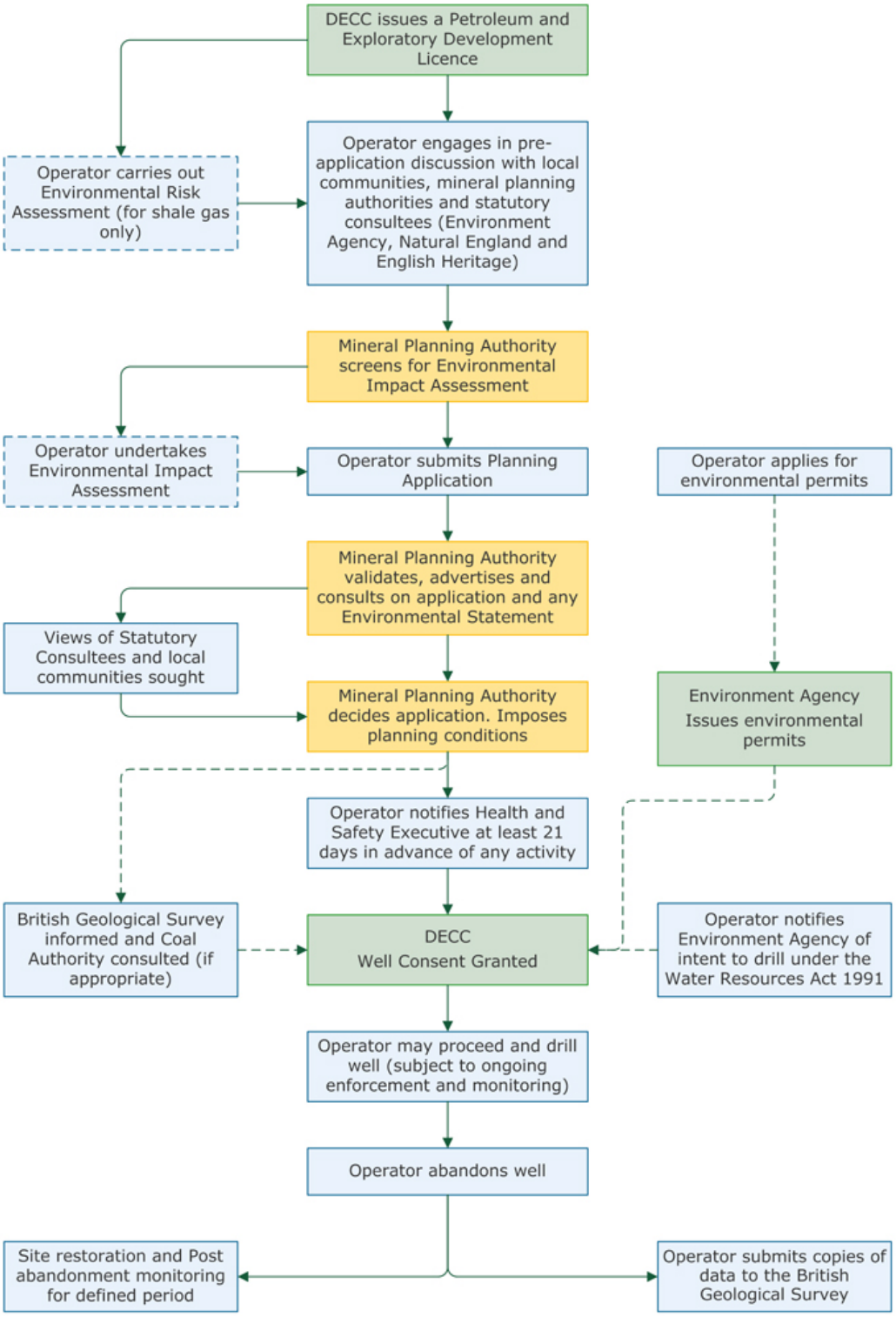
The Environment Agency is also a statutory consultee in the planning process and provides local mineral planning authorities (normally the county or unitary local authority) with advice on the potential risks to the environment from individual gas exploration and extraction sites.

The operator must notify the Health and Safety Executive of the well design and operation plans at least 21 days before drilling is due to start. The Health and Safety Executive inspects the well design to ensure that measures are in place to control major hazards to people from well-related activities and accidents. They then seek final consent from DECC.

DECC's Regulatory Roadmap publication (103) provides detailed information on the process operators must follow when seeking to drill for any form of onshore oil and gas in the UK.

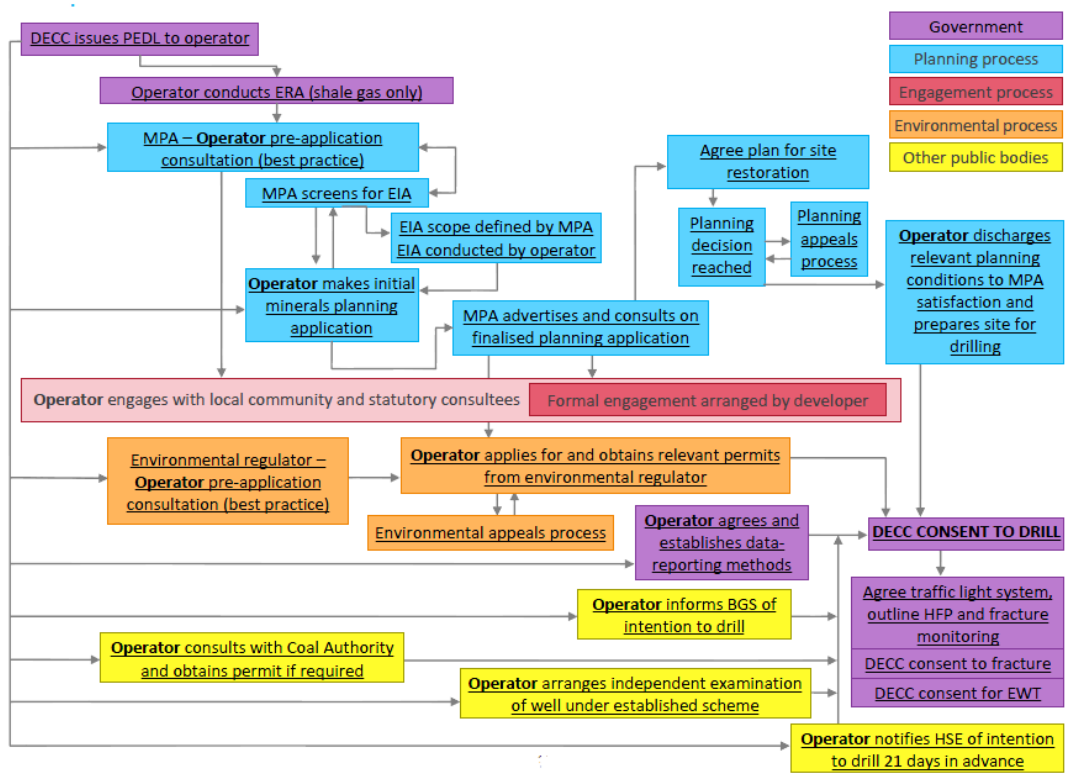
From DECC (113)

Figure 6-2: Outline of process for drilling an exploratory well



From Planning Practice Guidance (114)

Figure 6-3: Routemap for onshore oil and gas exploration



BGS British Geological Survey
DECC Department of Energy and Climate Change
ERA Environmental Risk Assessment
MPA Minerals Planning Authority
PEDL Petroleum and Exploratory Development Licence

From DECC (103)

6.3 Summary of the duties of a Director of Public Health

6.3.1 This section aims to identify which services - commissioned or delivered by Public Health England (PHE) and NHS England - need to be 'assured' by Directors of Public Health (DsPH) in Local Authorities (LA).

6.3.2 The term 'assure' in the context of a specific duty on DsPH is not a term that has been identified as being used in the legislation. However the term appears to loosely describe the role that is inferred from needing to deliver the two general duties of the DsPH (set out below) and the fact that many of the services that achieve those aims are not within the direct control of the DsPH (having been delegated by the Secretary of State to PHE or NHS England). The duties of a DPH are:

- to take such steps as it considers appropriate for the purpose of protecting the public from disease or other dangers to health; and
- to take such steps as it considers appropriate for improving the health of the people in its area.

6.3.3 The first duty arises from s.2A National Health Service Act 2006 (115) (as inserted by s.11 H&SC Act 2012) and delegated to local authorities by the Secretary of State under

Regulation 8 of *The Local Authorities (Public Health Functions and Entry to Premises by Local Healthwatch Representatives) Regulations 2013* (116).

6.3.4 The second duty arises from s.2B National Health Service Act 2006 (115) (as inserted by s.12 H&SC Act 2012). Specific provisions relating to this duty are set out in Regulations 4, 6 & 7 of *The Local Authorities (Public Health Functions and Entry to Premises by Local Healthwatch Representatives) Regulations 2013* (116).

6.3.5 In March 2013 House of Commons Communities and Local Government Committee heard evidence on the role of local authorities in health issues (117). In a written evidence submission Sheffield City Council made the following point regarding the challenge for DsPH to 'assure' services commissioned and managed by other agencies:

"The precise way in which the DPH is expected to hold other public health agencies to account without either the commissioning budget or formal managerial authority, is not clear."

6.3.6 In the Government's response to the Committee (118) the following was stated in relation to health protection: (emphasis added)

"The Department of Health has published revised guidance on *The Local Authorities (Public Health Functions and Entry to Premises by Local Healthwatch Representatives) Regulations 2013*,[7] agreed with the Faculty of Public Health, the Association of Directors of Public Health, Public Health England and the Local Government Association. This clarifies the crucial and influential role that directors of public health, on behalf of local authorities, and PHE will play in protecting the health of their local populations. **Directors of public health will provide information, advice, challenge and advocacy on behalf of their local authority, to promote preparation of effective health protection arrangements by relevant organisations, such as NHS bodies, operating in their local authority area.**"

"PHE should agree with local authorities the specialist health protection support, advice and services that it will provide; this agreement should build on existing arrangements between the NHS, local authorities and the PHE centres. Experienced staff are in place to ensure that PHE can assist in the local, regional and national responses, in the event of a health emergency."

6.3.7 LCC state that it is through the DPH that the council discharges its duties regarding health protection and health promotion. The following paragraphs summarise the health protection and health promotion duties of DsPH that may require such an 'assuring' role.

6.3.8 The key provision that appears to create a duty that health protection services provided by PHE or NHSE need to be 'assured' by Directors of Public Health (DsPH) in Local Authorities (LA) is Regulation 8 of *The Local Authorities (Public Health Functions and Entry to Premises by Local Healthwatch Representatives) Regulations 2013* (116). Figure 6-4 quotes text from Regulation 8 (emphasis added):

[7] Please see HM Government of Great Britain (116) for full reference.

Figure 6-4: Regulation 8 of *The Local Authorities (Public Health Functions and Entry to Premises by Local Healthwatch Representatives) Regulations 2013*

8.-(1) **Each local authority shall provide information and advice to every responsible person and relevant body within, or which exercises functions in relation to, the authority's area, with a view to promoting the preparation of appropriate local health protection arrangements ("health protection arrangements"), or the participation in such arrangements, by that person or body.**

(2) **In discharging the requirement under paragraph (1), the local authority shall exercise the public health functions of the Secretary of State pursuant to section 2A of the Act** (Secretary of State's duty as to protection of public health).

(3) … [*omitted from quotation*]

(4) Local health protection arrangements are arrangements made for the purpose of protecting individuals in the area of the authority from events or occurrences which threaten, or are liable to threaten, their health.

(5) In discharging the requirement in paragraph (1), each local authority shall—

(a) consider in relation to each of the responsible persons and relevant bodies concerned what information and advice is necessary effectively to promote the preparation of the health protection arrangements by that person or body and the authority may accordingly provide different information and advice in each case; and

(b) **take such steps as it considers necessary to bring to the attention of the person or body concerned the information and advice which is relevant to that person or body**.

(6) The information and advice which a local authority shall provide in relation to health protection arrangements may address any threat to the health of individuals in the authority's area and, in particular, may concern arrangements to deal with the following

(a) infectious disease;
(b) **environmental hazards and contamination**; and
(c) extreme weather events.

(7) **The information and advice which is to be provided by the local authority in relation to health protection arrangements shall be determined by the authority having regard to the needs of individuals in the authority's area and may include information and advice relating to the following—**

(a) the appropriate co-ordination of roles and responsibilities between any responsible or relevant bodies;
(b) effective testing by the responsible and relevant bodies of the health protection arrangements;
(c) appropriate emergency provision to deal with incidents which occur outside the normal working hours of the responsible or relevant bodies;
(d) arrangements for epidemiological surveillance;
(e) arrangements for environmental hazard monitoring;
(f) arrangements with other local authorities for managing incidents which affect the area of more than one authority in an integrated and co-ordinated manner;
(g) arrangements for stockpiling of medicines and medical supplies.

From HM Government of Great Britain (116) *emphasis added*.

6.3.9 Regulation 8 requires Local Authorities (and by extension the DsPH) to exercise certain duties of the Secretary of State (the s.2A National Health Service Act 2006 (as inserted by s.11 H&SC Act 2012)). These are shown in Figure 6-5.

Figure 6-5: Protecting the public from disease or other dangers to health

(1) **The Secretary of State [DsPH] must take such steps as the Secretary of State [DsPH] considers appropriate for the purpose of protecting the public in England from disease or other dangers to health.**

(2) The steps that may be taken under subsection (1) include—

(a) the conduct of research or such other steps as the Secretary of State considers appropriate for advancing knowledge and understanding;
(b) providing microbiological or other technical services (whether in laboratories or otherwise);
(c) providing vaccination, immunisation or screening services;
(d) providing other services or facilities for the prevention, diagnosis or treatment of illness;
(e) providing training;
(f) providing information and advice;
(g) making available the services of any person or any facilities.

(3) Subsection (4) applies in relation to any function under this section which relates to—

(a) the protection of the public from ionising or non-ionising radiation, and
(b) a matter in respect of which the Health and Safety Executive has a function.

(4) In exercising the function, the Secretary of State must—

(a) consult the Health and Safety Executive, and
(b) have regard to its policies.

From HM Government of Great Britain (119)

6.3.10 *The Local Authorities (Public Health Functions and Entry to Premises by Local Healthwatch Representatives) Regulations 2013* provide further detail on what this duty requires:

- Regulation 8 imposes a duty on local authorities to provide information and advice to certain persons and bodies within their area in order to promote the preparation of, or participation in, health protection arrangements against threats to the health of the local population, including infectious disease, environmental hazards and extreme weather events.

6.4 National guidance on health protection

6.4.1 National guidance issued in May 2013 by the Department of Health in conjunction with PHE and the Local Government Association describes the situation with respect to health protection (120).

- The DsPH are responsible for the local authority's contribution to health protection matters, including the local authority's roles in planning for, and responding to, incidents that present a threat to the public's health. PHE has responsibility to deliver the specialist health protection response, include the response to incidents and outbreaks, through the PHE Centres which take on the functions of the former Health Protection Units.
- In practice this means early and ongoing communication between the PHE Centre and DPH regarding emergency health protection issues to discuss and agree the nature of response required and who does what in any individual situation.
- The local health protection system therefore involves the delivery of specialist health protection functions by PHE, and local authorities providing local leadership for health. In practice, local authorities and PHE will work closely together as a single public health system. This joint working with clarity of responsibilities between them is crucial for safe delivery of health protection.

- Practical guidance is provided in Annex B of the guidance. It is recommended that this is reviewed by DsPH.

Shared duty for quality of public health protection and improvement services

6.4.2 It should also be noted that the Health and Social Care Act 2012 (119) creates a duty on the Secretary of State, NHS England and DsPH to secure continuous improvement in the quality of services provided to individuals for or in connection with— "protection or improvement of public health":

- H&SC Act 2012 s.2 assigns this duty to the Secretary of State;
- H&SC Act 2012 s.11 defines this duty, which is then delegated to local authorities (and by extension DsPH) by the Secretary of State under Regulation 8 of the Local Authorities (Public Health Functions and Entry to Premises by Local Healthwatch Representatives) Regulations 2013 ;
- H&SC Act 2012 s.23 assigns this duty to the NHS Commissioning Board (NHS England);

6.4.3 Furthermore other organisations are also required to obtain or give advice in relation to this duty:

- H&SC Act 2012 s.26 requires that Clinical Commissioning Groups (CCGs) seek advice from persons who (taken together) have a broad range of professional expertise in protection or improvement of public health;
- H&SC Act 2012 s.62 requires that Monitor seek advice from persons who (taken together) have a broad range of professional expertise in protection or improvement of public health;
- H&SC Act 2012 s.240 notes that regulations may confer functions on the National Institute for Health and Care Excellence (NICE) in relation to the giving of advice to persons (whether or not in the United Kingdom) in relation to any matter concerning or connected with the protection or improvement of public health.

6.5 Conclusion

6.5.1 The legislation appears to create a situation where DsPH have a shared duty for quality of public health protection and improvement services. DsPH are therefore potentially in a situation where they are not consulted, or whereby other organisations provide conflicting or duplicated advice.

6.5.2 The DPH's involvement relates to their statutory assurance role for health protection, including providing information, advice, challenge and advocacy on behalf of the local authority, to promote preparation of effective health protection arrangements by relevant organisations, operating in the local authority area. Environmental hazards and contamination are particularly relevant issues for this application. As part of this duty the DPH can provide advice on:

- the appropriate co-ordination of roles and responsibilities between any responsible or relevant bodies; and
- effective testing by the responsible and relevant bodies of the health protection arrangements.

6.6 Recommendation

6.6.1 This is a new extraction process for UK regulators. Effective testing of the health protection arrangements is advisable.

6.6.2 This could include the use and robustness of monitoring systems to confirm that below ground: fault, aquifer or gas migration impacts, both during drilling and hydraulic fracturing and longer term do not pose a risk to health protection.

6.6.3 This could also include the associated reporting, interpretation of results, and the subsequent review of actions which may be required, be that change to activities at the site, or development of new local or national policy or regulation.

7 Population profile

7.1 Introduction

7.1.1 The proposed developments are in Fylde Borough Council. The mid-2012 population estimate for Fylde District is 76,000 (121).

- Preston New Road is in Warton and Westby Ward (E05005205).
- Roseacre Wood is in Newton and Treales Ward (E05005198).

7.2 Summary profile for Fylde

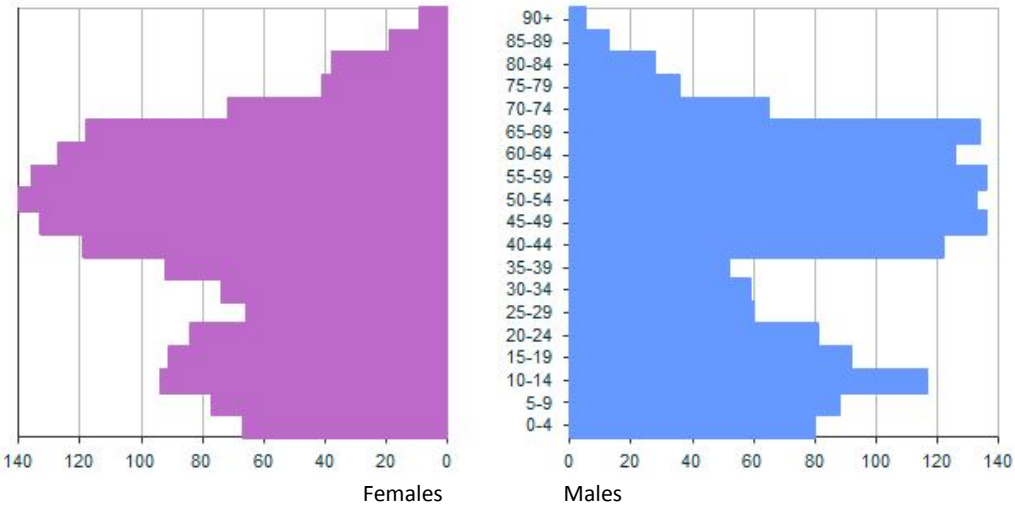
7.2.1 The following summary health profile provides context to the review and relevant population health issues.

Population, age and gender

7.2.2 In 2011 the population of Newton and Treales Ward was 3,227 and the population of Warton and Westby Ward was 4,801 (122).

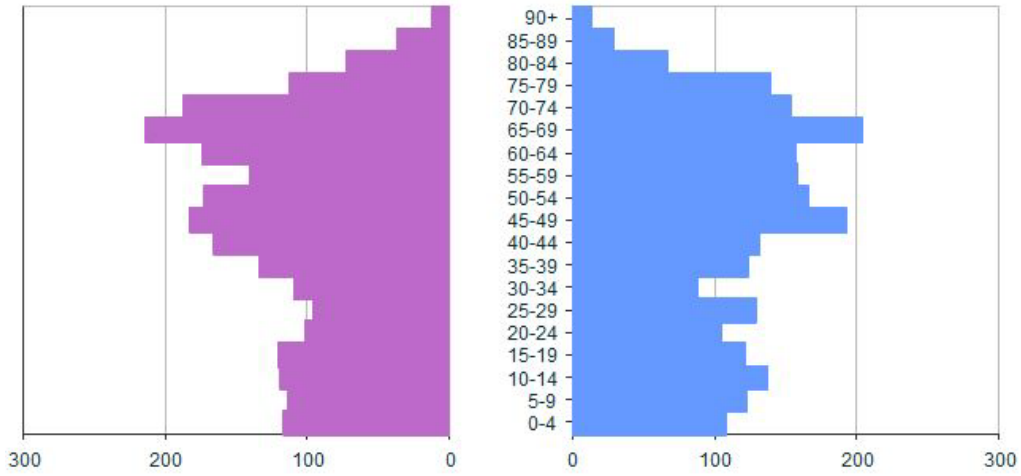
7.2.3 Figure 7-1 and Figure 7-2 show age pyramids for male and female numbers per five-year age group (2012) for each of the wards. Figure 7-3 shows the corresponding age pyramid for Lancashire. These figures, and Table 7-1, show that the wards have smaller proportions of young people (aged under 16 and 16-24) than the Lancashire and England averages. The wards have a higher proportion of older people (aged 65-84) than the Lancashire and England averages.

Figure 7-1: Newton and Treales: age pyramid male and female numbers per five-year age group, 2012



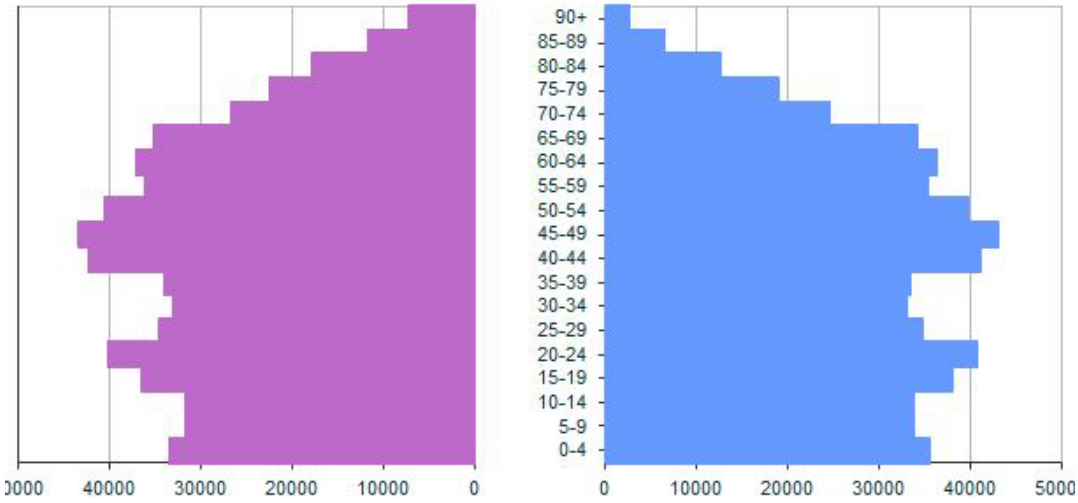
Source: ONS ©Crown Copyright, from Public Health England (123)

Figure 7-2: Warton and Westby: age pyramid male and female numbers per five-year age group, 2012



Source: ONS ©Crown Copyright, from Public Health England (124)

Figure 7-3: Lancashire: age pyramid male and female numbers per five-year age group, 2012



Source: ONS ©Crown Copyright, from Public Health England (125)

Table 7-1: Percentages of total population per age group, 2012

	u16	16-24	25-64	65-84	85+
Warton and Westby	16.2	8.5	49.1	24.3	2.0
Newton and Treales	17.8	9.8	54.1	16.8	1.5
Lancashire	18.3	12.0	50.9	16.4	2.4
England	18.9	11.7	52.4	14.6	2.3

From Public Health England (123-125)

Relative risk for selected health conditions

7.2.4 Table 7-2 and Table 7-3 show relative risks for selected health conditions for a 25 year period (1985-2009) for Newton and Treales Ward and for Warton and Westby Ward

respectively for both males and females (126). The relative risk represents the risk of an area (ward) relative to average risk in England and Wales. These are adjusted for age, deprivation and chance fluctuations due to small numbers.

Table 7-2: Newton and Treales Ward: relative risks for selected health conditions (1985-2009)

Area	Newton and Treales Ward	
	Females	Males
Bladder Cancer	Above average relative risk 1.08 (0.93-1.24)	Average relative risk 1.00 (0.87-1.14)
Brain Cancer	Below average relative risk 0.94 (0.79-1.10)	Average relative risk 0.98 (0.87-1.10)
Breast Cancer (Females only)	Below average relative risk 0.93 (0.85-1.00)	
COPD	Above average relative risk 1.53 (1.13-2.00)	Above average relative risk 1.51 (1.14-1.93)
Heart Disease	Above average relative risk 1.24 (1.03-1.46)	Above average relative risk 1.26 (1.11-1.42)
Kidney Disease	Below average relative risk 0.91 (0.62-1.28)	Average relative risk 0.96 (0.71-1.24)
Leukaemia	Below average relative risk 0.88 (0.75-1.01)	Below average relative risk 0.90 (0.77-(1.04)
Liver Cancer	Above average relative risk 1.35 (1.02-1.76)	Above average relative risk 1.34 (1.00-1.74)
Low Birth Weight	Above average relative risk 1.09 (0.93-1.26)	Average relative risk 1.06 (0.90-1.22)
Lung Cancer	Above average relative risk 1.14 (0.91-1.40)	Above average relative risk 1.08 (0.88-1.29)
Mesothelioma Cancer	Above average relative risk 1.19 (0.57-2.17)	Average relative risk 1.02 (0.66-1.48)
Prostate Cancer (Males only)		Average relative risk 0.97 (0.84-1.10)
Sill births	Above average relative risk 1.13 (0.83-1.48)	Average relative risk 1.02 (0.79-1.29)
Skin Cancer	Above average relative risk 1.10 (0.87-1.36)	Below average relative risk 0.89 (0.70-1.11)

Confidence intervals shown in brackets

Table provided by LCC, data from Environment and Health Atlas for England and Wales (126)

Table 7-3: Warton and Westby Ward: relative risks for selected health conditions (1985-2009)

Area	Warton and Westby Ward	
	Females	Males
Bladder Cancer	Above average relative risk 1.11 (0.97-1.25)	Average relative risk 1.03 (0.92-1.15)
Brain Cancer	Average relative risk 0.96 (0.81-1.12)	Average relative risk 1.00 (0.88-1.11)
Breast Cancer (Females only)	Average relative risk 0.97 (0.90-1.04)	
COPD	Above average relative risk 1.37 (1.06-1.72)	Above average relative risk 1.25 (0.99-1.53)
Heart Disease	Above average relative risk 1.16 (1.00-1.33)	Above average relative risk 1.12 (1.01-1.24)
Kidney Disease	Below average relative risk 0.92 (0.64-1.25)	Average relative risk 0.96 (0.74-1.21)
Leukaemia	Below average relative risk 0.89 (0.77-1.01)	Below average relative risk 0.92 (0.80-1.04)
Liver Cancer	Above average relative risk 1.40 (1.09-1.76)	Above average relative risk 1.44 (1.12-1.80)
Low Birth Weight	Average relative risk 1.05 (0.91-1.91)	Average relative risk 1.06 (0.92-1.21)
Lung Cancer	Above average relative risk 1.18 (0.97-1.39)	Average relative risk 1.03 (0.87 – 1.20)
Mesothelioma Cancer	Above average relative risk 1.27 (0.66-2.20)	Average relative risk 1.05 (0.74-1.42)
Prostate Cancer (Males only)		Average relative risk 0.99 (0.86-1.11)
Sill births	Above average relative risk 1.11 (0.82-1.44)	Average relative risk 1.04 (0.81-1.30)
Skin Cancer	Above average relative risk 1.10 (0.90-1.31)	Below average relative risk 0.90 (0.73-1.09)

Confidence intervals shown in brackets

Table provided by LCC, data from Environment and Health Atlas for England and Wales (126)

Mental health and wellbeing

7.2.5 LCC describe the profile of mental health and wellbeing across Lancashire and identify the needs of specific groups including older people and children and young people (127). LCC state that need for mental health services is affected by the current economic conditions. They identify the importance of promoting well-being and of dealing with mild to moderate mental health problems as well as those which are moderate to severe and those which endure over time (128).

7.2.6 LCC state that demand is likely to be driven by changes in the number who need services: there will be more people who need services because the population is increasing, not because mental illness is itself becoming more common (127).

Summary profile

7.2.7 Figure 7-4 sets out health indicators for the borough: these are a general set of indicators and not a set generated specifically for the current study. The set is therefore not specific to the potential effects of shale gas exploration and extraction.

7.2.8 Public Health England's 2014 health profile for Fylde summarises health in the district as follows (121):

- The health of people in Fylde is varied compared with the England average. Deprivation is lower than average, however about 1,400 children live in poverty. Life expectancy for both men and women is similar to the England average.
- Life expectancy is 6.5 years lower for men and 8.6 years lower for women in the most deprived areas of Fylde than in the least deprived areas.
- Over the last 10 years, all-cause mortality rates have fallen: this is a trend for England, and so cannot be considered a local phenomenon. The early death rate from heart disease and stroke has fallen and is similar to the England average.
- In Year 6, 12.8% of children are classified as obese, better than the average for England. The level of GCSE attainment is better than the England average.
- The estimated levels of excess weight and adult physical activity are worse than the England average. Estimated levels of adult smoking are better than the England average. The rate of people killed and seriously injured on the roads is worse than the England average. The rate of sexually transmitted infections is better than the England average. The rate of new malignant melanoma is worse than the England average.
- Priorities in Fylde include addressing long term conditions, reducing alcohol harm and reducing falls.

7.2.9 Relevant issues are:

- levels of physical activity and excess weight;
- mental health and wellbeing; and
- road safety.

Figure 7-4: Health summary for Fylde (2014)

Significantly worse than England average
Not significantly different from England average
Significantly better than England average

Domain		Indicator	Local No Per Year	Local value	Eng value	Eng worst	Regional average^ / England Average / England Worst / 25th Percentile / 75th Percentile / England Best / England Range	Eng best
Our communities	1	Deprivation	2,575	3.4	20.4	83.8		0.0
	2	Children in poverty (under 16s)	1,435	12.5	20.6	43.6		6.4
	3	Statutory homelessness	10	0.3	2.4	33.2		0.0
	4	GCSE achieved (5A*-C inc. Eng & Maths)	422	65.1	60.8	38.1		81.9
	5	Violent crime (violence offences)	586	7.7	10.6	27.1		3.3
	6	Long term unemployment	224	5.0	9.9	32.6		1.3
Children's and young people's health	7	Smoking status at time of delivery	121	18.3	12.7	30.8		2.3
	8	Breastfeeding initiation	n/a	-	73.9	40.8		94.7
	9	Obese children (Year 6)	70	12.8	18.9	27.3		10.1
	10	Alcohol-specific hospital stays (under 18)	7	48.6	44.9	126.7		11.9
	11	Under 18 conceptions	33	26.9	27.7	52.0		8.8
Adults' health and lifestyle	12	Smoking prevalence	n/a	13.4	19.5	30.1		8.4
	13	Percentage of physically active adults	n/a	50.6	56.0	43.8		68.5
	14	Obese adults	n/a	21.1	23.0	35.2		11.2
	15	Excess weight in adults	139	69.1	63.8	75.9		45.9
Disease and poor health	16	Incidence of malignant melanoma	27	31.8	14.8	31.8		3.6
	17	Hospital stays for self-harm	182	268.5	188.0	596.0		50.4
	18	Hospital stays for alcohol related harm	513	637	637	1,121		365
	19	Drug misuse	282	6.1	8.6	26.3		0.8
	20	Recorded diabetes	3,638	6.1	6.0	8.7		3.5
	21	Incidence of TB	1	2.6	15.1	112.3		0.0
	22	Acute sexually transmitted infections	437	574	804	3,210		162
	23	Hip fractures in people aged 65 and over	130	581	568	828		403
Life expectancy and causes of death	24	Excess winter deaths (three year)	59	19.6	16.5	32.1		-3.0
	25	Life expectancy at birth (Male)	n/a	79.1	79.2	74.0		82.9
	26	Life expectancy at birth (Female)	n/a	82.8	83.0	79.5		86.6
	27	Infant mortality	4	5.8	4.1	7.5		0.7
	28	Smoking related deaths	167	286	292	480		172
	29	Suicide rate	7	-	8.5			
	30	Under 75 mortality rate: cardiovascular	58	74.9	81.1	144.7		37.4
	31	Under 75 mortality rate: cancer	111	143	146	213		106
	32	Killed and seriously injured on roads	40	53.0	40.5	116.3		11.3

From PHE (121)

7.3 Recommendation

7.3.1 The population of the wards in which the current applications are located have a higher proportion of older people than the Lancashire and England averages. As might be expected there are a range of pre-existing mental and physical health conditions.

7.3.2 LCC should ensure that a baseline of actual health conditions is developed for the local area to enable the health effects of exploration for shale gas to be identified. This would require the use of existing datasets and survey work to establish the local conditions. This will link in with the monitoring of actual affects if the extraction and exploration of shale gas proceeds. We consider short- and longer-term approaches for such a study; we also consider the governance of the study and the study design.

Governance

7.3.3 The governance of the study design, data collection, analysis and reporting will be of critical importance. The protocol for the study should ensure that community groups are included in identifying the geographical areas where data is collected, identifying the questions that are posed, the analysis and the reporting of results. This can include capacity building for local groups.

Study design

7.3.4 The information should be collected prior to site preparation commencing. This should include self-reported health and other measures of health status.

7.3.5 The geographical scope of the study will need to be defined but it should include people living and working close to sites that are subject to applications for shale gas exploration and extraction. This could also include people and communities in the wider PEDL area.

7.3.6 A sample that is representative of the population for age and sex profiles for the geographical area covered by the study should be involved. A control group, resident in areas not subject to applications for shale gas exploration and extraction, may be identified and included in the study for comparison.

7.3.7 The independence, timeframe, recruitment and outcome measures would be important. Teratogenic and inter-generational effects, including economic inter-generational effects, could be considered.

7.3.8 The timeframe for the monitoring is important: Kovats recommends including the long-term implications of waste disposal, fugitive methane emissions, and other legacies with implications for human health (43). The appropriate timeframe for monitoring would need to be established through a review of the literature but given that inter-generational effects are possible a study that spans 20 to 30 years should be considered.

7.3.9 The literature search identified the following studies that describe surveys with communities living close to shale gas extraction:

- longitudinal analysis of community stressors (60);
- community surveys (75);
- ethnographic work (69);
- stakeholder perceptions of natural gas (67); and
- ways that care providers can include environmental histories (72).

7.3.10 Studies that collect information from individuals about health status will require ethical clearance.

Short-term

7.3.11 Use existing data sources to develop a profile of the local area. The Joint Strategic Needs Assessment (JSNA) should be used (129). National data sources could be interrogated for the area surrounding the proposed sites. Some national data sources are suggested below.

- **Health Survey for England** (HSfE): this is a monitoring tool that looks at health across England (130). Although their sample size in any part of the country is relatively small they take measurements (physical & biochemical, e.g. blood glucose) and they conduct interviews with people.
- **The Clinical Practice Research Datalink** (CPRD): this is the English NHS observational data and interventional research service. CPRD services are designed to maximise the way anonymised NHS clinical data can be linked to enable many types of observational research and deliver research outputs that are beneficial to improving and safeguarding public health (131).
- **Environment and Health Atlas for England and Wales**: this is compiled by the UK Small Area Health Statistics Unit (SAHSU) at Imperial College London. SAHSU is part of the MRC-PHE Centre for Environment and Health which is funded by the Medical Research Council and Public Health England (126).
- **Local Health** (132) is part of the Health Profiles programme produced by Public Health England; it provides quality assured health information and it seeks to present the information clearly for users within the health service.

7.3.12 Establish links with existing and planned programmes to monitor the environmental status of air quality, water quality, etc. Such work should build on analysis undertaken as part of the EIAs.

7.3.13 Air quality, noise and transport effects on health will be amenable to quantitative analysis. The baseline would need to cover the population that may be exposed to any changes. Other areas where quantification may be possible (depending on available data) could include regional or national socioeconomic and energy security estimates. If a quantitative risk assessment (QRA) for the developments is developed, this could be reviewed and commentary provided on ranges and severities of impacts associated with unplanned events.

7.3.14 Other issues with potential implications for health include: fear; understanding of risk; attachment to place etc. These are not easily described in quantitative terms. It is better to examine these qualitatively. This is a different type of assessment, which is equally important.

7.3.15 In the short-term we suggest that LCC work with a local university to conduct the initial survey. Include local community and NGOs in this process and provide training to enable participation in study design, data collection, analysis and reporting.

Long-term

7.3.16 In the longer-term we suggest that LCC seek to include other areas, within the UK and in mainland Europe, where shale gas resources are being investigated and/or extracted.

7.3.17 In 2012 close to half of all EU Member States were interested in developing shale gas resources (79). Member States noted as being active in this area include Poland, Germany, Netherlands, UK, Spain, Romania, Lithuania and Denmark. Sweden and Hungary are also listed as being interested in developing activity in developing shale gas resources.

7.3.18 Industry could be approached for funding. A proposal could be put to the European Union for funding. A unit such as the Small Area Statistics Unit at Imperial College or the Environment & Human Health Unit, Peninsula College of Medicine & Dentistry could be approached to co-ordinate the proposal.

7.3.19 The study should be longitudinal eg it should follow people through time to enable analysis of change. It should use mixed methods eg self-reported health, biomarkers and qualitative research.

7.3.20 Community input should be sought from each participating region and Member State to ensure that the results of the study have a wide acceptance.

8 Findings from community engagement workshops

8.1 Introduction

8.1.1 We conducted two structured workshops with participants from local communities. The results are reported in full in the Community Engagement Report (9).

8.1.2 LCC organised the publicity, the venue, and the invitations in liaison with the two Parish Councils most closely affected.

8.1.3 The purpose of the workshops was to solicit local views on issues associated with shale gas exploration and extraction and health and wellbeing.

8.1.4 Approximately 30 people attended the first workshop. Approximately 80 people attended the second workshop.

8.1.5 Each workshop ran for approximately 2 ½ hours.

8.1.6 The views expressed in the workshops have been reproduced as faithfully as possible in this report.

8.1.7 The responses from workshop participants were collected, collated and recorded according to a schedule of determinants of health relevant to the exploration for, and extraction of, shale gas. BCA were not commissioned to align responses in the Community Engagement Report with information in the published or grey literature. The Community Engagement Report has not been shared with participants prior to publication and the factual statements it contains have not been verified. These steps could be undertaken in any further HIA work.

8.1.8 We were keen to ensure that all participants had a chance to express their opinions and relay their knowledge and experience. In the first workshop the participants stated that they wanted to hold the discussion in one large group. In the second workshop the discussion took place in facilitated small discussion groups. There were plenary sessions to give an opportunity for feedback to the whole group.

8.1.9 The participants were asked to identify:

- positive expectations about the proposal;
- barriers to, or conflicts around, the proposal;
- the potential effects (beneficial and adverse) of the proposal on determinants of health; and
- any suggestions to address the potential impacts (beneficial and adverse) identified.

8.1.10 The effects were identified against a list of determinants of health prepared by the HIA team and so the feedback in the workshops was structured and provided in systematic way.

8.2 Findings

8.2.1 In general, many of the over-riding responses about the two proposed exploration sites voiced by members of the local communities who attended the workshops were those of fear, anxiety and stress, which are affecting their mental wellbeing, with some people experiencing sleep disturbance and depression. These responses are associated with a lack of control over what might happen, leading to disempowerment and helplessness. Fears

about the potential effects of shale gas exploration and extraction on health and wellbeing were considerable.

8.2.2 In addition, the residents who attended the workshops felt that they did not have a voice, and that their concerns were not being addressed. These responses were associated with a lack of trust and/or confidence in the statutory and regulatory authorities responsible for either the regulation of shale gas exploration and extraction or the protection of residents' health and wellbeing. Again, these issues were affecting residents' mental wellbeing.

8.2.3 Furthermore, the residents in attendance were concerned about the approach of the Applicant, including taking note of inconsistencies in the information the Applicant had provided at various points during the planning application process, which led to further anxiety and stress. Residents also raised questions about practices in the shale gas exploration and extraction industry in general, which were a source of worry for them.

8.2.4 In the absence of information from other sources and/or the provision of information that appeared to be inconsistent, many of the residents who attended the workshops had found information on the effects of shale gas extraction and exploration from the published literature and the internet. This information mainly covered experience in the United States of America, Canada and Australia, with relatively little being found that related to the situation in the United Kingdom. Nonetheless, residents felt strongly that this information should be considered during the planning process. During the workshops, BCA explained the public health concepts of assessing the generalisability and applicability of any information from other countries.

8.2.5 Residents who attended the workshops felt that if planning permission was granted for the two proposals they would be placed at a disadvantage, while receiving no benefits whatsoever. Residents thought the main beneficiary would be the national Government of England, with the possibility of only some benefit accruing to the wider region as a whole.

Positive expectations

8.2.6 None of the residents who attended the workshops expressed any positive expectations about either of the two proposals for shale gas exploration and extraction.

Concerns

8.2.7 Residents at the two workshops expressed many concerns about the two proposals for shale gas exploration and extraction. Their concerns were focussed around:

- the proximity of the sites to residential dwellings, and that both proposals are located in a populated area;
- the potential effects on health and well-being, particularly for people who have pre-existing health conditions or who are otherwise vulnerable, such as children and young people and older people;
- the apparent lack of regulations to protect people's health and wellbeing;
- the nature of the impacts on health and wellbeing – potentially cumulative, long-term, teratogenic, inter-generational, irreversible, and unknown – with the possibility of synergistic effects from other developments in the area;
- the lag time between exposure to a health hazard and the appearance of any symptoms, signs or health outcomes;
- the industrialisation of the area, including changes in the rural nature of the landscape, and the threat to existing industries of agriculture and tourism;
- the potential for de-population of the area as people move out and no new people want to move in threatening the sustainability of some of the villages in the area;

- the nature of the planning applications, whether they would be temporary installations, and whether if planning permission was given this would set a precedent;
- the quality, content and length of the environmental statements submitted by the Applicant;
- the potential for gaps in the regulation of shale gas exploration and extraction processes, including the storage, transportation and disposal of waste products;
- the process of waste management and disposal on and off site;
- the skills and competencies of the regulatory and statutory authorities involved in shale gas exploration and extraction, given that it is a relatively new mining operation in the UK;
- the Applicant's arrangements for company structure, and associated governance and accountability, including legal liability;
- the life-cycle of the wells, and well and operational integrity;
- operation of the sites (e.g. for 24 hours a day) and the potential use of sub-contractors;
- the apparent lack of compensation for residents in the event of accidents, incidents, or damage to property or person;
- the need for and adequacy of Emergency and Contingency Planning;
- the national political context which could dominate any local considerations during the decision-making process.

Potential impacts on health and wellbeing

8.2.8 Residents who attended the first workshop did not identify any positive impacts on health and wellbeing. Residents at the second workshop reported that a few individual landowners may have benefitted financially from the proposals for shale gas exploration and extraction. No other potential positive impacts were identified. All other impacts that were identified in either workshop were negative.

Economic domain of determinants of health

8.2.9 On a personal level, of great concern to the people who attended both workshops was the potential loss of value on their residential properties. This concern was not simply related to a reduction in people's capital assets, but the potentially serious implications of such an asset loss irrespective of the time in a person's life-course. Thus, the inability to sell their house, either because other people would not want to buy in the area or because of negative equity, could mean that people are unable to move:

- for older people, they may be trapped in a property no longer suitable for their needs, and/or they cannot execute their retirement plans;
- for people of working age, they may not be able to take up a new a job opportunity or career move elsewhere.

8.2.10 In addition, this potential inability to realise assets may mean it is not possible for people to leave a legacy for their children or grandchildren.

8.2.11 In terms of the district, participants were concerned that the introduction of shale gas exploration and extraction would affect the viability of the two main existing industries in the area: agriculture (arable and dairy farming, market gardening and nurseries), and tourism, and associated leisure and recreation opportunities (such as caravanning, walking/rambling, horse-riding and cycling).

8.2.12 In terms of agriculture and other land-based businesses in the area, their viability was thought to be threatened by the potential for waste products from the shale gas exploration and extraction process, and/or the storage and transportation of waste water to spill, leak or be discharged into the local water system (aquifers, water table, and water courses) and thereby enter the food chain through arable or dairy products.

8.2.13 In terms of tourism and leisure-based industries in the area, the viability of these businesses was thought to be threatened by the potential for changes in the nature of the local landscape and in the nature of the traffic in the area.

- Changes to the landscape include visual disturbance from the construction of the wells and the practice of flaring of gas, which residents see as the start of the industrialisation of a rural landscape, combined with the potential for increased noise levels and the loss of tranquillity.
- Changes to local traffic include the introduction of HGVs on roads not built for heavy vehicles, affecting air quality, noise levels, the risk of road traffic accidents, and people's access to certain routes and locations.

8.2.14 In combination, the overall effect may mean that the viability of other businesses in the area, e.g. shops, is also threatened. Residents at the workshops considered it unlikely that the introduction of shale gas exploration and extraction would act to retain money in the local economy, would create jobs for local people or would help to develop their skills.

8.2.15 Residents did not believe that the community benefit payments from the Applicant would benefit them directly due to the way the money was administered and allocated.

Environmental domain of the determinants of health

8.2.16 Many of the potential impacts on health and wellbeing identified by residents at the workshop were related to environmental determinants of health. Greatest concern was expressed about air quality, and the potential for pollution from particulate matter 2.5 ($PM_{2.5}$), volatile organic compounds (VOCs), and methane. Concerns about soil and water quality focussed on the potential for contamination from leaks, spillages or discharges.

8.2.17 There was also great concern about the amount of water required for hydraulic fracturing, whether this would compromise water supplies for residents and businesses, especially during periods of drought/heavy demand, and the management, storage, transportation and disposal of the waste water, containing radon.

8.2.18 Other pollution of concern for residents at the workshops was the level of noise, especially given the quiet rural nature of the area, and the levels of light.

8.2.19 Residents were fearful of the potential for induced seismicity, not only in terms of earthquakes, damage to residences and other buildings, and the movement of geological faults with the potential contamination of aquifers, but also in terms of underground infrastructure that could be disrupted, such as pipes for gas, and water and sewage, and hazardous waste storage sites.

8.2.20 As noted under the economic domain, residents identified changes in the nature of the landscape, including visual disturbance, and changes in the nature of traffic, which would contribute to the loss of the landscapes rural nature. In conjunction, with these and other environmental effects of shale gas exploration and extraction, the biodiversity in the area was likely to be reduced, affecting both local residents and tourists/visitors to the area.

8.2.21 Residents at the second workshop also raised the issue of the potential for greenhouse gas emissions to be increased as a result of the extraction and use of shale gas. This would contribute to potential negative effects for a much wider population through climate change.

Social and personal domain of the determinants of health

8.2.22 Several factors were of concern to participants in relation to the social and personal domain of the determinants of health.

8.2.23 Residents who attended the workshops felt that reputation and image of the area would be changed with the introduction of shale gas exploration and extraction, and it no longer retain the character of being a quiet close-knit rural farming community. The area's reputation could be further damaged if environmental activists and other groups moved in to the area to protest against shale gas exploration and extraction.

8.2.24 Of most concern to participants at the workshops was the issue of safety, both personal and public. In terms of public safety, there was great concern about the potential for major and minor accidents and incidents associated with the process of shale gas exploration and extraction, and the transportation of waste products, and how this would affect the health and wellbeing of local people. This concern overlapped with concerns about access to emergency services (see Access domain below).

8.2.25 In terms of personal safety, there was concern about the increased risk of road traffic accidents (especially for pedestrians, cyclists, and horse-riders) arising from the increase in traffic volumes, specifically that of HGVs transporting waste water for disposal.

8.2.26 Residents thought that a combination of fears about personal and public safety and the increased risk of exposure to various types of pollution (see Environmental domain) were likely to mean that some people would not go out as much or take part in various leisure and recreational opportunities, and thereby experience reduced social contact and support and be at risk of social isolation, particularly older people.

8.2.27 In terms of food safety, there was concern that local aquifers, the water table and/or local water courses could become contaminated through leaks, spillages or discharges during the process of shale gas exploration or extraction, or the storage and transportation of waste water. Contaminants could then enter the food chain, via arable or dairy products.

8.2.28 Residents were also concerned that if shale gas exploration and extraction was introduced in the area there could be two main factors affecting social cohesion:

- Community severance in a physical sense, through the location of the two proposed sites and the choice of route for the HGVs used to transport waste water from the sites for disposal;
- Social division, through the disagreement among some members of the communities affected about the response to shale gas exploration and extraction.

8.2.29 Some people feared these factors could be exacerbated in the event of environmental activists and other groups entering the area to protest about shale gas exploration and extraction, with the potential for criminalisation of the local community.

Access domain of the determinants of health

8.2.30 Of greatest concern to the residents who attended the workshops was the effect of the introduction shale gas exploration and extraction in the local area on access to emergency services. This concern arose as a result of a combination of factors:

- existing ambulance response times can be poor;
- the proposals necessitate an increase in traffic volume, in particular the use of HGVs to transport waste water from the shale gas exploration and extraction sites for disposal, which increases the likelihood of increased congestion on local roads not built for heavy traffic, thereby hindering emergency response times further;
- the increased level of hazards in the local environment with the introduction of shale gas exploration and extraction, which may increase need for emergency services, especially in the event of an accident or incident; and
- existing Emergency Plans for the area, which do not take account of the introduction of shale gas exploration and extraction.

8.2.31 For those residents who had pre-existing health problems or cared for people with pre-existing health problems, e.g. respiratory and cardiovascular conditions, there was concern about access to primary and secondary care health services after the introduction of shale gas exploration and extraction in the light of potentially increased demand. Residents reported that access to certain existing services was poor, and they felt it would worsen if the planning applications were granted.

8.2.32 Other concerns about access were the restriction in leisure and recreation opportunities through a combination of factors:

- increased heavy traffic on the roads, possibly leading to congestion;
- increased risk of road traffic accidents
- air and noise pollution; and
- visual disturbance.

8.2.33 Residents were also concerned that these factors and the potential for health impacts would reduce their residential amenity particularly in the use of gardens.

Suggestions to address the potential impacts on health

8.2.34 Residents who attended the workshops made various suggestions to address the potential impacts of shale gas exploration and extraction on health and wellbeing. Many more recommendations were made in the second workshop than the first, although the main topics covered in both workshops included:

- extending the time period available for the determination of the planning applications to ensure that appropriate assessments of environmental and health factors can be completed;
- taking an evidence-based approach to, and apply public health principles to, the determination of the planning applications, including a consideration of information from other countries where hydraulic fracturing of shales takes place;
- establishing a restriction on the location of wells such that there are no residences, schools or businesses within a minimum distance of 2 km, as in New South Wales, Australia;
- the need for independent regulation and monitoring of the shale gas industry, which should include community representation and/or involvement;
- the need for monitoring and evaluation of the effects of shale gas exploration and extraction on the environment and on people's health and wellbeing;
- the need to establish a baseline of environmental quality and of people's pre-existing health status prior to shale gas exploration and extraction in the local area;
- ensuring the legal liability of the hydraulic fracturing of shales industry is covered and maintained over the long term (post abandonment);
- ensuring the Applicant undertakes to mitigate any of the adverse effects of hydraulic fracturing of shales, including devising a route for the HGVs transporting waste water that has the potential to do the least harm, to refrain from using hazardous chemicals at any stage in the exploration and extraction process, and to refrain from re-using water that has been used during hydraulic fracturing; and
- developing and testing with all relevant stakeholders Emergency and Contingency Plans that are fit for purpose in relation to the accidents and incidents that could occur during the process of shale gas exploration and extraction, including the management, storage, transportation and disposal of waste, in the local area.

9 Review of Environmental Statement prepared for Preston New Road

9.1 Introduction

9.1.1 We have reviewed the application's ES (18) with special reference to health and wellbeing. The ES, the report which is produced as a result of the Environmental Impact Assessment (EIA), is a useful source of information for the HIA. Many of the factors considered in the EIA will have an effect on health and wellbeing. However, human health is not a core topic for EIA. The difference in perspective and methodologies between EIA and HIA means that there are inevitably issues addressed in the EIA that can be expanded upon in a HIA.

9.1.2 The review identifies two main issues.

- The conclusions of the ES are based upon appropriate management of risk and enforcement of regulations and guidelines. Whilst it is generally acknowledged that the regulatory regime overseeing and enforcing safety standards for the emerging fracking industry should provide appropriate protection to the public and workforce (26), commentators have noted that it is evolving (101) while detractors have expressed doubt that current regulation is fit for purpose (41;102).
- The ES defers a number of issues until after the application has been determined: for example, it is unclear from the ES when the Environmental Management and Monitoring Plan (EMMP), which details the monitoring scope and reporting procedures, will be available; and it is unclear from the ES whether a quantitative risk assessment (QRA) has been, or will be, undertaken to determine the risks and responses required in the event of an unplanned emergency scenario. Whilst the ES may reasonably defer these issues to post application stages, the absence of these documents hinders the fuller consideration of potential health effects associated with the application.

9.1.3 On the basis of this review we find that the ES has been completed to fulfil the requirements of an EIA, as would be anticipated. As noted above we also find that it leaves much to the post application documentation and regulatory framework. We identify some technical clarifications that could be sought by the Director of Public Health for LCC in exercising that role's duty to 'assure' health protection for the area.

9.1.4 The ES finds no significant adverse health impacts for people living and working close to, or at, the site. HIA uses different thresholds and thus might reach different conclusions. The potential adverse impacts are generally greatest at the residential properties closest to the site. The overall burden for these residences is not currently known.

9.1.5 The ES finds no significant adverse health impacts for people living and working close to, or at, the site. HIA uses different thresholds and thus might reach different conclusions. The potential adverse impacts are generally greatest at the residential properties closest to the site. The overall burden for these residences is not currently known.

9.1.6 Until regulatory responsibilities and expectations have been more clearly described it may be difficult for the Director of Public Health for LCC to discharge his assurance duty with regard to health protection. Furthermore, until post application documentation, such as the QRA and EMMP, have been produced, it may be difficult to rule out the potential for health impacts to occur.

9.1.7 This is a detailed ES for the level of proposed development. Overall the ES appears to have provided the information which would have been expected, though there are some areas which need clarification. The main queries are listed below.

9.2 Clarifications sought

General

We suggest that the Director of Public Health for LCC:

9.2.1 Seeks clarification that the monitoring framework requirements set through the planning and permitting processes will address not only the sort-to-medium term impacts of disturbance and pollutants arising from the site to the local population, but also the potential for long-term (and potentially more widespread) legacy impacts on groundwater and ground gas. Such monitoring should be tied to an action plan with defined roles and responsibilities for notifying and responding to exceedances for the full period of the monitoring. We suggest that the Director of Public Health for LCC should remain engaged with the process and information that emerges on monitoring from the planning and permitting processes.

9.2.2 Requests that regulators collectively produce a document that summarises the application's adherence to the DECC Regulatory road map guidance(103); including the planning and permitting conditions and monitoring requirements that have been imposed at each step for the protection of public health.

9.2.3 Confirms when and what further information will be available regarding quantitative risk assessment (including unplanned events and reference to ½LFL[8]).

9.2.4 Seeks clarification of what effect (for example: direct, indirect, cumulative, differential, synergistic) the Project will have on proposed development within Fylde (134), including the proposed mental health unit at Whyndyke Farm.

9.2.5 Seeks further detail on the influence on people's perception of safety associated with property values, amenity value of outdoor space and levels of physical activity.

9.2.6 Confirms how the Applicant will ensure and demonstrate that all pollution will be as low as reasonably practical using BAT. This applies to air quality (including PM_{10} and $PM_{2.5}$), noise, vibration, light and any other release from the activities on site or associated with the site.

9.2.7 Request clarification on the cumulative impacts inter (between) rather than intra (within) topics presented in the ES. For example: the cumulative radiological impact to the closest residential receptors from radiological emissions (notably radon) associated with flaring, water (NORM) and any solid waste stored onsite; or the cumulative impact of all sources of potential disturbance and nuisance to the closest residential receptors (including noise, dust, light, traffic etc …).

Air quality

We suggest that the Director of Public Health for LCC:

9.2.8 Seeks clarification as to whether there will be periods of higher exposure to radon (e.g. during the 120 day flare period assumed by the radon modelling) than is suggested by the ES reporting the exposure levels as an annual effective dose. Notably whether peak levels will exceed 400 Bq/m^3 in any 24 hour period at any receptor (on or off site). [This clarification is unlikely to change the overall conclusion in terms of public health, but would assist in resolving this as an issue for the HIA.]

[8] Being outside the area where gas has dispersed from the source to a concentration of half its lower flammable limit (½LFL) is a recognised threshold of reasonable safety (133).

9.2.9 Request clarification of whether one or two flares have been included for the radon modelling. It would be useful for actual receptors and weather data to be used in the radon modelling. [This clarification is unlikely to change the overall conclusion in terms of public health, but would assist in resolving this as an issue for the HIA.]

9.2.10 Request additional modelling of the likely radon exposure levels during unplanned events (*e.g.* loss of gas containment at ground level) for occupational and residential receptor doses. For each radon modelling result (including those requested above), data in unit of µSv/year and Bq/m^3 would be useful. [This clarification is unlikely to change the overall conclusion in terms of public health, but would assist in resolving this as an issue for the HIA.]

9.2.11 Request information on what alternatives have been considered for the capture and the use of methane during the 90 day initial flow testing stage and clarify how the decision to flare has been reached.

Noise

We suggest that the Director of Public Health for LCC:

9.2.12 Requests additional mitigation be incorporated into the Project to ensure that at all receptors noise levels attributable to the Project (notably well pad construction, drilling and hydraulic fracturing) neither exceed the WHO general health based threshold of 50/55 dB $L_{Aeq,\ 16hr}$ (135); nor the WHO night noise threshold of 40 dB $L_{night,\ outside}$ (136). This recommendation is aligned with the HIA objective of minimising health impacts, rather than meeting statutory or regulatory limits.

9.2.13 We suggest that the Director of Public Health for LCC requests regulatory authorities control the working hours and days for Project activities, particularly hydraulic fracturing. Consideration could be given to only operating the fracturing pumps during weekday daytime and ceasing activity during weekends and bank-holidays.

9.2.14 For noise impacts attributable to the Project which are justified on the basis of being of a similar decibel level to background noise, requests further reporting of the frequency spectrum and time-structure of such noise to evidence that it will not be clearly audible against background levels.

Hydrogeology and ground gas

We suggest that the Director of Public Health for LCC:

9.2.15 Requests updates from the Environment Agency to be assured that:

- baseline data on methane in water is understood for the proposed operational area;
- emerging knowledge on fracture proliferation continues to inform monitoring requirements;
- the DPH is informed of any breach of regulation which may occur in the future should this application be granted; and
- monitoring regimes take account of long-term migrations and the potential deterioration of the well over time.

9.2.16 Seeks clarification of how, and for how long, the Applicant will monitor the project's effect on the permeability and mobility of surrounding geological strata and natural fractures to ground water. Confirming the hypothesis, advanced in the ES, that the Woodsfold fault creates a barrier to water movement between the ground water contamination of the application and the public water supply is particularly important. Sufficient information should be provided to satisfy the Director of Public Health for LCC that public water supply

will not be contaminated directly or indirectly as a result of the Project, including long-term impacts.

9.2.17 Requests further information on how the application will affect long-term low level gas permeation to the surface including permeation to the surface which may be distant to the proposed site. Estimates of potential surface concentrations and areas of effect would be helpful.

9.2.18 Seeks confirmation of what remediation action will be taken if a significant pathway, along a fault or other discontinuity, is established for gas to the surface.

9.2.19 Requests that regulators require an appropriate long-term monitoring plan post decommissioning / abandonment to ensure that the Project does not cause adverse legacy issues for air, ground or water contamination. Responsibility for monitoring should be clearly defined and set through condition, legal agreement and / or bond. The Director of Public Health for LCC should remain engaged with the monitoring information that emerges from the planning and permitting processes.

Climate change

We suggest that the Director of Public Health for LCC:

9.2.20 Seeks further specific clarification on long-term post abandonment impacts to climate change both: as well integrity degrades, potentially creating a pathway for natural gas (notably methane) to the surface; and long-term slow permeation of un-extracted natural gas to the surface as a result of hydraulic fracturing mobilising such gases from their current geological layer. Climate change is an increasingly important determinant of health.

Waste

We suggest that the Director of Public Health for LCC:

9.2.21 Confirms with the Environment Agency that the Project's impact on the capacity of regional waste sites to treatment/disposal of medical waste is being considered as part of the permitting process.

9.2.22 Seeks clarification regarding the presence, treatment and disposal or use of liquid hydrocarbons.

9.2.23 Seeks clarification on how much equipment, which has been radioactively contaminated with NORM, will need to be disposed of and what implication this has for waste management capacity.

9.2.24 Seeks clarification on how suspension brine will be disposed of, as the ES does not describe this waste management pathway.

Induced seismicity

We suggest that the Director of Public Health for LCC:

9.2.25 Considers Verdon (137) (amongst others), who, having looked at drilling, fracking and deep injection (for analogous processes), concludes that deep injections have a direct action on fault lines; and requests clarification of how this analysis relates to conclusions in the ES concerning impacts on induced seismology associated with hydraulic fracturing.

9.2.26 Requests clarification that the Applicant has considered the implications of induced seismic activity on salt/brine mining activity in the area.

9.2.27 Seeks supporting evidence on the degree of accuracy to which the microseismic arrays measure the extent of hydraulic fractures. Including clarification of the relationship

between fracture growth and the measurement of induced seismicity as a surrogate for this growth.

Visual impacts

We suggest that the Director of Public Health for LCC:

9.2.28 Seeks clarification on whether the flares will be associated with condensation plumes due to convection effect in the atmosphere under certain weather conditions. Any plume could increase visual disturbance and introduce an industrial element into the rural landscape.

Transport

We suggest that the Director of Public Health for LCC:

9.2.29 Seeks clarification on the locations and routes for hazardous and radioactive waste treatment. It is noted that hazardous loads are a familiar feature of the UK road network. Once the locations of relevant treatment facilities have been identified, the Director of Public Health for LCC could comment on the need for routing away from population centres and accident hotspots.

9.2.30 Confirms that the traffic impacts (including air quality) of the proposals have considered seasonal road congestion, for example during the summer months standing traffic can become a feature of roads leading into Blackpool.

Water resources

We suggest that the Director of Public Health for LCC:

9.2.31 Confirms with the regulator (EA) that the Project's impact on public water capacity in the event of hot weather, drought or other unusually high periods of increased demand is being considered as part of the permitting process.

10 Review of information prepared for Roseacre Wood

10.1 Introduction

10.1.1 We have reviewed the application's ES (19) with special reference to health and wellbeing. The ES, the report which is produced as a result of the Environmental Impact Assessment (EIA), is a useful source of information for the HIA. Many of the factors considered in the EIA will have an effect on health and wellbeing. However, human health is not a core topic for EIA. The difference in perspective and methodologies between EIA and HIA means that there are inevitably issues addressed in the EIA that can be expanded upon in a HIA.

10.1.2 The review identifies two main issues.

- The conclusions of the ES are based upon appropriate management of risk and enforcement of regulations and guidelines. Whilst it is generally acknowledged that the regulatory regime overseeing and enforcing safety standards for the emerging fracking industry should provide appropriate protection to the public and workforce (26), commentators have noted that it is evolving (101) while detractors have expressed doubt that current regulation is fit for purpose (41;102).
- The ES defers a number of issues until after the application has been determined: for example, it is unclear from the ES when the Environmental Management and Monitoring Plan (EMMP), which details the monitoring scope and reporting procedures, will be available; and it is unclear from the ES whether a quantitative risk assessment (QRA) has been, or will be, undertaken to determine the risks and responses required in the event of an unplanned emergency scenario. Whilst the ES may reasonably defer these issues to post application stages, the absence of these documents hinders the fuller consideration of potential health effects associated with the application.

10.1.3 On the basis of this review we find that the ES has been completed to fulfil the requirements of an EIA, as would be anticipated. As noted above we also find that it leaves much to the post application documentation and regulatory framework. We identify some technical clarifications that could be sought by the Director of Public Health for LCC in exercising that role's duty to 'assure' health protection for the area.

10.1.4 The ES finds no significant adverse health impacts for people living and working close to, or at, the site. HIA uses different thresholds and thus might reach different conclusions. The potential adverse impacts are generally greatest at the residential properties closest to the site. The overall burden for these residences is not currently known.

10.1.5 The ES finds no significant adverse health impacts for people living and working close to, or at, the site. HIA uses different thresholds and thus might reach different conclusions. The potential adverse impacts are generally greatest at the residential properties closest to the site. The overall burden for these residences is not currently known.

10.1.6 Until regulatory responsibilities and expectations have been more clearly described it may be difficult for the Director of Public Health for LCC to discharge the duty of assurance with regard to health protection. Furthermore, until post application documentation, such as the QRA and EMMP, have been produced, it may be difficult to rule out the potential for health impacts to occur.

10.1.7 This is a detailed ES for the level of proposed development. Overall the ES appears to have provided the information which would have been expected, though there are some areas which need clarification. The main queries are listed below.

10.2 Clarifications sought

General

We suggest that the Director of Public Health for LCC:

10.2.1 Seeks clarification that the monitoring framework requirements set through the planning and permitting processes will address not only the sort-to-medium term impacts of disturbance and pollutants arising from the site to the local population, but also the potential for long-term (and potentially more widespread) legacy impacts on groundwater and ground gas. Such monitoring should be tied to an action plan with defined roles and responsibilities for notifying and responding to exceedances for the full period of the monitoring. We suggest that the Director of Public Health for LCC should remain engaged with the process and information that emerges on monitoring from the planning and permitting processes.

10.2.2 Requests that regulators collectively produce a document that summarises the application's adherence to the DECC Regulatory road map guidance (103); including the planning and permitting conditions and monitoring requirements that have been imposed at each step for the protection of public health.

10.2.3 Confirms when and what further information will be available regarding quantitative risk assessment (including unplanned events and reference to ½LFL[9]).

10.2.4 We suggest that the Director of Public Health for LCC should seek reassurance that any use of or changes to the MoD Inskip site is not associated with a public or occupational increased risks from electrocution or EMF exposure.

10.2.5 Seeks further detail on the influence on people's perception of safety associated with property values, amenity value of outdoor space and levels of physical activity.

10.2.6 Confirms how the Applicant will ensure and demonstrate that all pollution will be as low as reasonably practical using BAT. This applies to air quality (including PM_{10} and $PM_{2.5}$), noise, vibration, light and any other release from the activities on site or associated with the site.

10.2.7 Request clarification on the cumulative impacts inter (between) rather than intra (within) topics presented in the ES. For example: the cumulative radiological impact to the closest residential receptors from radiological emissions (notably radon) associated with flaring, water (NORM) and any solid waste stored onsite; or the cumulative impact of all sources of potential disturbance and nuisance to the closest residential receptors (including noise, dust, light, traffic etc …).

Air quality

We suggest that the Director of Public Health for LCC:

10.2.8 Seeks clarification as to whether there will be periods of higher exposure to radon (e.g. during the 120 day flare period assumed by the radon modelling) than is suggested by the ES reporting the exposure levels as an annual effective dose. Notably whether peak levels will exceed 400 Bq/m^3 in any 24 hour period at any receptor (on or off site). [This clarification is unlikely to change the overall conclusion in terms of public health, but would assist in resolving this as an issue for the HIA.]

[9] Being outside the area where gas has dispersed from the source to a concentration of half its lower flammable limit (½LFL) is a recognised threshold of reasonable safety (133).

10.2.9 Request clarification of whether one or two flares have been included for the radon modelling. It would be useful for actual receptors and weather data to be used in the radon modelling. [This clarification is unlikely to change the overall conclusion in terms of public health, but would assist in resolving this as an issue for the HIA.]

10.2.10 Request additional modelling of the likely radon exposure levels during unplanned events (*e.g.* loss of gas containment at ground level) for occupational and residential receptor doses. For each radon modelling result (including those requested above), data in unit of µSv/year and Bq/m^3 would be useful. [This clarification is unlikely to change the overall conclusion in terms of public health, but would assist in resolving this as an issue for the HIA.]

10.2.11 Request information on what alternatives have been considered for the capture and the use of methane during the 90 day initial flow testing stage and clarify how the decision to flare has been reached.

Noise

We suggest that the Director of Public Health for LCC:

10.2.12 Requests additional mitigation be incorporated into the Project to ensure that at all receptors noise levels attributable to the Project (notably well pad construction, drilling and hydraulic fracturing) neither exceed the WHO general health based threshold of 50/55 dB $L_{Aeq,\ 16hr}$ (135); nor the WHO night noise threshold of 40 dB $L_{night,\ outside}$ (136). This recommendation is aligned with the HIA objective of minimising health impacts, rather than meeting statutory or regulatory limits.

10.2.13 We suggest that the Director of Public Health for LCC requests regulatory authorities control the working hours and days for Project activities, particularly hydraulic fracturing. Consideration could be given to only operating the fracturing pumps during weekday daytime and ceasing activity during weekends and bank-holidays.

10.2.14 For noise impacts attributable to the Project which are justified on the basis of being of a similar decibel level to background noise, requests further reporting of the frequency spectrum and time-structure of such noise to evidence that it will not be clearly audible against background levels.

Hydrogeology and ground gas

We suggest that the Director of Public Health for LCC:

10.2.15 Requests updates from the Environment Agency to be assured that:

- baseline data on methane in water is understood for the proposed operational area;
- emerging knowledge on fracture proliferation continues to inform monitoring requirements;
- the DPH is informed of any breach of regulation which may occur in the future should this application be granted; and
- monitoring regimes take account of long-term migrations and the potential deterioration of the well over time.

10.2.16 Seeks clarification of how, and for how long, the Applicant will monitor the project's effect on the permeability and mobility of surrounding geological strata and natural fractures to ground water. Confirming the hypothesis, advanced in the ES, that the Woodsfold fault creates a barrier to water movement between the ground water contamination of the application and the public water supply is particularly important. Sufficient information should be provided to satisfy the Director of Public Health for LCC that public water supply

will not be contaminated directly or indirectly as a result of the Project, including long-term impacts.

10.2.17 Seeks clarification as to whether non-hazardous drilling mud will be used when drilling through faults, particularly the Mid-Elswick Graben Faults. Alternatives to drilling through this fault could be set out.

10.2.18 Requests further information on how the application will affect long-term low level gas permeation to the surface including permeation to the surface which may be distant to the proposed site. Estimates of potential surface concentrations and areas of effect would be helpful.

10.2.19 Seeks confirmation of what remediation action will be taken if a significant pathway, along a fault or other discontinuity, is established for gas to the surface.

10.2.20 Requests that regulators require an appropriate long-term monitoring plan post decommissioning / abandonment to ensure that the Project does not cause adverse legacy issues for air, ground or water contamination. Responsibility for monitoring should be clearly defined and set through condition, legal agreement and / or bond. The Director of Public Health for LCC should remain engaged with the monitoring information that emerges from the planning and permitting processes.

Climate change

We suggest that the Director of Public Health for LCC:

10.2.21 Seeks further specific clarification on long-term post abandonment impacts to climate change both: as well integrity degrades, potentially creating a pathway for natural gas (notably methane) to the surface; and long-term slow permeation of un-extracted natural gas to the surface as a result of hydraulic fracturing mobilising such gases from their current geological layer. Climate change is an increasingly important determinant of health.

Waste

We suggest that the Director of Public Health for LCC:

10.2.22 Confirms with the Environment Agency that the Project's impact on the capacity of regional waste sites to treatment/disposal of medical waste is being considered as part of the permitting process.

10.2.23 Seeks clarification regarding the presence, treatment and disposal or use of liquid hydrocarbons

10.2.24 Seeks clarification on how much equipment, which has been radioactively contaminated with NORM, will need to be disposed of and what implication this has for waste management capacity.

10.2.25 Seeks clarification on how suspension brine will be disposed of, as the ES does not describe this waste management pathway.

Induced seismicity

We suggest that the Director of Public Health for LCC:

10.2.26 Considers Verdon (137) (amongst others), who, having looked at drilling, fracking and deep injection (for analogous processes), concludes that deep injections have a direct action on fault lines; and requests clarification of how this analysis relates to conclusions in the ES concerning impacts on induced seismology associated with hydraulic fracturing.

10.2.27 Requests clarification that the Applicant has considered the implications of induced seismic activity on salt/brine mining activity in the area.

10.2.28 Seeks supporting evidence on the degree of accuracy to which the microseismic arrays measure the extent of hydraulic fractures. Including clarification of the relationship between fracture growth and the measurement of induced seismicity as a surrogate for this growth.

Visual impacts

We suggest that the Director of Public Health for LCC:

10.2.29 Seeks clarification on whether the flares will be associated with condensation plumes due to convection effect in the atmosphere under certain weather conditions. Any plume could increase visual disturbance and introduce an industrial element into the rural landscape.

Transport

We suggest that the Director of Public Health for LCC:

10.2.30 Seeks clarification from both LCC and the Highways Agency that the proposed traffic flow (including consideration of vehicles sizes, percentage increases in movements and road suitability for large vehicles) will not lead to increased accidents along the proposed routes, nor a compromise to the use of these routes for cycling or walking.

10.2.31 Seeks clarification on the locations and routes for hazardous and radioactive waste treatment. It is noted that hazardous loads are a familiar feature of the UK road network. Once the locations of relevant treatment facilities have been identified, the Director of Public Health for LCC could comment on the need for routing away from population centres and accident hotspots.

10.2.32 Confirms that the traffic impacts (including air quality) of the proposals have considered seasonal road congestion, for example during the summer months standing traffic can become a feature of roads leading into Blackpool.

Water resources

We suggest that the Director of Public Health for LCC:

10.2.33 Confirms with the Environment Agency that the Project's impact on public water capacity in the event of hot weather, drought or other unusually high periods of increased demand is being considered as part of the permitting process.

10.2.34 Seeks clarification on the implication of United Utilities' disclosure that the network does not support the Project's highest flow rate scenario for the Roseacre Wood site.

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